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REVIEW

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Can disorders of subjective time inform the differential diagnosis of psychiatric disorders? A transdiagnostic taxonomy of time

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Abstract

Aim: Time is a core aspect of psychopathology with potential for clinical use and early intervention. Temporal experience, perception, judgement and processing are distorted in various psychiatric disorders such as mood (depression and mania), anxiety, autistic, impulse-control, dissociative and attention-deficit/hyperactivity disorders. Can these disorders of time be used as early diagnostic or predictive markers? To answer this question, we develop a Transdiagnostic Taxonomy of (disordered) Time (TTT) that maps on to the symptomatological, phenomenal, perceptual and functional descriptions of each underlying disorder in a $2 \times 2 \times 2$ state space. Temporal distortions may precede functional decline, and so assist efforts at early detection and intervention in at-risk groups.

Method: Firstly, this article integrates a psychological model of how time is processed with a subjective or phenomenological model of how time is experienced or perceived. Secondly, the integrated combined model of time is then used to heuristically map major psychiatric disorders on to the basic elements of temporal flow and integration.

Results: The TTT systematically describes the basic temporal nature of eight diagnostic categories of psychiatric illness. It differentiates between diagnoses primarily associated with distorted "macro-level" phenomenal temporal experiences (i.e. anxiety, dissociation/PTSD, depression, and mania) from those primarily related to distorted 'micro-level' temporal processing (i.e. psychotic, impulse-control, autistic and attention-deficit/hyperactivity disorders).

Conclusions: The TTT allows differential diagnostic classification of various psychiatric disorders in terms of a possible underlying time disorder, making it useful for future diagnostic and predictive purposes using novel techniques of temporal processing, time perception, passage of time, and time perspective.

KEYWORDS
empirical testing, mental disorders, phenomenology, subjective time, transdiagnostic classification

1 | INTRODUCTION

Neuroscientific and philosophical approaches to time are a recurrent theme in psychopathology (Broome, 2005). Recent studies in phenomenological psychiatry propose that radical alterations in subjective temporality are central to the experience of mental ill-health (Fuchs, 2013). In particular, recent work shows abnormal time experience in many conditions including depression (Stanghellini et al., 2017), autism spectrum disorders (ASD; Vogel et al., 2018), schizophrenia (Stanghellini et al., 2015) and eating disorders

(Stanghellini & Mancini, 2019). Psychological and psychophysical investigations have also demonstrated the importance of temporal processing in disorders such as depression (Thönes & Oberfeld, 2015), schizophrenia (Lalanne et al., 2010; Martin et al., 2013; Martin et al., 2014) and autism (Casassus et al., 2019; Vogel et al., 2018). These findings raise the question of whether disorders of time can become clinically useful as predictors of disorder or markers for the early intervention of psychiatric conditions. Our paper addresses this gap in our current clinical-diagnostic knowledge, building upon and extending recent convergence of phenomenological and computational approaches (Martin et al., 2013; Stanghellini et al., 2017; Thönes & Stocker, 2019; Vogel et al., 2019).

Our proposal is that 'surface' level manifestation of psychiatric symptoms appear in many cases as expressions of deeper disturbances of basic constituent features of consciousness, with time consciousness a core aspect of consciousness per se (Kent & Wittmann, 2021). Nelson et al. (2020) argue that time experience and other phenomenological domains at these deeper levels (e.g. selfhood, affectivity, and embodiment) can be integrated with surface-level symptoms, although this requires these deeper phenomenological domains to be operationalized and dimensionalized (Fernandez, 2019). Time is a prime candidate for this purpose because it is inherently dimensional (i.e. objectively quantifiable as clock-time measurements but also as subjective reports of duration or passage) and is supported by decades of clinical data on psychopathological time perception (Kitamura & Kumar, 1983; Lehmann, 1967; Mezey & Cohen, 1961; Tysk, 1984). Whereas other phenomenological domains can also be cast in dimensional terms (Nelson et al., 2020), time has several scientific and clinical advantages: (1) it is objectively quantifiable; (2) it is prone to introspection as a comparatively well-understood concept from an early age (Droit-Volet, 2013; Tillman et al., 2018) and (3) although not universal (Janca & Bullen, 2003), time is mostly standardized across cultures.

