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Motivation for reward as a function of required effort: Dissociating the 'liking' from the 'wanting' system in humans

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Abstract Recent studies investigating the neurobiology of reward motivation in animals have begun to deconstruct reward into separable neural systems involving the 'liking' of a reward (hedonic enjoyment of consumption) versus the 'wanting' of a reward (incentive salience to obtain reward). To date, however, it is unclear whether these systems are also separable in humans. We examined this question by manipulating the effort (clicking on a moving square) required for participants to obtain a reward (humorous versus non-humorous cartoon). Overall, as the required effort to view a humorous cartoon increased, participants were less likely to choose this reward. Moreover, individual differences in cartoon preference predicted cartoon choice at low levels of required effort, but not at high levels of required effort. These findings suggest that manipulating effort may be a valid method for dissociating the 'liking' from 'wanting' components of reward motivation in humans.

Keywords Reward · Motivation · Effort · Pleasure · Humor

Motivation to obtain rewards is one of the fundamental drives underlying much of both human and non-human animal behavior. By deconstructing the different components of motivation, researchers have begun to come to a better understanding of a wide range of both normal behaviors including reward anticipation (Knutson et al. 2001) and decision-making (McClure et al. 2004), and abnormal behaviors such as impulsive gambling (Iancu et al. 2008) and drug addiction (Robinson and Berridge 2003). Studies of the neurobiology of motivation for reward have highlighted two dissociated neural systems of motivation that seem to underlie much of these behaviors; the 'liking' of a reward versus the 'wanting' to obtain that reward (Berridge and Robinson 2003). 'Liking' a reward involves the mesolimbic opioid system and reflects the hedonic enjoyment that organisms receive from the consumption of that reward (whether it be eating a food or receiving a drug). In contrast, 'wanting' a reward involves the mesolimbic dopaminergic system and reflects the incentive salience that motivates an organism to obtain the reward.

It is becoming increasingly clear that deconstructing motivation into the separable components of 'liking' and 'wanting' is important for understanding critical aspects of human behavior. For example, Robinson and Berridge (2003) theorize that addiction to drugs involves the hypersensitization of the 'wanting' system without necessarily affecting the 'liking' system. That is, one can be highly motivated to obtain drugs without necessarily enjoying them once obtained. It has been difficult, however, to empirically dissociate these two systems in humans without the pharmacological manipulations used in animal studies and the pharmacologically induced brain changes inherent in studies of drug addiction. Despite these difficulties, recent studies have begun to investigate the dissociation of these processes by manipulating aspects of rewards (Finlayson et al. 2007), such as reward type (Finlayson et al. 2008) and novelty (Zandstra et al. 2000), and by examining the different neural regions that are associated with anticipating a possible reward (more closely linked with the 'wanting' system) and receiving that reward (more closely linked with the 'liking' system; Knutson et al. 2001).

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In this paper, we describe a promising non-pharmacological method to examine the dissociation of liking and wanting in humans that involves manipulating the effort required to obtain a reward. We define 'required effort' as the amount of work that is necessary to obtain a specified goal. In studies with rats, as the effort required to obtain a preferred reward increases, rats choose instead to eat a non-preferred 'easy-access' reward (Salamone et al. 2007). Moreover, not only does expending effort to obtain a reward seem to involve the same dopaminergic systems that are implicated in 'wanting' the reward (Salamone et al. 1997; Salamone et al. 1991), but further, pharmacological manipulation of these dopaminergic systems (injecting dopamine antagonists) influences the effort expended to obtain the reward without affecting the rats' preference for the reward (Salamone et al. 1991). Thus, manipulating the effort required to obtain a reward may be a valid, noninvasive, way of dissociating the 'liking' system from the 'wanting system' in humans.

