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Affective Experience and Motivated Behavior in Schizophrenia Spectrum Disorders: Evidence From Clinical and Nonclinical Samples

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Objective: Individuals with schizophrenia have been found to exhibit emotion–behavior decoupling, particularly with respect to anticipated, rather than experienced events. However, previous research has focused on how emotion valence translates into motivated behavior, ignoring the fact that emotion arousal should also modulate emotion–behavior coupling. Few studies have examined emotion–behavior coupling in prepsychotic conditions. This investigation aimed to examine the nature and extent of

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SL designed the study, collected and analyzed the data, and wrote up the first draft of the manuscript. AA, CT, CC, ML, and PW administered the tests and conducted the clinical rating and interview for patients in Study 1 and Study 2. YS, ZL, YW, and CY administered the test to participants in Study 3. EH and EC interpreted the data and commented significantly to the final draft of the manuscript. RC generated the idea and closely supervised the study design, data interpretation, and write-up of the manuscript. All authors contribute to and have approved the final text. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest This study was supported by grants from the Beijing Training Project for the Leading Talents in S & T (Z151100000315020), the Strategic Priority Research Programme (B) of the Chinese Academy of Science (XDB02030002), the National Science Fund China (81088001, 81571317, 91132701), the Key Laboratory of Mental Health, Institute of Psychology. These funding agents had no further role in the study design; in the collection, analysis and interpretation of the data; in the writing of the manuscript; and in the decision to submit the paper for publication.

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emotion valence– and arousal–behavior coupling across the schizophrenia spectrum. ***Method:*** We examine how emotional valence and arousal couple with behavior in 3 groups of individuals (25 individuals with chronic schizophrenia; 27 individuals early in the disease course, and 31 individuals reporting negative schizotypal symptoms). Participants completed a task using slides to elicit emotion and evoke motivated behavior. We compared participants with their respective matched control groups to determine differences in the correspondence between self-reported emotion valence/arousal and motivated behavior. ***Results:*** Both groups with schizophrenia reported similar affective experiences as their controls, whereas individuals reporting negative schizotypal symptoms showed "in-the-moment" anhedonia but not emotion–behavior decoupling. In addition, the schizophrenia groups' affective experiences corresponded less well to their behavior relative to controls. ***Conclusions:*** Our findings suggest emotion–behavior decoupling along both valence and arousal dimensions in schizophrenia but not in participants with high levels of schizotypal symptoms. Findings appear to support the idea that emotion–behavior decoupling differs in nature and extent across the schizophrenia spectrum. Interventions to recouple emotion and behavior may be particularly helpful in allowing people with schizophrenia to gain functional independence.

Keywords: motivation, reward, anhedonia, schizophrenia, schizotypy

Anhedonia and avolition are core features of the negative syndrome of schizophrenia (Andreasen, 1989; Kay, Fiszbein, & Opler, 1987), and predict poor long-term outcomes (Herbener, Harrow, & Hill, 2005; Kirkpatrick, Fenton, Carpenter, & Marder, 2006). Contrary to clinicians' impressions that anhedonia is prevalent in schizophrenia, laboratory studies using immediately present emotion inducing stimuli consistently suggest that people with schizophrenia experience positive emotions to pleasant stimuli similarly to controls. However, emotional experience may be more ambiguous in schizophrenia, and people with schizophrenia report more negative emotion to neutral and pleasant stimuli as well as more positive emotion to unpleasant stimuli (Cohen & Minor, 2010). Meta-analytic evidence additionally shows that people with schizophrenia and healthy individuals both find emotional stimuli to be similarly arousing (Llerena, Strauss, & Cohen, 2012). Nonetheless, it appears that the experience of emotion does not drive the same degree of effortful behavior in schizophrenia as it does in healthy individuals, thus contributing to a low level of motivated behavior in people with schizophrenia, a phenomenon termed *emotion–behavior decoupling* (Heerey & Gold, 2007; Lui et al., 2016).

Recent research posits that an interconnected emotional/cognitive–behavioral framework operates to translate emotion into motivated behavior (Barch & Dowd, 2010; Heerey & Gold, 2007; Trémeau et al., 2010). However, it is important to note that emotion states vary in their ability to motivate behavior. Berridge (2003, 2007) distinguishes "liking"—that is, the ability to enjoy pleasurable stimuli in the immediate environment—from "wanting"—that is, the ability to anticipate future pleasure—and suggests that wanting better predicts motivation than does liking.

Examining emotion–behavior coupling offers promise for understanding avolition in schizophrenia. For example, Heerey and Gold (2007) elegantly demonstrated defective emotion–behavior coupling in individuals with chronic schizophrenia using a behavioral paradigm. When presented with emotionally evocative slides of positive, neutral, or negative nature, schizophrenia and healthy participants reported similar affective experiences in both emotion valence and arousal. Interestingly, the key feature distinguishing the two groups' behavior was the failure to translate emotional salience into motivated behavior in individuals with schizophrenia. This emotion–behavior decoupling appeared to be more severely impaired during wanting than liking. However, the strength of an affective experience (i.e., emotion arousal) should modulate the degree to which the experience of wanting and liking drive behavior. Thus, more arousing affect should intensify motivated behavior. Unfortunately, because Heerey and Gold (2007) only examined the role of emotion valence in motivation, the degree to which emotion arousal drives motivated behavior remains unknown. The paucity of empirical evidence in this important area is noteworthy, because arousal is believed to contribute to activation of behavioral responses and motivational processes (Lowe & Ziemke, 2011).

It is possible that this defective translation of emotion into motivated behavior reflects the underlying neuropathological disease process of schizophrenia. However, no prior study has examined whether emotion–behavior decoupling constitutes a trait marker. Interestingly, Meehl (1989) proposed that anhedonia and avolition symptoms are trait markers of the underlying genetic vulnerability of schizophrenia, which are often present in schizotypy (Tsuang, Stone, Tarbox, & Faraone, 2002). Meehl's proposition that schizotypy constitutes a condition "at-risk" of developing schizophrenia has been supported by evidence from follow-up (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994) and epidemiological studies (van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009) as well as the association between dopamine dysfunctions and schizotypy (Mohr & Ettinger, 2014). Though only a small proportion of individuals with schizotypy eventually develop clinical schizophrenia (Chapman et al., 1994), schizotypy offers an opportunity to examine putative trait markers before the onset of psychosis. Moreover, the hypothesized progressive developmental pathology in schizophrenia, together with the complex interplay between intrinsic disease factors and extrinsic factors such as medications and institutionalization may confound putative trait markers and may, for instance, aggravate emotion–behavior decoupling in the course of the disease (Carpenter, Heinrichs, & Wagman, 1988; Kirkpatrick et al., 2006). However, there is a paucity of empirical evidence for the evolution of emotion–behavior decoupling over the course of schizophrenia.

