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Spending One's Time: The Hedonic Principle in *ad Libitum* Viewing of Pictures

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The hedonic principle maintains that humans strive to maximize pleasant feelings and avoid unpleasant feelings. Surprisingly, and contrary to hedonic logic, previous experiments have demonstrated a relationship between picture viewing time and arousal (activation) but not with valence (pleasure vs. displeasure), suggesting that arousal rather than the hedonic principle accounts for how individuals choose to spend their time. In 2 experiments we investigated the arousal and hedonic principles underlying viewing time behavior while controlling for familiarity with stimuli, picture complexity, and demand characteristics. Under *ad libitum* conditions of picture viewing, we found strong relationships between viewing time, valence, and facial corrugator electomyographic (EMG) activity with familiar but not novel pictures. Viewing time of novel stimuli was largely associated with arousal and visual complexity. We conclude that only after initial information about the stimulus is gathered, where we choose to spend our time is guided by the hedonic principle.

Keywords: emotion, valence, arousal, approach, avoidance, viewing time

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Motivational hedonism is one of the most powerful frameworks in which to explain human behavior. In its extreme form, motivational hedonism claims that only pleasure and pain determine human behavior (e.g., Bentham, 1789). In psychology the hedonic principle is usually considered to be the primary explanation of approach–avoidance motivation. Approach motivation is defined as instigating behavior toward a positive event (or stimulus, outcome, expectancy) whereas avoidance motivation works oppositely, instigating behavior away from a negative event (Elliot, 2006; Cacioppo, Priester, & Berntson, 1993). Although traditionally approach–avoidance motivation was treated as isomorphic to motor behavior (Schneirla, 1959), modern theories also emphasize the psychological aspect as one avoids or approaches events without any movements at all but by choosing to keep the situation as it is (Elliot & Covington, 2001). For example, avoiding a meeting by not attending it (i.e., avoiding by not approaching), or approaching a friend during a meeting by not leaving and extending the meeting (i.e., approaching by not avoiding; Elliot, 2006). Although there are limits to the explanatory power of the hedonic principle in fully describing approach–avoidance motivation and overt behavior (Carver & Harmon-Jones, 2009; Higgins, 1997; Tamir, Chiu & Gross, 2007), there is a general consensus about its importance, especially in describing behavioral tendencies (Elliot & Covington, 2001).

One fundamental prediction of the hedonic account of approach–avoidance motivation is that approach related tendencies to a stimulus will be associated with the degree to which the stimulus elicits a pleasant emotional experience. In the same vein, avoidance related tendencies should be associated with the degree to which the stimulus elicits unpleasant feelings. Note that this prediction emphasizes the relationship between behavioral tendency and the conscious experience of emotion. Although the link between emotional experience and approach–avoidance motivation is frequently assumed, only limited research has been done on this topic; consequently, the scope of the association as well as its boundary conditions are not yet clear.

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Evidence for Hedonic Principle in Approach–Avoidance Motivation

Indirect evidence for the hedonic association between conscious emotional feelings and approach–avoidance tendencies is provided by research on attitudes showing bidirectional influence between attitudes toward objects and motor movements (e.g., Neumann & Strack, 2000; Chen & Bargh, 1999). Two well-known examples are the experiments done by Chen and Bargh (1999) showing that participants were faster to respond to negative words when pushing a lever away (avoid) than when pulling it toward them (approach), and were faster to respond to positive stimuli when pulling the lever than when pushing it away (see also Solarz, 1960). Here, stimuli (words) had a semantic value but the role for the actual emotional experience of valence (pleasant and unpleasant feelings) in the conflict between pulling/pushing a lever and the valence of the stimuli was not assumed, measured or demonstrated. On the contrary, accumulated data suggest that the effect of stimulus' valence on hand flexion/extension is judgment-specific occurring only when tasks involve judgments of stimulus valence (good vs. bad) but not in valence-irrelevant judgments (female vs. male) (Rotteveel & Phaf, 2004). The fact that the congruency effect emerges only in valence-relevant judgments suggests that the source of the conflict is at the level of stimulus evaluation (e.g., categorization or response selection) and not necessarily related to conscious experience of emotions (see also Neumann & Strack, 2000; Förster & Dannenberg, 2010 for similar views).

Further indirect evidence comes from studies showing that the eyeblink defensive reflex is enhanced in the context of unpleasant feelings and is diminished in the context of pleasant feelings (see Lang, Bradley & Cuthbert, 1990 for review) with the possible moderating effect of arousal (Globisch et al., 1999). The eyeblink reflex in response to a probe (e.g., abrupt sound) was augmented when participants viewed pictures that elicited unpleasant feelings and was reduced when they viewed pictures that elicited pleasant feelings. Although it is not clear that the emotional modulation of the startle is related to emotional experience (Bradley, Lang & Cuthbert, 1993) and although the affective modulation of startle does not demonstrate that pleasant feelings are associated with approach tendencies (rather, pleasant feelings reduces the defensive reflex), it may still serve as some support of the possible association of emotional experience in the modulation of the reflex related to approach–avoidance motivation.

One informative approach to examining the hedonic principle can be found in how individuals choose to "pay" attention or "spend" their time. These turns of phrase allude to the cost associated with the allocation of our limited mental resources. If the hedonic principle holds true, the time we spend attending to an object should be a transaction toward the increase in pleasure or avoidance of displeasure. As visual animals, viewing time provides a unique window into approach–avoidance behavior. Several studies have examined more directly the relationship between the conscious experience of emotions and approach–avoidance motivation by using a paradigm of free viewing of emotional stimuli. The logic of this paradigm is that voluntary prolonged viewing time of still images reflects approach motivation (i.e., motivation to be exposed to the stimuli), whereas shorter durations reflect avoidance motivation (i.e., motivation to cease contact with the stimuli; Horley, Williams, Gonsalvez & Gordon, 2003; Lang, Greenwald, Bradley & Hamm, 1993; Rinck & Becker, 2006; Hillman, Rosengren, Smith, 2004; Suri, Sheppes & Gross, 2012). Thus, the prediction of the hedonic principle is straightforward: participants will view longer a stimulus that makes them feel pleasant and will view shorter a stimulus that makes them feel unpleasant.

In a typical such experiment, participants were presented with emotional pictures and instructed to "view the pictures for as long as desired" and to "press a key to terminate slide presentation" (e.g., Lang et al., 1993). Surprisingly, no hedonic relationship has been found using this paradigm, with participants spending as much time viewing pictures eliciting unpleasant feelings as pleasant feelings. That is, the predictor of viewing time was not valence but arousal ratings (i.e., the degree of activation experienced when viewing these pictures) (Bradley, Cuthbert & Lang, 1991; Cuthbert, Bradley & Lang, 1996; Hamm, Cuthbert, Globish & Vaitl, 1997; Lang et al., 1993; Patrick, Bradley & Lang, 1993; Vrana, Spence & Lang, 1988). Additionally, electrodermal activity (EDA), which is positively correlated with arousal ratings, was predictive of viewing time (Lang et al., 1993), whereas corrugator electromyography (EMG) activity, which is correlated with valence ratings (Larsen, Norris, & Cacioppo, 2003), showed no association. Together, these results suggest an "arousal principle" associated with affective salience, rather than a hedonic principle in the free viewing time behavior (Lang, 1995).

A recent modified version of the task (Suri et al., 2012) did not measure viewing time but showed that when participants are asked to decide which of two pictures they prefer to view again in the following trial, they were mainly driven by the hedonic principle, preferring pleasant over unpleasant pictures. It was also found that hedonic motivation is not exclusive and that arousal has an independent influence on such decisions as well. Yet, in Suri et al. (2012) viewing time was not measured directly but assessed as a parameter of explicit decision making (i.e., deciding which picture they preferred to see for a second time). So, although these results are relevant to decision making, they may not reflect the actual viewing time that participants spend exposed to emotional stimuli.

In addition to the recent results of Suri et al. (2012), which show the hedonic effect in decision making, methodological constraints in the traditional viewing time paradigms (e.g., Lang et al., 1993) make it premature to conclude that the arousal principle is the sole underlying mechanism for approach–avoidance motivation in viewing time behavior. Specifically, a variety of factors, other than emotional feelings, could influence viewing time and were not controlled for in previous research. Here we emphasize two such important variables: prior exposure to the stimulus and the structural complexity of the stimulus.