In the current study, we presented participants with the choice of exerting varying amounts of effort to obtain rewarding versus non-rewarding outcomes. We hypothesized that, paralleling findings from non-human animal studies, as the effort required to obtain a reward increased, participants would be more likely to choose the 'easy-access' non-rewarding outcome. We hypothesized further that as the effort required for the reward increased, participants' preferences for the reward would become increasingly dissociated from their willingness to exert the required effort. In other words, participants' preference for the rewarding (over non-rewarding) outcome would influence their choices at low levels of required effort, but not at high levels of required effort.

Method

Participants

Participants responded to advertisements placed in the San Francisco Bay Area region on Craig's List (http://sfbay.craigslist.org), a community-based website that provides classifieds and forums for local regions. Individuals who responded to the advertisements were initially interviewed over the telephone. Fifty-seven individuals who were fluent in English and were between 18 and 60 years of age were invited and came to the laboratory to participate in this study. Of these 57 participants, 1 did not complete the task and 1 completed the task incorrectly, resulting in a final sample of 55 participants for the analyses (26 females; Mean age = 36.3 years, SD = 12.4).

Materials

Reward stimuli

We used funny and unfunny single-panel cartoons as our reward and non-reward stimuli, respectively. Cartoons such as these have been shown to activate similar mesolimbic reward regions of the brain as do other rewarding stimuli (e.g., money, juice; Mobbs et al. 2003). Unlike with money, however, people do not have an automatic association between expending effort and viewing a funny cartoon. In addition, compared to juice, viewing humorous cartoons may be less susceptible to satiation effects in which the value of the reward decreases with increased consumption, allowing us to repeat several trials and, thereby, to assess effort more reliably. Finally, although most people enjoy humor, appreciation of humor is subject to individual differences, allowing us to explore how individual differences in humor preference are related to differences in willingness to expend effort to view the cartoons.

The specific cartoons used in this study were used in a previous fMRI experiment showing that enjoyment of these cartoons elicited activity in mesolimbic reward regions of the brain (Mobbs et al. 2003). A total of 84 different cartoons were used, half of which were made 'unfunny' by replacing the humorous caption with a non-humorous caption.

Effort-reward task

Preference ratings

To index how much participants 'liked' the funny versus unfunny cartoons, participants were first shown six pairs of cartoons side by side on the computer monitor. In each pair, one of the cartoons was an original 'funny' cartoon and the other was an 'unfunny' cartoon (position on the screen was counterbalanced). Participants rated their preference for the cartoons on a scale from 1 (strongly prefer LEFT cartoon) to 7 (strongly prefer RIGHT cartoon), with a rating of four representing a lack of preference for either cartoon.

Enjoyment ratings

To corroborate that these preference ratings reflected differences in 'liking' for the cartoons, participants were then presented with the same 12 cartoons from the preference task one at a time. Participants were asked to think back to when they first saw these cartoons in the preference task and to rate how much they liked the cartoon by clicking on a visual analog scale that extended along the bottom half of the screen from 0 pixels ('not liked at all') to 636 pixels ('extremely liked').

Choice task

To demonstrate their 'wanting' of the cartoons, participants were then given the opportunity to "*choose between viewing a cartoon that has been rated on average as being 'funny' versus a cartoon rated on average as being 'not funny'*." The cartoons in this task had not been seen before by participants. Each deck of cartoons ('funny', 'unfunny') was associated with a 'click-count' that specified how many times the participants would have to click on a moving square before viewing the cartoon from the chosen deck. This click-count represented the effort participants would have to expend to view their chosen cartoon. The moving square task consisted of a 2 × 2 inch black square appearing at random locations on the computer screen. The participants' task was to use the mouse to click on the square. After each successful mouse click, the mouse cursor was returned to the center of the screen and the square appeared in a new location. This moving square task is similar to tasks used in previous studies to induce effort (Klein et al. 2005) and was designed to be engaging but neutral. There were 36 trials of this task with 6 trials for each of 6 click combinations that represented differential effort required to view a cartoon from the funny deck. The click combinations were (funny:unfunny): no differential effort (1:1; 15:15; 30:30); medium effort (15:1; 30:15); and large effort (30:1). There were three blocks with 12 trials each (2 trials of each of the 6 click combinations). Trials were randomized within each block.

