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ORIGINAL RESEARCH

Investigating the dynamics of affect: Psychological mechanisms of affective habituation to pleasurable stimuli

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Abstract Affective habituation (i.e., reductions in stimulus-evoked affective reactions as a result of previous exposure) may serve a functional purpose. However, little is know about the psychological mechanisms underlying this process. To elucidate the characteristics of affective habituation, two experiments that examined affective reactions to repeated exposures of pleasurable stimuli were conducted. Results of these experiments indicated that habituation trajectories are characterized by linear decreases in affect. Results also demonstrated that habituation can be slowed by the introduction of novel stimuli (i.e., ‘‘novelty effects’’), effects that are dimensional (rather than taxonic) in nature. Experiment 2 demonstrated that habituation is mediated by conceptual rather than perceptual processes. Depressed and anhedonic individuals were not more susceptible to habituation in either experiment. The current findings and previous theorizing suggest that habituation may be an important component of an adaptive affective processing system that promotes effective responses to salient stimuli and prevents compulsive reward-seeking behavior.

Keywords Affective habituation · Affective dynamics · Reward-seeking behavior · Conceptual processes · Anhedonia

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Introduction

Affective dynamics—changes in stimulus-evoked affective reactions as a function previous exposure—have received a great deal of attention from psychologists (Fechner 1966; Maslow 1937; Solomon and Corbit 1974; Zajonc 1968). This is understandable considering its potential implications for consumer behavior (Cox and Cox 2002), interpersonal attraction (Moreland and Beach 1992), and conceptualization of psychological disorders (Solomon and Corbit 1973). Nevertheless, it is still unclear how and why affective reactions to the same stimulus can vary across circumstances. Why is it that when we first hear a song on the radio, it is affectively neutral, but after hearing it several times, we begin to like it? Why do we get bored with that song after the radio overplays it during the next few months? The present study examines this second process, the affective habituation to pleasurable stimuli.

Exposure effects

Investigating the influence of exposure on affective and evaluative responses has been a principal method of affective dynamics research. Most studies have used Zajonc's (1968) mere exposure paradigm, in which varying numbers of exposures of neutral visual stimuli are presented either supraliminally or subliminally, after which some dependent measure of affect regarding each stimulus is collected. Hundreds of studies using this paradigm have been performed. Results of key studies, reviews, and meta-analyses of mere exposure research indicate two general affective dynamics processes (Bornstein 1989; Harrison 1977; Stang 1974): (1) unreinforced stimulus exposure up to a certain frequency results in enhancement of affect toward that stimulus (i.e., ''mere exposure'' effects); and (2) with increasing exposure frequency and duration, shorter periods between exposure and rating, and homogeneous rather than heterogeneous stimulus presentations, positive affect declines.

Bornstein and others have concluded that a two-factor model is most consistent with a majority of mere exposure findings (Bornstein 1989; Harrison 1977; Stang 1974). This model predicts that affect brightens when an unfamiliar stimulus becomes familiar and perceptually fluent (i.e., easier to process). When the stimulus becomes familiar and curiosity wanes, individuals begin to habituate to the pleasurable properties of the stimulus, finding it less attractive with each exposure. More recently, affective dynamics have been examined in affect-laden, familiar stimuli, which are more typically involved in day-to-day experience. In contrast with the affective dynamics of neutral, unfamiliar stimuli, which generally demonstrate small habituation effects only after extended repetition, habituation is especially pronounced for strongly valenced, familiar stimuli and can occur with relatively few exposures (Dijksterhuis and Smith 2002; Wong and Root 2003).

Affective habituation

Empirical support of affective habituation demonstrates that affective responses decline after repeated presentations of emotional stimuli. Electrodermal reactions (Klorman 1974; Mangelsdorff and Zuckerman 1975) and blink magnitude, skin conductance, and facial corrugatory electromyographic startle reflex responses diminish rapidly with repeated presentation of the same visual stimulus (Bradley et al. 1993). Neurophysiological evidence for affective habituation has also been documented. Functional magnetic resonance imaging signal decrements in areas related to emotional processing (e.g., prefrontal cortex and amygdala) occur after repeated presentation of positive and negative emotional facial expressions (Breiter et al. 1996; Hart et al. 2000; Wright et al. 2001). Two studies have demonstrated habituation to affect-laden stimuli under subliminal exposure conditions. Dijksterhuis and Smith (2002) showed that repeated subliminal exposure to extreme positive and negative words caused them to be later judged (both implicitly and explicitly) as less emotionally valenced than equivalent non-exposed words. Wong and Root (2003) utilized a subliminal affective priming task in which happy and sad faces were briefly presented and followed by a neutral Chinese ideograph mask. Subjects judged ideographs as more positive when happy faces served as subliminal primes; however, these effects disappeared during a second block of trials, suggesting that subjects habituated to the affective properties of the faces. Thus, there is ample evidence of affective habituation across various measures of affective responses.

Theoretical support of affective habituation argues that it would be maladaptive not to habituate to affective stimuli (Dijksterhuis and Smith 2002). The emotional response to stimuli is an important ability that helps organisms effectively evaluate and respond to their environment (LeDoux 1996). This capability, which is thought to be regulated by an affective processing system, provides a quick estimate of the significance of environmental stimuli (Cacioppo and Berntson 1999; Fazio 2001; Fowles 2001). The intensity with which this system reacts to a stimulus signals the degree of potential benefit or danger. After the system signals in response to a salient stimulus, other cognitive and behavioral responses are necessary to effectively react to the stimulus. For example, after positive affect is generated from perceiving food, problem solving and approach behavior is instigated to attain the food; after negative affect is generated from perceiving a predator, escape behavior is initiated. If, however, the affective system were to continually respond to a stimulus after an initial encounter (and fail to habituate), general psychological resources which could be devoted to effectively responding to the stimulus would be depleted (Dijksterhuis and Smith 2002). Thus, habituation may free up general psychological resources allowing organisms to behaviorally respond to stimuli in an effective manner. Habituation may also free up resources within the affective processing system so that emotional signals can be generated in response to subsequent non-redundant salient stimuli.

As noted above, the affective processing system is important because it cues approach and avoidance behavior that is necessary for survival. Consequently, this system may play a role in preventing maladaptive behaviors, such as the repetitive pursuit of a single reinforcing stimulus. As a characteristic of this system, habituation might be the basis of a novelty-seeking mechanism that inhibits such compulsive behavior. By diminishing the affect-enhancing properties of recently experienced pleasurable stimuli, habituation may cause abandonment of these stimuli and motivate pursuit of novel stimuli that can brighten affect. Consider the role of habituation in feeding behavior. A nutritious diet requires consumption of a wide variety of foods. Without habituation, a single type of food would consistently remain pleasurable after every meal. As a result, dietary intake of necessary nutrients would be limited because organisms would be motivated to consume their favorite food during every meal (Rolls et al. 1986).

