



Research Paper

Disturbed time experience during and after psychosis

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ABSTRACT

Disturbances in time experience have been argued to play a significant, if not causative role in the clinical presentation of schizophrenia. Phenomenological considerations suggest a fragmented or dis-articulated time experience causing both primary symptoms such as hallucinations, delusions, and self-disorders, as well as an intersubjective desynchronization. We employed content analysis on material collected from patients diagnosed with schizophrenia using the Time Questionnaire to generate hypotheses on possible disturbances of time experience in schizophrenia. As a key result we find evidence for the distinction between acute psychotic and post-psychotic syndromes. Acute psychosis is predominantly a disturbance of the passage of time, whereas the remission from psychosis is primarily defined by changes in the experience of the explicit structure of time integrating past, present, and future. We discuss our findings with regards to previous insights and observations on time experience and time perception. We suggest our findings hold significance for the diagnostic and therapeutic understanding of schizophrenia as well as for future integrative research on time experience in general.

1. Introduction

Time experience has repeatedly been proposed as disturbed or altered in mental disorders (Minkowski, 1923; von Gebattel, 1928; Lewis, 1932; Schilder, 1936; Straus, 1947; Hartocollis, 1975; Fuchs, 2001, 2005, 2007a, 2013; Wyllie, 2005; Kupke, 2005, 2009; Zukauskas et al., 2009; Gallagher, 2012; Moskalewicz, 2015; Stanghellini et al., 2017; Martin et al., 2018; Vogel et al., 2018a, 2018b), and particularly in schizophrenia (Bouman and Grünbaum, 1929; Minkowski, 1933; Blankenburg, 1971; Vogeley and Kupke, 2006; Fuchs, 2007b; Kupke, 2009; Stanghellini et al., 2015; Moskalewicz, 2018). Meta-analysis of time perception and temporal processing has suggested that patients with schizophrenia may be liable to a higher variability in the function of an internal clock mechanism (Thoenes and Oberfeld, 2017). Structural psychopathology (Stanghellini, 2009, 2010) has implicated a disturbance in time experience as the phenomenon potentially underlying several core features of the disorder (Vogeley and Kupke, 2006; Fuchs, 2007b; Stanghellini et al., 2015; Fuchs and Van Duppen, 2017). The concept most frequently brought forward proposes that this is caused by a disturbance in the basic sense of self (Nelson and Sass, 2017) due to a *fragmented* (Vogeley and Kupke, 2006) or *dis-articulated*

time experience (Fuchs, 2007b; Stanghellini et al., 2015; Fuchs and Van Duppen, 2017). According to this concept the temporal continuity underlying conscious awareness no longer proceeds smoothly, but disintegrates. The automatic implicit incorporation of new and salient information into an ongoing stream of consciousness fails and the integration of perceptual information over time into a coherent sequence of meaningful events is no longer possible. Symptoms of schizophrenic psychosis have been described as a retroactive compensatory mechanism that reduces uncertainty, surprise, and subsequently fear, that is caused by the unpredictable perceptual input; e.g. delusive perceptions as alternative explanations for unpredicted events, delusional thought and systematized delusions as an alternative explanatory model, or thought insertions and hallucinations as thoughts externalized from basic self-continuity (Fuchs, 2013; Fuchs and Van Duppen, 2017).

With respect to the social context, the concept of a fragmented or disarticulated time experience emphasizes the significance of time experience for intersubjective synchronization and social interaction. It suggests that due to the disintegration of basic self-coherence (Vogeley and Kupke, 2006; Fuchs, 2013), patients suffering from schizophrenia lose touch with their environment leading to an intersubjective

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Table 1
Introductory literature on time experience and schizophrenia.

Fuchs, T. (2013). Temporality and psychopathology. <i>Phenomenology and the cognitive sciences</i> , 12 (1), 75–104.	Phenomenological reflection on time experience in mentally healthy individuals, and corresponding psychopathology in patients with depression and schizophrenia
Minkowski, E. (1933). <i>Le temps vécu</i> . Paris, d'Array.	Classical canonical phenomenological work on undisturbed and psychopathological variants of time experience
Stanghellini, G., Ballerini, M., Prezenza, S., Mancini, M., Raballo, A., Blasi, S., & Cutting, J. (2015). Psychopathology of lived time: abnormal time experience in persons with schizophrenia. <i>Schizophrenia bulletin</i> , 42 (1), 45–55.	Qualitative analysis of patient records to identify psychopathological disturbances of time experience in depression and schizophrenia
Thoenes, S., & Oberfeld, D. (2017). Meta-analysis of time perception and temporal processing in schizophrenia: Differential effects on precision and accuracy. <i>Clinical psychology review</i> , 54, 44–64.	Meta-analysis of experimental results on time perception in schizophrenia
Vogel, D. H., Falter-Wagner, C. M., Schoofs, T., Krämer, K., Kupke, C., & Vogeley, K. (2018c). Flow and structure of time experience—concept, empirical validation and implications for psychopathology. <i>Phenomenology and the Cognitive Sciences</i> , 1–24.	Phenomenological considerations underlying the work presented herein; qualitative analysis of data from mentally healthy individuals
Vogeley, K., & Kupke, C. (2006). Disturbances of time consciousness from a phenomenological and a neuroscientific perspective. <i>Schizophrenia Bulletin</i> , 33 (1), 157–165.	Proposal that integrates the psychopathology of time in schizophrenia with neuroscientific findings