The goal of the current article is to provide the framework for operationalization and dimensionalization of time disorders in various psychiatric conditions for possible diagnostic and predictive purposes. To this end, and based on previous accounts (Thönes & Stocker, 2019; Vogel et al., 2018), we first develop a conceptual model of subjective time integrating phenomenology and experimental psychology. Secondly, we then differentiate distortions of subjective time in a range of psychiatric conditions to sketch a transdiagnostic taxonomy of time (TTT).

2 | A BRIEF TAXONOMY OF TIME

Recent progress has moved towards a "standard framework" of subjective time. Vogel et al. (2018) proposed a phenomenologically-based model, whereas Thönes and Stocker (2019) provide a more psychological model based on objective experimental approaches. With the addition of a further component to Thönes and Stocker (2019) (i.e. time perspective), the current proposal integrates these two approaches a multi-dimensional model of psychopathological distortions in subjective time.

In their phenomenological model, Vogel et al. (2018) distinguish between two primary layers of subjective time (*Micro* and *Macro*) divided into sub-domains (*Flow* and *Structure*). The term "Structure" has several contradictory meanings in the time perception literature and so we have chosen a different term to Vogel et al. (2018), namely *Integration*. The concept of Integration refers here to temporal summing or smoothing, in that events at different discrete points in time are linked and connected with each other; Integration here and in the following denotes such temporal integration (Golesorkhi et al., 2021; Wolff et al., 2022). Taken in such a processing context, temporal Integration may underlie the constitution of the three-fold structure on both micro- and macro-levels. Hence, temporal Integration retains the meaning of Structure in their model through the connotation of *structural integrity*, meaning that the past, present and future are all well-defined, consistent and intrinsically stable. On the micro layer, integration also covers other crucial concepts of structure such as protention, retention, presentation and through the concept of an extended present moment which relies on exactly the kind of temporal integration we described above as it allows extending our consciousness beyond an isolated point of experience (Dorato & Wittmann, 2020). We do not perceive the present moment *at the time*, in other words, our conscious experience is always delayed while also predicting what is coming next (Hogendoorn, 2022). As such, a temporally integrated present moment spans a non-zero duration which we can further extend through short-term or working memory (Kent, 2019; Wittmann, 2011).

Moving on from Vogel et al. (2018) phenomenological model of subjective time, the more psychological model of Thönes and Stocker (2019) distinguishes different aspects of time used in experimental paradigms, termed here *Processing*, *Perception* and *Passage* of time. In integrating these two models, we add *Perspective* as an additional psychological domain, which has a longstanding evidence-base in mental health research and practice (Keough et al., 1999; Mooney et al., 2017; Wang et al., 2020; Zimbardo & Boyd, 2015). We have also slightly modified the Thönes and Stocker (2019) model to bring passage on equal footing with perception instead of being subsumed within a category that includes duration judgement (Wearden, 2015). These four psychological domains and the four phenomenological domains are capitalized when explained in further detail below.

Figure 1 depicts the two models and a combined cognitive-phenomenological framework, showing how the cognitive domains of processing, perception, passage and perspective map on to the phenomenal domains of micro and macro layers of integration and flow. Perception and perspective represent integration in micro and macro layers, respectively. Processing and passage represent flow (i.e. continuity between events) in micro and macro layers, respectively.

The most basic constituent of subjective time is the ability to discriminate between events in time so that everything is not experienced as occurring 'all at once' (cf. B-series; McTaggart, 1927). This is a primordial sense of flow or change. In the case of temporal processing in the micro layer, this happens automatically (unconsciously) and early in infant development with regard to motor and