Familiarity, or the previous exposure to a stimulus, could influence viewing time in two ways: by reducing the effect of stimulus complexity and by reducing the effects of curiosity and explorative behavior. Stimulus complexity (e.g., a busy scene vs. a single object) is strongly associated with viewing time behavior (Wohlwill, 1968). Consequently, the effect of stimulus complexity on perceptual identification could mask or interfere with viewing time behavior, rendering the approach–avoidance strategies latent. It was shown that previous exposure typically eases stimulus recognition by lowering the perceptual identification thresholds (Tulving, & Schacter, 1990) and facilitates performance on object naming (Murray et al., 1993; Srinivas, 1993), fixation rate (Faw & Nunally, 1968), reaction time (RT) to mental load (Escera, Alho, Winkler & Naatanen, 1998), visual search (Frith, 1974; Wang, Cavanagh & Green, 1994), and viewing time (Olney, Holbrook & Batra, 1991). Facilitating perceptual identification, in turn, could reduce the effect of stimulus complexity on viewing time (Wohlwill, 1968) and reveal the underlying motivational patterns of approach and avoidance. To the extent that viewing time of emotional pictures is influenced by perceptual identification and stimulus complexity, and to the extent that the hedonic pattern underlies viewing time behavior, we might expect to find a stronger hedonic pattern with familiar stimuli (i.e., with prior exposure) than with novel (i.e., first exposure) ones.

A second way in which previous exposure to a stimulus can affect the hedonic pattern is through reducing exploratory behavior on viewing time. Rodents demonstrate dominant explorative behavior in the first encounter with an aversive situation, whereas avoidance is strongly manifested only with prior exposure (e.g., Almeida, Garcia & De Oliveira, 1993; Bertoglio, & Carobrez, 2000). To the extent that human participants show exploratory behavior in the first encounter with the emotional pictures, we predict that a clear hedonic reaction might only be manifested upon second exposure.

Present Study

The main aim of the present work is to reexamine the “arousal principle” as a sole underlying explanation of the viewing time behavior of emotional pictures. Specifically, in addition to arousal, we control for familiarity (first vs. second exposure) and stimulus complexity, two important factors in object recognition, in order more closely examine whether there exists an “hedonic principle” in free viewing time.

In addition, we employed two types of valence ratings systems to estimate the conscious experience of emotions. Emotion experience (self-reports of emotions) is typically modeled by one of two dimensional models: by two dimensions of bipolar valence and arousal (the valence-arousal model), or by two separate dimensions of pleasure and displeasure (the bivariate valence model). The two models are analytically related (Kron et al., 2013): when pleasure and displeasure are estimated independently (through the bivariate valence model), on separate unipolar scales for the degree of pleasant feelings (PL) and unpleasant feelings (UN), arousal is a function of the two, usually very close to their sum, PL + UN, whereas bipolar valence is their subtraction PL − UN. Although analytically dependent, the two models were used to address different research questions and analysis strategies. We first used the bipolar valence and arousal scales to make an analysis comparable with the previous studies (e.g., Lang et al., 1993). We also used separate unipolar scales for PL and UN to better pinpoint the relative contribution of PL and UN feelings in predicting viewing time. This will permit analyzing the degree to which viewing time is tied specifically to pleasure versus displeasure—providing a more complete picture of the hedonic principle in viewing time.

Experiment 1

Experiment 1 is composed of 4 independent experiments (Experiments 1a–1d) that share a very similar design and three experimental aims: (a) to examine the effect of familiarity on viewing time, (b) to statistically control for the effect of structural complexity of the stimuli, and (c) to examine the association between the viewing time of pictures and the hedonic pattern of emotional feelings using a task whose purpose is not obvious to participants. If the hedonic principle is related to the viewing time of pictures then we expect self-reports of bipolar valence to be positively associated with viewing time (i.e., a longer viewing time with more pleasant feelings). Arousal-related viewing time behavior should be manifested in positive association between self-reported arousal and viewing time behavior.

Shared Methodological Aspects of Experiments 1a–1d

Participants. University of Toronto students completed the experiments for monetary compensation or a course credit. Females and males were independently assigned to experimental condition to ensure equal number of females and males in each condition. See Table 1 for details about participants of each experiment.

Stimuli. Images were selected from the International Affective Picture System (IAPS) (Lang, Bradley & Cuthbert, 1997) such that all possible combinations of arousal and valence of the IAPS were represented, as well as samples of all the main content

Table 1
Overview of Experiments 1a Through 1d

Experiment	1a	1b	1c	1d
No. of participants	40 (30 females)	48 (27 females)	42 (20 females)	32 (20 females)
No. of participants guessed	2	6	4	7
Data points omitted from analysis (3 *SD*)	1.5%	0.02%	0.01%	0.02%
Affective ratings scales	Bipolar valence arousal	Two unipolar valence scales	Two unipolar valence scales	Two unipolar valence scales
Order of free and fixed viewing tasks	Counter-balanced	Counter-balanced	Counter-balanced	Fixed before free viewing task
Fixed exposure time to pictures (ms)	6000	6000	500	6000

Note. No. of participants = Number of participants in the analysis. No. of participants guessed = Number of participants who guessed that viewing time was recorded and were replaced by new participants. Data points omitted from analysis (3 *SD*) = Percentage of data points that were omitted from the analysis because of a deviation greater than 3 *SD* from the general mean (of each participant). Affective rating scales = Type of rating scales that were used to measure self-reports of emotional experience. Order of free and fixed viewing tasks = Whether the design is counter balanced between fixed and free viewing tasks. Fixed exposure time to pictures = Presentation time of pictures in the fixed viewing task.

categories (e.g., babies, mutilated bodies). With these aspects in mind we selected two separate subsamples of images.

We selected 60 images for subsample 1 with the goal of covering the entire IAPS space of valence and arousal. To ensure that the stimuli were randomly chosen and were equally spaced across the arousal-valence IAPS space, we used an in-house algorithm (see Figure 1; Kron et al., 2013). The algorithm randomly selected a sample of 60 images such that the resulting two dimensional shape of the selected sample was the same as the original shape of the IAPS set, and all of the images were spread across this shape in a uniform manner.

The second subsample (subsample 2) consisted of 35 pictures. We selected stimuli to represent different content categories, that is, aversive, neutral, or pleasant. Most of the categories we chose following Hamm et al. (1997). Categories included mutilated bodies (mean arousal [a] 6.29, and mean valence [v], 1.93), guns and aggressive animals (a: 5.84, v: 3.41), spiders and snakes (a: 5.99, v: 3.7), household objects and mushrooms (a: 3.14, v: 4.93), and erotic pictures (a: 6.35, v: 6.47). We also added two more categories, babies and baby animals (a: 4.75, v: 7.87), and extreme sports (a: 6.05, v: 6.7), to balance out the categories with aversive images. For each category we selected five pictures.

Affect rating scales. Participants rated their emotional experience on two separate scales of arousal and bipolar valence. The arousal scale ranged from 1 (*clam/low arousal*) to 9 (*high arousal*), whereas the bipolar valence scale ranged from −5 to 5, that is, from *strong unpleasant* to *strong pleasant* feelings.

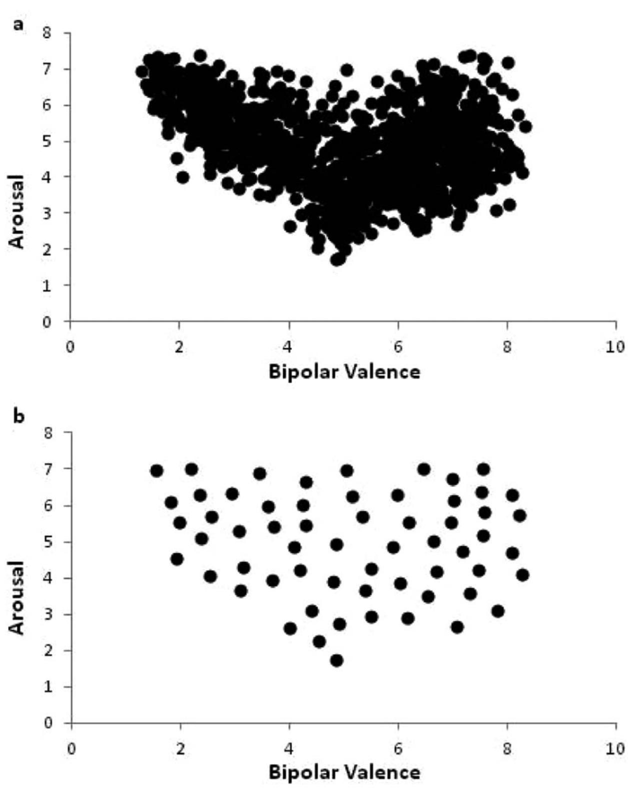

Figure 1. A sample of pictures covering the combinations of bipolar valence and arousal values of the IAPS space. (a) Distribution of all pictures of the IAPS pool over the arousal and bipolar valence plane/space. (b) Distribution of the algorithmically selected sample of 60 pictures over the arousal and bipolar valence plane/space.

