



Daily life evidence of environment-incongruent emotion in schizophrenia



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ARTICLE INFO

Article history:

Received 15 February 2014

Received in revised form

1 July 2014

Accepted 19 July 2014

Available online 28 July 2014

Keywords:

Experience sampling method

Emotion regulation

Anhedonia

Negative affect

Positive affect

ABSTRACT

Researchers have recently hypothesized that negative emotion in positive situations may be one mechanism for understanding emotion dysfunction in schizophrenia. Using ecological momentary assessment, we examined the relationship between emotion experience and environmental context in the daily lives of participants with and without schizophrenia. Participants with ($n=47$) and without schizophrenia ($n=41$) were provided a cellular telephone and called four times a day for one week. During each call participants rated their emotion experiences, described their current activities, and rated enjoyment from those activities. In line with previous research, participants with schizophrenia reported higher negative emotion overall relative to participants without schizophrenia, but equivalent levels of positive emotion and activity enjoyment. In line with the environment-incongruent negative emotion hypothesis, participants with schizophrenia evidenced a weaker relationship between reported enjoyment of current activities and current negative emotion compared to participants without schizophrenia. In addition, lower neurocognition predicted this weak relationship between negative emotion and context in the schizophrenia group. These findings provide ecologically valid support for environment-incongruent negative emotion in schizophrenia, and suggest that people with schizophrenia with more impaired neurocognition may have more difficulties regulating negative emotion.

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1. Introduction

There is growing evidence that elevated negative emotion is an important feature of emotion dysfunction in schizophrenia. Self-report and ecological momentary assessment (EMA) studies have found that people with schizophrenia report more negative emotion compared to people without schizophrenia and that higher negative emotion is related to symptom onset, poor functioning, and lower quality of life (Myin-Germeys et al., 2000, 2003, 2005; see Horan et al., 2008). Recently, emotion regulation deficits have attracted attention as potential mechanisms behind elevated negative emotion in schizophrenia (Horan et al., 2013; Kimhy et al., 2012; Strauss et al., 2013). For example, compared to people without schizophrenia, people with schizophrenia have higher stress reactivity (for review see Myin-Germeys and Van Os, 2007). In one study, Myin-Germeys et al. (2001) found that participants with schizophrenia reported a greater increase in negative affect in response to daily life stress. Further, individuals with schizophrenia use cognitive emotion regulation strategies less frequently than those without the disorder (Kimhy et al., 2012; Van der Meer

et al., 2009). This may be because cognitive regulation of emotions is less effective in schizophrenia. For example both Horan et al. (2013) and Strauss et al. (2013) found that while people without schizophrenia had attenuated neural responses to negative pictures appraised in a neutral context versus a negative context, participants with schizophrenia exhibited no such attenuation. These findings suggest that people with schizophrenia have more difficulty using cognitive strategies to down-regulate negative emotion in response to aversive stimuli.

1.1. Stimulus-incongruent negative emotion in schizophrenia

Elevated negative emotion in people with schizophrenia may not be limited to negative experiences, but may also “seep” in to positive experiences. While studies with the general population have shown that people typically report feeling positive emotion in positive circumstances and negative emotion in negative circumstances (Larsen et al., 2001), people with schizophrenia may experience *stimulus-incongruent* negative emotion, that is, negative emotions in putatively positive and neutral environments (Park et al., 2009; Cohen et al., 2010, 2011; Strauss and Herbener, 2011; Trémeau et al., 2009; Ursu et al., 2011; for review see Kring and Elis, 2013). For example, a meta-analysis of laboratory mood induction tasks by Cohen and Minor (2010) indicated that when positive and negative emotional responses were measured

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independently (i.e., not on a bipolar unpleasant to pleasant scale, but with a separate measure for pleasantness and unpleasantness), people with schizophrenia reported higher negative emotion during positive and neutral stimuli compared to people without schizophrenia, even while reporting equivalent positive emotion. The authors propose that these findings may reflect higher emotional ‘ambivalence’ with particular deficits in negative emotion regulation in schizophrenia. That is, people with schizophrenia may experience negative emotion even while *simultaneously* feeling positive emotions during pleasurable experiences. Additional laboratory studies support stimulus-incongruent emotion in schizophrenia (Park et al., 2009; Trémeau et al., 2009; Strauss and Herbener, 2011; Ursu et al., 2011). For instance, across several types of emotionally evocative stimuli (pictures, words, and sounds) Trémeau et al. (2009) found that while participants with and without schizophrenia reported similar stimulus-congruent emotion ratings, schizophrenia participants reported higher stimulus-incongruent emotion to both positive and negative stimuli. These lab findings are supported by self-report studies finding that psychosis may be associated with higher trait ambivalence (Kwapil et al., 2002; Kerns, 2006; Kerns and Becker, 2008).