desynchronization (Fuchs, 2007b, 2013). This preconscious desynchronization induces both experiential and behavioral symptoms, is reflected in the predominance of intersubjective themes in delusion (Huber and Gross, 1977), and ultimately leads to social withdrawal and other negative symptoms (Bovet and Parnas, 1993; Montag et al., 2011). Conceptually, the disruption of time experience as described for schizophrenia can be assumed to emerge from pre-conscious processing (Vogeley and Kupke, 2006). A brief overview of introductory literature is presented in Table 1.

To our knowledge, no systematic empirical study on altered time experience in schizophrenia has been undertaken and sufficiently validated. A wealth of studies has investigated time experience in schizophrenia from a psychopathological and phenomenological perspective; however, without any systematic empirical data-driven approach. One exception has retrospectively analyzed clinical reports from 301 patients with schizophrenia in an attempt to isolate and define so-called “abnormal time experience (ATE)” (Stanghellini et al., 2015). The authors were able to identify four different types of ATE in 109 out of 301 patients, namely “disruption of time flowing”, “dépà vu/vécu”, “premonitions about oneself” and “premonitions about the world”. We employed a qualitative approach using inductive summarizing content analysis (SCA, acc. to Mayring, 2014; Vogel et al., 2018a, 2018b, 2018c) in order to generate data driven hypotheses and research directions.

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2. Methods

2.1. The time questionnaire

To properly address the qualitative aspects of time experience, we employed the recently introduced Time Questionnaire (TQ). The TQ was designed to qualitatively address as many aspects of the experience of time as possible by using open questions. It has been successfully used in three studies on the experience of time focusing on individuals with autism spectrum disorder (Vogel et al., 2018a), patients with major depressive disorder (Vogel et al., 2018b), and healthy participants (Vogel et al., 2018c).

The TQ's questions (Table 2) are based on the established literature in the field and the underlying concept of human time experience as consisting of two time layers, namely *flow* and *structure* (Kupke, 2009; Vogel et al., 2018c). Questions (Q) 1–3 address the experienced flow or passage of time, with Q1 asking as broadly as possible and Q2–3 inquiring more specifically into the dependency on contextual and situational factors. Q4–7 address the experience, concepts, and subjective meaning of the structural domains of time, namely past, present, and future. Additional space is provided for participants to add further

Table 2
The time questionnaire.

1. How do you experience the passage and flow of time?
2. Does the passage and flow of time change in the presence of other persons? If 'yes', how?
3. Does the passage and flow of time change in relation to surroundings or situation (e.g. workplace, spare time)? If yes, how?
4. Does the present appear to be a point in time or an extended period in time? If you experience the present as an extended period in time, how long does the present last?
5. How do you experience the present and what does it mean to you?
6. How do you experience the past and what does it mean to you?
7. How do you experience the future and what does it mean to you?

subjectively relevant aspects about the experience of time. Participants are instructed to write as much or as little as they find adequate. In order to promote data saturation (Sandelowski, 1995; Mason, 2010; Glaser and Strauss, 2017) participants are provided with as much time as needed to complete the TQ.

2.2. Analysis

Completed questionnaires were analyzed using *summarizing content analysis* (SCA; Mayring, 2014). We decided to use an inductive, hypothesis-free approach intended to derive new hypotheses from qualitative material in a data driven approach. Generally speaking, the approach of SCA aims to describe an investigated phenomenon in as much detail as possible. It is not intended to generate quantitative data. SCA follows a strict systematic summarizing process of analysis. First, redundancies and thematically superfluous material is deleted. The remaining text is paraphrased into common language by correcting and adjusting false grammar, spelling and punctuation. Second, statements referring to a single topic are isolated. The smallest possible part of the material to be isolated was defined as ranging from a single word to multiple sentences. The largest possible part of the material that could form a statement was defined as everything addressing one question. For each participant, descriptive categories were generated for each isolated statement, until all paraphrases had been assigned to a category. Then, the material was re-screened, and categories of similar or identical content were repetitively merged to form a coherent categorical system.

The emerging categorical system was presented to two independent inter-coders (T.B., T.H.). In addition to the paraphrased material, inter-coders were provided with an explication, a coding rule, an anchor example and a code for each of the categories. The inter-coders assigned one category to each isolated statement according to explanation and coding rule. Inter-coder agreement was calculated using Krippendorff's

alpha (Krippendorff, 2004; Hayes and Krippendorff, 2007).