Structural complexity assessment. The complexity scale was adopted from Todd et al., (2012), which asked participants to evaluate the complexity of a picture by selecting a value ranging from 1 (*very simple*) to 9 (*very complex*), while specifically instructed to ignore the hedonic content. We collected these measures using a different sample of 25 participants (16 females).

Design. Each participant performed 2 tasks: a free viewing task and a rating task. Participants were randomly allocated to one of two conditions: in one, the free viewing task was first, followed by the rating task, and in the other, the rating task was first followed by the free viewing task.

Free viewing task. Participants viewed all 95 pictures: 60 of subsample 1 (stimuli covering all of the IAPS space) and 35 of subsample 2 (content categories). Pictures from the two subsamples were combined and presented randomly in one block. During this task participants voluntarily pressed a keyboard key to move from one picture to the next.

Fixed viewing task. Participants viewed the same 95 pictures. Each trial consisted of viewing a stimulus and then rating it: an IAPS picture was presented for six seconds followed by the two rating scales of arousal and valence.

Procedure. Participants provided informed consent and were allocated to one of the two conditions. Before the free viewing task, participants completed a short practice session of 4 trials with a distinct picture set, to ensure that the viewing time was not affected by unfamiliarity with the task. To distract participants from the purpose of the free viewing task, they were connected to an electrode that participants were told measured their heart rate. The goal was to make participants believe that the aim of this task was to record changes in heart rate and not viewing time. To make the cover story more vivid, before starting the task participants saw a graph of their heart rate on a screen. The experiment was conducted on a computer, using a 19“ monitor, located 0.5 m away from the participant.

When the free viewing task was first, participants were instructed, “Before the main part of the experiment, we want you to see a set of pictures. Press the spacebar to move from one picture to the next.” When this task was second, participants were instructed, “Before you leave, we want you to see the pictures one more time. Press the spacebar to move from one picture to the next.”

Before the fixed viewing task, participants went through a practice run. The aim was to introduce the scales and to make sure that participants rated their actual emotional experience while watching the pictures. Specifically, we showed them a picture and said, “We are going to show you a picture now. Just look at it and notice how it makes you feel.” After, participants had a chance to recognize the feelings elicited by the stimulus, we asked them to rate those feelings on two scales. For the arousal scale the instructions were as follows: “If you look at a picture and you feel very aroused, excited or wide awake, pick 9. If you feel very calm, bored, or not aroused, pick 1.” For the bipolar valence scale, we said, “When looking at the picture, if you feel extremely pleasant pick 5, if you feel extremely unpleasant pick −5, and if you do not have either pleasant or unpleasant feelings pick 0.” (Lang et al., 1997).

Before debriefing, participants were asked to fill out a questionnaire indicating their age, gender and what they thought was the purpose of both parts of the experiment. We used the questionnaire to determine if participants were aware that viewing time was recorded.

Data reduction.

Participants who guessed the aim of the experiments. After analyzing the post experiment debriefing questions, we identified and replaced participants who guessed that viewing time was recorded (see Table 1 for details).

Outliers. Viewing times that were longer or shorter than three standard deviations from the mean of each participant were omitted from analysis (see Table 1 for details).

Standardization. Viewing time (milliseconds) scores were standardized for each participant so the contribution from each participant to the average would be equal (see Appendix for viewing time raw data descriptive statistics). All self-report rating scales and stimulus complexity scales were standardized to reduce the effect of scale structure and variance of scale on model coefficient (the pattern of results remained the same when scales were used with raw scores).

Statistical analysis. Experiments 1a to 1d are reported from four perspectives: whole IAPS space analysis, content category based analysis, unipolar pleasure and displeasure, and statistical control for stimulus complexity.

Whole IAPS space analysis. Whole IAPS analysis was done using subsample 1. Given the hierarchical nature of the data, whole IAPS space analysis was estimated via Linear Mixed Model (Proc Mixed, SAS) with participants as a random factor. Unless specifically reported, all model coefficients are partial regressors: analysis conducted with standardized viewing time as the dependent variable and standardized rating scales (bipolar valence and arousal) as predictors. Simple effects (e.g., association of bipolar valence with viewing time in the first exposure) were estimated in two separate models, one for the first exposure and one for the second exposure. Interaction effects were added separately to address a specific research question. For example, to estimate the interaction component comparing the association of valence with viewing time in first versus second exposure, the model includes arousal, valence and valence × dummy variable (code first vs. second exposure). To estimate the interaction of arousal, we compute the second model with valence, arousal, and arousal × dummy (first vs. second) as predictors. Although reported in terms of linear mixed models, the pattern of results remained the same in the item-based analysis and regression for repeated measures (Lorch & Myers, 1990).

Category-based analysis. Category based analysis was done using subsample 2. Within participants, we computed the mean viewing time for each of the seven categories. The viewing time means were subjected to further analysis. Viewing time scores of the seven categories were ordered by the value of bipolar valence (see horizontal axis in Figure 5) and were entered into a mixed design ANOVA model (proc glm, SAS) as a repeated variable with the order of the free viewing task (first vs. second) as the between participants factor.

Entering categories into the model according to their valence value enables us to estimate two trends across categories: quadratic and linear. A quadratic pattern would reflect arousal-like behavior and a linear one would be equivalent to a hedonic pattern.

Unipolar pleasure and displeasure. Effects of unipolar pleasure and displeasure were estimated using subsample 1 (“whole IAPS space”). The pattern of the bivariate correlations between pleasure, displeasure, and viewing time suggests reciprocal suppression (Conger, 1974; Tzelgov & Henik, 1991) in the first exposure and multicollinearity (Gunst & Webster, 1975) in second exposure. Following this interpretation of the bivariate associations, in first exposure pleasure and displeasure are entered together to the same linear mixed model and partial coefficients are reported. In the second exposure, to avoid multicollinearity, pleasure and displeasure are estimated in separate models.

Statistical control for stimulus complexity. Control for stimulus complexity was done by adding stimulus complexity scores as an additional predictor to the linear mixed model.

Meta-analysis. For each research question, we also report the results of the meta-analysis of Experiments 1a–1d. Meta-analysis was performed by analyzing data from the four experiments within one linear mixed model (Sheu & Suzuki, 2001) with the subject as a random factor and the experiment as a fixed (class) factor.

Experiments 1a-1d

Table 1 provides an overview description of the four experiments.

Experiment 1a. In Experiment 1a we compared the condition in which free viewing time was first (and fixed viewing was second) with the condition in which free viewing time was second (and fixed viewing time was first). Valence and arousal were computed from bipolar valence and arousal scales.

Experiment 1b. Experiment 1b was designed to provide a near complete replication of Experiment 1a, employing exactly the same design with one exception: instead of rating feelings on bipolar valence and arousal scales, participants rated their emotional experience on unipolar valence scales. Using the bivariate scales allows us to examine the effect of arousal (pleasure + displeasure) and bipolar valence (pleasure − displeasure), as well as to specify the potentially separate roles of pleasant and unpleasant valence in viewing time behavior.

Experiment 1c. In Experiments 1a and1b we chose an initial picture presentation time of six seconds in order to be comparable with previous literature. However, if mere familiarity is the crucial component of the hedonic pattern in viewing time behavior, we would expect it to emerge even if pictures were presented briefly. For example, previous work showed that reliable emotional experience was elicited even when pictures are presented for 500 ms (Codispoti, Bradley & Lang, 2001). Experiment 1c was designed to provide further evidence for the familiarity effect by examining whether the hedonic pattern is retained after such a brief exposure (500 ms) to the pictures. If familiarity is responsible for the hedonic pattern, then we would expect that the viewing time would still follow the hedonic pattern even with a brief first exposure to the pictures. Experiment 1c is similar to Experiment 1a except for the brief presentation time of the pictures in the fixed viewing time task, in which participants viewed each picture for 500 ms (and not 6000 ms as in the previous experiments) and rated their feelings on unipolar PL and UN scales.