The current study

Although previous research and logical reasoning indicate that affective habituation exists and may serve a functional purpose, little is known about the psychological mechanisms underlying this process. Increasing our understanding of habituation through empirical research may, like research of other affective dynamic processes (e.g., Cox and Cox 2002; Moreland and Beach 1992; Solomon and Corbit 1973; Zajonc 1968), elucidate the nature of motivation and have implications for consumer, interpersonal, and psychopathological behavior. The current studies were therefore conducted to identify mechanisms and characteristics of affective habituation. The notion that habituation is instrumental for adaptive affective processing guided our hypotheses about its characteristics. These studies had four objectives: (1) to demonstrate affective habituation using a repeated assessment rating paradigm; (2) to examine novelty effects on habituation; (3) to evaluate habituation at percept- and concept-dependent levels; and (4) to investigate habituation from an individual differences framework.

Objective 1: show habituation using a repeated assessment rating paradigm

Advancement of research examining basic elements of affective dynamics may be limited by the common paradigm being employed (i.e., stimuli are exposed repeatedly and then rated). The long delay between exposure and assessment in this procedure potentially masks habituation (Harrison 1977). During delays, subjects are likely to process unrelated information, which may add error to ratings. In contrast, immediate assessment directly after each exposure should allow for a more accurate measure of a stimulus's affective properties during, rather than after, the dynamic process. To overcome limitations of rating delay, the current study utilized repeated assessments, performed immediately after each exposure.

This paradigm involves a 20-presentation sequence during which subjects rate how pleasurable they find a presented stimulus after every exposure, resulting in 20 assessments per sequence. Over the 20-exposure sequence, positively sloped trajectories indicate sensitization effects and negatively sloped trajectories indicate habituation effects. Trajectories with steep slopes indicate a more extreme affective dynamic process than trajectories with flat slopes. We expected to show that this paradigm is sensitive in detecting habituation to pleasurable stimuli by demonstrating reductions in affective ratings over a 20-exposure sequence (i.e., a negatively sloped trajectory).

Objective 2: demonstrate novelty effects

The current studies also attempted to elucidate the mechanisms and characteristics of affective habituation. As mentioned above, novelty seeking might function to oppose habituation processes. If this were the case, exposure to novel stimuli should result in less degradation in affect than exposure to redundant stimuli. Indeed, Bradley et al. (1993) demonstrated that after repeated stimulus exposure and habituation, introducing novel stimuli (equal in pre-exposure emotional intensity) resulted in substantial increases in affective responses. Furthermore, mere exposure studies have demonstrated that heterogeneous rather than homogenous stimulus exposure sequences produce higher affect ratings (Bornstein 1989), indicating that the introduction of novelty may counteract habituation. Based on these findings and our rationale that habituation promotes novelty seeking, we expected sequences with more stimulus variability to demonstrate less habituation, an outcome labeled a ''novelty effect.'' Put another way, affect should decline faster on a 20-item sequence involving the repeated presentation of a single stimulus than on a separate 20-item sequence that alternates multiple different stimuli.

Objective 3: evaluate level of processing

We were also interested in determining the level of processing at which habituation occurs (i.e., perceptual or conceptual). We addressed this by examining whether individuals habituated to the perceptual or conceptual properties of stimuli. If habituation is a percept-dependent process, then novelty effects should be equal for any type of newly introduced stimuli, so long as they are different from the habituated stimulus in *form*. If, however, habituation occurs at a concept-dependent level, exposure to new stimuli that are conceptually different from the habituated stimulus should promote greater novelty effects than conceptually redundant novel exposures because of differences in *type*. If habituation is indeed a mechanism underlying novelty seeking, it should be concept-dependent. Conceptually driven habituation would ensure reward-seeking behavior is diverse among meaningful characteristics (e.g., seeking fruit, meat, and grains) and prevent compulsive pursuit of one type of reinforcers (e.g., seeking raspberries, strawberries, and blueberries). We therefore expected novelty effects to be larger when novel stimuli are conceptually variable (CV) (i.e., from different semantic categories) than conceptually consistent (CC) (i.e., from the same semantic category). In terms of the repeated assessment rating procedure, this hypothesis would be supported if the range of slopes among sequences with differing degrees of CV novelty were larger than the range of slopes among sequences with differing degrees of conceptually redundant (but perceptually variable) novelty.

Objective 4: examine individual differences

Our final objective was to examine affective habituation from an individual differences framework by investigating its relation to other relevant measures of affect. It is possible that some individuals are more vulnerable to habituation to pleasant stimuli than others. For example, depressed people are unable to consistently attain pleasure from normally pleasurable stimuli. This may be due to rapid habituation. The few studies that have examined relationships between dynamic affective processes and mood-related traits and states have focused primarily on anxiety (e.g., Kruglanski et al. 1996; Schick et al. 1972). However, Bornstein et al. (1990) showed that individuals who tend to lose interest in pleasurable activities demonstrate smaller exposure-induced increases in affect. Therefore, the inability to perceive pleasure (i.e., anhedonia) and depression may be associated with rapid habituation to pleasant stimuli. At the same time, depression may be associated with rapid habituation to negative stimuli, which may be related to emotional blunting present in depression. However, we focus the current investigation on habituation to pleasant stimuli and its relation to deficient positive affect in depression. We hypothesized that anhedonic and depressed individuals would habituate to pleasurable stimuli more rapidly than normally hedonic individuals.

In the current report, Experiment 1 tests the sensitivity of the online rating paradigm to detecting habituation and novelty effects. It also examines relations of self-report measures of mood and anhedonia with habituation and novelty effects. Experiment 2 replicates findings from the first experiment but also evaluates whether conceptual variability enhances novelty effects to uncover whether habituation is a concept- or percept-dependent process. This experiment also includes an additional measure of anhedonia and attempts to better characterize novelty effects.

Experiment 1

Method

Participants

From the general undergraduate population 213 university students were recruited to participate in this study. The sample was 75% female and had an average age of 23.1 (*SD* = 5.7). Among the students 70% were African American, 19% Asian, 24% Caucasian, 21% Hispanic, and 7% listed their ethnicity as ‘‘other.’’ Mean Beck Depression Inventory—Second Edition (BDI-II) score was 10.9 (*SD* = 9.6). In return for their participation, subjects received course credit.

