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Patients With Schizophrenia Demonstrate Dissociation Between Affective Experience and Motivated Behavior

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Self-reported emotional experience does not differ between patients with schizophrenia and healthy individuals, suggesting that the anhedonia in schizophrenia instead reflects decoupling of affect from motivated behavior. In 2 behavioral conditions, participants with schizophrenia and healthy participants were able to prolong or decrease exposure to stimuli while stimuli were present or alter the likelihood of future exposure to stimuli on the basis of internal representations. They also provided self-reports of affective experience. Patients showed weaker correspondence between behavior and ratings than did comparison participants. The effect was amplified when patients responded on the basis of internal rather than evoked stimulus representations. These data suggest that the motivational deficits in schizophrenia reflect problems in the ability to translate experience into action.

Keywords: anhedonia, dopamine, reward, schizophrenia

Deficits in emotion and motivation have long been recognized as core features of schizophrenia and are often linked in the clinical lore. For example, if schizophrenia caused stimuli previously experienced as pleasurable to diminish in hedonic value, as in anhedonia, one might imagine that the motivation to obtain such rewards would similarly fade (Blanchard, Mueser, & Bellack, 1998). Indeed, clinical observers beginning with Bleuler (1950) have noted that, "In mild cases, where wishes and desires still exist, [patients] will nevertheless do nothing toward the realization of these wishes" (p. 70).

However, research suggests that the abulia noted by Bleuler (1950) is not due to a failure of emotional experience. Studies have repeatedly shown that individuals with schizophrenia describe pleasure in response to positive stimuli and report enjoying them as much as healthy individuals (Aghevli, Blanchard, & Horan, 2003; Berenbaum & Oltmanns, 1992; Kring & Neale, 1996). Moreover, patients with schizophrenia show relatively normal affective startle modulation (Curtis, Lebow, Lake, Katsanis, & Iacono, 1999). Such findings provide evidence of intact emotional experience, despite reductions in emotional expressivity (Earnst et al., 1996; Myin-Germeys, Delespaul, & deVries, 2000). Nonetheless, the literature documents persistent deficits in goal-seeking behaviors among patients with schizophrenia (Crespo-Facorro et al., 2001; Herbener & Harrow, 2002; Torres, O'Leary, & Andreasen, 2004). Thus, it appears possible that these motivational problems are not due to an inability to experience emotion but stem instead from poor coupling of affect with behavior, that is, the failure of a salient emotional experience to motivate an appropriate response (Schmidt et al., 2001).

This probable dissociation between stimulus salience and motivated behavior is consistent with evidence from basic neuroscience that suggests that reward has multiple components. Berridge and Robinson (2003) have made the distinction between *wanting*, the motivation to engage a set of effortful behavioral responses to obtain a desirable reward, and *liking*, the degree to which a reward is experienced as pleasurable on consumption. This dissociation has been related to the avolition present in schizophrenia (Kring & Bachorowski, 1999).

Multiple lines of evidence point to the critical role of dopamine in modulating reward-seeking behavior (wanting) rather than in the consummatory behaviors that are fundamental to reward experience (liking; Robinson, Sandstrom, Denenberg, & Palmiter, 2005). For example, rats administered moderate doses of the dopamine antagonist haloperidol to the nucleus accumbens showed normal food preferences during a food-choice task. However, when given the choice to either free-feed on ordinary rat chow or to bar press to obtain a preferred food, treated rats showed decreased bar pressing in favor of free-food consumption, whereas untreated rats obtained the majority of their food rewards through bar pressing (Berridge, 1996). Complementary results have been found with respect to preference for sweets (Pecina, Cagniard, Berridge, Aldridge, & Zhuang, 2003). Moreover, dopamine concentrations in nucleus accumbens selectively affect the amount of effort an animal will exert to obtain a reward (Wyvell & Berridge, 2000). Abnormalities in dopaminergic signaling might therefore be expected to specifically alter reward-seeking behavior, which is based on reward value representations, rather than interfere with consummatory behavior, which occurs in the presence of a stimulus.

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Other evidence suggests that dopamine cell activity may be critically involved in signaling the salience of motivationally relevant events rather than simply the rewarding qualities of a stimulus (Pezze & Feldon, 2004; Reis, Masson, de Oliveira, & Brandao, 2004). In particular, dopamine release accompanies aversive experiences, such as tail pinching in rats (D'Angio, Serrano, Rivy, & Scatton, 1987), and may play a role in aversive conditioning (Young, 2004).

Taken together, alterations in dopaminergic signaling, as in schizophrenia, may interfere with the representation and scaling of the motivational salience of environmental stimuli. Specifically, dopaminergic dysfunction in striate regions is implicated in positive symptoms of schizophrenia, such as hallucinations and delusions (Kapur & Mamo, 2003), and has been suggested to disrupt the assignment of incentive salience to environmental stimuli. One prominent model of such dysfunction proposes that during the schizophrenia prodrome dopamine neurons begin to fire independent of the motivational salience of environmental cues and independent of the context within which cues occur, leading to diminished capacity to adaptively code stimulus salience (Kapur, 2003; Kapur, Mizrahi, & Li, 2005). In addition, dysfunction in nucleus accumbens, a region involved in reward processing that receives dopaminergic inputs, is associated with decreased volitional behavior (Juckel et al., 2006) and is thus thought to relate to negative symptoms, such as affective blunting and avolition.

Cognitive factors may also undercut the ability to couple motivational salience and behavior (Barch, 2005). For example, the degree to which an individual can activate a stimulus representation in working memory and use that representation to motivate behavior may prove important in understanding motivational deficits. It has long been known that individuals with schizophrenia show deficits in working memory function (Lee & Park, 2005). Therefore, it stands to reason that working memory ability may relate to the degree to which stimulus salience and motivated responding are coupled among individuals with schizophrenia.