2.3. Participants

Participants were recruited from patients admitted for in-patient treatment to the Clinic for Psychiatry and Psychotherapy, Brandenburg Medical University at Immanuel Klink Rüdersdorf and from patients being treated in its outpatient clinic. Patients were considered for inclusion in this study if the clinical diagnosis was any of the following on the schizophrenia spectrum: schizophrenia (ICD-10, F20.0), acute polymorphic psychotic disorder with symptoms of schizophrenia (ICD-10, F23.1) or schizoaffective disorder (ICD-10, F25) (World Health Organization, 1992). Patients were only considered for inclusion, if they had neither a record of comorbid neurological disease nor was there any neurological comorbidity detectable in the clinical diagnostic procedures, thus excluding organic brain disease as well as mental retardation (IQ < 70). Further excluding criteria were significant psychiatric comorbidities, like current manic or hypomanic or depressive episodes, bipolar disorder, personality disorders, and addiction. All individuals eligible for inclusion were diagnostically rescreened in a clinical interview conducted by a senior psychiatrist. They were included into the study only if they then met diagnostic criteria for schizophrenia according to ICD-10 (F20.0) and if significant psychiatric co-morbidity could again be ruled out.

Patient screening and subsequent study inclusion were conducted from February 2016 to June 2017. In-patients were typically rescreened and tested the week before their discharge from hospital treatment, meaning that testing took place in a post-acute state. Out-patients were screened at routine appointments in the outpatient clinic. The screening procedure encompassed the following instruments: the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987), the Beck-Depression-Inventory (BDI-II) (Hautzinger et al., 1995) and a multiple choice vocabulary test (Wortschatztest, WST) (Schmidt and Metzler, 1992). BDI-Scores were used to screen for depressive comorbidity and to approximate depressive symptom severity, as depression is a condition known to potentially cause changes in time experience (Vogel et al., 2018b). In three cases, participants reached scores displaying significant depressive symptoms. However, clinical screening did not confirm major depression, and the score was interpreted as indicating a severe schizophrenic negative syndrome, which was corroborated by high scores on the PANSS negative scale. PANSS was used to estimate schizophrenic symptom severity and individual functioning. WST Scores were used to calculate verbal IQ and to guarantee speech comprehension, proper production of written material, and sufficient intellectual capacity to cope with the complex subject of time experience. Demographics and results from BDI-II, PANSS and WST are summarized in Table 3. All participants except one received antipsychotic medication; two patients were still on small dosages of benzodiazepines remaining from previous higher dosage acute treatment. To our knowledge, none of the included patients were taking any psychoactive drug other than prescribed over the period of testing.

2.4. Limitations

Inductive content analysis is primarily intended to describe an observed phenomenon in as much detail as possible. Its primary goal is to create new hypotheses through a data driven approach to a phenomenon. By employing an open question questionnaire without time restrictions we expect to acquire data both as unprejudiced and saturated as possible (Sandelowski, 1995; Mason, 2010; Glaser and Strauss, 2017). However, any such approach can only directly assess explicit aspects of time experience (Vogel et al., 2018c, for terminology also see Fuchs, 2005; Kupke, 2009). Although highly structured and coordinated, the method must remain interpretative and hence is vulnerable to oversimplification and false negatives. It is important to keep in mind that any frequency of responses reported as results is not a

measurement and that no valid statistical inferences can be drawn from it.

Responses to the TQ rely on the participants' ability to understand and produce written text. This ability may be impaired in schizophrenia and results are thus limited. We addressed this limitation by controlling for verbal IQ.

It needs to be emphasized that due to patient selection and treatment heterogeneity our findings are severely limited in interpretability. Data saturation was observed at 22 participants, yielding a relatively small sample size. Our patients were included into this study in a post-acute state and the presence of productive psychotic symptoms was not necessary for inclusion. This means that whenever patients made reports on their experience during psychosis or we made inferences on the relationship between psychosis and remission, the respective statements were retrospective and potentially subject to recall-bias. Almost all patients received antipsychotic medication, and we cannot rule out that time experience is significantly influenced by medication effects or that our results were affected by non-uniform treatment. Additionally, any assumptions on underlying neural processes have to remain highly speculative.

3. Results

The data saturated at 22 participants. 227 statements were isolated from the material. We identified 32 categories which could be assigned to five different groups roughly corresponding to the differentiation between *flow* and *structure* as made by the TQ (Vogel et al., 2018c). The first group consisted of fourteen categories addressing the experience of the passage of time (100 statements, app. 44% of all statements, categories K01–14). The second group consisted of eight categories concerning the present (53 statements, app. 23% of all statements, categories K15–22). The third group consisted of four categories addressing the past (36 statements, app. 16% of all statements, categories K23–26). The fourth group concerning the future consisted of five categories (36 statements, app. 16% of all statements, categories K27–31). The last group was a single category labeled *Rest* (2 statements, app. 1% of all statements, category 32) for statements which were too unspecific or too divergent from the explications of the other categories. The categorical system is presented in Table 4. Calculation of Krippendorff's alpha displayed a strong inter-coder agreement of $\alpha = 0.824$.