After participants completed the required number of clicks for their choice, they viewed a cartoon from their chosen deck and then rated how much they liked that cartoon using the same visual analogue scale described above.

Effort enjoyment

After each block, participants took a short break (<1 min) and rated how much they liked the 'mini-task' (moving square task) on a scale of 1 (greatly like the mini-task) to 7 (greatly dislike the mini-task). This scale was reverse-scored in subsequent analyses so that higher scores reflect more enjoyment of the mini-task.

Data analysis

We used HLM6 (Raudenbush et al. 2008) to create a series of hierarchical linear models to examine predictors of participants' choices to view funny cartoons. We began by specifying a Level 1 (trial-level) model, which then informed our Level 2 (participant-level) models, which in turn informed more specific intercept models at Level 1. The outcome variable for all models was a Bernoulli (binary) distribution of choice with each trial coded as '0' and '1' if participants chose to view a cartoon from the unfunny or funny decks, respectively.[1]

$$\Phi = P(\text{choice} = 1/\beta)$$

$$\text{Log}(\Phi/(1-\Phi)) = \beta_0$$

The main Level 1 predictor was differential *effort* required to view the funny cartoon. Because choice did not differ among the 3 click combinations in which effort was equal (1/1 = 93%, 15/15 = 91%, and 30/30 = 88%), these trials were combined and dummy-coded as 0. Similarly, choice did not differ among the 2 click combinations indicative of 'medium effort' (15/1 = 64%, 30/15 = 68%); consequently, these trials were dummy-coded as 1. The remaining 'high effort' trials (30/1) were coded as 2, and the effort variable was then centered so that the intercept represented 'average effort.'[2] We also added *trial* as a Level 1 predictor, centered to the middle of the task (between trials 17 and 18), to test for possible satiation effects on cartoon choice. No error term at Level 1 was estimated because there was no evidence that the error deviated from the expected Bernoulli distribution.

Level 2 predictors included *preference* for funny cartoons[3] (which was standardized for interpretability of intercepts and coefficients), *effort enjoyment* (which was also standardized), and *gender* (which was mean-centered). Gender was included in the analysis because previous studies have found significant gender differences in humor (Azim et al. 2005). For each model, we tried to balance interpretability with completeness; thus, we first added all of our predictors and then deleted from the model the

[1] In the interest of space, we only show here the combined Level 1 and Level 2 equations with the Level 1 betas replaced by the Level 2 gammas and errors.

[2] Because we fully crossed the number of clicks (1, 15, 30) with each cartoon type (funny, unfunny), grouping the click combinations into three levels of effort (low, medium, high) resulted in an unequal number of trials across the levels of effort. Beyond possible differences in statistical reliability for these different trial groupings, it is unclear whether this affected cartoon choice, or any of our other variables of interest. In any case, future investigations should address this issue either by having equal numbers of trials within all levels of effort, or by systematically varying the frequency of certain types of trials and measuring the effect on reward choice.

[3] We operationalized 'liking' in terms of participants' preference for funny versus unfunny cartoons instead of the enjoyment ratings because these preference judgments were designed to match more closely the format of the choice task (i.e., viewing pairs of novel cartoons), thus constraining the tasks to differ only in the critical contrast of 'liking' versus 'wanting.' This operationalization is supported statistically as well; when adding both preference and enjoyment ratings in an HLM model predicting choice and controlling for the effects of trial and required effort, only preference significantly predicts average cartoon choice, $\beta = .6$, $p < .01$ (enjoyment: $\beta = -.07$, *ns*).

predictors with t-values below 1.7 ($\sim p > .1$).[4] Level 2 predictors were treated as random effects; that is, error terms were estimated at each Level 2 equation to allow for randomly varying slopes (Bryk and Raudenbush 1992). We report robust standard errors for the models that included *preference* because this variable did not follow a normal distribution, $S - W = .92$, $p = .002$, and because robust standard errors rely less on assumptions of normality than do regular standard errors (Hox 2002). Finally, we used restricted maximum likelihood to estimate the coefficients. Level 1 variables are shown in bold.