To better understand the association between hedonic experience and volitional responding, we devised a task to examine effortful behavior in response to affective stimuli. Modeled on a paradigm developed by Aharon and colleagues (2001), the present task used pleasant, neutral, and unpleasant images to elicit behavioral measures of wanting and liking. *Wanting,* operationalized as the degree to which effort is exerted to seek or avoid future stimulus exposure, used a key-press procedure allowing participants to press for stimuli they wanted to see again or avoid seeing. This key-press procedure was performed after stimulus offset and, therefore, required memory representations of stimulus value. Hereafter this measure will be termed *representational responding*. A measure of consummatory behavior was obtained by examining the degree to which participants would work to prolong or reduce exposure to a perceptually available stimulus. This measure is conceptually related to *liking* because individuals who experience the presence of stimulus as pleasurable are expected to work harder to prolong access to it. Because this measure was elicited during stimulus exposure, we refer to it as *evoked responding*. In addition, we note that this is not a pure measure of liking because it also captures aspects of wanting, such as stimulus satiety, along with the ability to accurately internalize stimulus salience. Finally, we obtained a self-report measure of the hedonic value of each stimulus, which we call *liking*.

In the present study, we sought to examine coherence in the motivational systems of individuals with schizophrenia. On the basis of previous research (e.g., Kring & Neale, 1996), we predicted that participants with schizophrenia would not differ from comparison participants in their self-reported experience (liking) of positive, neutral, and negative stimuli. We also tested several novel predictions. First, we expected positive and negative slides to have less motivational salience for participants with schizophrenia than for comparison participants and, therefore, to be less well differentiated by effortful behavior from neutral slides across behavior conditions. Second, we hypothesized that patients would show degradation in the coupling of self-reported liking with behavior in the representational but not evoked responding conditions. Third, we expected both self-reported anhedonia and working memory to relate to behavior in the representational but not evoked conditions, given that reporting on past affective experiences and responding to stimuli that are no longer present both rely on the ability to represent hedonic value.

Method

Participants

Participants included 41 outpatients with diagnoses of schizophrenia or schizoaffective disorder and 31 healthy participants. Patient diagnoses were assessed with the Structured Clinical Interview for *DSM–IV* (SCID; First, Spitzer, Miriam, & Williams, 2002). All patients were currently receiving antipsychotic medications with no prescription changes for at least 4 weeks prior to participation (see Table 1 for sample characteristics). Patients were deemed clinically stable by their clinicians and were capable of providing informed consent, as documented by a set of standard probes. Symptom assessments included the Brief Psychiatric Rating Scale (BPRS; Overall & Gorham, 1962) and the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1989). Comparison participants were free of psychiatric diagnoses as indicated by the SCID, were not taking psychiatric medications, and had no family history of psychosis. Potential participants were excluded if there was evidence of neurological injury or disorder, substance abuse or dependence, or other disorder capable of affecting task performance. After study procedures were described, participants gave written informed consent. The University of Maryland's institutional review board approved the study.

Procedures

To evaluate the wanting and liking components of the motivational system, participants completed three experimental procedures. In the first, they viewed and rated 42 slides, each containing sets of three images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005) on a computer. Fourteen pleasant, 14 neutral, and 14 negative slides made up the set. The three photos on each slide were items of similar content, valence, and arousal (see Figure 1). Participants rated the degree to which each slide was experienced as pleasurable and arousing using 9-point Likert scales anchored by *extremely [unpleasant/calm]* and *extremely [pleasant/arousing]*. Participants had unlimited time to make their ratings. Slides were removed from the screen after rating. Pleasantness and arousal ratings did not differ from the average IAPS ratings of the image sets for either group ($ps > .35$). This procedure served as a measure of hedonic experience (liking) and required little effortful behavior.

Shortly after rating each slide for pleasantness and arousal, wanting or representational responding was assayed. Prior to the rating procedure, participants were informed that they would later view a slideshow containing some of the slides they had rated. Participants were instructed to rapidly press the "n" and "m" keys (using the index and middle fingers of

Table 1
Participant Characteristics

Variable	Comparison participants	Schizophrenia patients	*p*
Age (years; $M \pm SD$)	43.52 ± 11.07	43.93 ± 9.21	.864
Age at illness onset (years; $M \pm SD$)		22.75 ± 7.26	
Education (years; $M \pm SD$)	14.52 ± 2.44	12.78 ± 2.25	.003
Paternal education (years; $M \pm SD$)	13.38 ± 4.52	13.52 ± 4.16	.975
Gender (male:female)[a]	15:16	26:14	.154
Race[a]			.336
African American	9	16	
Caucasian	22	23	
Other	0	2	
Antipsychotic medication (*n*)			
Low dopamine affinity[b]		6	
Low/medium dopamine affinity[c]		13	
Medium/high dopamine affinity[d]		13	
High dopamine affinity[e]		8	
Unclassified[f]		1	
Clinical ratings			
BPRS ($M \pm SD$)		36.49 ± 8.49	
SANS ($M \pm SD$)		33.67 ± 14.67	

Note. BPRS = Brief Psychiatric Rating Scale; SANS = Scale for the Assessment of Negative Symptoms.
[a] Group differences tested with chi-square. [b] Clozapine. [c] Clozapine + risperidone or clozapine + fluphenazine. [d] Risperidone, olanzapine, ziprazidone, or aripiprozole. [e] Haloperidol or fluphenazine. [f] Aripiprozole.

the same hand) if they wanted to see a slide again, or the "x" and "z" keys if they did not. They were told that the more presses they made, the more likely it was that they would or would not see the slide again. They were instructed to press only in response to motivationally salient slides, those they strongly liked or disliked, and not to slides of low significance. With the exception of one patient who did not press during this procedure, all participants pressed for at least five slides, and no one pressed for every slide (number of slides responded to: $M_{\text{Comparison}} = 23.48$, $SD = 10.14$; $M_{\text{Patient}} = 26.68$, $SD = 11.53$), $F(1, 70) = 1.85$, $p = .24$. There was a 3-s delay between post-rating slide offset and the start of the 2-s response window. Slides were not visible during this procedure. Participants were given 2 s of rest prior to presentation of the next slide for rating.