3.1. Category group "passage of time"

Most of the categories within this group referred to the subjective experience of velocity of the passage of time (categories 01, 02, 04, 05, 10, 11, 12, 13; n = 45 statements, app. 20% of statements). Four categories indicated changes in subjective velocity due to activities, situational or relational factors (categories 01, 02, 04, 05; n = 39 statements, app. 17% of statements), indicating either an acceleration while active (categories 01; n = 8, 32% of participants), while engaged in pleasant activities (category 02; n = 9, 41% of participants), by virtue of desirable company (category 04; n = 11, 50% of participants) or a deceleration when engaged in unpleasant activities (category 05; n = 8, 36% of participants). Categories 10 and 11 referred to changes in the velocity of the passage of time during acute psychosis, with category 10 (n = 5, 23% of participants) indicating an increase in velocity and category 11 (n = 4, 18% of participants) indicating a decrease in velocity during the psychotic episode as compared to non-acute or even healthy periods. Category 12 and 13 included reports on a general experience of time as passing either slowly (category 12; n = 9, 41% of participants), or fast (category 13; n = 12, 55% of participants). Interestingly, seven participants (32% of participants) gave both reports on experience of time as passing generally fast and generally slow. Category 03 (n = 3, 14% of participants) coded for statements that during pleasant activities the experience of the passage of time seemed to fade or be of a lesser importance. In category 14 (n = 7, 32% of participants) patients

Table 3
Participant descriptions.

	BDI-score	Verbal IQ	Age	Number of hospitalizations	Years of pharmacological treatment	Years since first diagnosis	PANSS total	P. positive	P. negative	P. global	Gender
01	23	89	35	3	8	8	64	9	23	32	m
02	0	101	45	4	12	13	39	8	12	19	f
03	15	118	39	3	4	7	72	12	25	35	m
04	36	82	35	5	16	17	72	8	32	32	m
05	9	101	29	2	10	11	55	10	21	24	m
06	8	97	42	5	18	19	57	10	21	26	m
07	8	112	26	1	0.25	1	65	24	10	31	f
08	21	130	31	1	5	6	48	11	14	23	f
09	5	94	33	8	16	17	113	28	35	50	m
10	23	101	33	2	3	12	55	11	14	30	f
11	15	104	31	11	14	14	72	10	19	43	f
12	13	97	34	6	4	6	73	14	31	28	m
13	16	104	38	2	5	6	60	13	18	29	m
14	29	97	24	3	4.5	11	61	17	18	26	m
15	41	92	35	5	7	9	80	11	32	37	f
16	13	95	37	14	14	14	64	15	18	31	m
17	0	101	39	25	20	20	85	17	29	39	m
18	2	107	35	1	0.17	1	35	7	8	20	m
19	27	91	29	3	6	7	45	12	11	22	m
20	15	112	39	2	1	1	51	11	11	29	m
21	6	88	19	3	1	1	45	12	9	22	m
22	19	124	42	9	12	14	57	27	8	22	f

reported difficulties with or a complete loss of the sense of time, during psychosis ($n = 4$), after psychosis ($n = 1$), or generally ($n = 2$), e.g. through undirected activity, loss of structure, absorption by one's own thoughts, or in a broader sense losing touch with the external world. In several statements participants referred to time as being experienced variably with regards to situational factors without giving explications as to the nature of variance (category 06; $n = 11$, 50% of statements). Conversely, statements within category 08 ($n = 6$ statements, 27% of participants) explicitly denied significant contextual or situational influence on the experienced velocity of the passage of time and category 07 ($n = 5$; 23% of participants) indicating a more general variance in the passage of time. Category 09 ($n = 2$, 9% of participants) stated that the passage of time during psychosis was dominated by the feeling of something being about to happen at any moment, with patients' descriptions seemingly mirroring descriptions of delusional mood.

3.2. Category group "the present"

More than half of our participants referred to the present as an extended experience (category 16; $n = 12$, 55% of participants) with accounts of the length ranging from 10 s to several months. The extension of the present seemed to depend on its content, with participants defining the present as the current activity or life phase (category 19; $n = 6$, 27% of participants). However, there was also one category defining the present as restricted to a point in time (category 15; $n = 7$, 32% of participants), three participants reported the present being both extended and non-extended. Several participants experienced the present as happening "now" (category 17; $n = 8$ statements, 36% of participants), exhibiting overlapping content with both the experience of time as being extended (4 overlaps) and non-extended (2 overlaps), indicating that between subjects the experience of "now" could refer to the present being a current time span as well as being a current point in time. Appositely, category 18 ($n = 3$, 14% of participants) indicated that the experience of the present was non-stationary. Three categories dealt with the ability to influence and shape the present (categories 20, 21, 22; $n = 17$, 7% of statements). Several participants stated that the present could be influenced (category 20; $n = 5$, 23% of participants) and had to be made use of (category 22; $n = 7$, 32% of participants), meaning there was an imperative to spend the present consciously or in a personally rewarding and meaningful way. Strikingly, participants stated that their present was useless or insufficiently utilizable and

passing by without meaning (category 21; 5 statements, app. 23% of participants).

3.3. Category group "the past"

Most of the statements within this group referred to the past as a personally significant period of time which shaped individual personality and character (category 26; $n = 16$ statements, 73% of participants). Six participants from this category and one additional participant stated that the past exerted a negative influence on the present or life in general (category 24; $n = 7$, 32% of participants). The past was further deemed unchangeable, completed, or simply "over" (category 25; $n = 10$ statements, 45% of participants). For few participants the past had no further significance (category 23; $n = 3$ statements, 14% of participants).