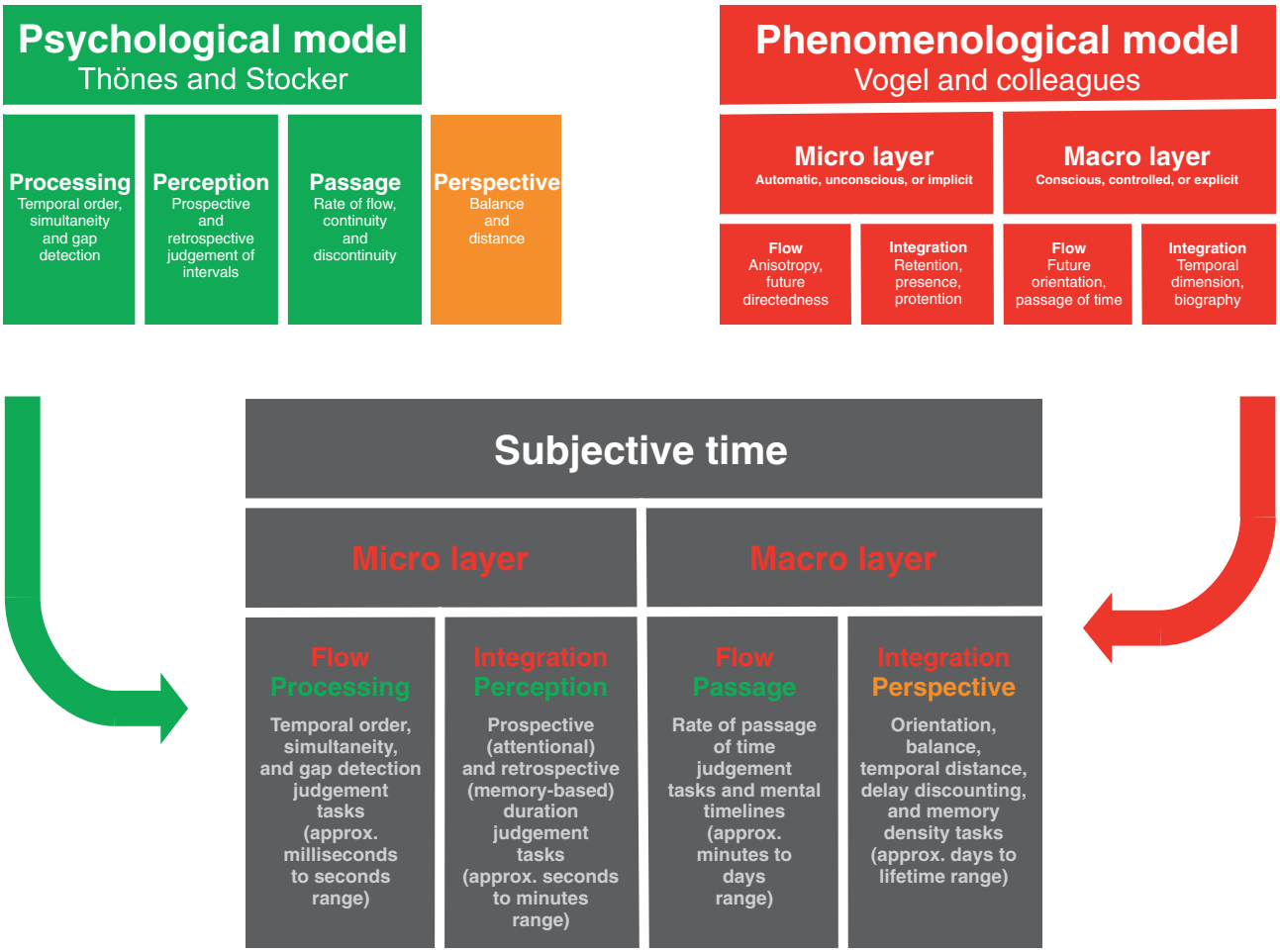

FIGURE 1 Integrated model of subjective time. Upper panels: Summaries of cognitive (left) and phenomenological (right) conceptual models proposed by Thönes and Stocker (2019) and Vogel et al. (2018), with the addition of perspective to the cognitive framework. Lower panel: A combined cognitive-phenomenal conceptual framework mapping cognitive domains of processing, perception, passage and perspective on to micro and macro layers of flow and integration (originally called structure)

perceptual timing abilities but, by about the age of three, can be made explicit using words like 'before' or 'after', 'longer' or 'shorter' (Droit-Volet, 2013). Despite these acquired skills of explicit temporal language, implicit Processing skills continue to function to control aspects of motor and perceptual timing, namely Micro Flow. Tests for temporal order and simultaneity/gap judgements show how individuals process temporal information to construct this primordial sense of flow between events (Thönes & Stocker, 2019).