Experiment 1d. In Experiments 1a to 1c when the free viewing time was collected in the second task, the first task consisted of watching each picture for a fixed amount of time (6 s), which was immediately followed by an evaluation of emotional experience by self-report scales. As such, two different factors could influence the shift into the hedonic pattern in the second task: first, it could be the mere exposure to the pictures; that is, the pattern emerges in response to a familiar picture but not a novel one. The alternative cause could be related to the fact that participants *rated* their feelings in the first task. The two processes (watching the pictures and ratings them) were confounded in the previous experiments and hence could not be teased apart. The aim of Experiment 1d is to examine the hedonic pattern in the second task when the first task includes only viewing pictures for the same fixed interval and not rating them. If the hedonic pattern is observed even when pictures are only watched and not rated, it will be plausible to conclude that the main difference between the first and the second tasks is familiarity, that is, in the first task the pictures were novel and in the second task the pictures were familiar, and this is the factor responsible for the hedonic pattern of the viewing time in the second task but not the first.

Results

"Whole IAPS space analysis": the relationship between bipolar valence, arousal and viewing time. IAPS space analysis is based on sample 1, which represents all possible combinations of bipolar valence and arousal in the IAPS space. Such analysis is important to ensure that the associations of valence and arousal and viewing time are not restricted to one specific configuration of bipolar valence and arousal scores.

Bipolar valence. As is clearly evident from the forest plot in Figure 2, a consistent pattern emerges from all four experiments: during first exposure to the stimuli, there is no evidence of a significant linear relationship between bipolar valence and free

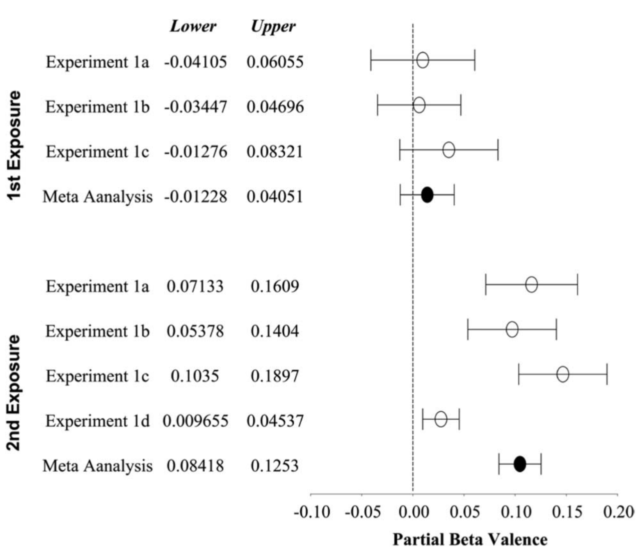

Figure 2. Forest plot and confidence intervals (α = .05) table for the role of valence in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no relationship between valence and viewing time. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion and standardized bipolar valence, arousal, and stimulus complexity as predictors.

viewing time. However, a consistent significant linear relationship emerged between bipolar valence and viewing time in the second exposure indicating that participants spent the most time watching pleasant pictures and least time watching unpleasant pictures, when stimuli were familiar. This pattern is consistent in all four experiments and in the meta-analysis.

In accordance with the pattern that shows no relationship between bipolar valence and viewing time in first exposure and a consistent relationship in the second exposure, the interaction of bipolar valence with first versus second exposure is significant and consistent in all four experiments and the meta-analysis (see Figure 3).

Arousal. As is apparent from the forest plot in Figure 4, arousal shows a significant linear relationship with viewing time (higher arousal associated with longer viewing time) for both first and second exposures. The pattern of a positive linear relationship between arousal and viewing time emerged in 3 of 4 experiments and in the meta-analysis. Arousal did not show a significant linear relationship in Experiment 1c.

Category-based analysis. Next we will examine the hedonic pattern on a different set of pictures which were sampled in advance to represent seven content categories covering the bipolar valence spectrum (subsample 2): mutilated bodies, snakes and spiders, guns and aggressive animals, household objects, erotic pictures, and babies and baby animals (see Methods–Stimuli–Subsample 2). This analysis is important for three reasons: first, to replicate the results of the 'whole IAPS space" analysis with a different set of pictures; second, to enable a more direct comparison with the previous research that used category analysis (Hamm et al., 1997); and third, to examine whether the different trends of associations between viewing time in the first versus second task are category-specific.

Categories were ranked according to their bipolar valence value from unpleasant to pleasant (see Figure 5). Given that categories were selected and ranked by their bipolar valence values, to make comparison between valence and arousal meaningful, linear relationship between bipolar values and viewing time is analyzed to represent association with bipolar valence and quadratic association between bipolar valence values and viewing time will be analyzed as proxy to association to arousal.

Bipolar valence. Figure 5 and Table 2 summarize the results of content category analysis. Consistent with the above "whole IAPS space" analysis, in all four experiments and in the meta-analysis valence shows no significant linear (i.e., hedonic) pattern with novel pictures. However, replicating the analysis of the "whole IAPS space" subsample, bipolar valence showed a significant linear relationship with viewing time (pleasant pictures were viewed longer) upon second exposure. A significant linear relationship emerged in all four studies and in the meta-analysis. The interaction effect—the comparison between the associations of valence in the first versus second exposure—is less consistent: there was a marginally significant effect in Experiments 1a and 1c, a significant effect in Experiment 1b, and a significant effect in the meta-analysis.

Arousal. Replicating the results of the "whole IAPS space" subsample, a significant quadratic (arousal-like) trend emerges with novel pictures (see Table 2 and Figure 5). However, unlike

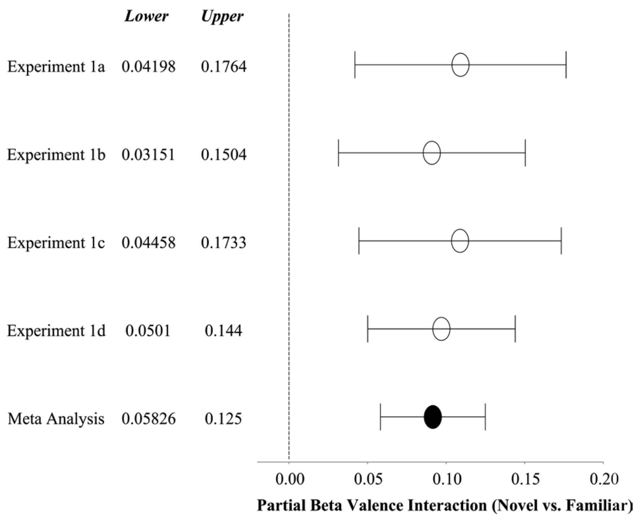

Figure 3. Forest plot and confidence intervals ($\alpha = .05$) table for the interaction of valence with first versus second exposure in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no interaction. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion, first versus second exposure as classification factor, and standardized bipolar valence, arousal stimulus complexity, and interaction component as predictors.

the "whole IAPS space" subsample, analysis for second exposure arousal showed no significant association with viewing time in either of the experiments, but showed a significant association in the meta-analysis. The interaction effect—the

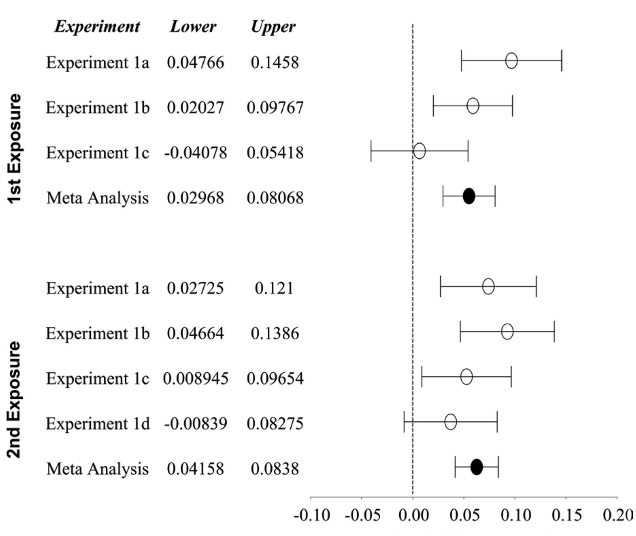

Figure 4. Forest plot and confidence intervals ($\alpha = .05$) table for the role of arousal in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no relationship between arousal and viewing time. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion and standardized bipolar valence, arousal, and stimulus complexity as predictors.