Measures

Demographic information was assessed by an author-constructed questionnaire. Anhedonia was assessed by the Snaith-Hamilton Pleasure Scale (SHAPS; Snaith et al. 1995), which is a 14-item Likert format questionnaire asking participants to agree or disagree with statements of their probable hedonic response to pleasurable situations (e.g., ‘‘I would enjoy my favorite television or radio program’’). Four responses are possible: ‘‘Strongly disagree,’’ ‘‘Disagree,’’ ‘‘Agree,’’ or ‘‘Strongly agree.’’ Each item on the SHAPS is worded so that higher scores indicate greater pleasure capacity. A total score is derived by summing the responses to each item, with higher SHAPS total scores indicating greater pleasure capacity. It covers four domains of hedonic experience: interest/pastimes, social interaction, sensory experience, and food/drink (Snaith et al. 1995). Participants completing the SHAPS are instructed to respond based on their ability to experience pleasure ‘‘in the last few days.’’ This scale has shown adequate overall psychometric properties (Snaith et al. 1995). The SHAPS demonstrated adequate internal consistency in this experiment ($\alpha = .93$). Depression was assessed with the BDI-II (Beck and Steer 1996). The BDI-II also showed excellent internal consistency ($\alpha = .94$).

Procedure and materials

Participants were run in cohorts of approximately five individuals per session. They were told that the experiment examined the perception of pleasure and the relation between pleasure experience and mood and were asked to work quietly. During sessions, participants completed questionnaire measures first and then the visual display procedure, which was conducted with the lights dimmed. During the visual display procedure, each participant viewed the same projection screen. All pictures were loaded by a computer and displayed via an electronic projector producing of images approximately 5′ by 5′ in size. Each sequence within the visual display procedure contained 20 picture presentations. Each exposure was 5 s in duration and followed by a 5-s black screen. Participants were instructed to look at pictures for all 5 s and then rate how pleasurable each presentation was during the subsequent black screen period. This approach prevented long delays between exposure and rating while preserving the equality of each exposure across participants (i.e., exposures were always 5 s). Participants were asked to rate each presentation as a unique experience, separate from the other presentations.

Paper and pencil ratings were made on an 82 mm visual analog scale (VAS) with ‘‘not pleasurable at all’’ and ‘‘extremely pleasurable’’ at left and right anchors, respectively. Thus, the range of possible ratings was 0–82. Each rating sheet included 10 VASs arranged vertically, with one scale per row. Therefore, each 20-exposure section required participants to use two full rating sheets. A

VAS, rather than a 5–11 point Likert format scale, was chosen because it was thought to be more sensitive to subtle changes from exposure to exposure.

Stimuli were selected from the International Affective Picture System (IAPS; Lang et al. 2001). The IAPS is a set of normative emotional stimuli for experimental investigations of emotion and attention. Each IAPS picture has been rated for valence (i.e., pleasure) and arousal by a large sample of college students, similar in characteristics to the current sample. For the current experiment, pictures of people playing water sports were used because of their strong positive valence and high arousal. High arousal and valenced pictures were chosen because we thought that they were most susceptible to habituation. The four pictures used in this experiment were similar in arousal and valence ratings in the IAPS normative sample (Tubing Pic. No. 8420: M valence = 7.76, M arousal = 5.56; Sailing 8170: M valence = 7.63, M arousal = 6.12; Waterskiing 8200: M valence = 7.54, M arousal = 6.35; Windsurfing 8080: M valence = 7.73, M arousal = 6.65). Valence and arousal were rated on separate 9-point scales in the IAPS standardization sample.

This experiment used a 20 (Exposure) × 2 (Stimulus Variability: 1-Stimulus vs. 4-Stimuli) within-subject factorial design. The Exposure factor corresponded to the 20 presentations in each sequence. The Stimulus Variability factor corresponded to whether sequences contained one stimulus repeated 20 times or 4 stimuli presented 5 times. Thus, by comparing the slope of affective trajectories across the two stimulus variability conditions, we could evaluate novelty effects. The order of sections (1-Stimulus first vs. 4-Stimuli first) was counterbalanced across subject groups. The picture used in the 1-Stimulus sequence was randomly selected from the set of 4 total stimuli for each session. The 4-Stimuli sequence always began with the same stimulus used in the 1-Stimulus sequence for that session. Exposure sequences utilized a heterogeneous systematic presentation format, meaning that in the 4-Stimuli condition an individual picture was followed (and preceded) by the same picture each time it was exposed. For example, a 1-Stimulus condition would have the following sequence: Tubing, Tubing, Tubing, Tubing ... Tubing, Tubing. Its corresponding 4-Stimuli sequence: Tubing, Sailing, Waterskiing, Windsurfing, Tubing, Sailing, Waterskiing, Windsurfing, Tubing, Sailing, Waterskiing, Windsurfing, Tubing, Sailing, Waterskiing, Windsurfing, Tubing, Sailing, Waterskiing, Windsurfing.

Data analysis

Habituation and novelty effects were analyzed using the SAS GLM Procedure (SAS Institute Inc. 2003), with the multivariate repeated measures option for ANOVA. Because different stimuli were used in the two Stimulus Variability conditions, we were concerned that we might violate homogeneity of variance (HOV) assumptions for ANOVA, which could lead to spurious findings. Because we were unaware of a HOV test for repeated measures analyses, we randomly assigned each of the 20 exposure data points to represent either the 1-Stimuli or 4-Stimuli conditions. Levine's test of HOV revealed no significant effects for any of the 20 exposure points, all Fs < 1.98 and Ps > .16 Due to missing data, sample size varied across analyses using individual differences measures (SHAPS n = 156; BDI-II n = 211). All analyses controlled for order effects (i.e., whether the 1-Stimulus or 4-Stimuli sequence was shown first). Type I error levels for analyses were set at the .05 level. Bonferroni corrections were used when necessary to keep α_{FW} at .05 (e.g., when examining non-linear effects).

Results

To satisfy objective 1, the demonstration of habituation, we expected to show a repeated measures Exposure effect. A significant Exposure effect would indicate that the slope is not flat, therefore an affective dynamic process is occurring (either habituation or sensitization). An exposure effect corroborated with graphical presentation of a negatively sloped function in which pleasure ratings decline with subsequent trials would suggest that habituation (rather than sensitization) processes were operating. A significant Exposure effect, $F(19, 193) = 8.22$, Wilks' $\lambda = .55$, $P < .0001$, $\eta^2 = .45$, was found, indicating that dynamic affective processes were operating. Graphed results in Fig. 1 demonstrate that negative slopes characterized both 1-Stimulus and 4-Stimuli exposure sequences, indicating that habituation (rather than sensitization) was operating during both exposure sequences.