Such Processing abilities may be attenuated in autism spectrum disorders (ASD), especially for tasks that measure the temporal binding window (TBW). A systematic review of timing and time perception studies reported four studies of wider or larger TBW's (and none with narrower or shorter TBW's) for adults and children with ASD using predominantly bimodal flash/beep psychophysical tasks (Casassus et al., 2019). A wider TBW means simultaneity can still perceived between less proximal stimuli in ASD than non-neurodivergent people.

Flow within the macro layer, which is less automated and develops later in childhood (Droit-Volet, 2013; Labrell et al., 2020), is indexed by experimental paradigms testing how individuals experience the Passage of time (cf. fast versus slow) and construct mental timelines, both of which are high-order explicit representation of temporal continuity and change (Droit-Volet et al., 2017; Vogel et al., 2018). Abnormally fast or slow passage of time is especially salient in mania and depression, respectively (Bschor et al., 2004; Moskalewicz & Schwartz, 2018; Stanghellini et al., 2017; Thönes & Oberfeld, 2015).

Temporal integration relates to the way the present moment is generated within the continuous stream of perceptual input to create a unique sense of 'now' that is distinct from past or future events (cf. the A-series; McTaggart, 1927). Within the micro layer, prospective and retrospective duration judgements indicate how individuals integrate their perception of time so that it can be measured against clock-time and communicated. Perception in this micro layer of subjective time is how children develop a sense of 'now' from more primordial, event-based demarcations of temporal flow (cf. before and after), and also how they learn to 'tell the time' explicitly in terms of duration (Labrell et al., 2020). Problems with perception and reduced

temporal integration in the micro-layer is most evident in attention deficit and hyperactivity disorder (ADHD) in children (Barkley et al., 1997; Nejati & Yazdani, 2020; Smith et al., 2002; Toplak & Tannock, 2005).

Temporal Integration in the macro layer relates to how individuals create a unique perspective on certain global features of their biographical past, present and future (Keough et al., 1999; Vogel et al., 2018; Zimbardo & Boyd, 2015). Perspective does not mean differing first- versus third-person accounts of the same event. Instead, it is how individuals view their overall individual life narrative (cf. "biography" in relation to macro integration; Vogel et al., 2018). Individuals dynamically balance their time perspective emphasizing different aspects (e.g. positive or negative, hedonistic or fatalistic) of the past, present and future experiences depending on the context or task at hand. Disbalance occurs when one of the past, present or future comes to dominate the others regardless of context. A balanced time perspective correlates with positive well-being (Drake et al., 2008), which is functionally different from imagining or recalling specific autobiographical events (Kwan et al., 2013). Instead, perspective is more related to constructs such as temporal delay discounting (Kwan et al., 2013; Lempert & Pizzagalli, 2010), temporal distance (Bar-Anan et al., 2006; Liberman et al., 2007; Rinaldi et al., 2017) and temporal orientation (Maglio & Trope, 2019). Problems with time perspectival macro integration are evident in conditions like post-traumatic stress disorder (PTSD) wherein, like depression (Wang et al., 2020), the past dominates the present and attenuates the future (Sword et al., 2014).

3 | A TRANSDIAGNOSTIC TAXONOMY OF TIME

We maintain that the above associations between disordered time experience and certain psychopathologies are not isolated examples. Instead, we propose that a transdiagnostic system explaining categorical psychopathologies can be informed by dimensional changes in underlying time disorders. Following the conceptual model of Figure 1, we further propose that subjective time varies along certain dimensions (i.e. Flow and Integration from high to low) on both micro- and macro-layers from ordered to disordered. This variation ranges continuously from moderate or 'healthy' degrees in non-pathological mental states, to extreme or 'unhealthy' degrees in mental states associated with psychiatric disorder. The next sections will align extreme distortions subjective time in each of the eight quadrants from Figure 2 with temporal distortions that have been demonstrated in different psychiatric disorders including depression, schizophrenia, anxiety, mania, autism spectrum disorder (ASD), attention deficit and hyperactivity disorder (ADHD), dissociative disorders, and disorders of impulsivity such as addiction, eating disorders and obsessive–compulsive Disorder (OCD). Figure 2 serves a heuristic purpose illustrating the logical construction of the TTT.