3.4. Category group "the future"

Statements describing the future as connected to goals, wishes and hopes were identified as most frequent (category 28; $n = 10$ statements, 45% of participants). Participants indicated that the future could be actively shaped and influenced (category 29; $n = 6$ statements, 27% of participants). In contrast to this positive outlook, there were both a nearly equivalent number of statements referring to the future as time without perspective, which could not be influenced and had no personal significance (category 30; $n = 9$ statements, 41% of participants) and descriptions of the future as predominantly linked to fears and worries (category 27; $n = 6$ statements, 27% of participants). Although our participants stated to plan their future (category 31; $n = 5$ statements, 23% of participants), the time spans open to planning were described as subjectively (too) short by more than half of the participants in this category.

4. Discussion

Our results grossly affirm preexisting observations and insights on time experience in schizophrenia, but also contribute considerably to previous knowledge and provide a more differentiated profile of time experience over the course of schizophrenia. According to the TQ we will discuss and interpret our findings along the passage of time and the structure of time. We found a significant difference in descriptions

Table 4
The categorical system with examples from the material.

The passage of time		
K01	When active time passes quickly.	Time flies when you are busy.
K02	During pleasant activities time passes quickly.	When work is fun, time flies.
K03	During pleasant activities the passage of time is not noticed.	At home, I spend time with my family and do not watch the clock. I am fulfilled by the activity and I do not mind the time.
K04	In the presence of others time passes quickly.	When I am with other persons, time passes quickly because of communication.
K05	During unpleasant activities time passes slowly.	During repetitive tasks time slows down.
K06	The experience of time varies relative to situational context.	When I have to do things I do not want to do, the time before is unbearable.
K07	The experience of time varies independent from situational context.	Sometimes time is slow, sometimes it is fast no matter where I am.
K08	The passage of time does not change depending on situational context.	The passage of time does not change in the presence of others. The passage of time does not depend on the situation.
K09	The passage of time is overlain by premonition.	I feel a strong tension, as if something was about to happen at any moment.
K10	The passage of time seems accelerated during psychosis.	During the acute phase, time passed faster.
K11	The passage of time seems slowed down during psychosis.	During psychosis, I felt like time was passing slower than usually.
K12	Time passes slowly.	Often I feel like I am stretching time. Then, time passes slower.
K13	Time passes quickly.	Time passes very quickly for me.
K14	There is a diminished sense for the passage of time.	During my illness days and nights passed entirely unnoticed. My awareness of time is less pronounced than before. Sometimes the perception of time is wrong-headed and the moment and its meaning seem to slip into the background. Time becomes a minor matter when fear and anxiety rule my life.
The present		
K15	The present is not extended in time.	I experience the present like a point in time.
K16	The present is extended in time.	The present is 10 s.
K17	The present is now.	The present is now.
K18	The experience of the present is variable.	How I experience the present depends on what is happening.
K19	The present is the current activity or life phase.	Present is now and here, e.g. that I am just participating in a study.
K20	The present can be influenced.	I try to actively shape the present and I am happy about every day that I can spend according to my own wishes and with people who are close to me.
K21	The present cannot be made use of.	I was apathetic and also people could not change anything about it. Sometimes time just trickles away.
K22	The present has to be made use of.	Mostly I try to make use of my time. Now, as my illness is fading, I experience time which I spend with friends and family more intensely and I try to utilize it completely.
The past		
K23	The past had no influence.	The past does not have any meaning for me.
K24	The past has a negative influence on the present.	The past matters every day, which causes a lot of stress for me. My everyday life is influenced by thousands of memories.
K25	The past is over and unchangeable.	The past cannot be changed.
K26	The past shapes an individual.	The past is a part of me just like my nose.
The future		
K27	The future is associated with fear and worries.	The future is fear.
K28	The future is associated with goals, wishes and hopes.	The meaning of future equals hope.
K29	The future can be influenced.	I can shape and influence my own future.
K30	The future cannot be influenced/is meaningless/is lacking perspective.	The future is of little personal importance to me. The past has shown that my plans, no matter how vague or concrete will always be crossed somehow. Too much planning makes me ill. I do not plan anymore.
K31	The future can be planed (short term).	Usually I only plan one week ahead.

Table 5
Time experience in schizophrenia.

Experience	Definition	Related categories
a) Time experience during psychosis		
Variability in velocity of passage of time independent from context.	Time is experienced as passing both fast and slow. Changes in experience occur independent from obvious situational changes.	07, 08, 10, 11, 12, 13
Premonitions and feeling of imminence.	The passage of time contains a feeling of imminence, peculiarity, and loss of self-evidence. The sense for time/the passage of time may fade.	09, 10, 11, 14
b) Time experience after psychosis		
Desire to overcome the illness and make use of the present.	The desire to utilize the present and spent time worthwhile in light of past distress.	20, 22, 26, 28, 29
Inability to make use of the present and/or live future directed.	The past psychosis cannot be integrated into the present. The present cannot be used to influence the future. The future seems less predictable.	21, 13, 14, 30, 31

related to the experience during and after psychosis. The key features of time experience in schizophrenia identified in our analysis were the high variability in the velocity of the passage of time independent from context during psychosis, premonitions and feeling of imminence during psychosis and the desire to overcome the illness and make use of

the present combined with an inability to make use of the present and/or live future directed after psychosis (Table 5). These key findings support the differentiation along the passage of time and the structure of time. Furthermore, they introduce the necessity to distinguish between acute psychosis and the post-psychotic state respectively.