Finally, to better understand motivated behavior in the presence of a stimulus, a measure of consummatory behavior (evoked responding) was included in the study. Participants saw a slideshow with 30 of the previously viewed slides (10 of each valence). The slideshow was identical for all participants. In the absence of responding, slides were visible for 5 s. Repeatedly pressing the "n" and "m" keys increased viewing time, whereas pressing the "x" and "z" keys shortened it. As above, participants were not required to press for stimuli and were told that pressing would not alter the total task length. Except for one comparison participant who exhibited no pressing during this procedure, all participants pressed for at least 3 slides, and no participant pressed for every slide (number of slides responded to: $M_{\text{Comparison}} = 18.03$, $SD = 7.57$; $M_{\text{Patient}} = 22.02$, $SD = 7.61$), $F(1, 70) = 4.82$, $p = .03$. The maximum time participants were able to view the slides was 10 s. Each trial lasted 12 s, including at least 2 s of rest after slide offset. The task took 40 to 45 min, depending on how fast participants rated the slides.

The task was programmed using E-prime stimulus presentation software (Psychology Software Tools, http://www.pstnet.com). In addition, participants completed the Chapman Physical and Social Anhedonia Scales (Chapman, Chapman, & Raulin, 1976) and two working memory measures: Letter Number Sequencing (LNS) and Spatial Span (SS; Wechsler, 1997). The present study was part of a larger decision-making study. Participants were paid $20/hr for participation.

Data and Analysis

There were four types of button pressing possible during the task. These were presses to *seek desirable* or *avoid undesirable* stimuli (representational responding) and presses to *retain desirable* or *remove undesirable* stimuli (evoked responding). The evoked responding measure allowed participants to increase or decrease slide-viewing time. Consequently, participants pressed more for pleasant than unpleasant stimuli because of the longer response window. Response window variability was equated by calculating button presses per second per slide for each type of button pressing.

To examine correspondence between self-reported liking and behavior, we calculated the correlation between each participant's pleasantness ratings and button presses per second for each type of button pressing. To uphold the assumption of normality for further analysis, correlation coefficients were converted to *z* scores with Fisher's transformation. Predictions were tested using correlation and mixed model analysis of variance (ANOVA) in SPSS 12.0. Adjustments for multiple comparisons used Bonferroni's correction.

Results

Self-Reported Liking

As seen in Figure 2, group by slide valence ANOVAs showed that groups reported similar experiences of the slides. For pleasantness, neither the group main effect, $F(2, 69) = 2.19$, $p = .14$, $\eta_p^2 = .03$, nor the group by valence interaction approached significance, $F(2, 69) = 0.15$, $p = .86$, $\eta_p^2 = .01$, although the main effect of slide valence showed that negative, neutral, and positive slides were rated differently, $F(2, 69) = 28.06$, $p < .001$, $\eta_p^2 = .42$. An identical pattern of results was observed for arousal ratings: main effect of slide valence, $F(2, 69) = 9.65$, $p < .001$, $\eta_p^2 = .13$; main effect of group, $F(2, 69) = 0.09$, $p = .77$, $\eta_p^2 < .01$; group by valence interaction, $F(2, 69) = 0.24$, $p = .79$, $\eta_p^2 < .01$. These