Stimulus-incongruent emotion activation appears to be particularly salient in the case of negative emotion, with elevated stimulus-incongruent negative emotion related to negative symptoms and symptom severity (Park et al., 2009; Trémeau et al., 2009; Strauss and Herbener, 2011). These results are in line with neuroimaging studies that indicate elevated amygdala activation during neutral stimuli in schizophrenia (Anticevic et al., 2012) and reduced activation in frontal regions supporting emotional processing (Taylor et al., 2012). EMA studies support negative emotion dysregulation, finding that people with schizophrenia report more negative emotion than people without schizophrenia (Myin-Germeys et al., 2000, 2003, 2005; Oorschot et al., 2013), and, intriguingly, a recent EMA study found that people with schizophrenia evidenced less differentiation of positive and negative emotions in daily life (Kimhy et al., 2014). Although individuals typically reciprocally activate positive and negative emotion (Larsen et al., 2001) people with schizophrenia may have more independent or even coactivation of positive and negative emotion. Further, while people with schizophrenia experience elevated negative emotion, they typically rate their daily activities as enjoyable as those without (see Myin-Germeys et al., 2000, 2011; Gard et al., 2007; Oorschot et al., 2013). Thus they may experience elevated negative emotion even while reporting equivalently pleasurable circumstances, although this has not been tested directly. Rather, EMA studies thus far have emphasized either positive and negative emotion or pleasure appraisals of activities. Research thus far on the disconnect between emotional experience and emotion-eliciting stimuli in schizophrenia has been conducted primarily in the laboratory. It remains unclear if stimulus-incongruent negative emotion found in laboratory tasks extends to *environment*-incongruent emotion in daily life, and whether such environment-incongruent emotion experience is related to other areas of impairment, such as positive or negative symptoms or neurocognition.

Importantly, examining emotion dysregulation in daily life provides insight to emotion regulation strategies that laboratory studies have a limited capacity to measure. For example, in the majority of laboratory emotion regulation studies the stimuli presented is largely beyond the participants' control. These tasks measure the participant's *capacity* to manage emotional reactions elicited by the stimuli. However, in daily life people have more freedom to choose and modify environments to which they are exposed. That is, to use the terminology of the process model of emotion regulation (Gross and Thompson, 2007), in daily life

people can use situation selection and situation modification to regulate their emotions. Situation selection and situation modification occur early in the emotion generation process and thus may be particularly effective for avoiding undesirable emotional responses. For instance, people with schizophrenia may seek out environments that are more familiar and emotionally predictable. It is possible that while people with schizophrenia may have a more stimulus-incongruent negative emotion in the lab, they may be able to select situations that will elicit a “pure” positive emotional response in daily life. EMA is uniquely suited to study whether or not environment-incongruent emotion is still evidenced in schizophrenia when situation selection and situation modification emotion regulation strategies are available. More thoroughly understanding the relationship between emotion and enjoyment of activities would be promising, as it would provide implications for psychosocial treatments for both emotion regulation and negative symptoms such as anhedonia.