Analyses of non-linear effects revealed that the 1-stimulus conditions showed a linear pattern. In contrast, the 4-Stimuli condition showed a 19th degree polynomial function, $F(1, 212)$, 11.07, $P < .001$. Non-linear effects in the 4-Stimuli conditions appear to have resulted from relative differences among stimuli and are unlikely to be a reflection of the habituation process. Indeed, Fig. 1 illustrates that subjects appeared to rate each stimulus' pleasantness relative to other stimuli in a consistent fashion. Figure 1 also shows that the hedonic properties of each stimulus in the 4-Stimuli condition tended to decline in a linear fashion each time that stimulus was presented (i.e., every four exposures). Figure 2 illustrates the five exposures of each stimulus (first, second, third, fourth) within the 4-Stimuli condition to demonstrate the trajectory of each individual stimulus. Thus, the five exposures for the first stimulus are the 1st, 5th, 9th, 13th, and 17th exposures

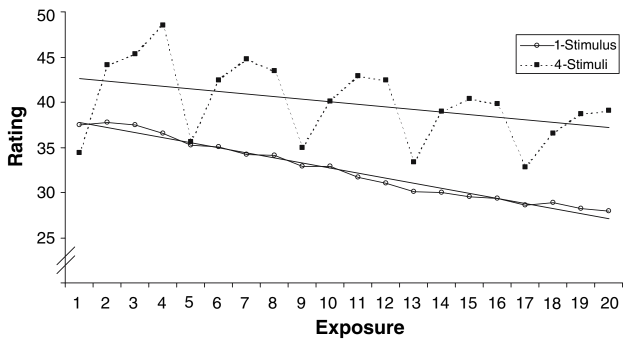

Fig. 1 Mean affect ratings for 1-Stimulus and 4-Stimuli conditions. Solid, unbroken lines represent linear trendlines for each condition. Differences in slope were significant as qualified by an Exposure × Stimulus Variability interaction. 1-Stimulus linear slope trajectory = –.56; 4-Stimuli linear slope trajectory = –.28. Because the 1-Stimulus condition demonstrated a steeper affective trajectory, the interaction suggests that novelty reduces degree of affective habituation

of the 20-exposure sequence and the five exposures for the second stimulus are the 2nd, 6th, 10th, 14th, and 18th exposures. Non-linear analyses for each stimulus' five-exposure trajectory within the 4-Stimuli sequence were not significant, supporting the notion that habituation demonstrated in this paradigm was a linear process. Therefore, slopes of linear trendlines fit to each condition were used to index the overall rate of habituation for both the 1-Stimulus and 4-Stimuli conditions. Linear trendlines for each condition are illustrated as solid unbroken lines in Fig. 1.

To satisfy objective 2, the demonstration of novelty effects, we expected to show a significant Exposure × Stimulus Variability interaction. This interaction corroborated with graphical presentation that 4-Stimuli sequences were less negatively sloped than 1-Stimulus sequences would suggest that the introduction of novelty counteracts habituation processes (i.e., a ''novelty effect''). An interaction of Exposure and Stimulus Variability was found, $F(19, 193) = 4.47$, Wilks' $\lambda = .69$, $P < .0001$, partial $\eta^2 = .17$. The trendline of the 1-Stimulus condition had a slope of –.56 whereas the slope of the 4-Stimuli condition trendline was –.28. In other words, subjects lowered their ratings by approximately ½ of a point per an exposure on average during the 1-Stimulus sequence and ¼ of a point per an exposure on the 4-Stimuli sequence.[1] Thus, the interaction was indicative of a novelty effect.

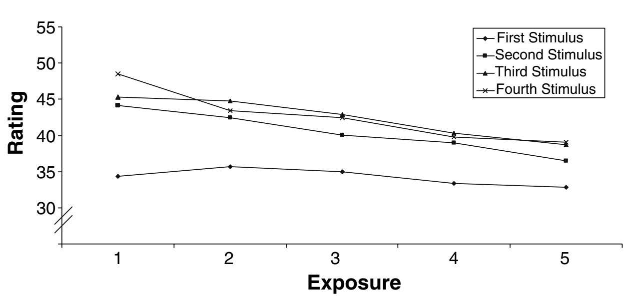

Fig. 2 Mean affect ratings for each stimulus in the 4-Stimuli exposure condition. Solid broken lines represent the first, second, third, fourth, and fifth time a stimulus was presented within the 20-exposure sequence. Trend analyses indicated that the trajectories fit a linear trend

To satisfy objective 4, the relation of affect questionnaires with habituation was analyzed in separate models that included BDI-II and SHAPS scores as independent variables. We expected to show significant moderation of Exposure effects by affect measures, thus indicating a relation between affect and habituation processes. ''Levels effect'' analyses (Tabachnick and Fidell 2001) were performed to examine associations of depression and anhedonia with affect ratings averaged over the 20-exposure intervals. More anhedonic individuals measured by the SHAPS did not rate stimuli differently when responses were averaged over the 20 exposures, $F(1, 153) = 1.47$, $P = .23$. Analyses using the BDI-II also did not show levels effects, $F(1, 153) = 1.08$, $P = .30$. There was also no evidence of modulation of habituation effects by the BDI-II or SHAPS.

Discussion

Results from Experiment 1 supported our two hypotheses regarding the characteristics of habituation: (1) individuals habituate to the affective properties of stimuli with repeated exposure as demonstrated by the repeated assessment rating paradigm; and (2) habituation can be reduced by introducing novelty. The non-linear trend in the 4-Stimuli condition was unexpected as these stimuli were rated affectively equivalent in the IAPS normative sample. It is possible that the VAS may be more sensitive to subtle differences between stimuli that are not apparent through Likert response formats, which were used in the original IAPS normative sample. Nevertheless, systematic differences between the stimuli did not impact overall levels of habituation, which appeared to operate in a linear fashion.

Although all stimuli used in this experiment had approximately equal pre-exposure affective properties and each condition had an equal number of total presentations,

[1] It is important to note that the current paradigm characterizes habituation of affect during an entire 20-exposure sequence, regardless of the number of exposures of individual stimuli. There are systematic differences in exposures to each individual stimulus across conditions: 20 versus 5 in Experiment 1. Thus, the novelty effect indicates that if only a certain number of opportunities for stimulus exposure are available, higher levels of affect will be maintained over time when stimuli are diverse. This should not to be confused with the notion that decline in affect after each exposure to an *individual stimulus* is reduced if those exposures are interspersed among exposures with other stimuli.

exposure sequences with variable stimuli generated flatter habituation trajectories. This suggests that the novelty of newly introduced stimuli can slow down the reduction of affect and thereby counteract habituation.

Examination from an individual differences framework did not support our expectation that more depressed and anhedonic individuals would demonstrate higher rates of habituation. Moreover, anhedonic and depressed individuals did not report lower average affective responses (i.e., levels effects). Based on the findings of Experiment 1, several factors warrant further explanation.