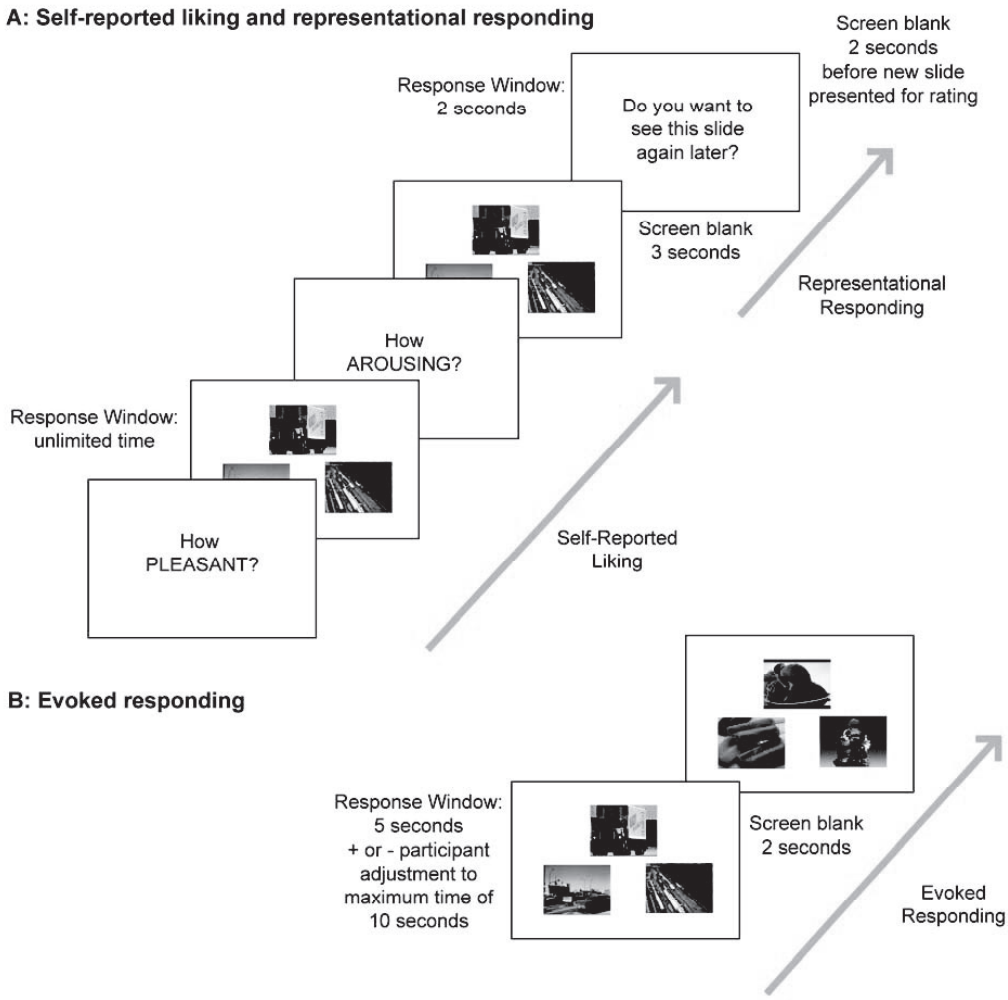

Figure 1. Study procedure. A: The self-report and representational responding measures were interleaved such that participants rated the pleasantness and arousal of each slide and were then given the opportunity to respond for future exposure to the slide. A new slide was presented for rating 2 s after the representational responding condition concluded. B: Participants' responses served to either prolong or decrease viewing time for the image being rated.

results are consistent with prior studies of self-reported affect to evocative images in schizophrenia.

Motivational Salience

Groups did not differ significantly in the total number of button presses during the study ($M_{\text{Comparison}} = 905.39$, $SD = 416.46$; $M_{\text{Patient}} = 773.31$, $SD = 449.40$), $F(1, 70) = 1.62$, $p = .21$; nor did they differ on the average number of presses per second made during the representational ($M_{\text{Comparison}} = 10.86$, $SD = 4.23$; $M_{\text{Patient}} = 9.81$, $SD = 6.20$), $F(1, 70) = .64$, $p = .43$, or evoked conditions, averaged over slide valence ($M_{\text{Comparison}} = 8.36$, $SD = 4.36$; $M_{\text{Patient}} = 6.90$, $SD = 3.77$), $F(1, 70) = 2.23$, $p = .14$. Therefore, to test the behavioral salience of differently valenced slides, button presses per second were subjected to a 2 (group) $\times$ 2 (behavior condition) $\times$ 3 (slide valence) ANOVA. Slide valence was determined according to participant's own liking ratings. We had predicted poor behavioral discrimination of slide valence among patients relative to healthy participants. As Figure 3 shows, the group by valence interaction was significant, $F(2, 70) = 23.33$, $p < .001$, $\eta_p^2 = .25$. In both representational and evoked conditions, patients' button presses to differently valenced slides were more similar across valence than were those of comparison participants. That is, participants with schizophrenia showed less behavioral discrimination among differently valenced slides than did comparison participants, despite well-differentiated affective ratings. In addition, we found a main effect of slide valence, $F(2, 70) = 79.38$, $p < .001$, $\eta_p^2 = .53$, showing less pressing to neutral than to positive and negative slides ($ps < .01$), and behavior condition, showing more pressing in the representational compared with the evoked responding condition, $F(1, 70) = 23.99$, $p < .001$, $\eta_p^2 = .26$.

The deficit among patients was more descriptively captured by the three-way interaction that showed that depending on slide valence, patients' behavior was more similar to that of healthy

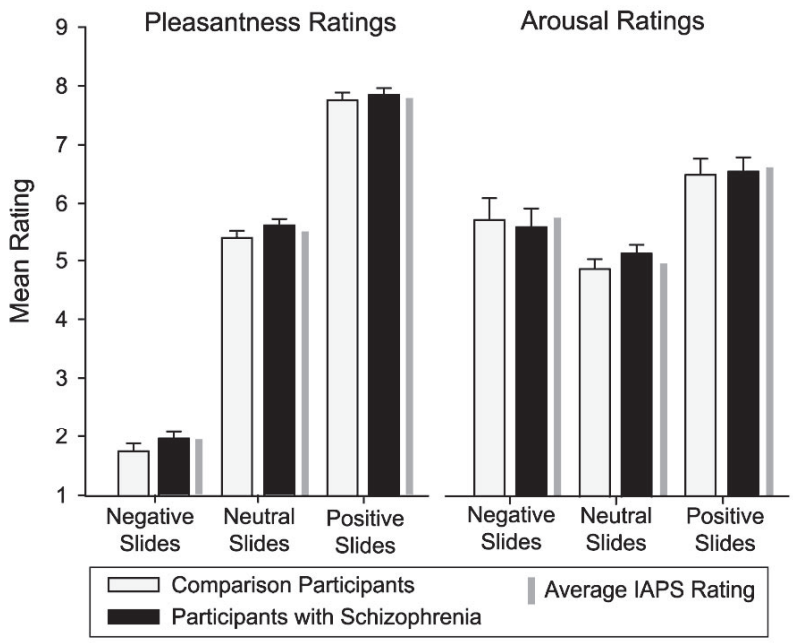

Figure 2. Self-reported hedonic value. The average International Affective Picture System (IAPS) pleasantness and arousal ratings are shown for comparison purposes (dark gray lines). Bars show mean ratings and standard errors across groups.

participants in the evocative than in the representational condition, $F(2, 70) = 5.29$, $p = .02$, $\eta_p^2 = .07$, driven by their responses to neutral items. Specifically, patients made relatively fewer button presses to negative slides in both conditions ($ps < .01$), along with relatively more button presses to neutral ($p = .01$) and fewer to positive slides ($p = .04$) in the representational responding condition. Comparison participants did not differ across conditions for slides of neutral valence ($p = .43$). Note that patients and comparison participants did not differ in button presses to neutral or positive slides in the evoked responding condition ($ps < .14$).