1.2. Current study

The current study used EMA, a methodology developed to measure experiences in-the-moment (e.g., Csikszentmihalyi and Larson, 1987), to investigate environment-incongruent negative emotion in the daily lives of people with and without schizophrenia. Research assistants called participants four times a day for a week, and asked them about their current emotional state (including several positive and negative emotions), their current activities, and how much they were enjoying these activities. We also examined the *relationship* of emotion ratings to activity enjoyment ratings. A weak relationship between emotion ratings and activity enjoyment ratings would indicate that emotion experience is disconnected from fluctuations in pleasure appraisals of the environment. For example, for most people positive emotion goes up and negative emotion goes down as they engage in pleasurable activities. However, if negative emotion stays elevated even as one engages in pleasurable activities, this would constitute environment-incongruent negative emotion. This can be compared to measuring incongruent emotion in lab tasks, where emotion experience is not as sensitive to the hedonic quality of the stimulus. However in contrast to most lab tasks, we examined how reports of in-the-moment emotional experience were related to pleasure appraisals of the environment rather than only emotion appraisals of stimuli. We predicted that, in line with past EMA studies, people with schizophrenia would endorse higher negative emotion compared to participants without schizophrenia in their daily life. In addition, consistent with lab findings, we predicted that negative emotion would be more weakly related to participants' ratings of current activity enjoyment in people with schizophrenia than in those individuals without schizophrenia. One possible explanation for such a finding is that people with schizophrenia may be unable to appropriately regulate their negative emotions to conform to their current circumstances (or, put differently, that the current pleasurable experience was not regulating the higher negative emotion). We also investigated whether there is positive emotion congruity (i.e. a connection between the environment and positive emotions) or whether emotion dysregulation is specifically limited to negative emotion. If the problem is limited to negative emotion only we expect to find a weaker relationship between negative emotion and activity enjoyment. However, if the problem is a general emotional disconnect from pleasure in the environment, we expect both positive and negative emotions to have a weaker relationship to pleasure appraisals of the environment. We also examined the relation between positive and negative emotions to determine if positive and negative emotional experiences were more independent in schizophrenia or if participants with schizophrenia

activate positive and negative emotions as reciprocally as individuals without schizophrenia. Finally emotions and their relation to the environment were examined as a function of symptoms and neurocognition in our schizophrenia group, with the prediction that negative symptoms and symptom severity would predict negative emotion dysregulation.

2. Method

2.1. Participants

Schizophrenia ($n=31$) and schizoaffective disorder ($n=16$) participants were recruited among several ongoing studies at the San Francisco Veterans Affairs Medical Center and the University of California San Francisco. Participants without schizophrenia ($n=41$) were recruited from the community through fliers and internet advertising. To qualify for the study, all participants had to indicate that they had no neurological disorder, no history of head trauma, no substance abuse in the last six months, and English fluency. Additionally, people with schizophrenia were excluded if they reported changes in their medication or dosage in the past month or hospitalization in the past three months. People without schizophrenia were excluded if they had a history of an Axis I disorder diagnosis. All participant diagnoses were determined using the DSM-IV–Clinician Version (SCID: First et al., 1997). There were no demographic differences between participants with and without schizophrenia with the exception of employment and relationship status (see Table 1).

2.2. Procedure

The study procedure was explained to participants during an initial orientation meeting. At this meeting participants provided informed consent, were trained to use the cellular telephone, and practiced a telephone assessment with a research assistant. Following the orientation, participants were called and audio recorded by a trained research assistant four times a day for seven days, between the hours of 9 a.m. and 9 p.m. Similar to past EMA studies (Myin-Germeys et al., 2000; Granholm et al., 2008, 2013), calls were spaced at least 1 h apart and at most 6 h apart, and such that no two calls occurred at the same time of day across the week. After the week of calls, participants met with a research assistant to return the telephone, and to fill out questionnaires including a demographic form.

Table 1
Demographic characteristics.

Characteristic	Participants with schizophrenia $n=47$	Participants without schizophrenia $n=41$
Age	39.55 (13.95)	36.83 (14.89)
Education –years (S.D.)	13.9 (2.55)	14.55 (2.05)
Parental education – years (S.D.)	13.95 (2.75)	14.25 (3.46)
Chlorpromazine Eq. (S.D.)	418.14 (555.67)	NA
Gender %		
Male	35, 74%	26, 63%
Female	12, 26%	15, 37%
Ethnicity $n, \%$		
African American	6, 13%	5, 12%
Caucasian/ white	18, 38%	21, 51%
Asian	9, 19%	8, 19%
Latino	8, 17%	6, 15%
Other	6, 13%	1, 2%
Employment, $n, \%^{**}$		
Full time	2, 4%	10, 24%
Part time	6, 13%	18, 44%
Unemployed	39, 83%	13, 32%
Relationship status, $n, \%^{*}$		
Not in a relationship	33, 70%	22, 53%
Dating	4, 8%	12, 29%
Cohabiting/ married	7, 14%	6, 14%
Missing	3, 6%	1, 2%