To comprehensively examine the nature and extent of emotion–behavior decoupling across the schizophrenia spectrum and over

the course of schizophrenia, we conducted three cross-sectional studies. Study 1 recruited individuals with chronic schizophrenia (>5-year illness duration) in a general adult psychiatric clinic. Study 2 recruited individuals with recent-onset schizophrenia (<5-year illness duration) in an early psychosis intervention program. Study 3 recruited individuals reporting symptoms of negative schizotypy from among a large pool of healthy volunteers in the community. The subtype of negative schizotypy was used in view of its inherent high prevalence of anhedonia and avolition compared with other schizotypy subtypes. Using a behavioral paradigm as in Heerey and Gold's (2007) study, we examined the degree to which emotion valence and emotion arousal correspond to motivated behavior. We predicted that (a) there would be a defective translation of both emotion valence and emotion arousal into motivated behavior in individuals with schizophrenia spectrum disorders/symptoms; and (b) a greater decoupling would be found in individuals in the chronic stage than those early in the illness.

Study 1

Materials and Method

Participants. We recruited 25 clinically stable individuals with a *DSM–IV* (First, Spitzer, Gibbon, & Williams, 1996) diagnosis of schizophrenia (mean duration of illness = 14.64 years, *SD* = 8.77 years) from a psychiatric clinic in Hong Kong. We used a best-estimate approach to ascertain psychiatric diagnosis, based on structured clinical interviews (SCID-I; First et al., 1996) by two qualified psychiatrists, supplemented by information in medical records obtained in highly frequent follow-ups (average interval 4–8 weeks). We arbitrarily distinguished chronic schizophrenia from early schizophrenia using a cut-off of 5-year illness duration. Exclusion criteria were (a) history of substance abuse in the past 6 months, (b) history of any Axis I psychiatric disorders apart from schizophrenia, (c) history of electroconvulsive therapy in the past 6 months, (d) history of neurological disorder, (e) history of head injury with loss of consciousness for more than 30 min, and (f) mental retardation. We also recruited 22 age- and gender-matched healthy volunteers working in clinics and nongovernmental organizations in the neighboring community to serve as comparison participants. Structured interviews by a qualified psychiatrist ascertained that no comparison participants had any lifetime of *DSM–IV* mental disorder or family history of psychosis, nor met any exclusion criteria as for the schizophrenia group. All participants were Chinese in ethnicity.

Demographics and treatment histories were ascertained from case records of participants with chronic schizophrenia (see Table 1 for details). All participants with schizophrenia had medication histories. Notably, seven participants received first-generation antipsychotics and 18 received second-generation antipsychotics at

Table 1
Summary Statistics of Demographics, Clinical and Hedonic Capacity Performances for Patients With Chronic Schizophrenia and Healthy Controls (Study 1)

	Healthy group (n = 22)			Chronic schizophrenia (n = 25)				
	Mean	*SD*	Range (minimum, maximum)	Mean	*SD*	Range (minimum, maximum)	F/χ^2	p
Age	35.82	16.317		37.48	9.346		.189	.666
Gender (male vs female)	12 v 10			12 v 13			.654	.772
Handedness (right vs left)	22 v 0			25 v 0				
Education (years)	12.41	3.996		11.24	2.241		1.579	.215
Estimated IQ	118.55	18.508		106.80	18.184		4.802	**.034**
Mean button-pressing speed (press/second) in ACP task	3.373	1.445	.23, 5.77	3.275	1.592	.60, 6.67	.045	.832
Total no. press in anticipatory condition (press)	300.09	150.634	9, 555	295.40	185.317	50, 760	.009	.925
Average no. press per trial in anticipatory condition (press)	7.341	3.488	.21, 13.21	7.471	4.481	1.19, 18.13	.012	.913
Total no. press in consummatory condition (press)	497.77	273.103	85, 1033	456.00	270.200	80, 1087	.277	.601
Average no. press per trial in consummatory condition (press)	17.33	9.53	2.83, 37.77	17.110	11.150	2.67, 51.76	.005	.943
Total no. invalid trials in ACP task	2.86	8.114	0, 38	5.08	5.671	0, 19	1.201	.279
No. trial responded in anticipatory condition (42 trials in total	27.36	10.24	10,42	32.56	8.16	10, 42	3.74	.059
No. trial responded in consummatory condition (30 trials in total	20.23	5.50	10,30	24.32	5.60	12, 30	6.36	**.015**
PANSS positive				7.04	.20			
PANSS negative				12.36	3.47			
PANSS general				17.44	1.45			
Duration of illness (years)				14.64	8.77			
Medications (chlorpromazine equivalent, in mg)				365	361.3			

Note. IQ = intelligence; ACP task = Anticipatory and Consummatory Pleasure task; PANSS = Positive and Negative Syndrome Scale. *P*-values in bold are statistically significant at < .05.

the time of assessment, 10 participants additionally received anticholingerics (benzhexol) at a range of 2–8 mg daily, and two participants received benzodiazepines (one received lorazepam 2 mg daily and another received clonazepam 2 mg daily). Symptom measurements included the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987), which was completed by trained psychiatrists. We estimated intelligence using a prorating method based on the arithmetic, similarities and digit span subscales of the Chinese version of the Wechsler Adult Intelligence Scale–Revised (WAIS–R; Gong, 1992). The schizophrenia and healthy participants did not differ in education but differed in estimated IQ, $F(1, 45) = 4.802$, $p = .034$. The local Ethics Committee approved all study procedures. All participants gave written informed consent. Participants received no monetary reward or incentives of any kind (likewise for Studies 2 and 3 below).

Procedures. Participants completed the computerized Anticipatory and Consummatory Pleasure (ACP) task, as shown in Figure 1 (Heerey & Gold, 2007; Lui et al., 2016). Briefly, participants first viewed a series of emotionally evocative slides (14 positive, 14 neutral, and 14 negative). Each slide consists of three pictures drawn from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005), as in Heerey and Gold's (2007) and Lui et al.'s (2016) studies. The IAPS pictures used in the ACP task differed in normative valence and arousal according to IAPS norms, and have been found to effectively elicit a range of emotion valences and arousal levels in healthy populations. Participants rated their experiences of each slide's valence on a 9-point, Likert-style, bipolar scale anchored by *extremely unpleasant* (negative) and *extremely pleasant* (positive). Participants also rated the degree to which they experienced each slide as arousing on a 9-point Likert unipolar scale anchored by *extremely calm* and *extremely arousing*. In the first phase of ACP task, they were informed that some of the same slides would appear again later in the task but that they could alter the probability of stimulus exposure by rapidly pressing buttons on the keyboard. As both pleasant and unpleasant stimuli were used in the ACP task, participants' effort could be exerted for the purpose of pleasure-seeking or aversion-avoiding in terms of future stimulus exposure. They could press buttons *M* and *N* in rapid succession to seek the future presentation of a slide or *X* and *Z* to avoid a slide in the future. The response window for button pressing in this phase was 2 seconds. They viewed and could respond to a total of 42 slides in this phase. Because participants pressed buttons only after stimulus offset, this response phase operationalized emotion–behavior coupling in the "anticipatory" condition. In the second task phase, participants viewed 30 slides (10 positive, 10 neutral, and 10 negative) and had the opportunity to prolong or shorten stimulus exposure by completing the same button-press procedure during stimulus exposure. The response window for button pressing in each trial of this phase varied from 2 to 10 seconds. The more rapidly participants pressed the *M* and *N* buttons, the longer the slide presentation time; likewise, the more rapidly participants pressed *X* and *Z* buttons, the shorter the presentation time. If no buttons were pressed, the slide was visible for 5 seconds. As this response was evoked by "in-the-moment" affective experiences, it operationalized emotion–behavior coupling in the "consummatory" condition. It should be noted that the response in the consummatory condition captures a certain aspect of wanting, but less so than that in the anticipatory condition. It should also be noted that the ACP task captures both pleasure-seeking and aversion-avoiding behavior, we therefore use the terms *anticipatory* and *consummatory* conditions in the subsequent passages, to denote the idea of wanting and liking. On average, the comparison group pressed buttons in 27.36 trials ($SD = 10.24$) and 20.23 trials ($SD = 5.50$) during the anticipatory and consummatory conditions, respectively; whereas the patient group responded to 32.56 trials ($SD = 8.16$) and 24.32 trials ($SD = 5.60$), respectively.