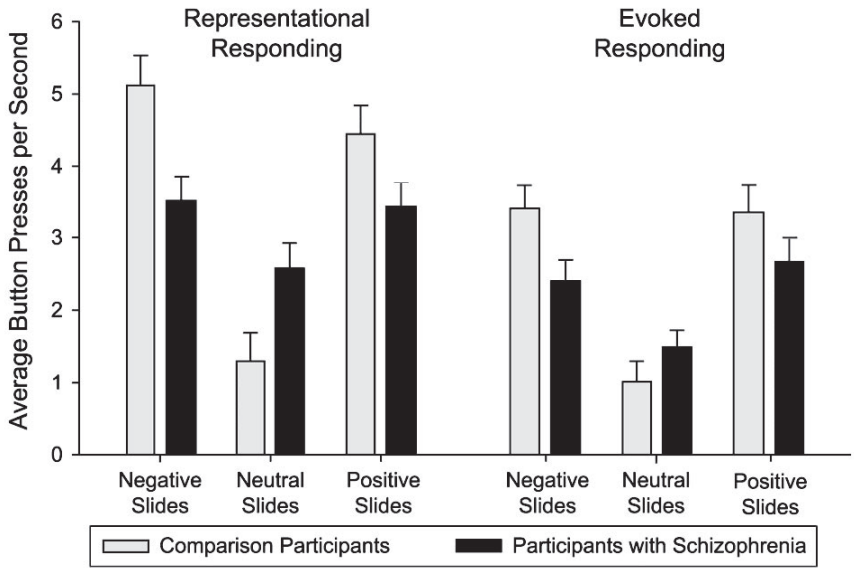

Figure 3. Motivational salience of positive, neutral, and negative stimuli. Bars show means and standard errors across representational and evoked responding conditions. Negative, neutral, and positive slides represent slide valence according to each participant's rating of hedonic value.

Finally, the group main effect failed to reach significance, $F(1, 70) = 2.56$, $p = .11$, $\eta_p^2 = .04$, as did the Condition × Group interaction, $F(2, 70) = 0.17$, $p = .69$, $\eta_p^2 < .01$, and the Condition × Valence interaction, $F(2, 70) = 1.53$, $p = .21$, $\eta_p^2 = .02$.

Correspondence Between Behavior and Liking

We had predicted that patients with schizophrenia would show less correspondence—that is, the degree to which button presses per second correlate with liking ratings—in the representational compared with the evoked conditions. To test this prediction, the *z*-transformed correlations between behavior and self-report were analyzed in a 2 (group) × 2 (behavior condition) × 2 (stimulus desirability; see *Data and Analysis*) ANOVA. Healthy participants showed greater correspondence between behavior and self-report across conditions, $F(1, 62) = 11.36$, $p = .001$, $\eta_p^2 = .16$. Nonetheless, the predicted Group × Condition interaction emerged, $F(1, 62) = 4.42$, $p = .04$, $\eta_p^2 = .07$ (see Figure 4). Compared with healthy participants, patients showed less correspondence in the representational than in the evoked responding condition, thereby suggesting that patients have more difficulty generating behavior on the basis of internal representations than in the direct presence of an evocative stimulus.

Other findings emerged in this analysis. Undesirable images elicited greater correspondence than desirable ones, $F(1, 62) = 35.01$, $p < .001$, $\eta_p^2 = .36$, and desirability interacted with group such that undesirable images did not show increased correspondence to the same degree for patients as for healthy participants, $F(1, 62) = 4.64$, $p = .04$, $\eta_p^2 = .07$. Correspondence was stronger in the evoked than in the representational responding condition, $F(1, 62) = 22.40$, $p < .001$, $\eta_p^2 = .27$, which is not surprising considering that both ratings and evoked responses occur in the direct presence of the stimulus, whereas representational responses must be invoked from memory. Neither the Behavior Condition × Desirability interaction, $F(1, 62) = 2.63$, $p = .11$, $\eta_p^2 = .04$, nor the three-way interaction emerged, $F(1, 62) = 0.25$, $p = .62$, $\eta_p^2 < .01$.

Self-Reported Anhedonia and Behavior

If patients with schizophrenia have intact affective experiences but poor capacity to represent them, then self-reported anhedonia and representational responding ought to be related, whereas self-reported anhedonia and evoked responding ought not. To test this idea, we computed patients' correlations between each of the Chapman Anhedonia Scales and measures of the correspondence (*z*-transformed scores) between representational responding and liking and between evoked responding and liking, both averaged across slide desirability, as correlations did not differ for desirable and undesirable slides. Physical anhedonia was not related to correspondence in either representational ($r = –.10$, $p = .41$) or evoked responding conditions ($r = –.02$, $p = .89$). However, social anhedonia was significantly associated with representational ($r = –.26$, $p = .03$) but not evoked responding ($r = –.12$, $p = .34$).