* $P < 0.05$,

** $P < 0.001$

Participants were compensated \$2 per call and \$44 for returning the telephone and charger for a total possible compensation of \$100 for the week of participation, consistent with past EMA studies (Galloway et al., 2008). Participants were also paid \$10 per hour for the clinical assessment, orientation, and debriefing.

2.3. Clinical assessment

All participants with schizophrenia, with the exception of two who failed to return for the clinical assessment meeting, were administered the Positive and Negative Syndrome Scale (Kay et al., 1987), which assessed positive ($M=15.27$; $S.D.=5.02$), negative ($M=16.47$; $S.D.=5.31$), and total symptoms ($M=64.07$; $S.D.=13.49$). Additionally, in order to better assess “clinical burden,” that is to examine the effect of the participants’ most pronounced symptoms undiluted by the influence of other symptoms included in the composite variables, we used the value of the participants’ highest rated positive symptom ($M=4.00$, $S.D.=1.30$) and negative symptom ($M=4.02$, $S.D.=1.21$). Further, we investigated the PANSS ratings of anxiety ($M=2.7$, $S.D.=1.27$) and depression ($M=2.51$, $S.D.=1.27$) as these symptoms may be particularly relevant to emotion functioning.

2.4. Neurocognitive assessment

During a separate laboratory session participants with schizophrenia were administered the MATRICS neurocognitive battery (Nuechterlein, et al., 2008). To assess global cognition we created an average z-score of these measures, ($M=-0.99$; $S.D.=0.89$). Seven participants failed to return to complete the neurocognitive battery, however, there were no significant differences between these participants and those that completed the study.

2.5. The EMA interview

Each call consisted of an interview assessing the participant’s environment, activities, and goals (see Gard et al., in press, for details on methodology related to the larger study). Participants with schizophrenia responded to an equal number of calls, 80.61% ($S.D.=17.02$), compared to people without schizophrenia. 81.31% ($S.D.=14.43$), $t(86)=-0.91$, $P=0.85$. The present study analyses concerned current emotional state (e.g., “how angry are you currently feeling?”), current activities (“what are you doing?”), and enjoyment of activities (“how much are you enjoying this activity?”). Specifically, participants were asked during the telephone interview by live research assistants to rate on a scale from 0 (not at all) to 5 (very much) their current levels of a variety of positive and negative emotions, and enjoyment of their activities.

Means for positive emotion (including excitement and joy ratings; Cronbach’s $\alpha=0.75$) and negative emotion (including anxiety, fear, sadness, and anger ratings; Cronbach’s $\alpha=0.72$) were calculated for each call. Mean enjoyment was calculated for each call by averaging the enjoyment ratings of each current activity. Thus each timepoint had a summary negative emotion, positive emotion, and activity enjoyment score.

2.6. Data analysis strategy

Hierarchical Linear Modeling software (HLM; Bryk, Raudenbush, & Raudenbush, 1992) was used to model the data. HLM is used to examine data that has a nested structure, such as within-subjects observations, termed “Level 1” data, which are nested in between-subjects “Level 2” data and is the suggested analytic strategy for EMA (Schwartz and Stone, 1998). In the following analyses, within-subjects observation of negative emotion, positive emotion, and activity enjoyment were modeled at Level 1, while group membership (presence or absence of a schizophrenia diagnosis) was modeled at Level 2 for between-group analyses. Symptoms and neurocognition were modeled at Level 2 for analyses examining differences within participants with schizophrenia.

3. Results

While relationship status and employment were significantly differed between the groups, neither predicted positive emotion, negative emotion, or activity enjoyment and were not included in the analyses.