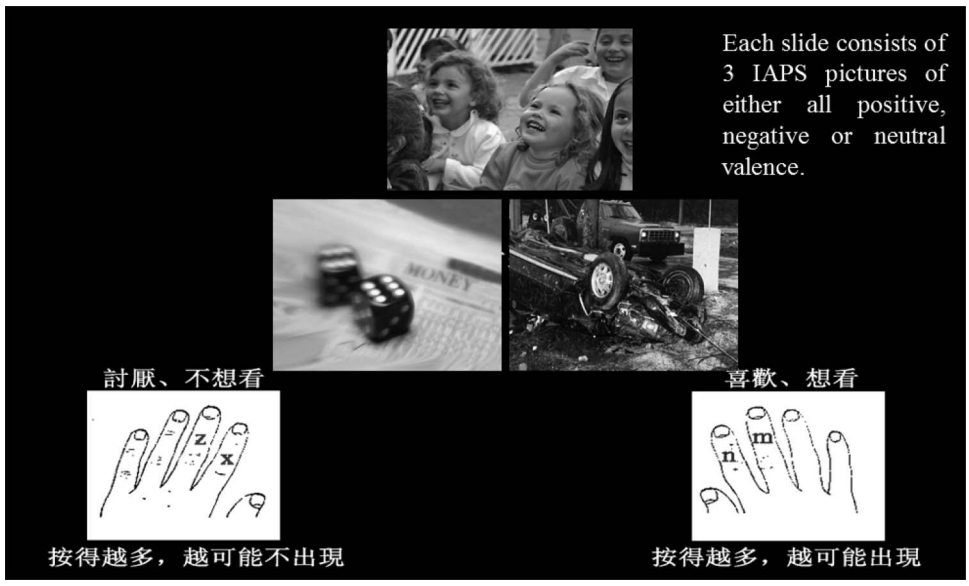

Figure 1. Example of a positive slide during the consummatory phase of the task. Participants pressed the *Z* and *X* keys to remove the image or the *N* and *M* keys to increase the time it was present. IAPS = International Affective Picture System.

Data analysis. To examine group differences in self-reported liking, valence and arousal ratings were subjected to 2 (between subjects factor: schizophrenia, healthy individuals) × 3 (within-subjects variable: positive, neutral, negative slide valence) mixed model ANOVAs.

To analyze the motivational salience of emotion valence (i.e., button pressing behavior elicited by pleasure/aversion during or after viewing the pictures in the ACP task), slide valence (the hedonic value of a slide) was determined on a participant-by-participant basis, as in Heerey and Gold's (2007) study. We transformed valence ratings of 1–3, 4–6, and 7–9 into negative, neutral, and positive slide valences, respectively. We deemed a trial invalid if participants rated a slide as negative but "incongruently" exerted effort to seek or prolong the stimulus exposure (>4 incongruent button presses), and vice versa for positive slides. However, button-pressing for both pleasure-seeking or aversion-avoiding were deemed valid for those slides rated as neutral. Together, this meant that we excluded an average of 2.86 trials (SD = 8.114) per comparison participant and 5.08 trials (SD = 5.671) per participant with schizophrenia, $F(1, 45) = 1.201$, $p = .279$). Notably, during the anticipatory condition, button pressing occurred for a fixed period of 2 seconds; whereas the response window in the consummatory condition varied among individual trials. In order to equate button pressing across the variable response windows in the two phases of the task, we calculated button-pressing speed on each trial as "presses/second". We analyzed the average button-pressing speeds with 2 (between-subjects factor: schizophrenia, healthy group) × 2 (within-subjects variable: anticipatory vs. consummatory condition) × 3 (within-subjects variable: negative, neutral, positive slide valence) mixed model ANOVAs.

To analyze motivational salience with respect to the degree to which a stimulus is emotionally arousing, we transformed arousal ratings of 1–3, 4–6, and 7–9 into low, moderate, and high arousal ratings, respectively. The mean button-pressing speed in response to low, moderate, high arousal slides was calculated, across different slide valences. In estimating the motivational salience of arousal, we did not exclude those trials in which the participants' self-reported slide desirability (pleasant vs. unpleasant) corresponded "incongruently" to the motivated behavior (pleasure-seeking vs. aversion-avoiding). These data were subjected to 2 (between-subjects factor: schizophrenia, healthy group) × 2 (within-subjects variable: anticipatory vs. consummatory condition) × 3 (within-subjects variable: low, moderate, high slide arousal) mixed model ANOVAs.

Results

Self-reported liking. Figure 2a shows the valence and arousal ratings. For valence ratings, neither the group main effect ($F(1, 45) = .086$, $p = .711$, partial eta squared = .002), nor group by valence interaction reached statistical significance ($F(2, 90) = 1.661$, $p = .203$, partial eta squared = .036), meaning that groups did not differ in how they rated slide valences. Likewise, there were no group differences in arousal ratings (group main effect: $F(1, 45) = .194$, $p = .662$, partial eta squared = .004; group by valence interaction: $F(2, 908) = 1.118$, $p = .311$, partial eta squared = .024). Thus, consistent with previous research (Cohen & Minor, 2010; Heerey & Gold, 2007; Llerena et al., 2012), there were no group differences in self-reported affective experiences to the slides and participants with chronic schizophrenia did not exhibit any impairments in experiencing "in-the-moment" pleasure/aversion.