Results

Manipulation check

Cartoons

Participants preferred funny cartoons significantly more than they did unfunny cartoons ($M = 4.9$, SE $= .15$ [vs. '4', which represents preferring neither]), $t(54) = 5.8, p < .001$. Participants also reported greater enjoyment of the funny cartoons ($M = 284.0$ pixels, SE $= 17.1$) than they did the unfunny cartoons ($M = 144.8$ pixels, SE $= 15.3$), $t(54) = 5.9$, $p < .001$. Finally, preference for funny cartoons was highly correlated with the difference in enjoyment ratings between funny and unfunny cartoons, $r(31) = .81, p < .001$.

Moving square task

A one-way (by time) repeated-measures analysis of variance (ANOVA) was conducted on the three moving square task ratings (made after every 12 trials). Because this analysis did not yield a significant effect of time, $F(2, 53) = 2.22$, *ns*, we averaged these ratings for subsequent analyses ($\alpha = .91$). Overall, participants reported neither significantly liking nor disliking the moving square task ($M = 3.60$, SE $= .22$ [vs. '4', which represents 'neither liking or disliking']), $t(31) = 1.9, p = .069$.

Required effort and cartoon choice

Our first hypothesis was that requiring effort to view a funny cartoon would decrease the likelihood that participants would choose that funny cartoon. To examine this hypothesis we first created an unconditional model with choice as the outcome and no predictors:

$$\mathrm{Log}(\Phi/(1-\Phi)) = \gamma_{00} + u_0$$

Supporting our contention that the cartoons were rewarding, participants chose cartoons from the funny deck more often than they did cartoons from the unfunny deck, $\gamma_{00} = 1.44$, SE $= .17$, $p < .001$ (odds ratio $= 4.27$). Next, we entered the two Level 1 predictors, required effort and trial number:

$$\mathrm{Log}(\Phi/(1-\Phi)) = \gamma_{00} + \gamma_{10}(\mathbf{effort}) + \gamma_{20}(\mathbf{trial}) + u_0 + u_1(\mathbf{effort}) + u_2(\mathbf{trial})$$

This model supports our first hypothesis that effort influences cartoon choice, $\gamma_{10} = -1.53$, SE $= .26, p < .001$. The odds ratio of .22 suggests that with each increased level of effort required to view a funny cartoon (i.e., from no effort to medium effort; from medium effort to high effort) participants were approximately 1/5th as likely to choose the funny cartoon. Thus, the more effort that was required to view a funny cartoon, the less likely participants were to choose it.

There was also a significant effect of trial on choice, $\gamma_{20} = .026$, SE $= .008$, $p < .005$. With each successive trial, participants were 1.03 times more likely to choose a cartoon from the funny deck. This finding is the opposite of what one might expect if participants' appreciation of the cartoons were becoming satiated over time, and further supports our use of cartoons as enduring rewards.

Effect of cartoon preference on the effort-choice association

Our second hypothesis was that preferring ('liking') the funny cartoons and choosing ('wanting') the cartoons would become increasingly dissociated with greater effort required to view the cartoons. To test this hypothesis, we first built a model with all of the Level 2 variables (preference, effort enjoyment, and gender) entered as predictors of each Level 1 variable (Table 1, cols. 2–5). Next, we removed those predictors with t-values under 1.7 ($\sim p < .1$), resulting in the following model:

$$\begin{aligned}\mathrm{Log}(\Phi/(1-\Phi)) = {} & \gamma_{00} + \gamma_{01}(\text{preference}) \\ & + \gamma_{02}(\text{effort enjoyment}) + \gamma_{10}(\mathbf{effort}) \\ & + \gamma_{11}(\text{preference})(\mathbf{effort}) \\ & + \gamma_{12}(\text{effort enjoyment})(\mathbf{effort}) \\ & + \gamma_{20}(\text{trial}) \\ & + \gamma_{22}(\text{effort enjoyment})(\mathbf{trial}) \\ & + u_0 + u_1(\mathbf{effort}) + u_2(\mathbf{trial})\end{aligned}$$

Results from this model are presented in Table 1, columns 6–9. Of note, gender did not significantly influence either cartoon choice or the slopes between effort or trial and choice; consequently, we removed gender from the model.