First, the stimuli used in Experiment 1 were highly arousing. Thus, it is unknown whether less arousing pleasurable stimuli have similar dynamic properties. Second, only two conditions of stimulus variability were used, leaving unclear whether novelty effects are dimensional or taxonic. That is, whether continued novelty effects occur with greater than two levels of stimulus variability, which would suggest dimensionality. Because habituation may underlie adaptive reward seeking, it is expected that it would be a dimensional process; however, previous investigations examining the dimensional versus taxonic nature of habituation are limited. Third, all the stimuli used were taken from the same semantic category. Thus, the current experiment does not address whether habituation occurs at percept- or concept-dependent levels, although as discussed in the introduction, there is reason to believe that it is conceptually influenced. Fourth, the null effect of depression and anhedonia on habituation may be a result of experimental limitations. Participants were recruited from the general undergraduate population, which led to a sample with low depressive severity and variability. This may have reduced power to detect effects of anhedonia and depression on habituation because associations are spuriously attenuated when variables lack adequate variability in scores. The low variability of affective distress in our sample might explain why more depressed and anhedonic participants did not show lower average pleasure ratings (i.e., absence of levels effects). Furthermore, it is possible that a different anhedonia questionnaire might demonstrate individual differences in affective dynamic processes. Experiment 2 was conducted to address these issues.

Experiment 2

Method

Participants

Because Experiment 1's failure to show individual differences in habituation may be a result of low variability and severity in depression and anhedonia, we attempted to create a heterogeneous sample by recruiting through two mechanisms. We screened 743 university undergraduate students for depression with the Center of Epidemiological Studies Depression Scale (Radloff 1977). Those scoring above the clinical cutoff (≥16) and other unscreened individuals from the general university population were combined to create a sample (n = 107) with adequate severity and variability in depression scores, mean BDI-II score = 12.3 (SD = 10.8) as compared with the previous experiment's sample (mean BDI-II score = 10.9; SD = 9.6). The sample was 70% female and had an average age of 23.0 (SD = 5.7). In the sample, 12% were African American, 24% Asian, 29% Caucasian, 27% Hispanic, 1% Native American, and 8% endorsed the category ''other.'' In return for their participation, subjects received course credit. Although variability in depression scores was maximized, this 2-pronged sampling strategy limits the generalizability of these results to either clinical populations or general undergraduate populations.

Because participation in this study was anonymous, we did not have access to whether subjects in our final sample were sampled from the screening strategy or from the general university population. Therefore, we could not compare the two groups. To better characterize the sample, we compared the current study's sample to that of Experiment 1. Normality and variability in the scores of the BDI were compared by analysis of the Shapiro-Wilk W-Statistic (Shapiro et al. 1968), which estimates the degree to which a sample departs from the normal distribution (higher numbers suggests more normality) and variance estimates. These analyses indicated that the current sample was more normally distributed than the Experiment 1's sample (W: 0.90 vs. 0.86). Variability of Beck Depression Inventory-II scores was also greater in the current sample (Variance: 96.5 vs. 93.0). While the mean depressive severity of the current sample was larger than the previous study's sample (Mean: 12.3 vs. 10.9), this difference was not statistically significant. The demographics of the previous sample were similar to that of the Experiment 2.

Measures

The measures were the same as in Experiment 1; however, the Fawcett Clark Pleasure Scale (FCPS; Fawcett et al. 1983) was added. The FCPS is a 36-item questionnaire asking participants to rate imagined hedonic reactions to hypothetical pleasurable situations (e.g., ''You sit watching a beautiful sunset in an isolated, untouched part of the world''). Unlike the SHAPS which instructs participants to respond based on their pleasure experience in the last few days, participants completing the FCPS are asked to respond based on their current state. Responses are made on a 5-point Likert format, with left and right anchors labeled: ''No pleasure at all'' and ''Extreme & lasting pleasure.'' Like the SHAPS, each item on the FCPS is worded so that higher scores indicate greater pleasure capacity. A total score can be derived by summing the responses to each item, with higher FCPS total scores indicating greater pleasure capacity. Items cover several domains of hedonic experience, including social activities, sensory experiences, and sense of mastery of difficult tasks. The FCPS demonstrates good overall psychometric properties in clinical and non-clinical samples (Fawcett et al. 1983). All measures demonstrated adequate internal consistency in this experiment (αs = .91–.94).

Procedure and materials

The format and instructions for the visual display procedure were the same as in Experiment 1. However, this experiment utilized a more complex 20 (Exposure) × 5 (Stimulus Variability: 1, 2, 3, 4, or 5 Stimuli) × 2 (Conceptual Variability: Conceptually Consistent vs. Conceptually Variable) within-subject factorial design. The Stimulus Variability factor now had five levels corresponding to the number of stimuli that were used in each sequence. We thought that five levels would be adequate to assess for dimensionality vs. taxonicity in novelty effects. The 1, 2, 4, and 5-Stimuli sequences repeated sequences of individual stimuli 20, 10, 5, and 4 times, respectively. The 3-Stimuli sequence repeated its 3-stimulus sequence 6 times, followed by the first two stimuli of the sequence for a total of 20 exposures.

Another difference from Experiment 1 was the addition of a Conceptual Variability factor to the design. This allowed us to assess for differentiation of novelty effects depending on whether novel stimuli were from single or multiple semantic categories. To accommodate for the new design, the procedure in Experiment 2 consisted of ten 20-exposure sequences. Five sequences composed the CC condition in which stimuli were from same semantic category (like the previous experiment which utilized pictures within the category of water sports). The remaining five sequences composed the CV condition in which stimuli were from different semantic categories (see below). Within each conceptual variability condition, stimulus variability differed along five levels.

High pleasure but moderate arousal pictures from the IAPS were chosen for this experiment to see if habituation and novelty effects generalized to less arousing stimuli. The pictures used in this experiment were similar to each other in valence and arousal. The mean of their average valence rating in the IAPS standardization sample was 7.44 (*SD* = .44). The mean of their average arousal rating was 4.52 (*SD* = .40). Pictures of pets comprised CC condition (Kittens, Pic. No. 1463; Kitten 1460; Cat 1540; Dog 1 1500; Dog 2 1510). Pictures from several semantic categories were selected for the CV conditions that were matched in affect valence and arousal to each stimulus in the CC condition (Fireworks 5480; Baby 2070; River 5820; Sky 5594; Galaxy 5300). Effect sizes were computed to determine the degree of difference between each matched pair using the *M* and *SD* of ratings in the IAPS norms sample. There was virtually no difference between the pairs (avg. |effect size| for valence: $d = 0.068$; avg. |effect size| for arousal: $d = 0.089$).