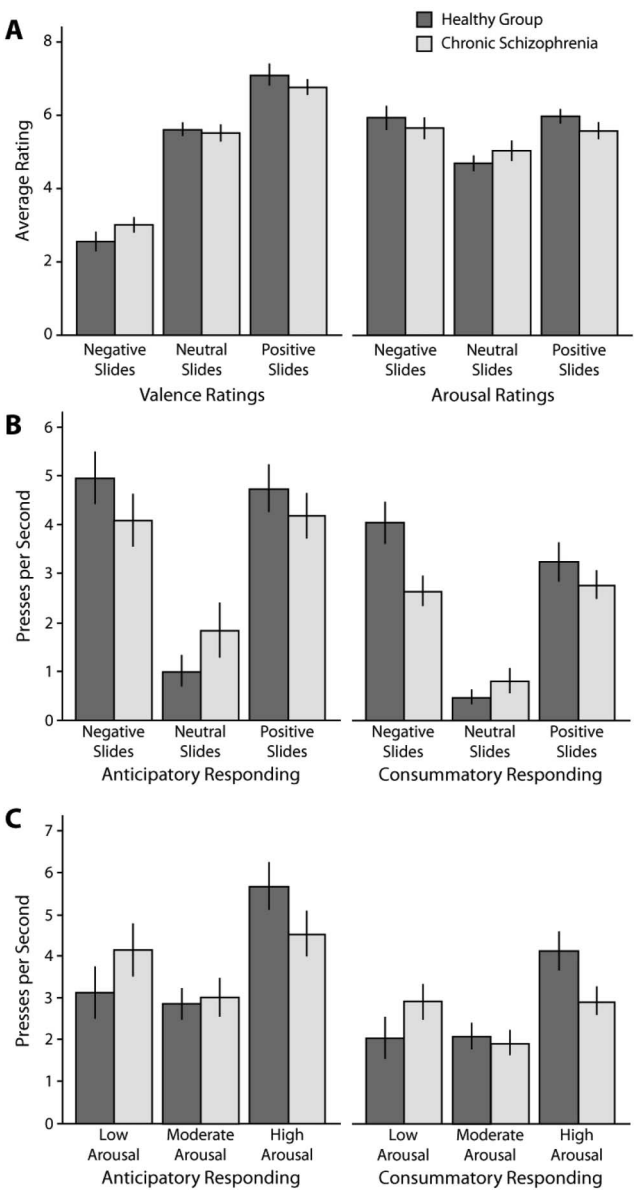

Figure 2. Study 1 results. A) Valence and arousal ratings for participants with schizophrenia and healthy participants across slides of negative, neutral and positive valence. B) Motivated behavior (button presses per second) across slide valence and condition (anticipatory, consummatory responding), split by participant group. C) Motivated behavior (button presses per second) across slide arousal and condition (anticipatory, consummatory responding), split by participant group. The data are displayed in box plots. The center line is the median, the whiskers show the 1–3 IQR of the data. To show the full range of the data, all individual data points are plotted for each series.

Motivated behavior driven by emotion. Participants with schizophrenia responded at an average rate of 3.275 presses/

second (SD = 1.592), and healthy participants at 3.373 presses/second (SD = 1.445). There was no significant difference in average button-pressing speed between schizophrenia and healthy participants, $F(1, 45) = .045$, $p = .832$. Participants with schizophrenia exerted on average a total of 295.4 presses (SD = 185.4) and 456.0 presses (SD = 270.2) in the anticipatory and consummatory conditions respectively, similar to that exerted by healthy participants (anticipatory condition: 300.1 presses, SD = 150.6; consummatory condition: 497.8 presses, SD = 273.1). Thus, the two groups did not differ in the total effort exerted in either the anticipatory, $F(1, 45) = .009$, $p = .925$ or the consummatory, $F(1, 45) = .277$, $p = .601$ condition, implying that group differences across slides of different valences/arousal levels cannot be due to simple differences in button pressing behavior.

Button pressing speeds for slides of different valences appear in Figure 2b. As expected, the group main effect was not significant, $F(1, 45) = .643$, $p = .427$, partial eta squared = .014. However, the predicted group by valence interaction was significant ($F(2, 90) = 7.036$, $p = .002$, partial eta squared = .135), meaning that participants with schizophrenia pressed buttons at speeds that were more similar across slides of different valences than did healthy participants. However, the group by behavior condition interaction ($F(1, 45) = .432$, $p = .515$, partial eta squared = .010) and the three-way (group × behavior condition × valence) interaction ($F(2, 90) = .843$, $p = .425$, partial eta squared = .018) were not significant, meaning that we did not find group differences in behavior across the anticipatory and consummatory conditions based on the emotion valence of the slides.

Figure 2c shows button pressing speeds across slides of different arousal levels. As expected, the group main effect was not significant, $F(1, 33) = .103$, $p = .750$, partial eta squared = .003. However, the predicted group by arousal interaction was significant ($F(2, 66) = 6.798$, $p = .003$, partial eta squared = .171), meaning that participants with schizophrenia pressed buttons at speeds that were more similar across slides of different arousal-levels than did healthy participants. As above, the group by behavior condition interaction ($F(1, 33) = .211$, $p = .649$, partial eta squared = .006) and the three-way (group × behavior condition × arousal) interaction ($F(2, 66) = .073$, $p = .917$, partial eta squared = .002) were not significant, meaning that there were no behavior differences across the anticipatory and consummatory conditions based on slide arousal level.

Study 2

Materials and Method

Participants. We recruited 27 clinically stable individuals with a *DSM–IV* (First et al., 1996) diagnosis of schizophrenia (illness duration = 1.33 years, SD = .73 years) from an early psychosis intervention program in Hong Kong. Diagnosis was established with a best-estimate approach, as in Study 1. We also recruited 26 age- and gender-matched healthy volunteers from neighboring community. We applied the same recruitment procedures and exclusion criteria used in Study 1.

Demographics, clinical symptoms, and treatment histories of participants with early schizophrenia are shown in Table 2. As in Study 1, all participants with schizophrenia in Study 2 had medication histories. Notably, all except two participants received second-generation antipsychotics at the time of assessment, and two among them received clozapine. Thirteen participants additionally received anticholingerics (benzhexol) at the dose range of 2–8 mg daily. None received benzodiazepines. Schizophrenia and healthy participants differed in education, $F(1, 51) = 5.004$, $p = .030$ and estimated IQ, $F(1, 51) = 7.203$, $p = .010$.

Procedures and data analysis. Study 2 procedures were identical to those in Study 1. On average, the comparison group pressed buttons in 29.46 trials (SD = 6.56) and 19.77 trials (SD = 4.39) during the anticipatory and consummatory conditions, respectively; whereas the schizophrenia group responded to 32.22 trials (SD = 9.10) and 25.22 trials (SD = 5.35), respectively. In estimating the motivational salience of valence, we excluded an average of .3463 trials (SD = .6288) per comparison participant and 2.1487 trials (SD = 2.8917) per schizophrenia participant, due to incongruity between motivated behavior (pleasure-seeking or aversion-avoiding) and self-reported slide desirability, $F(1, 52) = 9{,}651$, $p = .003$. As in Study 1, we did not exclude any trials in estimating the motivational salience of arousal.

Results

Self-reported liking. Figure 3a shows the valence and arousal ratings. For valence ratings, neither the group main effect ($F(1, 51) = .593$, $p = .445$, partial eta squared = .011), nor group by valence interaction reached statistical significance ($F(2, 102) = 1.819$, $p = .179$, partial eta squared = .034). Likewise for arousal ratings (group main effect: $F(1, 51) = .878$, $p = .353$, partial eta squared = .017; group by valence interaction: $F(2, 102) = 2.318$, $p = .121$, partial eta squared = .043). Thus, participants with early schizophrenia and healthy participants reported similar experiences of slides "in-the-moment".