Our findings indicated that in line with previous research people with schizophrenia ($M=2.23$, $S.D.=1.47$) and without schizophrenia ($M=2.39$, $S.D.=1.32$) did not differ significantly on positive emotion, $t(86)=-0.64$, $P=0.53$, Cohen’s $d=0.13$., nor was there a significant difference between how enjoyable people with schizophrenia ($M=3.42$, $S.D.=1.47$) and without

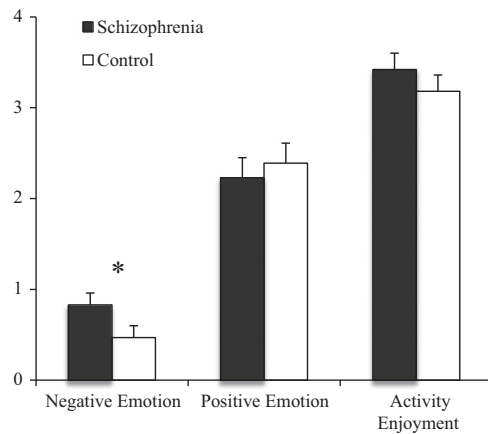


Fig. 1. Emotion and activity enjoyment ratings between participants with and without schizophrenia. *Note:* Emotions and activity enjoyment were rated on a scale from 0=not at all, 1=a little bit, 2=somewhat, 3=a fair amount, 4=quite a bit, 5=very much. * $P < 0.01$.

schizophrenia ($M = 3.18$, $S.D. = 1.42$) found their activities over the course of the week, $t(86) = 1.22$, $P = 0.23$, Cohen's $d = 0.26$.¹ However, people with schizophrenia ($M = 0.83$, $S.D. = 0.93$) experienced significantly more negative emotion compared to people without schizophrenia ($M = 0.47$, $S.D. = 0.64$), $t(86) = 3.09$, $P = 0.003$, Cohen's $d = 0.66$, supporting past daily life studies that emotion dysfunction in schizophrenia is characterized by elevated negative emotion (see Fig. 1).

Next, we examined whether the relationship between negative emotion and activity enjoyment differed between people with and without schizophrenia. A stronger negative relationship between negative emotion and activity enjoyment would indicate that as activities become more enjoyable participants would report lower negative emotion, a pattern which we expected to be typical of participants without schizophrenia. A weaker relationship would point to a disconnect between environmental context and negative emotion activation, which we hypothesized would characterize the people with schizophrenia. A model predicting negative emotion from activity enjoyment and group membership indicated that there was a cross-level interaction of group by activity enjoyment. In other words, in line with a negative emotion regulation deficit, this finding indicates a weaker relationship between current enjoyment and negative emotion in people with schizophrenia than in people without schizophrenia, $t(86) = 2.07$, $P = 0.04$, Cohen's $d = 0.45$ (Fig. 2). Examining this model separately by group, we found that participants without schizophrenia had a significant negative relationship between negative emotion and activity enjoyment, $t(40) = -4.02$, $P < 0.001$, Cohen's $d = 1.33$, while participants with schizophrenia evidenced a relationship between negative emotion and activity enjoyment at only at a trend level, $t(46) = -1.71$, $P = 0.09$, Cohen's $d = 0.50$. Thus, an increase in activity enjoyment is connected to a decrease in negative emotion for people without schizophrenia, while there was less of a connection between appraisals of the environment and negative emotion for people with schizophrenia.

We examined whether this pattern was limited to negative emotion dysregulation, or if people with schizophrenia also evidenced environment-congruent positive emotion given the environment. We found no difference in the activation of positive emotion in relation to activity enjoyment between participants with and without schizophrenia, $t(86) = -1.28$, $P = 0.20$, Cohen's $d = 0.27$. A model examining the relationship between reports of