[4] We used a liberal threshold of $p < .1$ for inclusion in the initial models to minimize Type II error by providing for the possibility that predictors could become significant with greater degrees of freedom (gained when non-significant predictors are removed from the model). We then report only those effects that become significant at $p < .05$ after this initial step.

Table 1 Hierarchical linear modeling of cartoon choice

Predictors	Full model				Model with non-significant* predictors removed			
	Coefficient (odds ratio)	SE	*t*	*p*	Coefficient (odds ratio)	SE	*t*	*p*
Intercept: average choice								
Intercept	1.785 (5.96)	0.190	9.37	<.001	1.754 (5.78)	0.185	9.51	<.001
Gender	0.017 (1.02)	0.379	0.05	.965				
Preference	0.600 (1.82)	0.158	3.80	.001	0.539 (1.71)	0.162	3.33	.002
Effort enjoyment	0.579 (1.78)	0.201	2.87	.006	0.546 (1.73)	0.198	2.76	.008
Effort slope								
Intercept	−1.563 (0.21)	0.235	−6.65	<.001	−1.550 (0.21)	0.235	−6.59	<.001
Gender	0.627 (1.87)	0.472	1.33	.190				
Preference	−0.271 (0.76)	0.152	−1.78	.080	−0.382 (0.68)	0.150	−2.54	.014
Effort enjoyment	0.717 (2.05)	0.226	3.18	.003	0.712 (2.04)	0.215	3.31	.002
Trial slope								
Intercept	0.028 (1.03)	0.008	3.69	.001	0.025 (1.03)	0.008	3.23	.003
Gender	0.023 (1.02)	0.015	1.55	.128				
Preference	0.011 (1.01)	0.007	1.52	.134				
Effort enjoyment	0.031 (1.03)	0.010	2.94	.005	0.027 (1.03)	0.009	2.94	.005

* Non-significant at $p < .1$

Note: $n = 55$

In addition, because cartoon preference did not predict the slope between trial and choice, that term was also eliminated from the model.

Our hypothesis was supported: cartoon preference significantly predicted average choice as well as the slope between effort and choice (Fig. 1a). With each standard deviation increase in preference for funny cartoons, participants were on average 1.7 times more likely to choose the funny cartoon, but this odds ratio decreased by a factor of .7 for each level increase in effort required to view the cartoon. To further examine the level of effort ('none' or 'high') at which these preference slopes diverged, we altered the Level 1 effort variable in the current model by setting its intercept to either 0 (corresponding to 'no effort') or 2 (corresponding to 'high effort'). When no effort was required, there was a significant effect of cartoon preference, with greater cartoon preference predicting greater likelihood of choosing the funny cartoon. Importantly, however, there was no effect of cartoon preference on cartoon choice when 'high effort' was required (Table 2). These results support our hypothesis that preference for a reward becomes dissociated from choosing that reward as the effort required to obtain the reward increases.

Effect of effort enjoyment on cartoon choice

Effort enjoyment exhibited a pattern of results nearly opposite that of cartoon preference in the above models (Tables 1 and 2; Fig. 1b). Whereas cartoon preference was characterized by a negative slope between choice and effort, effort enjoyment was characterized by a positive slope. Examination of the 'no' and 'high' effort intercept models in Table 2 suggests that effort enjoyment played no role in choice when there was no required effort to view the funny cartoon; in contrast, when high effort was required, participants high in effort enjoyment were more likely to choose the funny cartoon. When the interaction terms of preference and effort enjoyment were entered into the models, they were not significant predictors, indicating that preference and effort enjoyment were independent predictors of cartoon choice.