Motivated behavior driven by emotion. Participants with early schizophrenia responded at an average rate of 4.626 presses/second (SD = 1.902), and healthy participants at 4.733 presses/second (SD = 1.565). There was no significant difference in button-pressing speed between schizophrenia and healthy participants, $F(1, 51) = .049$, $p = .825$. Participants with schizophrenia exerted on average a total of 429.7 presses (SD = 188.3) and 801.0 presses (SD = 436.1) in the anticipatory and consummatory conditions, respectively, similar to that exerted by healthy participants (anticipatory condition: 470.4 presses, SD = 152.1; consummatory condition: 679.1 presses, SD = 295.5). Thus, the two groups exerted comparable effort in the anticipatory, $F(1, 51) = .742$, $p = .393$ and consummatory, $F(1, 51) = 1.407$, $p = .241$ conditions in the ACP task.

Button-pressing speeds for slides of different valences are shown in Figure 3b. As expected, the group main effect was not significant, $F(1, 51) = 1.548$, $p = .219$, partial eta squared = .029. However, the predicted group by valence interaction was significant ($F(2, 102) = 8.945$, $p < .001$, partial eta squared = .149), implying emotion valence–volition decoupling in early schizophrenia. The group by behavior condition interaction was not significant ($F(1, 51) = .358$, $p = .552$, partial eta squared = .007). Interestingly, the three-way (group × behavior condition × valence) interaction did reach statistical significance ($F(2, 102) = 4.374$, $p = .019$, partial eta squared = .079). A series of post hoc ANOVAs found that participants with early schizophrenia

Table 2
Summary Statistics of Demographics, Clinical and Hedonic Capacity Performances for Patients With Early Stage of Schizophrenia and Healthy Controls (Study 2)

	Healthy group (n = 26)			Early schizophrenia (n = 27)				
	Mean	*SD*	Range (minimum, maximum)	Mean	*SD*	Range (minimum, maximum)	F/χ^2	p
Age	21.35	2.897		22.96	4.493		2.403	.127
Gender (male vs female)	12 v 14			19 v 8			3.2	.074
Education (years)	13.35	1.810		12.19	1.962		5.004	**.030**
Estimated IQ	119.27	11.155		110.07	13.613		7.203	**.010**
Handedness (right vs left)	25 v 1			25 vs 2			.981	.61
Mean button pressing speed (press/second) in ACP task	4.733	1.565	2.091, 8.425	4.626	1.902	1.422, 8.375	.049	.825
Total no. press in anticipatory condition (press)	470.35	152.684	204, 804	429.70	188.268	90, 812	.742	.393
Average no. press per trial in anticipatory condition (press)	11.199	3.635	4.857, 19.143	10.231	4.483	2.143, 19.333	.742	.393
Total no. press in consummatory condition (press)	679.12	295.486	223, 133	800.96	436.107	156, 1860	1.407	.241
Average no. press per trial in consummatory condition (press)	22.637	9.850	7.433, 44.333	26.699	14.537	5.2, 62	1.407	.241
Total no. invalid trials in ACP task	.347	.629	0, 2	2.148	2.892	0, 10	9.651	**.003**
No. trial responded in anticipatory condition (42 trials in total	29.46	6.56	18, 42	32.22	9.10	10, 42	1.59	.212
No. trial responded in consummatory condition (30 trials in total	19.77	4.39	13,30	25.22	5.35	10.30	16.37	**<.001**
PANSS_positive				11.52	3.664			
PANSS_negative				16.16	6.681			
PANSS_general				23.52	5.803			
Duration of illness (years)				1.33	.73			
Medications (chlorpromazine equivalent)				306.7	302.1			

Note. IQ = intelligence; ACP task = Anticipatory and Consummatory Pleasure task; PANSS = Positive and Negative Syndrome Scale. *P*-values in bold are statistically significant at < .05.

differed significantly from comparison participants in button pressing speed for avoiding negative slides in the anticipatory condition ($F(1, 52) = 9.346$, $p = .024$, after Bonferroni correction), but not in other conditions ($ps > .05$, after Bonferroni correction). We also replicated Heerey and Gold (2007)'s findings of a significant three-way (group × valence × behavior condition) interaction, implying the emotion–behavior decoupling is more severe in the anticipatory rather than the consummatory condition.

Button-pressing speeds for slides of different arousal-levels are shown in Figure 3c. As expected, the group main effect was not significant, $F(1, 44) = .134$, $p = .716$, partial eta squared = .003. The predicted group by arousal interaction was significant ($F(2, 88) = 4.551$, $p = .016$, partial eta squared = .094), implying emotion arousal–behavior decoupling in early schizophrenia. The group by behavior condition interaction was not significant ($F(1, 44) = .022$, $p = .884$, partial eta squared < .001). As above, the three-way interaction (group × behavior condition × arousal) reached statistical significance ($F(2, 88) = 6.397$, $p = .004$, partial eta squared = .127). Post hoc ANOVAs found that participants with early schizophrenia tended to press fewer buttons in response to high-arousal slides in the anticipatory condition ($F(1, 52) = 5.987$, $p = .108$, after Bonferroni correction), but not in any other conditions ($ps > .50$, after Bonferroni correction).

Study 3

Materials and Method

Participants. A total of 1,863 college students in Guangzhou, Canton Provence of China, completed the Chapman Social Anhedonia and Physical Anhedonia Scales (Chapman, Chapman, & Raulin, 1976). These two scales have been translated and validated in the Chinese setting and demonstrated to be able to measure negative schizotypy features in the general population (Chan et al., 2015; Wang, Neumann, Shum, & Chan, 2012). We standardized and averaged the scores of both scales to calculate a composite score for negative schizotypy traits. We then identified individuals with high prevalence of negative schizotypy traits and those without (comparison participants) based on the composite scores. Among the total of 1,863 students, 31 were classified as having traits associated with negative schizotypy >1 *SD* above the mean. An additional 28 were identified as comparison subjects based on low negative schizotypy composite scores (>1 *SD* below the mean). Both groups participated in Study 3.