4.1. Variability in the passage of time

One of the key findings is variability in the experience of time in schizophrenia. Remarkably, in our group of patients with schizophrenia, both statements of a slow passage of time and statements of a quick passage of time were made by the same individuals, without explicit mention of corresponding change in behavior or situational context. Previous studies of our group provided much more homogeneous data in control persons, patients with major depression and patients with autism (Vogel et al., 2018a, 2018b, 2018c). This may suggest that the experienced passage of time in schizophrenia is subject to a higher situation-independent fluctuation than in other mental conditions. In mentally healthy individuals no generally slow passage of time could be discerned (Vogel et al., 2018c), and during depression, statements on a slowed passage of time were not made by the same individuals who stated that time passed quickly (Vogel et al., 2018b).

As it has previously been proposed that changes in the experience of the passage of time may reflect other changes in time experience or even changes in the stream of consciousness (Sackett et al., 2010; Stanghellini, 2017, p. 43 ff.; Stanghellini and Mancini, 2017, p. 56 ff.; Vogel et al., 2018b, 2018c), it can be hypothesized that the variability in the experienced velocity of the passage of time is a manifestation of a similar disturbance on a deeper layer of time experience (Kupke, 2009; Vogel et al., 2018c). As such, the variability in velocity may indicate an experiential correlate of a disturbance of coherent integration of new information on the proposed micro layer of time and thus corroborate the preexisting theories on disrupted time experience in schizophrenia. However, as our method does not allow for the ratification of such a proposal it must remain speculative.

Our analysis does not show any changes of time experience during or after psychosis in the presence of others. This indicates that a potential disturbance of intersubjective time concerning temporal flow does not mainly manifest itself on a higher, explicit temporal level. Yet, patients retrospectively stated that during psychosis they suffered from a reduced or diminished sense for the passage of time which may reflect disturbances in intersubjective temporality (Fuchs, 2007b, 2013), self-coherence (Vogeley and Kupke, 2006; Nelson and Sass, 2017), and temporal coordination (Carroll et al., 2008, 2009).

It is particularly interesting that when confronted with an open questionnaire on time experience, participants seemed to intuitively connect symptoms of their illness with their experience of time. Whether this is simply circumstantial due to the dominance of the experienced symptoms or whether this reflects a correspondence or even causality will have to be investigated in the future.

4.2. Premonition and imminence

Our analysis describes an experience of time overlain by a feeling of imminence corresponding psychopathologically to delusional mood (Conrad, 1958). However, in accordance with previous considerations on time experience in schizophrenia (Kupke, 2009; Stanghellini et al., 2015), the feeling of premonition is at its core a temporal phenomenon and corresponds to the distinct experience in schizophrenia as *antefestum* (Kimura, 2003; Pringuey et al., 2003). Delusional mood in this sense is an experience of constant potentiality, even before anything meaningful or attention-grabbing has occurred. This enduring experiential saturation has been interpreted to stem from dysfunctional protentional processes in time experience (Fuchs, 2007b; Fuchs and Van Duppen, 2017), especially in early psychosis (Stanghellini et al., 2015). Protention describes the future directed portion of temporal perception and of the extension of conscious experience primarily on the micro layer of time (Kupke, 2009; Husserl, 2012; Fuchs, 2013). The temporal aspect of the passage of time being influenced by future directed premonitions clearly illustrates the interconnectedness of flow and structure of time experience (Kupke, 2009; Vogel et al., 2018c).

4.3. Structure of time: making use of the present

Concerning the overall structure of time experience, our analysis suggests that the fundamental order of past, present, and future remains intact. However, patients reported an alteration of the experience of the present both during and after psychosis. A characteristic and dominant feature was the desire to live a “normal life” as sharing one's present with others. This could reflect the need to re-establish the temporal connection with others after the remission of psychosis. This would mean that intersubjective temporality resynchronizes with treatment success and with advancing remission the patient becomes aware of the time lost to the psychotic episode. Retrospectively this implies intersubjective desynchronization during psychosis which does not become apparent during the psychotic episode due to the experiential isolation of the patient.

Whether this experience of illness and recovery is specific to schizophrenia, or if it applies to all forms of episodic or cyclic illnesses remains to be investigated. However, our analysis suggests that it holds a notable significance for patients suffering from schizophrenia. This seems to be further highlighted by statements indicating that this desire to live a shared present cannot be sufficiently fulfilled and in some statements patients expressed the need to relearn how to enjoy and live their present.

These reports and their interpretation may help to better understand the development of post-psychotic depression. In accordance with findings on time experience and depression (von Gebattel, 1928; Straus, 1928; Binswanger, 1960; Fuchs, 2001, 2013, 2005; Kupke, 2005; Wyllie, 2005; Gallagher, 2012; Moskalewicz, 2015; Stanghellini et al., 2017; Vogel et al., 2018b), stating that the inability to adequately live time and influence one's present and future, the felt inability of being unable to enjoy a present shared with loved ones may reflect a neglected but significant psycho-social stress factor.