Working Memory and Representation

Representational responding depends on a form of working memory—working memory for motivational salience. We therefore expected that working memory might relate to representational but not evoked responding. We correlated the working memory measures LNS and SS, which notably do not involve reward representations, with patients' Fisher-transformed correlations between representational responding and liking and between

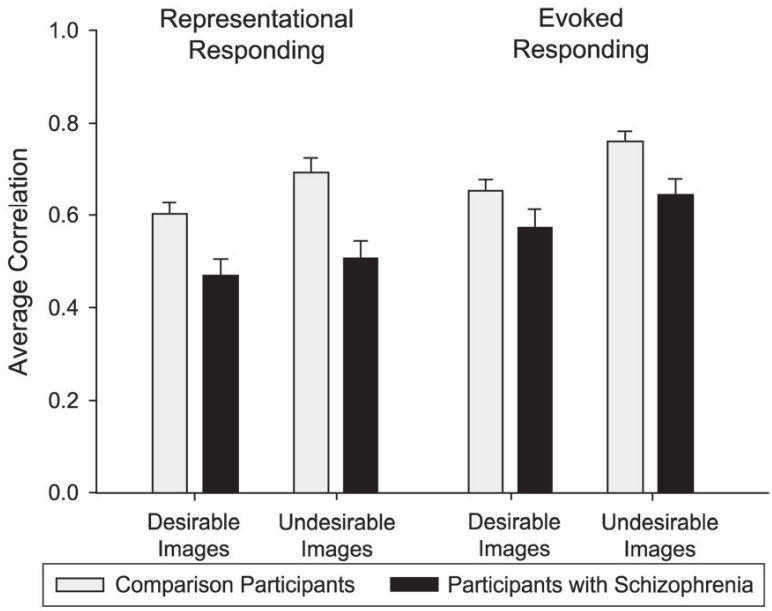

Figure 4. Correspondence between volitional responding and self-report. Bars reflect the degree of correspondence between self-report and behavior across wanting and liking for both desirable and undesirable images. Error bars show standard errors.

evoked responding and liking, averaged across slide desirability. Both measures were related to representational responding, such that better working memory predicted better correspondence (SS: $r = .31$, $p = .01$; LNS: $r = .36$, $p < .01$). Neither measure predicted evoked responding (SS: $r = .14$, $p = .29$; LNS: $r = .17$, $p = .17$). This analysis confirmed our reasoning that representational ability is implicated in the degree to which behavior and value are coupled in schizophrenia.[1]

Symptom Effects

To understand how behavior related to patients' symptoms for both motivational salience and correspondence, SANS total score (excluding the attention items) and positive and negative symptom scores on the BPRS were correlated with each cell in the preceding analyses. With respect to motivational salience, none of the symptom measures correlated with button presses per second ($ps > .14$) in any of the Behavior Condition (representational or evoked responding) × Slide Valence (positive, neutral, or negative valence) cells (see *Motivational Salience*). With respect to the coupling of behavior and self-report (see *Correspondence Between Behavior and Liking*), patients' positive and negative symptoms on the BPRS were unrelated to correspondence between behavior and self-report for any Behavior Condition (representational or evoked responding) × Slide Desirability (desirable or undesirable images) cell ($ps > .34$). However, patients with higher SANS scores showed weaker correspondence when pressing for undesirable images in the representational responding condition ($r = –.32$, $p = .05$). Neither SANS total score nor any SANS subscale related to correspondence in any other cell in the analysis ($ps > .14$). It would seem to be the case then that negative symptoms, as rated by clinicians, are surprisingly unrelated to direct measures of motivational salience and to the link between hedonic experience and motivated behavior, an issue we plan to explore in future work.

Relationship to Demographic Variables

Participants with schizophrenia differed from healthy participants on education, although not on paternal education. To understand whether education was related to participants' liking ratings, motivational salience, or to the correspondence between behavior and self-report, we examined correlations between participants' education and paternal education for each cell in the aforementioned analyses. Within the groups, none of the variables was significantly related to either participant education or paternal education ($ps > .11$). It is therefore likely that differences in education are not responsible for differences in results.

Although groups did not differ statistically in proportion of men to women, the patient group had somewhat more men than women. Gender differences are frequently reported on emotion-related tasks (e.g., Schneider, Habel, Kessler, Salloum, & Posse, 2000). Moreover, it has been suggested that women with schizophrenia may show more intact responses to affective stimuli than men (Salem & Kring, 1998). To determine whether there were differences in response patterns for women and men with schizophrenia, we reran our analyses of self-reported liking, motivational salience, and correspondence in the patient group, using gender as the between-subjects variable. Self-reports of liking differed depending on gender. Specifically, women with schizophrenia rated positive and negative slides as more positive and negative, respectively, than did men, $F(1, 62) = 5.44$, $p = .03$, $\eta_p^2 = .12$. With respect to the motivational salience of slides, there was a main effect trend for women to press more than men, $F(1, 40) = 3.17$, $p = .08$, $\eta_p^2 = .07$. There were no other gender differences in this analysis ($ps > .27$). The degree to which behavior corresponds with self-report was unrelated to gender ($ps > .23$). Thus, although women made somewhat more extreme ratings and tended to press more to all stimuli, overall patterns of behavior were similar among men and women.

Medication Effects

It is thought that dopamine plays a critical role in mediating reward seeking but not consumption. Insofar as our operational definitions have captured meaningful aspects of this construct, we would expect antipsychotic medication to affect the coupling of behavior with hedonic value. However, this post hoc analysis is inherently limited: In the absence of random assignment, medication effects were fully confounded with the patient characteristics that lead clinicians to prescribe particular drugs. Therefore, this analysis is purely exploratory.