We administered the Chinese version of the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) to cross-validate our results with respect to group status (negative schizotypy and nonschizotypy). We applied the same exclusion criteria used in the previous studies, along with the additional criterion that no Study

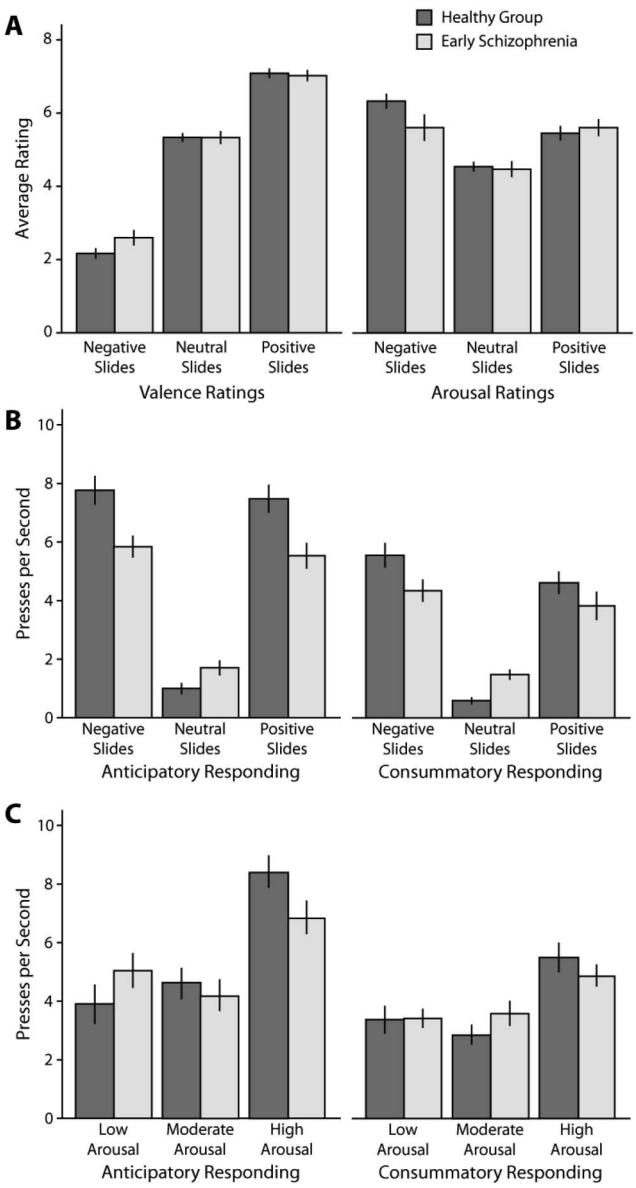

Figure 3. Study 2 results. A) Valence and arousal ratings for participants with schizophrenia and healthy participants across slides of negative, neutral and positive valence. B) Motivated behavior (button presses per second) across slide valence and condition (anticipatory, consummatory responding), split by participant group. C) Motivated behavior (button presses per second) across slide arousal and condition (anticipatory, consummatory responding), split by participant group. The data are displayed in box plots. The center line is the median, the whiskers show the 1–3 IQR of the data. To show the full range of the data, all individual data points are plotted for each series.

3 participant had any lifetime history of psychosis, as ascertained by a structured clinical interview (SCID-I; First et al., 1996).

Table 3 shows that the negative schizotypy group and the comparison group did not differ in age, gender, handedness, education, or IQ (*p*s > .05). The negative schizotypy group scored significantly higher in the SPQ interpersonal subscale, $F(1, 54) = 9.564$, $p = .003$, but the two groups did not differ significantly on the SPQ cognitive perceptual subscale or the SPQ disorganization subscale (*p*s > .05).

Procedures and data analysis. Study 3 procedures were identical to those in Studies 1 and 2. In estimating the motivational salience of emotion valence, we excluded an average of 7.74 trials ($SD = 4.74$) per participant with self-reported negative schizotypy and 9.53 trials ($SD = 2.71$) per comparison participant, based on incongruity between the button pressing (pleasure-seeking or aversion-avoiding) and self-reported slide desirability, $F(1, 57) = 3.070$, $p = .085$. No trials were excluded in estimating the motivational salience of emotion arousal.

Results

Self-reported liking. Figure 4a shows the valence and arousal ratings. For valence ratings, the group main effect ($F(1, 57) = 4.952$, $p = .030$, partial eta squared = .080) and the group by valence interaction ($F(2, 114) = 6.480$, $p = .007$, partial eta squared = .102) were significant, showing that participants reporting negative schizotypy traits had reduced ratings of positively valenced slides specifically ($F(1, 57) = 12.590$, $p = .003$, after Bonferroni correction). Kerns, Docherty, and Martin (2008) and Cohen, Callaway, Najolia, Larsen, and Strauss (2012) have reported similar findings in psychometrically defined schizotypal participants. For arousal ratings, the group main effect ($F(1, 57) = 1.668$, $p = .202$, partial eta squared = .028), and the group by valence interaction ($F(2, 114) = 1.295$, $p = .271$, partial eta squared = .022) were not significant, meaning that there were no group differences in reports of slide arousal.

Motivated behavior driven by emotion. The negative schizotypy group responded at an average rate of 4.063 presses/second ($SD = 1.509$), and the nonschizotypy group at 4.066 presses/second ($SD = 1.299$). There was no significant difference in button-pressing speed between participants with schizotypy traits and comparison participants ($F(1, 56) < .001$, $p = .994$). The negative schizotypy group exerted on average a total of 368.5 presses ($SD = 138.9$) and 427.9 presses ($SD = 271.1$) in the anticipatory and consummatory conditions respectively, similar to that exerted by comparison participants (anticipatory condition: 380.0 presses, $SD = 124.6$; consummatory condition: 389.6 presses, $SD = 181.8$). Thus, the two groups exerted comparable effort in the anticipatory, $F(1, 56) = .110$, $p = .741$ and consummatory, $F(1, 56) = .397$, $p = .531$ conditions of the ACP task.

Button-pressing speeds for slides of different valences are shown in Figure 4b. The group main effect ($F(1, 56) = .171$, $p = .681$, partial eta squared = .003), the group by behavior condition interaction ($F(1, 56) = 1.191$, $p = .280$, partial eta squared = .021), and the group by valence interaction ($F(2, 112) = .049$, $p = .588$, partial eta squared = .009) all failed to reach statistical significance. The three-way interaction effect was not significant, $F(2, 112) = .821$, $p = .443$, partial eta squared = .014, suggesting similar emotion valence-behavior coupling across the groups.

Button-pressing speeds for slides of different arousal-levels are shown in Figure 4c. As above, the group main effect ($F(1, 47) = .571$, $p = .454$, partial eta squared = .012), the group by arousal interaction ($F(2, 94) = 2.477$, $p = .095$, partial eta squared = .050), the group by behavior condition interaction ($F(1, 47) = 1.392$, $p = .244$, partial eta squared = .029), and the three-way

Table 3
Summary Statistics of Demographics, Clinical and Hedonic Capacity Performances for Individuals With Schizotypy and Nonschizotypy (Study 3)