Finally, there was also an interaction between effort and trial on cartoon choice (Table 1). As participants progressed through the choice task, those who reported greater enjoyment of the mini-task were increasingly more likely to choose the funny cartoon than were those who reported less enjoyment of the mini-task.

Discussion

We showed that requiring participants to exert effort to receive a reward dissociated how much people 'like' rewards from how much people 'want' rewards. We operationalized 'liking' a reward as participants' preference for humorous versus non-humorous cartoons, and 'wanting' a reward as choosing to view a humorous cartoon. As the required effort to obtain a reward increased, participants were less likely to exert effort for the reward and,

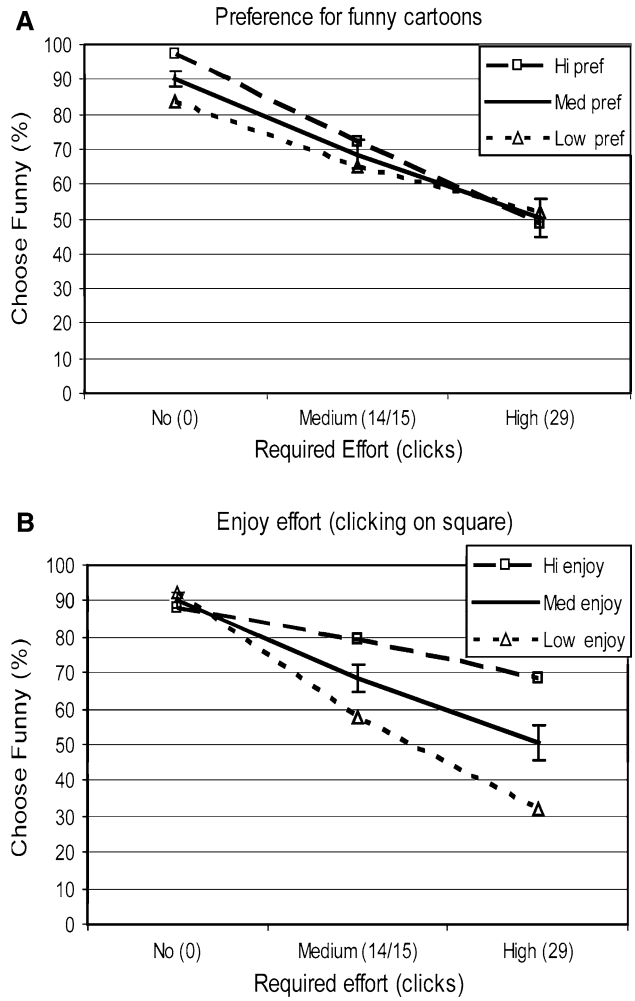

Fig. 1 Predicting choice for funny cartoons. Shown are regression lines with 'Med' representing each measure's mean, and 'Hi' and 'Low' representing 1 SD above and below each measure's mean, respectively. Error bars represent 2 SE's above and below each measure's mean. (**a**) Preference for funny cartoons predicts choosing funny cartoons when no effort is required but not when high effort is required. (**b**) On the other hand, enjoyment of effort (moving square task) predicts choosing funny cartoons only when some effort (medium or high) is required

importantly, their preference for the reward no longer predicted their choice to work for the reward. These results parallel findings from studies examining the influence of effort on reward motivation in rats (Salamone et al. 2007), and support the assertion that manipulating effort is a valid non-pharmacological method of dissociating the 'liking' from the 'wanting' systems in both humans and rats.