4.4. Structure of time: integrating past and future into the present

The past was experienced as predominantly negative. Both the experiences of having undergone substantial adversities and a feeling of relief afterwards were expressed. This experience of the past exemplifies the profound impact of a psychotic episode on the biography and the narrative of an individual (Bury, 1982). In their post-acute state, our patients' statements suggest an inability to integrate past experiences into a personal narrative, consistent with empirical findings on narrative identity in schizophrenia (Raffard et al., 2010; Allé et al., 2016). The negative experience of the past psychotic episode as mostly non-formative might be an additional retrospective expression of disturbed time experience during the psychotic state. Possibly also due to desynchronization, the experiences made during psychosis were only meaningful for patients while in an acute state. Patients in remission, however, can no longer make sense of the past experience in terms of their own non-psychotic narrative. Thus it cannot be adequately integrated into one's biography. This is in concordance with the subjectively short time spans subjectively accessible for future planning for our participants.

In line with the pre-existing concepts on temporality, time experience and lived time (Straus, 1928; von Gebattel, 1928; Fuchs, 2001, 2013; Broome, 2005; Kupke, 2005; Wyllie, 2005; Gallagher, 2012; Moskalewicz, 2015; Stanghellini et al., 2015; Vogel et al., 2018b, 2018c) the described inability to live and enjoy the present and to influence the future in a satisfactory way might stem from an inability to integrate the psychotic past into the present. As a consequence, the experience of the future seems to be affected by a loss of natural accessibility. Our patient's statements suggest an awareness of vulnerability to future events. Although the basic structure of time is still reflected in an association of the future with wishes and desires, it seems to be overshadowed by an experience of passivity and helplessness. Patients appear as if in a spectator mode, unable to take

possession of their own lives. Correspondingly, the wish to increase daily structure through future planning may reflect the attempt to actively regain control over time.

This awareness of vulnerability can be related to the reported experience of imminence during psychosis and may decrease with time after remission. However, it could otherwise be a feature of post-psychotic negative symptoms, states of depression or other psychosocial stress factors such as e.g. loss of social status. In another sense, awareness of vulnerability, presentation of a negative syndrome, and social decline are interpretable as a form of explicit intersubjective desynchronization, prolonging the loss of touch with reality after remission. From a therapeutic point of view, our findings highlight the importance of post-psychotic psychotherapy which may help patients with the intense experience of lost time and intersubjective desynchronization during psychosis by integrating the past illness into a coherent narrative identity by emphasizing a therapeutic future perspective (Blankenburg, 1989). Given that many statements of our subjects seemed to reflect a crisis in interpersonal relationships and a fundamental lack of hope for the future, recovery-oriented approaches might be helpful for many individuals by focusing on building supportive relationships and re-establishing future orientation.

4.5. Time experience over the course of psychosis

Our analysis provides evidence for the need to differentiate between two modes of time experience in schizophrenia: during psychosis and after remission from psychosis. The description of the psychotic mode of time experience (Table 4a) was characterized by either deceleration or acceleration of the passage of time independent from contexts or activities. Additionally, patients reported a feeling of imminence with regards to their own experience of time, most probably reflecting delusional mood.

The second state of time experience seemed to correspond to the description of negative symptoms after remission of acute psychosis, especially passivity and inability to experience pleasure. In our analysis patients reported an inability to utilize their present and to sufficiently influence the future. Importantly our analysis revealed a considerable post-acute desire to share the present with loved ones and to overcome negative aspects of their past, most dominantly the psychotic episode. Clearly the conflict between this desire to live the present and the simultaneous inability to do so may produce severe mental strain. The *post-psychotic features* (Table 4b) of time experience in patients with schizophrenia may form the basis of an important and novel therapeutic approach and understanding of post-psychotic suffering.

Interestingly, this conceptualization of time experience in schizophrenia separates the positive and the negative syndrome along the passage of time and the structure of time. During psychosis the experience of the passage of time changes; after remission it is primarily the structure of time which is affected. Conceptually this could imply a closer interconnection between temporal processing and the passage of time as compared to the structure of time. This adds to the discussion on the relationship between the temporal layers and their relationship to predictive processing and the brain (Kupke, 2009; Grush, 2016; Wiese, 2017; Vogel et al., 2018c).