	Nonschizotypy (n = 28)			Negative schizotypy (n = 31)				
	Mean	*SD*	Range (minimum, maximum)	Mean	*SD*	Range (minimum, maximum)	F/χ^2	Sig.
Age	18.75	.844		18.97	.983		.825	.368
Gender (male vs female)	14 vs 14			17 vs 14			1.38	.797
Education (years)	12.21	.499		12.45	.723		2.109	.152
Estimated IQ	121.536	10.851		120.133	11.849		.220	.641
Handedness (right vs left)								
Mean button pressing speed (press/second) in ACP task	4.066	1.299	1.60, 6.67	4.063	1.509	1.98, 7.93	.000	.994
Total no. press in anticipatory condition (press)	380	124.554	162, 637	368.548	138.904	144, 648	.110	.741
Average no. press per trial in anticipatory condition (press)	9.163	2.999	3.86, 15.17	9.194	3.747	3.43, 17.63	.001	.972
Total no. press in consummatory condition (press)	389.607	181.754	77, 754	427.871	271.069	89, 1561	.397	.531
Average no. press per trial in consummatory condition (press)	18.837	9.472	4.05, 41.06	18.598	12.064	3.54, 62.44	.007	.934
Total no. invalid trials in ACP task	9.536	2.715	3, 15	7.742	4.761	2, 21	3.070	.085
SPQ cognitive perceptual subscore	10.036	5.910	0, 21	8.750	6.305	1, 29	.620	.435
SPQ interpersonal subscore	5.852	4.936	0, 20	11.517	8.249	0, 28	9.546	**.003**
SPQ disorganization subscore	4.321	2.722	0, 10	5.552	4.453	0, 15	1.570	.215

Note. IQ = intelligence; ACP task = Anticipatory and Consummatory Pleasure task; SPQ = Schizotypal Questionnaire. *P*-values in bold are statistically significant at $< .05$.

interaction ($F(2, 94) = 1.874$, $p = .168$, partial eta squared = .038) all failed to reach statistical significance. Thus, although the negative schizotypy group tended to have less efficient arousal–behavior coupling ($p = .095$), on the whole, these data show that individuals with self-reported symptoms of negative schizotypy did not appear to exhibit emotion–behavior decoupling, contrary to participants with diagnoses of schizophrenia.

Discussion

The present research probed emotion valence– and arousal–behavior coupling across the schizophrenia spectrum, namely people in the chronic and early stages of the illness as well as individuals with psychometrically defined negative schizotypy. Overall, our findings suggest that the decoupling of emotional experiences and behavior differs in nature and extent across the schizophrenia spectrum. Indeed, we found that participants who self-reported high levels of negative schizotypy showed relatively little disturbance in emotion–behavior coupling. However, those at early and more chronic phases of the disorder showed greater impairment in translating both emotion valence and arousal into motivated behavior.

Our findings are largely consistent with the prior studies on people with schizophrenia (Heerey & Gold, 2007; Lui et al., 2016). Regarding emotion valence–behavior decoupling, the effect size of the group by valence interaction in Study 2 (partial eta squared = .149) is comparable to that in Lui et al.'s (2016) study (partial eta squared = .177); whereas the effect size of the group by valence interaction in Study 1 (partial eta squared = .135) is smaller than that in Heerey and Gold's (2007) study (partial eta squared = .25), possibly attributable to the fact that our sample had lower age and illness chronicity than in the prior study. However, regarding the "anticipatory-consummatory" differentiation of emotion–behavior coupling, our findings are partially different from the literature. Study 1 showed that emotion valence–behavior decoupling is similar across anticipatory and consummatory conditions, concurring with Lui et al.'s (2016) but contrary to Heerey and Gold's (2007) study. On the other hand, Study 2 showed that emotion valence–behavior decoupling is more severe in the anticipatory condition, consistent with Heerey and Gold's (2007) but contrary to Lui et al.'s (2016) study. Working memory impairment is believed to contribute to translating emotion into behavior (Barch & Dowd, 2010; Lui et al., 2016) but was not studied in our investigations, and this potential confound might have contributed to the divergent findings.

Moreover, whereas Study 1 suggested that emotion–behavior decoupling affects both pleasure-seeking and aversion-avoiding behavior in people with chronic schizophrenia, Study 2 suggested that such impairment affects aversion-avoiding rather than pleasure-seeking behavior. Gross (2002) proposed a process model of emotion regulation, which describes different points for emotions be to regulated, including situation selection, situation modification, attentional deployment, cognitive change, and response modulation. Based on Gross (2002)'s model, it is plausible that, compared to controls, participants with early schizophrenia are more likely to "down-regulate" and suppress negative emotions by cognitive change and response modulation, rather than "up-regulate" their encounters with negative stimuli by situation modifications (i.e., avoid unpleasant slides in the ACP task). The complicated interaction between emotion and cognition in people with schizophrenia (Aichert et al., 2013) should be further investigated in future studies.

Evidence supports the existence of three different subtypes of schizotypy, namely positive schizotypy, which is characterized by

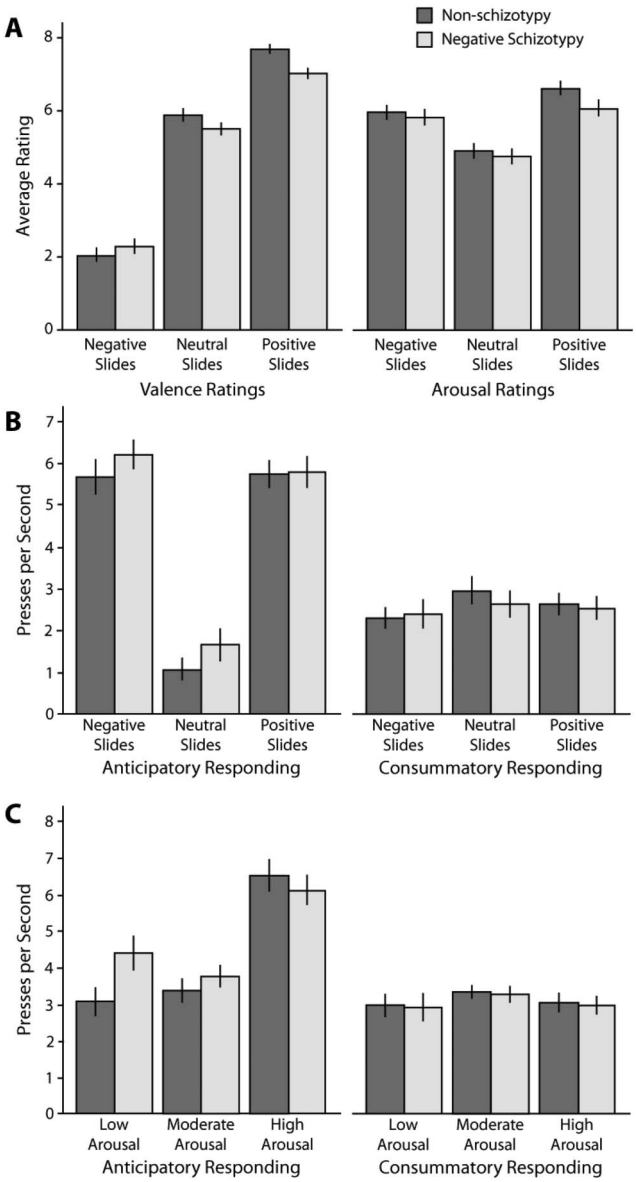

Figure 4. Study 3 results. A) Valence and arousal ratings for participants with negative schizotypy and comparison participants across slides of negative, neutral and positive valence. B) Motivated behavior (button presses per second) across slide valence and condition (anticipatory, consummatory responding), split by participant group. C) Motivated behavior (button presses per second) across slide arousal and condition (anticipatory, consummatory responding), split by participant group. The data are displayed in box plots. The center line is the median, the whiskers show the 1–3 IQR of the data. To show the full range of the data, all individual data points are plotted for each series.