The first distinction in the TTT is between disordered time on macro versus micro layers. Micro-layer time represents automatic processes with predominantly unconscious processing that, in addition to being expressed in explicit judgements, can also be rendered implicit in timing behaviours (Martin et al., 2014; Vogel et al., 2018). As such, passage and perspective are generally phenomenally accessible in the Macro layer, but processing and perceptual processes are not. For example, we can easily introspect and even control passage and perspective (e.g. "time seems to be passing slowly because I am bored, so I will do something to entertain myself"), but the processing or perception of simultaneity, durations, or intervals is generally reflexive and automatic. This may seem counterintuitive because Perception entails accessible contents and judgements about intervals, events or durations, but the *integrative process* of time Perception is itself not accessible, that is, how the time we perceive is constituted.

In order to understand how and when time is disordered in psychopathology, the difference between automatic, implicit timing processes and controlled, explicit time perception abilities is a critical distinction to understand neurodevelopmentally (Droit-Volet, 2013) and neurobiologically (Coull & Nobre, 2008). Although distinguishable, for practical and clinical purposes the two are often intermingled, overlapping or interdependent. For example, i n relation to time integration and self in schizophrenia, Martin et al. (2014) argue that "time is seen as an implicit aspect of processing which does not necessarily lead to a content of consciousness but, rather, shapes the conscious experience" (p. 6). This quote is in reference primarily to patients' processing and perception abilities, but experimental paradigms often require explicit judgement. Martin et al. (2014) note that the "implicit processing of time may be especially relevant for minimal self but cannot be explored without considering explicit aspects" (Martin et al., 2014; p. 6).

In a clinical setting, this means that patients will find it easier to report disturbances in macro flow (e.g. "too fast" or "too slow") or Integration (e.g. a negative or unbalanced perspective on their past, present or future). Depression is a prime example. Patients often report both a radical slowing or dilation of temporal flow (Fuchs, 2013; Thönes & Oberfeld, 2015) in addition to feeling that time is overly integrated because the present and future are 'dominated' by the past:

> Typical sentences: "Future gloomy, invaded by the past"; "Guilty about past life suffocates me"; "I'm guilty of many things of the past"; "I have to be punished for past misdeeds"; "I'm terrified because I have done something in the past" [...] "Very long day and long night"; "I'm dying slowly"; "Time seemed an eternity"; "Time seems to drag"; "Time slowed down"; "I speak slowly" (Stanghellini et al., 2017; p. 7).

These subjective reports are very clear and relatively easy to elicit. This stands in contrast to the more complex case of disordered time in schizophrenia, especially during acute phases of the illness, where there is a more subtle 'lengthening' of automatic, pre-reflexive temporal units, resulting in a prolonged 'now' that is more implicit than the 'slowing' experienced in depression (Martin et al., 2013). Typical phenomenological reports of patients relate to both flow and integration:

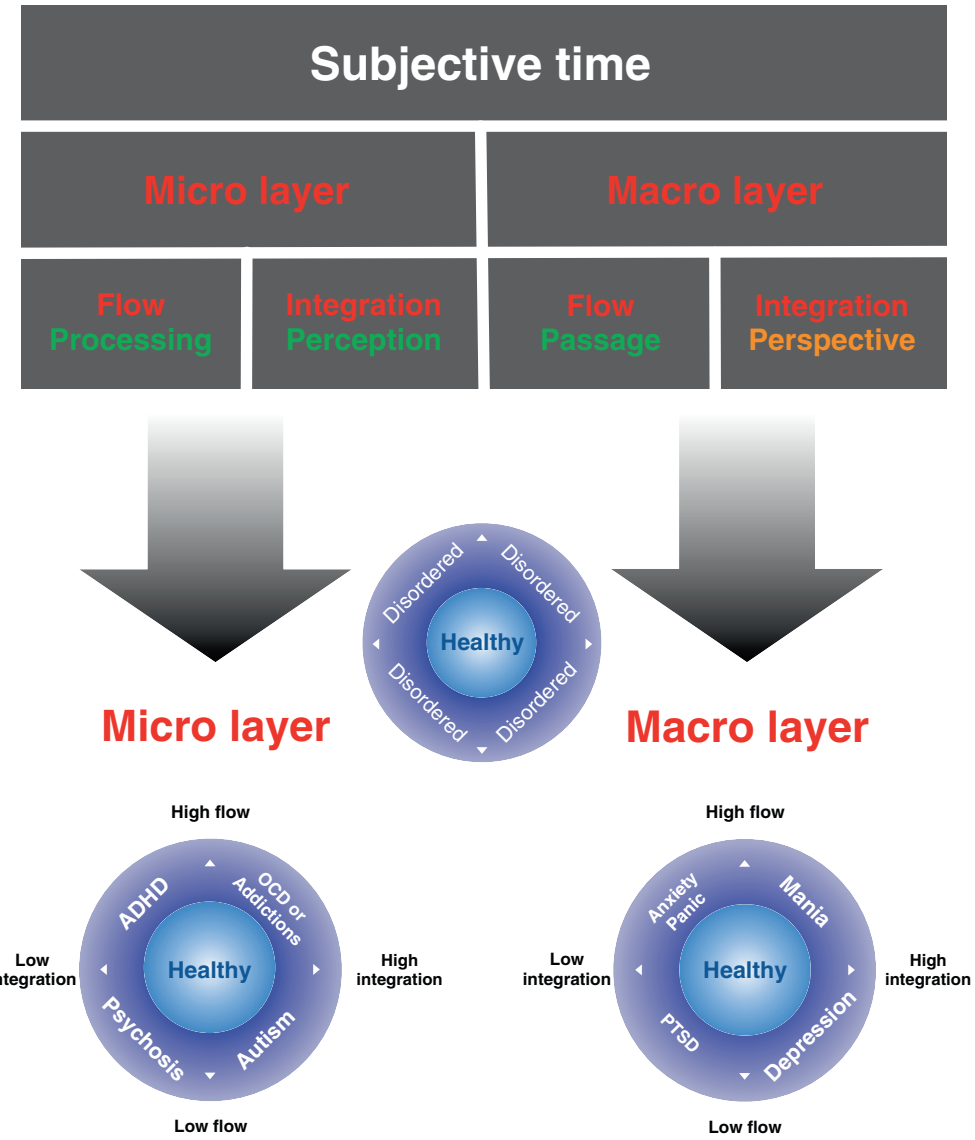

FIGURE 2 State space of healthy and disordered time. The framework of subjective time from Figure 1 converted into a state space of healthy and disordered time, the TTT. The hybrid framework represents a $2 \times 2 \times 2$ taxonomy of subjective time with healthy micro and macro time within the region of moderate levels of flow and integration. Subjective time is distorted or disordered in extreme regions of the state space, with different manifestations within eight diagnostic categories of psychiatric disorders

> "World like a series of photographs." "The time passes at jerky. I lost all the touch with time because I went sleeping." "Things glittering like a mirage like in desert." [...] "It was as if time was moving very slowly or quickly." "Mouth movement and speech of other out of synchronizing. One faster and the other slower." "Time slower, faster, timeless." [...] "I looked at a clock and it didn't mean anything."
>
> "It was all like a story. Middle of day seemed like night." "I felt I didn't know what the time was." [...] "I lost sense of time. Everything is a waste of time."
>
> "Time doesn't mean nothing because there is nothing to do, nowhere to go. Everything is closing around me." (Stanghellini et al., 2015; p. 51).

Meta-analyses of psychophysical and phenomenological studies confirm that depressed patients explicitly experience temporal slowing and dilation of the macro type (Thönes & Oberfeld, 2015). Thönes and Oberfeld (2017) conducted similar meta-analyses of time perception and temporal processing in schizophrenia and concluded that, unlike depression where the estimation of duration and temporal processing are both relatively preserved, micro-level disturbances of precision (but not accuracy) are severely impacted in schizophrenia. Schizophrenia and depression are therefore dissociated temporal processing and time perception, and potentially doubly dissociated given that passage or perspective were not addressed in either meta-analyses. We would argue that temporal Integration is impacted in depression as well as schizophrenia, but in distinct ways—on the micro-layer in schizophrenia and on the macro-layer in depression. Patients with schizophrenia exhibit micro-type impairments in the precision of their temporal processing without also experiencing a slowing of subjective time (Thönes & Oberfeld, 2017). The distinction between micro- and macro-type time disorders is the primary difference between many psychiatric disorders, as explained below.

4 | DISORDERS OF MACRO TIME: ABNORMAL EXPERIENCE OF TIME

As depicted in Figure 2, the macro layer of the TTT represents temporal distortions in flow and integration associated with depression, mania, anxiety, and PTSD, conditions in which flow and integration on the micro layer seem to be preserved. Specifically, subjects diagnosed with these disorders construct or constitute time in a normal way on the micro layer (processing or perception) but they suffer from distorted Passage or Perspective (macro layer).