Antipsychotic regimens were grouped into four categories on the basis of dopamine receptor affinity and the extent to which the compounds are easily displaced by endogenous dopamine release (Kapur & Seeman, 2001): low (clozapine; $n = 6$), low/medium (clozapine + risperidone, or clozapine + fluphenazine; $n = 13$), medium/high (risperidone, olanzapine, or ziprasidone; $n = 13$), and high (haloperidol or fluphenazine; $n = 8$). We did not classify one participant who was taking aripiprozole because of the drug's action as a partial dopamine receptor agonist. There was no relationship between medication and total button presses ($r = –.03$, $p = .87$). The Fisher-transformed correlations between behavior and self-report were subjected to a 4 (drug class) × 2 (behavior condition) × 2 (slide desirability) ANOVA. A trend emerged suggesting that the degree of dopamine blockade may indeed relate to the coupling of behavior and self-report, $F(3, 37) = 2.29$, $p = .09$. Patients on clozapine monotherapy and those on either haloperidol or fluphenazine appeared to drive this trend. These participants showed correspondence approximating that of healthy participants. Patients in the intermediate groups showed worse performance.

It is interesting that the most normal behavioral performance was observed in the drug conditions most different from one another in D2 receptor affinity. Although paradoxical from a pharmacological standpoint, this finding is relatively easily understood from a clinical–historical perspective. At the Maryland Psychiatric Research Center (MPRC), the vast majority of patients are taking atypical antipsychotics. The few patients who have remained on conventional agents have chosen to do so largely because they are doing well clinically and are unwilling to risk the

[1] The interested reader may wonder whether scores on the Chapman scales were similarly correlated with working memory performance. Physical anhedonia scores were strongly related to both SS ($r = –.38$, $p = .001$) and to LNS ($r = –.34$, $p = .005$) such that better working memory related to decreased reports of anhedonia. Social anhedonia was correlated with SS ($r = –.27$, $p = .03$) but only tended to relate to LNS ($r = –.23$, $p = .06$).

instability that follows treatment change. Similarly, MPRC was the first treatment center in the state of Maryland to offer clozapine treatment, resulting in a large cohort of patients beginning clozapine treatment. As with patients on conventional medications, those who have done well with clozapine monotherapy have remained in such treatment. Those who have not done well, because of either continued symptoms or intolerable side effects, were later switched to a new agent or received adjunctive risperidone. Thus, patients at both ends of the D2 affinity spectrum have a history of good clinical response and medication tolerance, whereas the two intermediate groups share a less optimal clinical picture. Despite these qualifications, the fact that the clozapine group so closely approximated normal performance is a noteworthy observation, suggesting that antipsychotics that are most easily displaced by endogenous dopamine may have an advantage for preserving the integrity of signaling within the motivational system.

Discussion

Patients with schizophrenia showed deficient ability to couple their behavior to the motivational properties of a stimulus, particularly when behavior required an internal stimulus representation. Representational but not evoked responding was predicted by self-reported social anhedonia, as well as measures of working memory, confirming our reasoning that anhedonia might relate to faulty representations of reward value. In addition, patients evidenced poor behavioral discrimination of stimulus valence, exhibiting enhanced responding to neutral items. Finally, relative to positive stimuli, those of negative valence seemed to have less motivational salience for patients in both representational and evoked conditions. Thus, this study provides evidence that schizophrenia involves a failure to accurately use representations of motivational salience to guide behavior.

The present study adds to a growing body of literature showing normal affective valuation among patients with schizophrenia and extends this work by highlighting a deficit in patients' ability to translate hedonic value into motor behavior. This is an important finding as it offers a new perspective on the nature of the motivational deficits that feature so prominently in the phenomenology of schizophrenia. Although patients with schizophrenia are able to experience the value of a stimulus "in the moment," they have difficulty linking behavior to value, particularly when they must do so outside the direct presence of an evocative stimulus.

Although the possibility exists that these findings were simply related to motor slowing among patients with schizophrenia, independent of motivational deficits, this is an unlikely interpretation of the present results for several reasons. First, if responses were affected simply by motor slowing, patients would have shown reduced pressing across all conditions, which was not the case—patients pressed more for neutral items. Second, the total number of button presses made by participants during the study did not differ across groups, nor did button presses per second for either condition when collapsed across slide valence or desirability. Therefore, it is likely that the observed group differences are related to aspects of the motivational system rather than to simple differences in motor ability.

Working memory related specifically to the correspondence between representational responding and self-reported liking. This finding suggests that working memory may play a role in the coupling of affect and behavior. For patients with schizophrenia, who have diminished working memory capacity, it may be the case that representations of affective stimuli are weaker and therefore have less power to activate motivational systems. These findings lend support to the notion that deficits in cognition amplify deficits in motivation, rather than the reverse (see Barch, 2005; Tomarken & Keener, 1998).

Self-reported social anhedonia also related to correspondence in the representational but not evoked conditions. It is unclear why social but not physical anhedonia showed this relationship. However, a number of studies have suggested that social anhedonia is predictive of the later development of schizophrenia spectrum disorders (Blanchard, Gangestad, Brown, & Horan, 2000; Blanchard, Horan, & Brown, 2001; Kwapil, 1998), whereas physical anhedonia is not (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994). Social anhedonia, then, may index a factor that is more strongly related to schizophrenia and therefore may show a unique relationship with the decoupling of affect from behavior.

An important and unanticipated finding in the present study relates to negatively valenced stimuli: Relative to positive stimuli, participants with schizophrenia appeared to find these both less evocative and less motivating than did comparison participants. This finding may relate to dopaminergic coding of stimulus valence. Although dopamine was initially thought to be the substrate of reward (Schultz, 2006), more recent evidence implicates dopamine in the experience of aversive events and in the experience of both primary and conditioned reinforcers (Young, 2004). The amount of dopamine released is roughly similar for positive and negative events (Fuchs, Nagel, & Hauber, 2005). Thus, dopamine release in and of itself does not allow an individual to discriminate stimulus valence but instead serves to allow for the recognition of motivationally important stimuli (Joseph, Datla, & Young, 2003).