4.6. Time experience and the Bayesian brain

Our findings not only complement existing hypotheses on time experience in schizophrenia but they also allow speculating about the putative neural correlates of disturbances in time experience in schizophrenia. Obviously any biological mechanism is not readily observable through phenomenological inquiries. Concerning time experience it has been proposed however, that phenomenological considerations concerning the preconscious prerequisites of the temporality of human consciousness converge with neuroscientific research findings on the neural mechanisms underlying time experience

(Vogele and Kupke, 2006; Vogel et al., 2018c). As both describe pre-conscious processes, neuroscientific and phenomenological approaches are directed towards the micro layer of time. As stated before we hypothesize the key pathology in schizophrenia to be located on this subpersonal and pre-conscious micro layer (Vogele and Kupke, 2006; Kupke, 2009; Vogel et al., 2018c). These subpersonal processes could possibly be explained by the preconscious predictive processes summarized in the account on the so-called “Bayesian Brain” (Fletcher and Frith, 2009; Friston, 2009, 2010). In brief, Bayesian predictive processing states that brain function and perception depend on the interaction between bottom-up sensory information and top-down predictions of the causes of sensory information (Friston, 2009). At any given moment the brain generates a prediction of the most likely state of a current perceptual input, compares predictions and input, calculates a so-called prediction error and updates the initial prediction according to the prediction error. Minimal prediction errors correspond to stable perceptions. In order to minimize the prediction error, the system is also required to account for naturally occurring variance in the perceptual input. Accordingly, each inference also contains the expected precision or uncertainty of the prediction error which might be encoded by dopamine release through its regulation of perceptual salience (Fletcher and Frith, 2009; Friston, 2009; Seth et al., 2012). Additionally, predictive processing is embedded into a hierarchical structure: Determined by precision and prediction error, incoming bottom-up information is compared to a higher top-down prediction potentially resulting in a new prediction error which again is compared to the prediction from the next hierarchy up, until the error has been resolved (Friston, 2009).

Concerning schizophrenia alterations in predictive processing have been implicated as the potential primary disturbances (Fletcher and Frith, 2009; Lalanne et al., 2010; Adams et al., 2013, 2015). In accordance with the so-called aberrant salience hypothesis (Kapur et al., 2005) schizophrenia is interpreted as being caused by a dysregulated release of dopamine in the brain which in turn affects the precision of error prediction. Consequently, errors are judged by the system to be of a higher relevance than under healthy circumstances and are passed up the hierarchy in order to explain the error and update beliefs accordingly (Fletcher and Frith, 2009). Unfortunately, the process starts out with a falsely evaluated prediction error and the higher hierarchies will not be able to fully explain it. According to the theory, this faulty mechanism causes sensorimotor and perceptual disturbances at lower levels and more pronounced phenomena such as delusion and hallucinations at higher levels (Fletcher and Frith, 2009; Adams et al., 2015; O’Callaghan et al., 2017). It has been suggested, that the heterogeneous presentation of symptoms between patients with schizophrenia may be due to variations in predictive processing impairments (Sterzer et al., 2018).

The constant updating of prior predictions and the resulting generation of new posterior predictions along a hierarchical structure may also explain the temporal flow and velocity (Hohwy et al., 2016), as well as structure, continuity and endurance (Wiese, 2017) in human experience. As this process appears strikingly similar to the phenomenological time synthesis (consisting of retention, presentation, and protention), the hierarchical predictive Bayesian processing therefore may represent the preconscious mechanisms correlating with time experience. Put simply, the system is constantly prepared to expect change resulting in the phenomenal experience of temporal flow (Hohwy et al., 2016).

This conceptualization can also be applied to our results concerning the experience of time during psychosis. First and as previously stated, alterations in prediction precision can explain the feeling of imminence or delusional mood (Fletcher and Frith, 2009), possibly related to dysregulated dopamine release (Kapur et al., 2005). Second, different dopamine levels would cause different expectations of changes and different velocities of passing time (Hohwy et al., 2016).

Obviously, these considerations cannot fully account for the

experience of velocity changes during psychosis. However, they may correlate to an apparent change between fast and slow velocity of time caused by increased variability in time experience. Conversely, reports of a decrease in the velocity of the passage of time could still be related to this variability. This is in accordance with findings from time perception research suggesting a more variable internal clock in schizophrenia (Thoennes and Oberfeld, 2017); although recently it has been proposed that duration perception and passage of time perception are mediated through separate neural systems (Droit-Volet, 2013; Lamotte et al., 2014; Droit-Volet and Wearden, 2016; Vogel et al., 2018b).

5. Conclusion

Our analysis allows to develop several novel hypotheses: (a) the exploration of time experience provides new insights into disturbed time experience in schizophrenia that appear to be related to the distinction between positive and negative syndromes and to different stages of the disease; (b) explicit time experience may pose a window into implicit time experience and hence temporal processing. Accordingly time experience is best investigated by using integrated research approaches on both a qualitative phenomenological and a quantitative (neuro-) psychological level (Heinze and Kupke, 2006; Arstila, 2011). We suggest that the processes underlying predictive processing, as well as the brains resting state are prime candidates for further study. Although our analysis suggests a relationship between disturbances in the experience of time and alterations in the constitution of the stream of consciousness and its underlying phenomenal and neural events, any conclusions or inferences as to this connection and its nature are highly speculative. Two targets for further investigation on temporal disturbances in schizophrenia have been proposed. On the one hand, the temporo-spatial organization of brain activity especially during the brain's resting state has been suggested as correlating to temporal experience (Northoff and Stanghellini, 2016). On the other hand, disturbances in interoception and related brain areas may underlie schizophrenic symptoms especially in relation to predictive processing (Seth et al., 2012). We hope that our findings and their discussion will inspire further research into the neural processes underlying time experience and its disturbance in mental disorders.

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The authors have declared that there are no conflicts of interest in relation to the subject of this study.

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