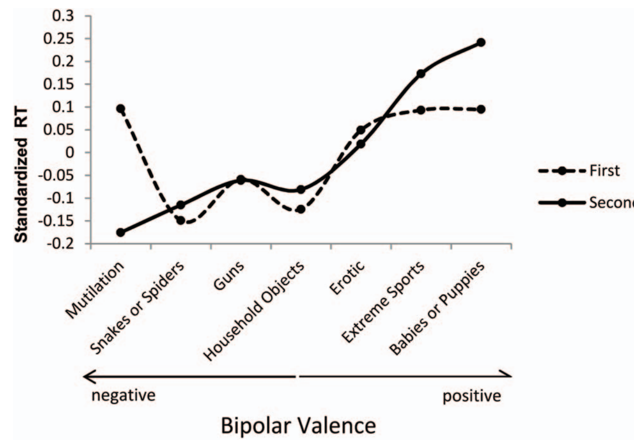

Figure 5. Hedonic and arousal trends in category based analysis. Content categories are ranked along the *x* axis according to theirs bipolar valence mean values. The dashed line represents standardized viewing time during the first exposure, and the continuous line represents the second exposure.

comparison of association of arousal in the first versus second exposure—was not significant.

The relationship between unipolar pleasure and displeasure in predicting viewing time. We next decomposed bipolar valence into unipolar pleasure and displeasure and examined their independent roles in viewing time of novel and familiar emotional pictures across Experiments 1b to 1d.[1]

Association of unipolar pleasure with viewing time. As can be seen in the forest plot in Figure 6, pleasure shows an inconsistent pattern of association with viewing time in the first exposure to the stimuli. However, consistent with the results showing a stronger bipolar valence association with viewing time with familiar pictures, in the second exposure to the stimuli, unipolar ratings of pleasant feelings show a significant linear association (pleasant pictures were viewed longer) with viewing time in all four experiments and in the meta-analysis.

Association of unipolar displeasure with viewing time. As can be seen in the forest plot in Figure 7, displeasure shows no significant association with viewing time in first exposure but it shows a significant negative linear association in the second exposure (Experiments 1c and 1d and meta-analysis).

Together, the patterns of pleasure and displeasure suggest a stronger effect of valence in the second exposure to the stimuli because of both the positive association of pleasure and the negative association of displeasure with viewing time. In other words, we can see an increase in viewing time when participants experi-

[1] Omitting Experiment 1a from analysis: Self-reports in Experiment 1a were measured by arousal and bipolar valence. Whereas there is strong evidence for converting pleasure and displeasure to arousal (PL + UN) and to bipolar valence (PL − UN), the reverse conversion, although possible, is less validated and hence will not be reported here. However, the analyzed RT of the free viewing time in Experiment 1a using the ratings of pleasure and displeasure from Experiment 1b (both experiments use the same pictures) showed similar significant results.

Table 2
Inferential Statistics (F Values) for Category-Based Analysis

	First presentation		Second presentation		Interaction with first versus second presentation	
Experiment	Bipolar valence	Arousal	Bipolar valence	Arousal	Bipolar valence	Arousal
1a	0.00	3.56	7.60*	0.35	3.94	1.12
1b	0.71	5.03*	14.64**	0.44	5.35*	0.94
1c	2.53	5.01*	14.42**	1.96	3.41	0.07
1d			4.85*	2.33		
Meta-analysis	1.97	13.20**	38.05***	4.08*	9.53**	2.20

* $p < .05$. ** $p < .005$. *** $p < .0005$.

enced pleasure and a decrease in viewing time when they experienced displeasure.

The relationship between stimulus complexity and viewing time. Across all four experiments, stimulus complexity was associated with free viewing time with both novel and familiar pictures (see Figure 8).

Figure 8 suggests that the effect of stimulus complexity on viewing time was slightly stronger during the first exposure than during the second exposure. The interaction effect analysis (see Figure 9) partially confirmed this impression. The interaction effect was significant for Experiments 1b and 1d, marginally significant for Experiment 1a, and not significant for Experiment 1c when pictures were first presented for 500 msec. Overall, a significant effect emerged in the meta-analysis of all four experiments.

Statistical control for stimulus complexity. Given the strong and consistent association of stimulus complexity with viewing time (see Figure 8), it is informative to see whether the effects of valence and arousal on viewing time remain after stimulus complexity is statistically controlled for (see also Data Analysis in the Method section).

The association of stimulus complexity with bipolar valence and arousal. To facilitate interpretation of statistical control, we first estimate the linear association of bipolar valence and arousal with stimulus complexity. The association was estimated within a linear mixed model (proc mixed SAS) in meta-analysis, with the experiment as a fixed between participants factor, the subject as a random effect, standardized arousal and bipolar valence as continuous predictors, and standardized scores for stimulus complexity as criterion (DV). Both arousal and bipolar valence are significantly linearly associated with stimulus complexity, $t = 26$ $p < .0001$, $t = -10$, $p < .0001$. Although inferential statistics of the difference between the association of valence and arousal with stimulus complexity is challenging, comparing the standardized

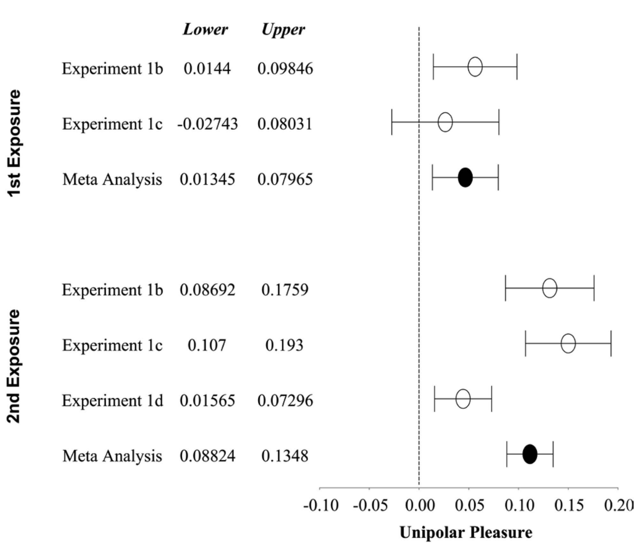

Figure 6. Forest plot and confidence intervals ($\alpha = .05$) table for the role of pleasant feelings in predicting free viewing time across Experiments 1b–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no relationship between pleasure and viewing time. Beta and partial betas (see Method) were computed from a linear mixed model which includes standardized viewing time as criterion, standardized pleasure (and standardized displeasure for novel pictures), and stimulus complexity as predictors.

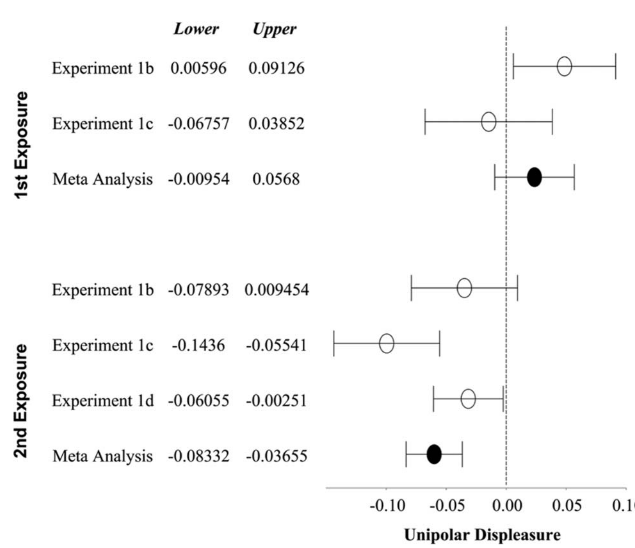

Figure 7. Forest plot and confidence intervals ($\alpha = .05$) table for the role of unpleasant feelings in predicting free viewing time across Experiments 1b–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no relationship between displeasure and viewing time. Beta and partial betas (see Method) were computed from a linear mixed model which includes standardized viewing time as criterion, standardized pleasure (and standardized displeasure for novel pictures), and stimulus complexity as predictors.

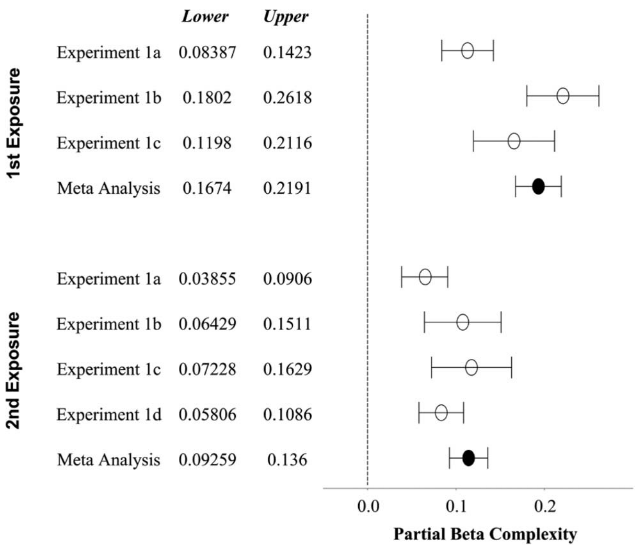

Figure 8. Forest plot and confidence intervals (α = .05) table for the role of stimulus complexity in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no relationship between stimulus complexity and viewing time. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion and standardized bipolar valence, arousal, and stimulus complexity as predictors.

coefficient might suggest a stronger association with arousal. We address this issue and its meaning for the interpretation of statistical control in the General Discussion.