Pictures were selected so that stimuli within CC and CV sets were perceptually variable and characterized by different colors, backgrounds, and non-focal objects. This is important because if the degree of perceptual similarity among the five pictures in the CC set was different than in the CV set, it could not be concluded that conceptual (rather than perceptual) processes underlie habituation effects. Researchers of similarity matching in computer vision and multimedia suggest that although pixel-wise or wavelet based similarity measures can objectively assess visual similarity, human subjective ratings are a more valid index of the ''perceptual'' similarity of visual stimuli (T. S. Huang, personal communication, July 18, 2006). Accordingly, we asked an independent sample of 16 psychology students to rate how perceptually similar (e.g., similarity in form, color, etc.), regardless of content similarity, were the pictures within the CC set and within the CV set. That is, individuals gave two independent ratings: one for the similarity of the 5 CV pictures and another for the 5 CC pictures. Multivariate repeated measures comparisons of perceptual similarity ratings showed no significant differences between the CC and CV sets, Wilks' $\lambda = .79$, $P = ns$.

Two reversed presentation orders were counterbalanced to reduce order effects. Order 1: CC-1-Stimulus, CV-5-Stimuli, CC-2-Stimuli, CV-4-Stimuli, CC-3-Stimuli, CV-3-Stimuli, CC-4-Stimuli, CV-2-Stimuli, CC-5-Stimuli, CV1-Stimulus. Order 2 utilized the reverse series. Because no stimulus selection effects were found in Experiment 1, stimuli used in each condition were consistent across all subjects to simplify the design. Exposure sequences utilized a heterogeneous systematic presentation format (an individual picture was followed by the same picture each time it was exposed within a condition) as in Experiment 1. Table 1 illustrates the exposure sequence for each condition.

Data analysis

Evaluation of habituation and novelty effects as well as the relationship between individual difference measures and habituation was accomplished using the same data analyses as Experiment 1. As in Experiment 1, we tested for HOV across the 10 (5 Stimulus Variability × Conceptual Variability) possible conditions for each exposure. To do this,

Table 1 Stimuli presentation sequences used in Experiment 2

Condition		Sequence	Slope
Conceptual Variability	Stimulus Variability		
CC	1	Kittens...	–.56
CC	2	Kittens, Kitten...	–.30
CC	3	Kittens, Kitten, Cat...	–.24
CC	4	Kittens, Kitten, Cat, Dog 1...	–.43
CC	5	Kittens, Kitten, Cat, Dog 1, Dog 2...	–.40
CV	1	Fireworks...	–.74
CV	2	Fireworks, Baby...	–.30
CV	3	Fireworks, Baby, River...	–.18
CV	4	Fireworks, Baby, River, Sky...	–.05
CV	5	Fireworks, Baby, River, Sky, Galaxy...	–.09

Note. CC = Conceptually Consistent; CV = Conceptually Variable; Slope = slope of linear trendline fit to the mean ratings of each condition's 20-exposure sequence (point change per rating)

we randomly assigned each of the 20 exposure data points to represent each of the 10 conditions. Levine's test of HOV revealed no significant effects for any of the 20 exposure points, all Fs < 1.70 and Ps > .10.

Results

In support of the repeated assessment rating paradigm's ability to demonstrate habituation, analyses revealed a significant Exposure effect, $F(19, 84) = 8.74$, Wilks' $\lambda = .43$, $P < .0001$, $\eta^2 = .57$, indicating that dynamic affective processes were operating. Similar to Experiment 1, 16th–19th degree polynomial functions were found when non-linear effects were analyzed. As illustrated in Fig. 3, graphed exposure sequences for multi-stimuli conditions showed a pattern similar to the first Experiment's 4-Stimuli sequence, characterized by linear trajectories for each specific stimulus. Thus, slopes of linear trendlines were used to examine rates of habituation as in Experiment 1. Table 1 illustrates that trendlines for all 10 sequences were negatively sloped, indicating that habituation (rather than sensitization) was operating during every exposure sequence.

As in Experiment 1, an interaction of Exposure and Stimulus Variability was found, $F(76, 27) = 1.82$, Wilks' $\lambda = .16$, $P < .05$, partial $\eta^2 = .60$, supporting the hypothesis that stimulus variability leads to novelty effects and less affective habituation. Trendlines of conditions with more stimulus variability were generally less negatively sloped (see Table 1), indicating that the significant interaction reflected novelty effects. Habituation tended to diminish with the addition of increasing levels of novel stimuli, especially in the CV condition (see slope estimates listed in Table 1 and trendlines in Fig. 4), suggesting that novelty effects in the CV condition were dimensional rather than taxonic.

To test whether habituation occurred at a concept- or percept-dependent level and to satisfy objective 3, we examined whether novelty effects were moderated by conceptual variability. A significant Exposure × Stimulus Variability × Conceptual Variability interaction corroborated by evidence that the spread of slopes within the 5 Stimulus

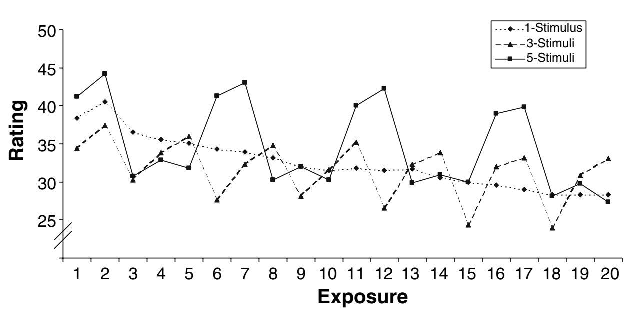

Fig. 3 Mean affect ratings for 1-, 3-, and 5-Stimuli sections within the Conceptually Consistent condition. As in Fig. 1's illustration of Experiment 1's data, the relative rating of individual stimuli relative to each other were consistent with subsequent presentations

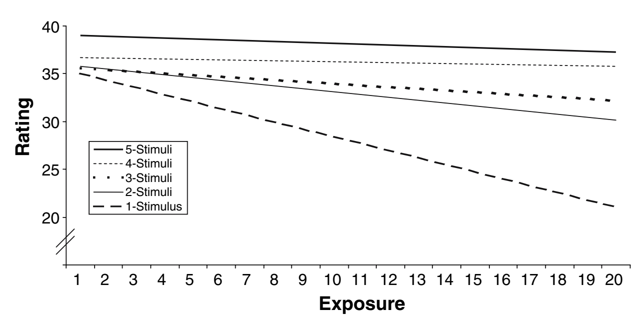

Fig. 4 Novelty slows affective habituation processes (a significant Exposure × Stimulus Variability interaction). Trendlines of Conceptually Variable sections are shown. See Table 1 for slope estimates

Variability levels in CV is greater that the spread of slopes within the CC condition would support the hypothesis that habituation is at least partially mediated by conceptual processes. In support of this hypothesis, a significant Exposure × Stimulus Variability × Conceptual Variability interaction was found, $F(76, 27) = 2.04$, Wilks' $\lambda = .15$, $P < .05$, partial $\eta^2 = .61$. The spread of slopes of trendlines for the CV condition was larger than the range of slopes in the CC condition (see Table 1 and Fig. 5), indicating that, in concordance with expectations, novelty effects were stronger when newly introduced stimuli were CV.