perceptual aberrations and magical ideations, negative schizotypy, which is characterized by lack of normal emotional and social functions, and disorganized schizotypy, which is characterized by eccentric behavior and speech (Mohr & Ettinger, 2014). The design of Study 3 recruited individuals with negative schizotypy rather than positive or disorganized schizotypy, in order to specifically capture emotion–behavior decoupling. Despite the use of this refined subgroup, we failed to demonstrate emotion–behavior decoupling as a trait marker. Though negative schizotypy is a valuable construct in understanding prepsychotic individuals, it is likely that there is a high degree of heterogeneity in the biological/psychological factors that lead individuals to report high levels negative schizotypy; for example, alexithymia (van't Wout, Aleman, Kessels, Larøi, & Kahn, 2004). Our negative findings in the negative schizotypy sample may have been related to this limitation of the construct. Moreover, rather than using 1.96 *SD* as the cut-off, the Study 3 sample consisted of individuals reporting negative schizotypy features 1 *SD* above and below the mean. Future research should recruit prepsychotic individuals based on different diagnostic constructs, such as those defined by the "ultra-high risk" criteria (Yung et al., 1998) and the "psychosis proneness" criteria (Miller et al., 2002). These diagnostic subgroups are more likely to exhibit features of positive or organized schizotypy and have higher conversion rates to clinical schizophrenia, compared with negative schizotypy. Contrary to individuals with schizophrenia, whose emotional experiences appear intact "in-the-moment," individuals with a high level of negative schizotypy show impairments in experiencing in-the-moment emotion, particularly with respect to positive valence. This finding is consistent with previous research, which showed that individuals reporting high levels of social anhedonia experienced less intense "in-the-moment" positive affect but similar "in-the-moment" negative affect, compared to controls (Kerns et al., 2008). However, our finding is opposite to Docherty, Sponheim, and Kerns's (2015) recent findings, which showed that unaffected relatives of people with schizophrenia with high levels of social anhedonia actually reported increased arousal ratings, instead of reduced valence ratings, to positively valenced slides. These differences may also be attributable to the different sampling methods for individuals with schizotypy.

Together, our research substantially enhances the understanding of emotion–behavior coupling in schizophrenia and the ways in which the course of the illness may shape its progression. We examined both emotion valence and arousal, finding that arousal–behavior coupling was impaired to different degrees depending on illness phase. Our work represents an important addition to the existing body of evidence, demonstrating this phenomenon in less chronic patient populations and showing that individuals at risk for developing schizophrenia appear to show healthy levels of emotion–behavior coupling. Although there is no apparent emotion valence–behavior decoupling in negative schizotypy, the disconnection between emotion and behavior is severe in both early and chronic schizophrenia. Indeed, disease chronicity appears to exacerbate emotion arousal–behavior decoupling, as the connection between emotion arousal and behavior is relatively preserved in negative schizotypy, but begins to degrade in early schizophrenia and becomes increasingly decoupled in chronic schizophrenia. We found no clear evidence that emotion–behavior decoupling in people with chronic schizophrenia is more severe in the anticipatory versus consummatory conditions. It is plausible that schizophrenia first affects emotion–behavior coupling in the anticipatory condition (as Study 2 findings suggest) and eventually extends to affect emotion–behavior coupling more broadly.

There are several limitations in our studies. The ACP paradigm only used visual images to elicit emotions, rather than the more complex stimuli (such as money, food, sex) one encounters in the

real world (Trémeau et al., 2010). Thus, findings must be generalized with care. Second, the ACP task uses a bipolar scale to measure participants' "in-the-moment" experiences of emotion valence, although recent empirical evidence suggests the coactivation of positive and negative emotions when individuals with schizophrenia view aversive stimuli (Cohen & Minor, 2010). The use of a bipolar scale limited our investigations with regard to the interesting phenomenon of "affective ambivalence in schizophrenia" (Trémeau et al., 2009), that is, positive emotions coupling with simultaneous negative emotions. Affective ambivalence could reduce motivational salience of affective stimuli regardless of positive valence or arousal level, or complicate the process of translating emotion into behavior, and thus may confound our results. Third, because the sample sizes for each of the three studies are small, we could only examine valence– and arousal–behavior coupling separately, without looking at valence-dependent emotion arousal and its effect on motivated behavior. Fourth, all our participants with schizophrenia were receiving dopamine-blocking medications, which may disrupt function in neural substrates crucial for wanting (Kapur, Mizrahi, & Li, 2005) and may partially explain task effects. Moreover, extrapyramidal side effects such as hand tremor and Parkinsonism might have affect psychomotor speed and thus button-pressing in the ACP task, Although there were no differences between healthy and schizophrenia/schizotypy samples in average button pressing, we did not measure motor control. Research in medication-naïve populations and use of tasks measuring motor control would help to resolve this issue. Nonetheless, given the high frequency of antipsychotic use in the treatment of schizophrenia, the present results are generalizable to the majority of the clinical populations having been diagnosed with this disease. Moreover, we only used the PANSS to measure negative symptoms; future studies should use more comprehensive scales, such as the Clinical Assessment Interview for Negative Symptoms (CAINS, Blanchard, Kring, Horan, & Gur, 2011). Furthermore, poor attention and low IQ are associated with schizophrenia but were not controlled for in the present studies. Last but not least, we did not directly compare the samples across our three studies because the samples were recruited from different sites and assessed by different researchers. There were also age differences across the samples. Although our findings suggest the different degrees of emotion–behavior decoupling across different stages of schizophrenia, we note that only a longitudinal study of the trajectory of emotion–behavior decoupling in the same individuals with schizophrenia could provide a precise answer about the evolution of this decoupling.

To conclude, we employed a sophisticated laboratory paradigm to examine the connection between motivation and affective experience in individuals with schizophrenia-spectrum symptoms and disorders. The evidence from our studies suggests that the nature and extent of emotion–behavior decoupling are different across the schizophrenia spectrum. Defective translation of emotional salience into motivated behavior may be a plausible neuropsychological underpinning of the "negative syndrome" of schizophrenia. From a clinical perspective, it should be noted that although individuals with schizophrenia have intact "in-the-moment" emotional experiences, their emotion predicts pleasure-seeking or aversion-avoiding behavior less well than that of healthy individuals (Heerey & Gold, 2007). This is likely one source of the severe difficulty people with schizophrenia experience in their everyday lives. Further research is needed to investigate the possibility of recoupling emotion and volition, by modifying the belief systems related to goal-directed behavior (Strauss & Gold, 2012), or building responses into habits. These strategies may be particularly helpful in allowing people with schizophrenia to gain functional independence, despite their difficulty in using affective experience to motivate behavior.

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