As outlined above, symptoms of depression commonly associate with low or slow passage of time (Kent, Van Doorn, Hohwy, & Klein, 2019; Thönes & Oberfeld, 2015; Vogeley & Kupke, 2007) as well as an overly-integrated orientation towards a negative view of the past (Kaya Lefèvre et al., 2019; Stanghellini et al., 2017; Wang et al., 2020). Excessive temporal integration in depression manifests as rumination about the (negative) past (Baddeley, 2013; Koval et al., 2012; Watkins & Brown, 2002), a sense of hopelessness about the future (Beck et al., 1974), a constricted time perspective (Kovacs & Beck, 1986), and increased focus on the present fatalistic beliefs (cf. fatalistic and hopeless attitude towards life; Kaya Lefèvre et al., 2019).

The meta-analysis by Thönes and Oberfeld (2015) updated the intuitive assumption that slowed temporal passage in depression should also impact estimates of duration by either lengthening or shortening responses on time perception tasks. However, their analyses found that the slowing of time in depression does not seem to impact estimates of duration in a straightforward manner as expected. Kent, Van Doorn, and Klein (2019) re-analysed the medium-length time production tasks in the meta-analysis to show that, with proper methodological selection, production tasks may be impacted under certain conditions (i.e. empty intervals) but in the opposite direction to what is expected if time is experienced as slow or dilated. Depressive time dilation is a very complex phenomenon that depends very much on the duration of the interval under consideration, the experimental paradigm, and other critical factors (e.g. range of intervals in the set, order of presentation of the intervals, etc.).

Mania is the opposite of depression in that Passage of time is radically accelerated and there is an extreme orientation to the future (Bschor et al., 2004; Moskalewicz & Schwartz, 2018). However, there is a similarity with depression in that people report being 'stuck' in the present, although for paradoxically opposite reasons (Gruber et al., 2012; Stanghellini et al., 2017). Bipolar disorder can be viewed as alternating between high and low temporal flow depending on whether the past (i.e. ruminations) or future (i.e. delusions) have "become present" and so constrict the patient's time perspective (Northoff et al., 2018). Mixed states may also occur at the boundary between mania and depression, where passage is alternatively fast or slow, but this has not been adequately researched to date.

Compared to mania and depression, which are highly integrated temporal experiences, low temporal integration within the Macro layer some loss of structural integrity within the present. In terms of macro temporal integration, time perspective therapy has been shown to be effective in treating PTSD (Sword et al., 2014). Drakulić et al. (2018) surveyed those affected by war and found that many phenomenological aspects of subjective time are impacted in those with PTSD compared to others who had been exposed to the same wartime conditions but not developed the condition. Macro flow (succession) and macro integration (goal directedness) were "more prominent and specific disturbances in subjects with PTSD compared to those with other disorders taken together" (p. 23). Explicit (macro flow) passage judgements were also significantly affected in PTSD but the direction of distortion, whether fast or slow, was not reported, just the deviation from sample median. Temporal extension into the future, similar to Perspective, was also related to the frequency of intrusive or avoidance/numbing symptoms.

Dissociation is a common feature of PTSD (Lanius et al., 2002), which also plays a mediating role between childhood trauma and later dissociation (Terock et al., 2016). Given there is considerable debate about the transdiagnostic overlap between depersonalisation and derealisation with schizophrenia-spectrum psychoses (Humpston et al., 2020), it may be that dissociative disorders fall somewhere between PTSD on the macro layer and, as explained below, schizophrenia on the micro layer. Furthermore, dissociative amnesia and fugue are perhaps the clearest-cut examples of temporal *dis*-Integration, where memories (retrograde and anterograde) completely disappear (Staniloiu & Markowitsch, 2014). dissociative identity disorder (DID) is similar in that conscious experiences, thoughts and actions may be accessible only to the alternate or host identity within a single patient, and so temporal Integration is typically degraded by some degree of amnesia (Kihlstrom, 2005). Low flow indexing slow experience of the passage of time in dissociative mental states is due to the fact that time slows down during traumatic events (Arstila, 2012).