In contrast to the null levels effect findings in Experiment 1 which utilized a sample with less depression variability, more anhedonic individuals generally rated stimuli as less pleasurable when responses were averaged over the 20 exposures: SHAPS, $F(1, 100) = 25.80$, $P < .0001$ and FCPS, $F(1, 100) = 21.26$, $P < .0001$. There was also a trend for a levels effect of the BDI-II in this sample, $F(1, 100) = 3.34$, $P = .07$. While anhedonic individuals rated stimuli as less pleasurable overall, there was no evidence for modulation of habituation effects by BDI-II, FCPS, or SHAPS (e.g., exposure by anhedonia or depression interaction), all Fs < 1.48, all Ps > .14.[2]

Discussion

Experiment 2 replicated the findings of Experiment 1, which showed that individuals habituate to the affective properties of stimuli with repeated exposure. It also replicated the finding that habituation can be compromised by introducing novelty and extended the findings to pleasant stimuli of moderate arousal. In concordance with Experiment 1, Experiment 2 showed that anhedonia and depression do not influence rates of habituation. However, in this experiment, anhedonia as measured by two instruments and depression (to a lesser extent) was associated with lower overall affective responses, suggesting that the variability and severity of affective symptomatology in this sample was adequate.

The introduction of novelty appeared to compromise habituation to a greater degree if novel stimuli were from non-redundant rather than redundant semantic categories. This was found despite that both CC and CV categories were matched for pre-exposure valence and arousal. In line with hypotheses, the 5-Stimulus CC condition produced a steeper habituation trajectory than the 5-Stimulus CV condition. Despite equal valence and arousal ratings in the IAPS standardization sample, the 1-Stimulus CV condition produced what appeared to be a steeper habituation trajectory than the 1-Stimulus CC condition (–.56 vs. –.74). This is important because differences in affective dynamic properties of these two specific stimuli may have explained the three-way interaction effect rather than the conceptual variability manipulation. However, the Exposure by Conceptual Variability interaction for these two conditions was non-significant, $F(19, 84) = 1.33$, Wilks' $\lambda = .77$, $P = .19$, indicating that the two slopes were not significantly different from each other.

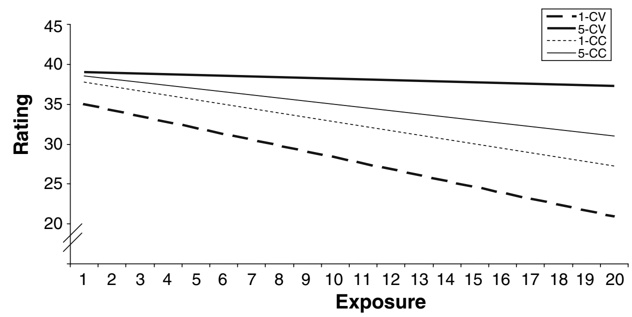

Fig. 5 Conceptually variable stimuli produce stronger novelty effects than conceptually consistent stimuli (a significant Exposure × Stimulus Variability × Conceptual Variability interaction). Trendlines are shown. CC = Conceptual Consistent; CV = Conceptually Variable; 1 = 1-Stimulus condition; 5 = 5-Stimuli condition. See Table 1 for slope estimates

Different from Experiment 1, this experiment included five levels of stimulus variability to examine whether the nature of novelty effects were dimensional or taxonic. Results showed that the introduction of each novel stimulus tended to cause a relative decrease in rate of habituation in CV conditions. In contrast, dimensional effects were not found in CC conditions. This may have been a result of the concept-dependent nature of habituation, wherein conceptually redundant stimuli that are perceptually novel do not have affect-enhancing properties beyond the first novel stimulus because of their conceptual redundancy. Taken together, the data indicate there are additional novelty effects beyond what is present in a 2-stimulus sequence when stimuli are conceptually different. Overall, these findings are inconsistent with a strict taxonic explanation and more aligned with a dimensional perspective of novelty.

General discussion

The results of Experiments 1 and 2 addressed the four main objectives of the current study: (1) to show affective habituation using a repeated assessment rating paradigm; (2) to evaluate novelty effects on habituation; (3) to assess

[2] It is possible that the ability to detect increased rates of habituation of depressed and anhedonic participants was limited due to floor effects. Depressed participants' ratings might not have had any room to decline because initial ratings were so low. Therefore, we created a percent habituation score for each condition to take this into account: (avg. 1st rating – avg. 20th rating)/avg. 1st rating. This score served as a dependent variable in models with Stimulus Variability, Conceptual Variability, and anhedonia/depression as independent variables. BDI-II, SHAPS, or FCPS did not associate with average percent habituation.

habituation at percept- and concept-dependent levels; and (4) to investigate habituation from an individual differences framework.

Both experiments supported the utility and sensitivity of the repeated assessment paradigm for examining affective dynamic processes. Affect declined in a linear fashion with each subsequent exposure. Because novelty effects were also present, it can be concluded that the linear decrease in affect ratings were due to affective habituation and not another psychological process (e.g., fatigue). This linear declining pattern contrasts with studies from the mere exposure literature demonstrating that positive affect ratings of unfamiliar, neutral stimuli follow quadratic functions resembling an inverted ''U'' (Bornstein et al. 1990; Kail and Freeman 1973; Stang and O'Connell 1974). Differences in the types of stimuli and response format in mere exposure experiments and the current study may explain this discrepancy. In the inverted ''U,'' affect increases with initial exposures, peaks, and then declines due to habituation. The initial increase in affect (i.e., the mere exposure effect) is thought to be caused by the reduction of uncertainty and the increase of perceptual fluency from repeated presentations of these unfamiliar and affectively neutral stimuli (Stimuli typically used in these experiments include Chinese ideographs, optical illusions, Welsch figures, or nonsense syllables: e.g., Bornstein et al. 1990; Kail and Freeman 1973; Stang and O'Connell 1974). In contrast, stimuli in the current studies were familiar and highly pleasurable at pre-exposure and were therefore unlikely to demonstrate marked increases in affect due to uncertainty reduction or perceptual fluency enhancement.