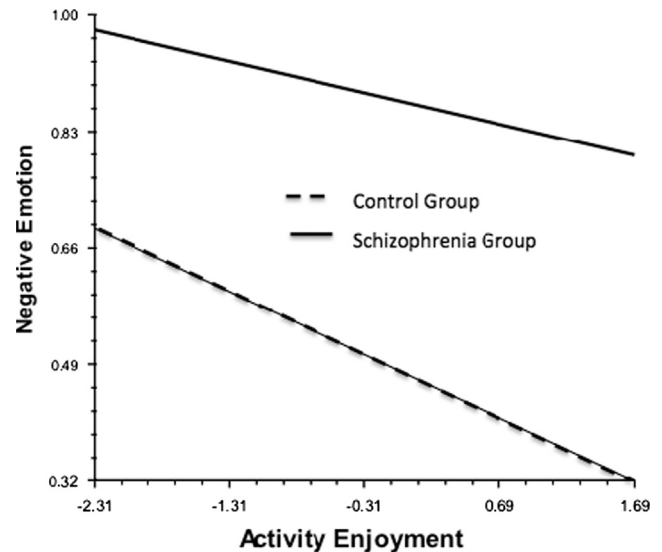


Fig. 2. Negative emotion and activity enjoyment (group mean centered) were more weakly related for participants with schizophrenia than participants without schizophrenia, $P = 0.03$.

positive emotion and negative emotion (that is, the emotion ratings that were not reported in relation to the environment) demonstrated that while an absence of schizophrenia and positive emotion both significantly and negatively predicted negative emotion, there was no cross-level interaction, $t(86) = 0.94$, $P = 0.35$, Cohen's $d = 0.20$, indicating that participants with and without schizophrenia did not differ in the degree to which in the moment positive emotion predicted negative emotion.

3.1. Within participants with schizophrenia

3.1.1. PANSS ratings

Positive symptoms, negative symptoms, overall symptoms, clinical burden, and anxiety failed to predict positive emotion, negative emotion, activity enjoyment, or the relationship between negative emotion and activity enjoyment in people with schizophrenia. Depression significantly predicted elevated negative emotion, $t(39) = 2.20$, $P = 0.03$, Cohen's $d = 0.70$, but did not predict any of the other variables.

3.1.2. Neurocognition

Overall neurocognition did not significantly predict positive emotion, negative emotion, or activity enjoyment. However, a cross-level interaction indicated that neurocognition did significantly moderate the relationship between negative emotion and activity enjoyment, such that participants with higher neurocognition scores had a stronger negative relationship between their reported negative emotion and activity enjoyment, $t(38) = -2.36$, $P = 0.02$, Cohen's $d = 0.77$ (see Fig. 3). Thus, people with schizophrenia with poor cognitive functioning reported negative emotion that was more independent of their ratings of enjoyment in activities.

4. Discussion

Employing an EMA methodology to investigate emotional dysregulation in the daily lives of people with and without schizophrenia, we found that while both groups had similar activity enjoyment appraisals and reported equivalent levels of positive emotion, participants with schizophrenia reported more negative emotion over the course of a week, providing further

¹ The finding on activity enjoyment was also reported in Gard et al., 2014.

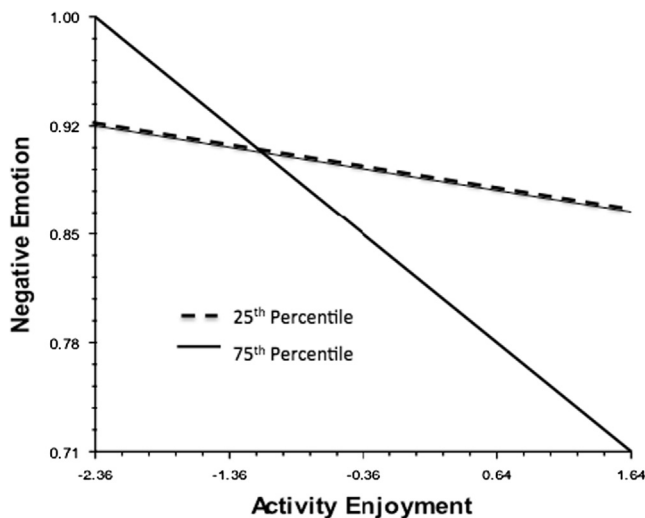


Fig. 3. Within the schizophrenia diagnosis group, negative emotion and activity enjoyment (group mean centered) were more weakly related for patients with lower neurocognitive functioning, $P=0.02$.

support for negative emotion dysregulation in schizophrenia. Critically, people with schizophrenia had weaker associations between their current negative emotion and activity enjoyment, indicating that negative emotion and the environmental context are less closely linked in this group. Within the schizophrenia participants, a weaker relationship between negative emotion and the environment was related to impaired neurocognitive functioning. Overall, these results support past findings of negative emotion dysregulation and provide ecologically informative evidence for incongruent negative emotion in schizophrenia.