The question of how differences in stimulus valence are coded within the dopamine system is still unresolved. It may be the case that stimulus differentiation relates to different mechanisms of release, for example, the direct activation of dopaminergic neurons by the firing of presynaptic dopaminergic neurons or indirect dopamine release into the synaptic cleft via the firing of cholinergic neurons (Cragg, 2006). It may also be that D1 receptors are specifically necessary for the coding of positive stimuli, whereas D2 receptors might be more related to the coding of negative stimuli (Young, Moran, & Joseph, 2005). Many antipsychotic drugs act on D2 receptors, leaving D1 receptors relatively uninhibited (Kapur & Seeman, 2001). If this is indeed the mechanism for differentiating positive from negative stimuli, negative stimuli may well be less salient than positive stimuli.

These findings appear to be consistent with everyday clinical observation of patients and have implications for treatment. In particular, the findings fit well with observations that patients seem to lack the desire to engage in pleasurable activities independently, although when forums for such activities are provided, patients are eager to participate and report enjoying them (Beck & Rector, 2000). Nonetheless, the chance to gain a reward was more motivating for patients than the chance to avoid an aversive outcome, an idea that resonates with many psychosocial treatment protocols for schizophrenia (Dickerson, Tenhula, & Green-Paden, 2005; Summerfelt et al., 1991). Extending from this, one might speculate

that high rates of substance use, including nicotine dependence, reflect the fact that highly salient primary reinforcers may have unusual motivational significance when representations of the significance of consequences fail to guide behavior. Interventions that rely on the physical presence of rewards may thus prove more motivating for patients than those that rely on consequences or deferred rewards. Such cues may serve to diminish reliance on internal representations in behavior generation.

Literature on the role of dopamine in the assignment of incentive salience suggests that excess dopamine may undermine ability to code stimulus salience and motivate behavior (Kapur, 2003; Schmidt et al., 2001). Therefore, it seems likely that faulty dopamine signaling is implicated in the present results (Lyne, Kelly, & O'Connor, 2004). However, the question of whether these findings are due to the effects of schizophrenia or its treatment remains unsettled. Both chronically high levels of dopamine, as in untreated schizophrenia, and high levels of receptor blockade from antipsychotic treatment alter dopaminergic neurotransmission. Animal models of reward salience show that dopamine blockade impairs motivated behavior in the presence of hedonically important stimuli (Berridge & Robinson, 1998). Nonetheless, anhedonia and avolition have been reported to characterize the schizophrenia prodrome (Malla et al., 2002) and are present among patients who are medication-free (Zhang, Peet, Ramchand, Shah, & Reynolds, 2001). Moreover, in a recent study of reward prediction, unmedicated patients with schizophrenia failed to show increased activations in ventral striatum compared with healthy participants (Juckel et al., 2006). These observations suggest that elevated dopamine alters phasic dopamine signaling and consequently impairs the assignment of hedonic value to stimuli, regardless of antipsychotic medication (Kapur, 2003). As a caveat to this reasoning, we note that many antipsychotic drugs affect neurotransmitters other than dopamine that are implicated in the control of reward processing and behavior. These include serotonin, noradrenaline, and glutamate (Kapur & Seeman, 2001). However, given the variety of medications in use by patients in our sample, it is unlikely that such effects played a consistent role in the present results, although their effects cannot be ruled out entirely.

Given the medication status of our patient sample, we understand that the present results are not an unambiguous test of affect and motivation among individuals with schizophrenia. We nonetheless believe them to be clinically important. Antipsychotic medication is a first-line treatment for schizophrenia, and the majority of treated patients take these drugs. For this reason, the present findings are highly relevant to the clinical presentation of treated individuals. Although important, medication-free studies are not a guarantee that results are unconfounded by dopaminergic manipulation. The typical 2-week washout period used in most medication-free studies may be inadequate to homogenize dopamine function in a sample, as patients are known to relapse at different rates (Mortimer, Williams, & Meddis, 2003). Moreover, the performance of first-episode, medication-naive patients may be affected by their clinical instability, and the acute dopamine dysregulation associated with such states may not be characteristic of the syndrome itself (Laruelle, 2000). Taken together, it is likely that aspects of both schizophrenia and its treatment have been captured in the present findings. Additional work with unmedicated individuals and patients who have been randomly assigned to antipsychotic medications will be necessary to disentangle the effects of schizophrenia from the effects of its treatment.

Finally, the biological and psychological significance of a stimulus may also be a factor in determining the degree to which it is important in the dopamine system. Our stimuli consisted of a variety of images and arguably do not constitute examples of primary rewards, which are likely to be more salient (McClure, York, & Montague, 2004). Replication of these findings using rewards, including foods, beverages, real money, or drugs such as nicotine, are necessary to better understand the coupling of affect and behavior in schizophrenia.

Conclusion

The present study demonstrated impairment in representational responding relative to evoked responding among individuals with schizophrenia, along with alterations in the degree to which the hedonic value of a stimulus was able to elicit behavior. These results lend support to the idea that the anhedonia that characterizes schizophrenia results from a breakdown in representational ability such that the motivational salience of a stimulus is poorly coupled to behavior, particularly outside the direct presence of that stimulus. In other words, the ability to rely on an internal representation of a stimulus to motivate behavior appears to be faulty among patients. Although these results require replication with other rewards and among individuals who are medication-free, this study provides important evidence about the nature of anhedonia among patients with schizophrenia.

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