From a theoretical perspective, the current findings and results from mere exposure research need not be incompatible. Both findings could be explained by the attenuation of emotional response hypothesis. The downswing in positive affect shown in the current study is thought to be a result of attenuation of pleasure caused by repeated exposure. The upswing in positive affect shown in mere exposure studies (i.e., before the asymptote on the inverted ''U''), may be a result of the attenuation of fear and uncertainly caused by repeated exposures (Bornstein 1989; Harrison 1977; Stang 1974). It is possible that if these studies used response scales ranging from ''Not negative'' to ''Extremely negative,'' they might also show a habituation of emotional response. Indeed, previous studies have shown that when response scales are in the negative affect direction, repeated exposure of strongly valenced, familiar stimuli causes a reduction of emotional response after repeated presentation (Dijksterhuis and Smith 2002; Wong and Root 2003).

Exploration of the second objective indicated that introduction of novel stimuli counteracted habituation. There are several explanations for these findings. It is possible that contrast effects might have been operating during multi-stimulus conditions; however, contrast cannot account for novelty effects found in both Experiments. Contrast effects would increase the relative differences between stimuli over exposure sequences but would not alter the overall trajectory's linear slope. Another possible explanation of the novelty effects found in both experiments is that more time passed in between exposures of a specific stimulus in conditions with greater stimulus variability, which could account for the pattern of novelty effects. This is a limitation of the current study, which could be addressed by future investigations of the temporal dynamics of the repeated exposure paradigm. Nevertheless, the current findings suggest that the introduction of novelty reduces affective habituation by counteracting concept-dependent habituation processes. This parallels results from previous investigations finding that affect ratings are greater after heterogeneous presentation sequences (similar to the multi-stimulus conditions in this study) than after homogenous presentations (Harrison and Crandall 1972; Kail and Freeman 1973; Stang and O'Connell 1974).

In reference to the third objective, Experiment 2 showed that novelty effects are greater when stimuli come from different rather than redundant semantic categories and that these effects cannot be explained by perceptual differences among stimuli. These findings indicate that exposure-induced habituation generalizes to novel stimuli that are similar in type thereby diminishing their hedonic properties. This suggests habituation is at least partially mediated by conceptual processes.

The few studies that have investigated stimulus variability have only utilized two conditions (Harrison and Crandall 1972; Kail and Freeman 1973; Stang and O'Connell 1974), including more recent studies, which have investigated habituation to familiar, strongly-valenced stimuli (Dijksterhuis and Smith 2002; Wong and Root 2003). At least three or more conditions of stimulus variability are required to examine whether the inclusion of more stimuli produces a dimensional versus taxonic effect on an affective dynamic process. Experiment 2 found what appeared to be dimensional effect for the introduction of conceptually variable novel stimuli as sequences with increasing stimulus variability generally demonstrated less habituation. This pattern was not apparent in CC conditions. This dissociation may be indicative of the concept-dependent nature of habituation, which may function to prevent the affective processing system from unnecessarily responding to further conceptually redundant stimuli.

From investigation of the study's first three objectives, we can infer that affective habituation to pleasurable stimuli is likely: (a) a linear process; (b) slowed by novelty effects that are dimensional in nature; and (c) concept-dependent. These characteristics suggest that habituation may underlie adaptive affective information processing by:

(1) preventing compulsive seeking of one class of reinforcing stimuli; (2) motivating exploratory behavior in search of diverse types of pleasurable stimuli; (3) preventing the affective information processing system from unnecessarily responding to redundant stimuli; and (4) allowing the affective processing system to properly signal when salient, non-redundant rewards are present.

Both experiments found no relation between rates of habituation and depression or anhedonia. Although we hypothesized increased habituation in depressed and anhedonic subjects, it may make sense that their affective dynamic processes would be intact. Otherwise, depressed individuals would not be able to overcome depressive episodes by engaging in pleasurable activities because novel events would loose their appeal quickly. Indeed, the clinical literature shows that depressed individuals respond well to interventions involving scheduling pleasurable activities (Hopko et al. 2003). Nevertheless, it is likely that either Experiment's sample contained few who met clinical criteria for major depression with melancholic features (APA 1994), a form of depression characterized by internal biological disturbance of emotional processing systems (Leventhal and Rehm 2005).

Implications of habituation to compulsive reward-seeking behavior

Although not addressed by the current study, it is possible that affective dynamic processes become dysregulated in individuals with addictive disorders. Addictive disorders are characterized by the compulsive pursuit of a single class of reinforcers. Compulsive reward-seeking behavior could be maintained by a failure to habituate to the affective properties of addiction-related stimuli because these cues would retain their affect-enhancing properties and hence, their capability to elicit approach behavior, even following circumstances of excessive exposure (for a similar argument, see Robinson and Berridge 1993).

Limitations and future perspectives

Implications of the current findings are tentative at this point because findings from the passive exposure laboratory design may not generalize to real world circumstances. In the real world, encountering stimuli is an active process whereby individuals construe their own perceptions of the environment (Lewis 2000). In addition, repeated exposures in the real world are typically not as systematic and do not occur within such short periods. Nevertheless, this study presents a novel paradigm to assess affective dynamics and is an initial step in evaluating mechanisms underlying habituation processes utilizing experimentally controlled conditions.

Several caveats regarding the online assessment paradigm should be noted. The visual display procedure in the current study utilized a passive, unreinforced, systematically heterogeneous, exposure sequence. Future studies may wish to examine habituation under other conditions to further characterize its mechanisms. Random heterogeneous exposure sequences may produce less habituation than systematic sequences like what was used in the current study because individuals may be less likely to develop accurate expectations of future presentations. This prediction is based on the idea that habituation is less marked when people spontaneously engage in different activities rather than systematically doing a wide range of activities (e.g., every Monday I go to yoga, on Tuesdays I go to cooking class, on Wednesday I go out to dinner, etc.). Another limitation of the current study is the utilization of only one method of affect assessment. Other studies have demonstrated habituation of psychophysical and neurophysiological responses (Bradley et al. 1993; Breiter et al. 1996; Hart et al. 2000), which are more convincing in ruling out demand characteristics than self-report. Finally, this study utilized only pleasurable stimuli. The use of an unpleasant stimulus condition would be helpful to distinguish whether repeated exposure results in a diminished pleasure response or an overall attenuation of emotional response. The diminished pleasure hypothesis would suggest that negative stimuli would be come more unpleasant with repeated exposure. The attenuation of emotional response theory would suggest that the emotional intensity of a stimulus, whether it is positive or negative, is reduced with subsequent exposures. Because previous studies have demonstrated habituation to both positive and negative stimuli, the current findings are more applicable to the diminished emotional response theory. Although the current study was primarily focused on the dynamics of pleasure, future studies utilizing the repeated assessment paradigm with negative stimuli could clarify this issue.

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