Statistical control for stimulus complexity—the association of bipolar valence and viewing time. When stimulus complexity was controlled for (forest plot in Figure 10), the association of bipolar valence with viewing time of novel pictures was inconsistent. In Experiments 1a and 1b no association was found, Experiment 1c showed a significant positive association (longer viewing time for pleasant feelings) and a significant association was found

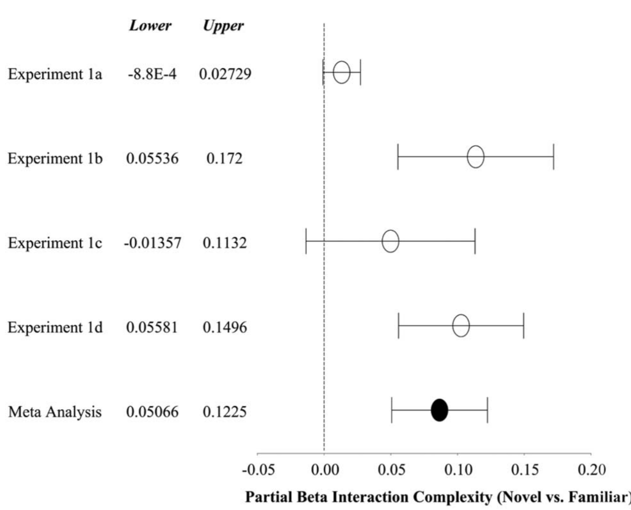

Figure 9. Forest plot and confidence intervals (α = .05) table for the interaction of stimulus complexity with first versus second exposure in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represent the inability to reject the null hypothesis about no interaction. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion, first versus second exposure as classification factor, and standardized bipolar valence, arousal stimulus complexity, and interaction as predictors.

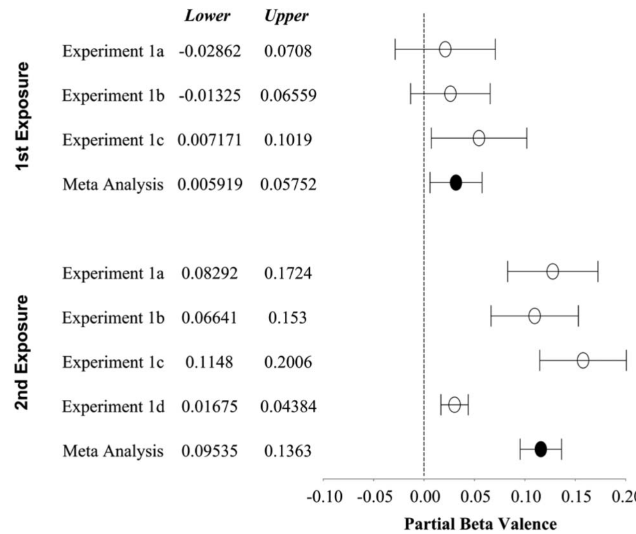

Figure 10. Forest plot and confidence intervals (α = .05) table for the role of valence in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no relationship between valence and viewing time. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion and standardized bipolar valence, arousal, and stimulus complexity as predictors.

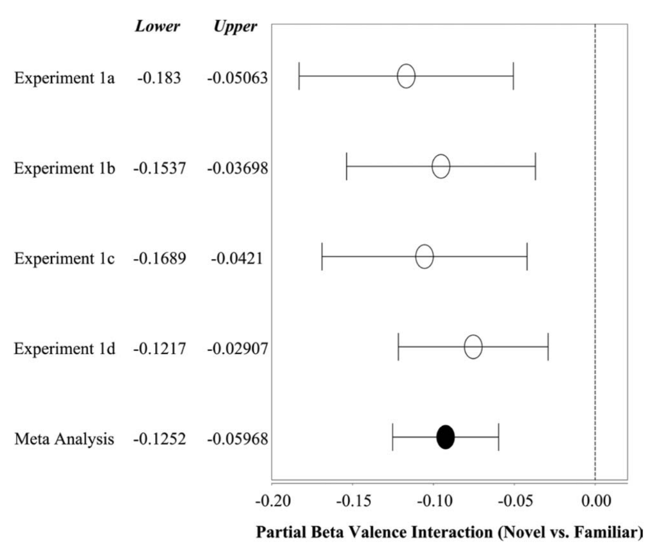

Figure 11. Forest plot and confidence intervals (α = .05) table for the interaction of valence with first versus second exposure in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no interaction. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion, first versus second exposure as classification factor, and standardized bipolar valence, arousal stimulus complexity, and interaction component as predictors.

in the meta-analysis of the three experiments. However, a positive association between bipolar valence and free viewing time (i.e., association of longer viewing time with higher ratings of pleasure) is consistent for familiar pictures and is evident in all four experiments and the meta-analysis. The interaction of bipolar valence with first and second exposure is significant and consistent (Figure 11).

Statistical control for stimulus complexity—the association of arousal and viewing time. The association of arousal with viewing time was dramatically reduced when we controlled for stimulus complexity (forest plot in Figure 12). When participants saw the pictures for the first time, a positive association between arousal and viewing time was found only in Experiment 1a. In Experiments 1b and 1c and in the meta-analysis we found no significant relationship between arousal and viewing time. When participants viewed familiar pictures, no association was found in Experiments 1c and 1d, marginal association was found in Experiment 1a, and a significant association was found in Experiment 1b. Overall, the meta-analysis suggests a small but significant association between arousal and viewing time in the second exposure.

Discussion

Hedonic and arousal patterns were estimated in free viewing time of emotional pictures and compared under the first and second exposures to the pictures (Experiments 1a–1c), with control for stimulus complexity, under conditions of brief exposure (Experiment 1c), and with control for the effect of ratings in the first exposure (Experiment 1d). In the analysis, patterns were analyzed using two different sets of stimuli, category-based and “whole IAPS space” analysis. In addition, in the third analysis we decomposed the effect of arousal and bipolar valence into independent effects of pleasure and displeasure (see Kron et al., 2013). Over all analyses and experiments, a consistent hedonic pattern emerged: free viewing time was longer for pleasure and shorter for displeasure with familiar (second exposure) but not with novel (first exposure) stimuli, even when controlling for arousal. Arousal alone showed a more complex pattern; with strong evidence for an association of arousal in both first and second exposure in the “whole IAPS space” but less so when stimulus complexity was statistically controlled. The strong and consistent effect of valence is in contrast with the previous findings, which did not show evidence of a hedonic pattern (e.g., Hamm et al., 1997; Lang et al., 1993). We will consider these differences in the General Discussion.

Previous studies have shown an “arousal principle” in viewing time behavior not only via self-reports but also through physiological activity. Electrodemal activity (EDA) is associated with self-reported arousal more than with bipolar valence, whereas corrugator Electromyography (EMG) activity is negatively associated with bipolar valence and not with self-reported arousal (Lang et al., 1993). According to this dissociation, and the findings for the arousal principal underlying viewing time behavior, it was previously found that viewing time task was associated with EDA but not with EMG (Lang et al., 1993). Experiment 2 examines the association between EDA and corrugator EMG activity and the free viewing time of emotional pictures, while examining and controlling for the effects of stimulus complexity and familiarity.