4.1. Evidence of incongruent negative emotion

Our findings are in line with several studies that have shown intact hedonic experience in schizophrenia (see Krings and Moran, 2008), equivalent enjoyment of life activities in people with and without schizophrenia (Gard et al., 2007), but higher negative emotion in schizophrenia (e.g., Myin-Germeys et al., 2000; Oorschot et al., 2013). For both groups, ratings of positive emotion were substantially higher than negative emotion, supporting past findings that people generally report feeling positive (e.g., Zelenski and Larsen, 2000). Further, while people with schizophrenia reported higher negative emotion than people without schizophrenia, both groups reported generally low levels of negative emotion across the week. This finding is consistent with past EMA studies examining emotional experience in schizophrenia (Myin-Germeys et al., 2000, 2003; Oorschot et al., 2013), and although the mean level of negative emotion is low in both groups, the difference between the groups represented a medium to large effect size. Thus while people with and without schizophrenia experience higher positive emotion compared to negative emotion in daily life, our study supports past findings of a negative emotion disturbance in schizophrenia.

Importantly, mirroring laboratory evidence that people with schizophrenia report higher negative emotion during positive stimuli (Trémeau et al., 2009; Cohen and Minor, 2010; Strauss and Herbener, 2011; Ursu et al., 2011), our results indicate that people with schizophrenia show a weaker relationship between negative emotion and current activity enjoyment. That is, negative emotion is not only dysregulated during negative experiences in schizophrenia (Horan et al., 2013; Kimhy et al., 2012; Myin-Germeys and Van Os, 2007; Strauss et al., 2013), but may remain

elevated even in pleasurable environments. Thus, increasing engagement in hedonic activities may not be sufficient to reduce negative emotion in people with schizophrenia. That is, our study provides preliminary evidence that a situation selection emotion regulation strategy may be less effective at dampening negative emotion for people with schizophrenia. Instead, these results point to the importance of targeting the internal regulation of negative emotion in interventions in schizophrenia. Of note, we did not examine the temporal relationship between emotion and environmental pleasure – future research should seek to understand the time course of emotion activation and situation selection emotion regulation.

We did not find evidence for a disconnect between positive emotion and the environment, and, in contrast to Kimhy et al. (2014), we did not find that people with and without schizophrenia differed in the extent to which their positive and negative emotions were related. Our data suggest that schizophrenia is not characterized by a disconnect between positive emotion and pleasure appraisals of the environment or more independence of positive and negative emotion, but rather is limited specifically to the elevation and dysregulation of negative emotion. This finding highlights the importance of negative emotion as a target for research and treatment in schizophrenia. Further, our finding that positive emotion and negative emotion are no less reciprocally activated in people with schizophrenia lends evidence that people with schizophrenia are not reporting emotions randomly – they report a similar relationship between positive and negative emotion as people without schizophrenia, only that negative emotion is elevated, and relatively disconnected from environmental appraisals.

4.2. Negative symptoms were not linked to environment-incongruent negative emotion

In contrast to laboratory studies that link stimulus-incongruent negative emotion and negative symptoms (Trémeau et al., 2009; Strauss and Herbener, 2011) we did not find a relationship between negative symptoms and negative emotion dysregulation in daily life. One reason may be that average symptom ratings in our sample were relatively low, and our null findings may be due to a limitation in the range of symptom ratings. However, analyses using the highest rated positive symptom and negative symptom as proxies for clinical burden still did not yield significant relationships with emotion and environmental enjoyment ratings.

Another possible reason for the null relationship between daily life reports of environment-incongruent negative emotion is that the relationship of environment-incongruent negative emotion with negative symptoms more broadly is not completely clear. For example while Trémeau et al. (2009) found a relationship between stimulus-incongruent negative emotion and PANSS overall, they did not report the relation between stimulus-incongruent emotion and the negative symptom subscale of the PANSS and failed to find a relationship with a different measure of negative symptoms. Further research is needed to elucidate which negative symptoms are most closely linked to dysregulated negative emotion.