Although cartoon preference did not predict choice at high levels of effort, participants' enjoyment of the effort itself did. The effect of participants' enjoyment of effort was independent of their preference for the reward, suggesting that as the required effort increased, participants made their choices based on the effort involved rather than on the reward at stake. This trade-off between the influence

Table 2 Hierarchical linear modeling of preference and effort enjoyment at different levels of effort

Models	Coefficient (odds ratio)	SE	*t*	*p*
Intercept—'no effort'				
Intercept	2.787 (16.23)	0.207	13.46	<.001
Preference	0.794 (2.21)	0.163	4.86	<.001
Effort enjoyment	0.071 (1.07)	0.207	0.34	.732
Intercept—'high effort'				
Intercept	−0.312 (0.73)	0.405	−0.77	.445
Preference	0.029 (1.03)	0.292	0.10	.920
Effort enjoyment	1.497 (4.47)	0.394	3.80	<.001

Note: Model is the same as presented in Table 1 except for altering the Level 1 predictor, effort, so that the intercept was either at 'no effort' or 'high effort.' Line breaks indicate different models. df = 52

of reward preference and required effort on reward choice is similar to findings from other studies of a trade-off between reward preference and the time delay to obtain the reward (Green and Myerson 2004; McClure et al. 2004). In these temporal discounting studies, participants are given the choice between a small reward now and a larger reward later; participants' degree of temporal discounting reflects their subjective valuation of immediate versus delayed rewards (Kable and Glimcher 2007). Thus, one possible explanation for the current findings is that our participants discounted reward value as a function of effort. In temporal discounting studies, reward value is often measured by reward choice; thus, future studies should examine whether it is people's 'liking' of a reward or their 'wanting' of a reward that is discounted with time and/or effort.

A possible limitation of the design of the current study is that whereas we manipulated and measured reward 'liking' by dividing the cartoons into humorous and non-humorous and assessed people's preferences, we measured 'wanting' only as cartoon choice. Thus, we assessed only the single dissociation of 'liking' from 'wanting,' and not the reverse dissociation of 'wanting' from 'liking.' Future studies should complete this double dissociation by manipulating 'wanting' independent of 'liking,' perhaps by varying reward deprivation/satiation (Zandstra et al. 2000).

This study joins similar investigations that have dissociated 'liking' from 'wanting' in humans (Finlayson et al. 2008; Finlayson et al. 2007; Zandstra et al. 2000), and extends their findings in several important ways. First, manipulating the effort required to obtain a reward has high ecological validity. One could argue that at least some effort is required for humans to obtain a large proportion of the rewards in their lives, from driving to the ice cream shop, to working several hours a week at one's job. Thus, the present findings highlight the importance of dissociating 'liking' from 'wanting' in more general behaviors.

Second, the task used in this study can be flexibly altered to examine how the dissociation between 'wanting' and 'liking' is influenced by other variables such as reward type, objective value, and relative deprivation. For example, we chose to use humorous cartoons because people enjoy being amused, as is evidenced by our data, and because the enjoyment of cartoons has been shown to activate similar reward-related regions of the brain as other types of reward, such as money or juice (Azim et al. 2005; Mobbs et al. 2003). By using a different type of reward, like money or primary reinforcers, future investigations could extend the potential applications of this task to other lines of inquiry such as organizational behavior.

Finally, this task has implications for investigating mental disorders that are characterized by difficulties or disruptions in reward motivation, such as schizophrenia (Horan et al. 2006) and depression (Henriques and Davidson 2000; Knutson et al. 2008). For example, although schizophrenia has been associated with anhedonia, recent studies show that schizophrenic patients are more impaired when anticipating pleasurable experiences than when 'consuming' these experiences (Gard et al. 2007). In conjunction with the current findings, one could further hypothesize that schizophrenic patients would also show decrements in their willingness to exert effort for rewards, but not in how much they prefer rewards versus non-rewards. Such a finding would provide further evidence for the selective impairment of the 'wanting' system in schizophrenia (Gard et al. 2007).

In sum, we have shown that 'liking' a present reward and choosing a future reward ('wanting') can be dissociated by varying the amount of effort required to obtain the reward. Dissociating these two components of reward has implications for understanding ecologically relevant behaviors such as job motivation and dieting. In addition, it is becoming increasingly clear that although these two components of reward are usually inseparable, understanding how these components can be differentiated may offer insights into mechanisms underlying symptoms of specific disorders, such as the anhedonia that is characteristic of schizophrenia and depression, and the drug-seeking behavior that typifies addiction.

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