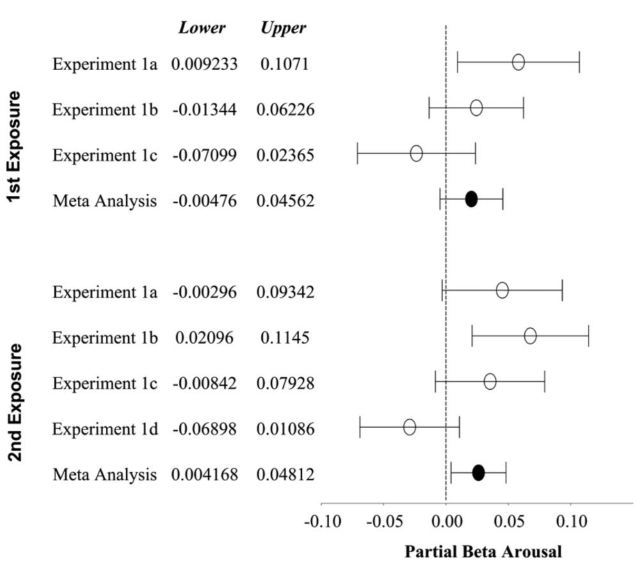

Figure 12. Forest plot and confidence intervals (α = .05) table for the role of arousal in predicting free viewing time across Experiments 1a–1d. Reference line (dashed line) on zero represents the inability to reject the null hypothesis about no relationship between arousal and viewing time. Partial beta was computed from a linear mixed model which includes standardized viewing time as criterion and standardized bipolar valence, arousal, and stimulus complexity as predictors.

Experiment 2

In Experiment 2 pictures were first presented for a fixed amount of time and self-reports (bipolar valence and arousal, PL and UN), as well as EDA and facial EMG activity, were collected (Lang et al., 1993). The free viewing task, during which viewing time was recorded, was second and identical to the tasks in Experiments 1a–1d.

In light of the results from the free viewing task of Experiment 1a–1d (which showed a hedonic pattern with familiar stimuli) we predict that, when familiar, a negative association between EMG and viewing time will be manifested whereas EDA, which is associated with self-reported arousal, will show low or no association.

Method

Participants. Thirty-two undergraduate students (21 females) from the University of Toronto performed the experiment for a course credit.

Stimuli. We sampled pictures from the IAPS (Lang et al., 1997). Two subsamples were used. The first subsample used an in-house algorithm to randomly select 40 pictures that covered the whole IAPS space, sampling all possible combinations of bipolar valence and arousal values. The second subsample ensured that extreme values of each combination of valence and arousal were included. These extremes have been found to affect EDA activity more than midrange or low values (e.g., Bradley et al., 2001). For the second subsample an additional four pictures were selected for each of the eight combinations of high/low × valence/arousal, resulting in a total of 32 pictures. Combining the two subsamples provided a full representation of the IAPS space (72 pictures).

Structural complexity assessment. In a pilot study, 20 participants (14 females) rated all of the stimuli sampled for this experiment using the same complexity scale as in Experiment 1.

Physiological response measurement. Physiological data were acquired using the 2004 BIOPAC System. Signals were sampled at 1000 Hz. Left eye corrugator EMG activity was measured with 4 mm electrodes which were placed according to Fridlund and Cacioppo (1986). Using ANSLAB 2.4, frequencies below 20 Hz were filtered, and then EMG signals were notched at 60 Hz and rectified. To measure EDA, two skin conductance electrodes were placed on the hypothenar eminence of the left index and middle fingers. The signal was acquired with a GSR100C BIOPAC amplifier.

Design. Each trial began with a blank screen presented randomly for a duration between 10 and 21 s, to avoid anticipatory responses and for recording of physiological signals. Then, a picture was presented for 6 seconds followed by the rating scales. On each trial participants rated their feelings according to one of the two self-report models, either bipolar valence and arousal or unipolar pleasant (PL) and unpleasant (UN) valence. As such, each participant rated half of the pictures according to the pleasant and unpleasant unipolar model and half of the pictures according to the bipolar-valence arousal model. We chose this approach so participants would not confuse the 4 rating scales, keeping them maximally independent, and more likely to show differences. To avoid confusion, the rating scales were presented in a fixed order for each participant for the entire experiment (e.g., in the bipolar valence model, arousal scale always appeared first and bipolar valence scale second). The order of scale presentation was counterbalanced between participants. The free viewing task was exactly as in Experiments 1 and 2: participants viewed 72 pictures, 40 pictures of subsample 1 (stimuli covering all of the IAPS space) and 32 pictures of subsample 2 (stimuli that represented extreme values of valence and arousal).

Procedure. To be comparable with previous literature and experiments on this topic, we used the traditional design in which viewing time was measured in the second phase, after measuring self-report and physiological reactions to the pictures (Bradley et al., 1991; Hamm, Cuthbert, Globish & Vaitl, 2007; Lang et al., 1993; Patrick et al., 1993; Vrana, Spence & Lang, 1988). Self-reports and physiological measure predictors were used to explain viewing time in a distinct portion of the data time series, ensuring data independence.

First, participants provided consent and measuring devices were connected. Instructions for rating valence and arousal were given followed by the IAPS protocol (Lang et al., 1997) and were the same as in Experiments 1a–1d. After a short practice (ratings of 3 pictures) participants watched all pictures and rated their feelings while corrugator EMG and EDA were recorded. After the last block of pictures participants performed the free viewing task. Specifically, we told them “Before you leave, we want you to see the pictures one more time. Press the spacebar to move from one picture to the next.” After the experiment, participants were debriefed to examine whether they were aware that viewing time was recorded to eliminate any participants who guessed the experimental hypotheses (see Method in Experiment 1).

Data reduction. Corrugator EMG responses were determined by dividing activity 1-s before picture presentation by the average change over the 6-s picture period (Lang et al., 1993; Larsen et al., 2003). EDA was estimated by log transformation (log[EDA + 1]) of the maximum change occurring between 1 and 4 seconds after picture onset (Bradley, Codispoti, Cuthbert et al., 2001; Lang et al., 1993).

Results

Two participants guessed that viewing time was recorded and were replaced. As in previous experiments, viewing times that were longer or shorter than three standard deviations from the mean of each participant were considered outliers (1.83% of data points) and were omitted from analysis.

Replicating the hedonic pattern of Experiments 1a–1d, bipolar valence and PL-UN scores were significantly positively related to viewing time $b_{Bipolar\ valence} = .12$, $t = 5.6$, $p < .0001$ and $b_{PL\text{-}UN} = .28$, $t = 6.3$, $p < .0001$, respectively. EMG corrugator activity was negatively correlated with viewing time, $b_{EMG} = -.03$, $t = -2.18$, $p < .03$. Arousal, PL + UN scores, and electrodermal activity, on the contrary, were not associated with viewing time, $t = 1.33$, $t = 1.30$, $t = .029$.

Discussion

Corrugator EMG signal and EDA are associated with self-reports of bipolar valence and arousal (e.g., Lang et al., 1993; Kron et al., 2013). Previous experiments presented an association between viewing time and EDA but not EMG as a support for the arousal principle in viewing time behavior. Here we revisited this association using a design in which viewing time was measured implicitly and examined the effect of stimulus exposure and complexity. In accordance with the behavioral results of Experiment 1 that showed a consistent hedonic pattern even when controlling for arousal, a negative association was found between free viewing time and corrugator EMG (longer viewing time was associated with less frowning). No relation was found with EDA. Mirroring self-report, facial skeletomotor activity is consistent with a hedonic principle in viewing time of familiar pictures.

General Discussion

In this work we empirically examined the hedonic and arousal associations between the conscious experience of an affect and the amount of time one chooses to view a picture. Viewing time was linearly related to bipolar valence ratings (the hedonic pattern) in response to familiar pictorial stimuli but not in response to novel ones. This pattern was consistent; it was demonstrated beyond and above the effect of arousal, replicated across multiple experiments, and across three separate sets of pictures, and in the “whole IAPS space” and the content category-based analyses. It was demonstrated using both bipolar and unipolar scales of valence, it remained when stimulus complexity was controlled for, and was supported by an equivalent pattern of corrugator EMG responses showing a negative association with viewing time of familiar pictures. The unique association between arousal and viewing time was less consistent than valence; significant effects of arousal were found in the meta-analysis of first and second exposures in the category content based analysis and in the meta-analysis of first exposure in the "whole IAPS space" analysis when stimulus complexity was controlled for. No effect of self-reported arousal and autonomic arousal was found in Experiment 2.