Additionally, this inconsistency between in-lab and daily life findings could be because of differences between in-lab and daily life methods. For example, in lab tasks the stimuli are chosen for the participant, whereas in daily life people are typically in familiar environments, which may be less ambiguous than the foreign situation in the lab. It is possible then that EMA studies may have some limitations on the individual variability seen in our group with schizophrenia. Future research should potentially examine both in-lab and daily life evidence of environment-incongruent emotion in schizophrenia.

4.3. Neurocognition predicts environment-incongruent negative emotion in schizophrenia

Poorer performance on a neurocognitive battery predicted a weaker relationship between negative emotion and the environmental context within our schizophrenia diagnosis group. There are a number of ways to interpret the relationship between dysregulated negative emotion and neurocognitive functioning. First, it is possible that participants with diminished neurocognitive functioning may be less able to accurately identify and verbalize their emotional experience. However, neurocognition was not related to overall levels of positive or negative emotion. One possible mechanism for the link between negative emotion dysregulation and neurocognitive deficits is that deficits in executive function may impact emotion regulation. That is, brain regions found to be impaired in emotion processing in schizophrenia such as the anterior cingulate cortex and dorsolateral prefrontal cortex (Taylor et al., 2012), are also recruited during cognitive tests. Intriguingly, this association points to cognitive remediation as a promising tool to target emotion dysfunction in schizophrenia. For example, recent research has found that targeted cognitive remediation normalizes neurological activation, improves executive functioning, and has lasting effects on social functioning (Subramaniam et al., 2012). Potentially, executive functioning improvements as the result of cognitive training may translate into improvements in emotion processing.

4.4. Limitations and future directions

While this study is the first to the best of our knowledge to provide daily-life evidence for environment-incongruent negative emotion in schizophrenia, it also has some limitations. First, our assessment of symptoms occurred during an in lab assessment with a clinician, rather than during the EMA assessments. Relatedly, our measure of substance use relied on self-report during the in-lab session rather than by a more objective measure or during the EMA interview. Thus, while we excluded individuals with active substance dependence we cannot determine from these data how symptoms and substance use may have influenced our findings in real time.

Second, it could be argued that schizophrenia participants may have had difficulty accurately reporting their current emotional state or current activity enjoyment, as several studies have found that schizophrenia is associated with alexithymia (Van der Meer et al., 2009). However, other research has indicated that people with schizophrenia employ the same understanding of emotion as people without schizophrenia (Kring et al., 2003), and we found differences only in negative emotion responding between the groups rather than overall erratic responding in participants with schizophrenia. Furthermore, in line with previous research neither positive nor negative emotion was lower in people with schizophrenia. Nonetheless, future studies may wish to include alexithymia as a potential factor in environment-incongruent emotion in schizophrenia.

Third, it is possible that daily contact from research assistants in this study may have increased positive emotion in our sample, particularly for people with schizophrenia for whom such contact may be limited (Gard and Kring, 2009). Relatedly, reports provided to live callers may be particularly vulnerable to social desirability bias. Future studies may wish to directly compare the responses generated by different EMA methods to examine potential reactivity to the method.

Fourth, it is not possible to determine from these data if people with schizophrenia experience environment-incongruent emotion activation in positive situations only (i.e., during activities that they enjoy), or if they also show environment-incongruent

emotions in negative situations as well (i.e., during activities that they are experiencing *dislike/displeasure*). In this study we only asked about activity enjoyment, and not activity displeasure. While we did indirectly test this hypothesis by examining the relationship between enjoyment and positive emotion, it is possible that positive emotions may be weakly related to the *displeasure* of a current activity in people with schizophrenia, indicating a problem with overall environment-incongruent emotional experience.

Finally, we can only speculate about the link between neurocognition and emotion dysregulation. Future research is needed to replicate and investigate potential mechanisms connecting neurocognitive impairment and negative emotion dysregulation, such as difficulty with emotion identification and impairments in neurocircuitry shared by cognitive and affective processing. Elucidating this relationship may point to potential targets of intervention such as improving emotion identification or cognitive remediation.

Funding

This project was supported by Award Number R21MH086801 from the National Institute of Mental Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Mental Health or the National Institutes of Health.

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