Role of Familiarity in the Hedonic Pattern of Free Viewing Time

The results reported here raise a question regarding the dynamics and the mechanism underlying the hedonic viewing time behavior. The hedonic pattern was not observed with novel visual stimuli but emerged strongly and consistently with familiar pictures. We, as did previous literature, assumed that the approach–avoidance dynamic is a primitive mechanism that would immediately manifest in response to novel stimuli. Consequently, strong hedonic approach–avoidance tendencies were expected with novel stimuli as well as familiar. The results reported here from three experiments (1a–1c) suggest that, at least for the case of viewing time toward visual emotional stimuli, such a mechanism is not immediate. We speculate two different mechanisms that could account for such a pattern of results and could serve as a starting point for future research. The first, a "perceptual account," is that the hedonic pattern does exist in the first exposure but is masked in our current design by stimulus complexity. The fact that stimulus complexity showed a high and consistent effect on viewing time in the first exposure (longer viewing time for more complex pictures) supports such an account. To further test this hypothesis, stimulus complexity should be experimentally held constant and not statistically controlled for as in our study. A second, "motivational account" for the absence of the hedonic pattern in the first exposure is the possible existence of a motivational conflict between the need for exploration and the hedonic principle. The conflict between explorative behavior and avoidance response is well studied in rodents (e.g., Bertoglio, & Carobrez, 2000), showing explorative behavior in the first trial and avoidance behavior only when the environment is familiar (Rodgers et al., 1996). Future research could differentiate between the perceptual and motivational explanations of the hedonic pattern of viewing time with familiar (but not novel) visual stimuli.

Valence Versus Arousal Patterns in Approach–Avoidance Motivation

The consistent hedonic patterns in response to familiar stimuli are in contrast to previous studies that used explicit free viewing tasks (e.g., Bradley et al., 1991; Cuthbert, Bradley & Lang, 1996; Hamm et al., 1997; Lang et al., 1993; Patrick et al., 1993; Vrana, Spence & Lang, 1988), which demonstrated no linear effect of either valence or corrugator EMG with viewing time as a second task, and instead found that stimuli eliciting pleasant and unpleasant feelings were viewed for the same amount of time—a strong significant association was found only between viewing time and arousal. On the surface, the main difference between the current design and previous research is the implicit versus explicit natures of the tasks. In the traditional paradigm participants are asked to view pictures for "as long as desired" and to "press a button to terminate slide presentation" (e.g., Lang et al., 1993). Here, we worked under the assumption that the traditional instructions might evoke other external motivations or demands that mask the hedonic pattern. Hence, we made an effort to obscure the fact that viewing time was recorded, and the few participants who guessed the purpose of the experiment were omitted from analysis. Comparing the viewing times in the implicit (this work) and more explicit (e.g., Hamm et al., 1997) tasks demonstrates that completely different processes are involved. For example, in the implicit task the average time participants would dwell on pictures of mutilated bodies was less than 3.5 s whereas the participants in Hamm et al. looked at pictures of mutilations for more than 7.5 s. Even participants in Hamm et al. who were *preselected* to reflect the "blood sensitive" population looked at pictures of mutilation for more than 5.5 s, that is, for more time than the average viewing time in the normal population in our sample. However, given that our work might be different from previous studies in aspects other than instructions (e.g., sampling method of pictures), it would be informative for future research to experimentally control implicit versus explicit viewing. In addition, arousal and valence are not only possible features of the emotional response but also a personal tendency (Barrett, 1998). It could be informative to examine the moderating effect of such individual differences to report feelings in terms of arousal or valence in the context of an approach–avoidance free viewing task.

Finally, another factor that might influence valence effects on approach avoidance motivation are biases in attentional encoding and disengagement. For example, negative events might attract and maintain attention, accounting for their extended looking time. However, it has now been established that positively valenced emotional stimuli are often equally as attentionally salient (e.g., Anderson, 2005; Todd et al., 2012) and prolong disengagement of attention to a degree similar to that of negative events (e.g., Most, Smith, Cooter, Levy & Zald, 2007). This attentional bias hypothesis cannot readily provide an explanation for the hedonic principle in viewing time, or to the shift from an arousal pattern with novel stimuli to an hedonic pattern with familiar stimuli. It would important in future studies to examine how measures of attentional engagement and disengagement, including measurement of eye movements, are related to how long an observer chooses to engage in viewing emotional events.

Stimulus Complexity

Stimulus complexity was associated with bipolar valence, arousal, and viewing time behavior. To the best of our knowledge, this study is the first to explore the association of arousal and bipolar valence with the complexity of the stimuli in the IAPS. The two "whole IAPS space" subsamples we used were selected by an algorithm to represent all possible combinations of arousal and valence in the IAPS. Consequently, we believe it would be safe to assume that the strong association between arousal, valence, and stimulus complexity is represented in the IAPS. The importance of the strong association of IAPS arousal and valence ratings with stimulus complexity is beyond the specific issue of free viewing time and likely influences many outcome measures (e.g., response times, eye movement monitoring, fMRI BOLD response, etc.) where the IAPS is employed. When controlling for stimulus features such as complexity, recent studies have shown that emotions evoked from complex scenes, including those from the IAPS, maintain their influence on attention and memory (Chapman, Johannes, Poppenk, Moscovitch, & Anderson, in press; Todd et al., 2012), including associated amygdalar modulatory influences (Todd et al., 2012).

The association of valence and arousal with stimulus complexity is also relevant to the interpretation of the results reported in this study. Controlling for stimulus complexity was important to evaluate the stability of the associations of valence and arousal with viewing time beyond stimulus complexity. The results suggest that valence remained almost free of influence of the statistical control for stimulus complexity. On the other hand, arousal patterns were significantly reduced after statistical control for stimulus complexity. However, the fact that arousal was strongly affected by stimulus complexity could be explained with the inherently stronger association between arousal and stimulus complexity within the IAPS. Hence, the cautious conclusion would be that, given the inherently stronger association of arousal and stimulus complexity in the IAPS, evidence of an hedonic pattern in free viewing time is stronger than that of arousal.

Limitations of Current Research and Future Directions

One limitation of the current design is that the distractor we used to direct participants' attention from the fact that viewing time is being measured (physiological experiment/pulse measurement) could initiate a motivational factor in itself that indirectly influences viewing time. For example, participants could think that for a specific valence or category, more time is needed to better capture their heart rate responses. Although we believe such an alternative explanation is less likely and does not as easily explain the different hedonic patterns in the first and second exposures, it would be important to control for this alternative.

We used emotional pictures as stimuli and implicit free viewing time as a proxy for approach–avoidance tendencies. It would be informative for future research to test the approach–avoidance motivation with novel versus familiar stimuli using different stimulus domains and other measurements of approach–avoidance. One possible direction of research is to examine the association between the conscious experience of emotion and motor action directly involving both novel and familiar emotional stimuli. Previous research provides only indirect evidence for such a relationship. Several experiments tested the conflict that emerged when pulling/pushing a lever in response to affective words (Chen & Bargh, 1999), facial expressions (Rotteveel & Phaf, 2004), or abstract stimuli (Duckworth, Bargh, Garcia, Chaiken, 2002), while the motor movement indicated categorization of stimuli as "good" or "bad." It would be informative to reexamine this issue with stimuli that elicit a strong and reliable affective response and to examine the relationship of pulling/pushing a lever to emotional feelings. One previous study examined posture movements in response to emotional stimuli using self-reports of feelings and found only partial support for any affective pattern, whether arousal or valence (Hillman et al., 2004).

In the same vein, it is commonly assumed that emotions are action tendencies, immediately activated by motivational programs to avoid or approach stimuli (e.g., Lang et al., 1993). It would be informative to empirically examine this assumption more closely. Specifically, it might be interesting to examine this assumption separately for two stimulus dimensions: physical intensity and content. Both stimulus intensity (e.g., loud vs. quiet sound) and stimulus content (e.g., sound of baby crying vs. sound of baby laughing) can initiate an affective response. However, the main evidence for immediate approach–avoidance responses comes from physiological reflexes in response to a stimulus' intensity and not the stimulus' content such as the startle response (e.g., initiated by the intensity and abruptness of a sound) or the pain withdrawal reflex. However, the extent to which an emotional response to the content of the stimuli (such as to pictorial stimuli) initiates an immediate approach–avoidance response, or is dictated by those systems, has not been examined thoroughly. It might be that emotional responses to content require a longer and more elaborate cognitive evaluation or explorative behavior and consequently are not dictated by an immediate approach–avoidance motivation, as we show here upon first exposure to complex scenes. The present results suggest that approach–avoidance motivation in these cases may be manifested in later stages after deeper levels of stimulus processing and potentially after emotional feelings have been experienced.

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Appendix

Viewing Time (milliseconds) Raw Data Descriptive Statistics

Experiment	Mean	Median	*SD*	Mean lower CL	Mean upper CL
			1st exposure		
1a	3384	2904	2354	3251	3518
1b	3641	3036	2984	3508	3775
1c	2914	2106	2852	2753	3076
			2nd exposure		
1a	2880	2363	2344	2747	3013
1b	3198	2241	2679	3047	3349
1c	2646	2173	1817	2546	2746
1d	2533	1757	2763	2414	2651

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