Anxiety, and in particular anxious arousal (Kent, Van Doorn, Hohwy, & Klein, 2019), involves a similar loss of temporal Integration but, unlike dissociation and PTSD, is accompanied by high (rather than low) temporal flow in the macro layer (Sarigiannidis et al., 2020). The lack of integration may be due to the relationship between anxiety and impaired spatial and temporal memory encoding of overlapping or ambiguous memories, an impairment that selectively affects the long-term recall of episodic memories (Bannerman et al., 2014). This degradation of macro temporal integration manifests because anxiety-related personality traits exaggerate the 'closeness' (i.e.,psychological distance) of future events, whereas depression-related personality traits do not (Rinaldi et al., 2017). As a result, anxiety is related to problems with future time Perspective (Kooij et al., 2018), whereas depression features problems with the past time perspective (Wang et al., 2020).

5 | DISORDERS OF MICRO TIME: ABNORMAL CONSTRUCTION OF TIME

Disorders in the micro layer of the TTT correspond to degraded constitution of time consciousness (Husserl, 1928/1991), meaning that

micro-layer processes constitute experiences on the macro layer (Vogel et al., 2018). Although patients diagnosed with psychosis, ADHD, OCD (and other compulsive disorders), and ASD may not offer non-cued reports of temporal disturbances in their conscious experience, they may still be able to identify or exhibit deficits in temporal processing and perceptual abilities. For example, psychophysical studies show that the temporal structure of the basic self (i.e. pre-reflexive, implicit sense of perspective) and consciousness in schizophrenia is characterized by an altered sense of demarcation (i.e. difficulty discriminating the present self) at the micro layer of implicit temporal processing and integration (Martin et al., 2013; Martin et al., 2014). When probed with temporal processing tasks that focus on succession or simultaneity of audiovisual stimuli, patients extend events over a "longer now" such that two events that healthy controls generally classify as discrete, patients often classify as simultaneous (Martin et al., 2013). This may reflect reduced or low flow of time on the micro-layer. At the same time, schizophrenia subjects also suffer from low integration on the micro layer such as when they confuse different moments in time through impaired temporal order and simultaneity judgements (Martin et al., 2014; Thönes & Oberfeld, 2017). Together, reduction in both flow and low integration on the micro layer can lead to what is described as a 'knot of stillness', which differs from the expansive, empty kind of slowing on the macro layer of flow experienced in depression (Stanghellini et al., 2015). Given that micro-layer processes constitute macro-layer temporal experiences (Vogel et al., 2018), psychotic individuals can also experience states mimicking depression and dissociation, especially for those exposed to more traumatic childhood experiences (Braehler et al., 2013).

Autism spectrum disorder (ASD) is also associated with low temporal flow on the micro layer but, unlike schizophrenia, shows high rather than low temporal Integration. As with psychosis, psychophysical studies show longer temporal integration (cf. a "longer now") for ASD patients in the form of larger or wider multisensory temporal binding windows (Casassus et al., 2019; Kwakye et al., 2011). This indicates low temporal flow on the micro layer in ASD. Hohwy et al. (2016) argue from a predictive processing perspective that, due to a paucity of higher-order predictions over longer timescales (Perrykkad & Hohwy, 2020b), ASD is characterized by reduced Flow which, in turn, causes sensory information to be processed for longer periods of time and in a more "detail-focused, local fashion, with less embedding into a larger context" (Hohwy et al., 2016; p. 331). A systematic review of time perception in ASD by Casassus et al. (2019) found a primary deficit in higher-order (cf. larger context) time perspective called 'diachronic thinking' (i.e. ability to place discrete events along a continuous temporal dimension). Allman and Meck's (2012) earlier review generally agreed with this conclusion and cited the 'weak central coherence' hypothesis of ASD to explain why individuals fail to 'see the big picture' of time, which is highly compatible with the disruption of flow on the micro layer.

In addition to low Flow, ASD exhibits abnormally high integration on the micro layer which clinically, we postulate, is manifest in the often obsessive repetitive behavioural patterns in this disorder. Studies of temporal integration suggest that ASD and schizophrenia spectrum disorders are similar when it comes to multisensory temporal binding windows but that unisensory acuity may be spared or even enhanced in ASD (Zhou et al., 2018). Enhanced unisensory acuity would provide greater temporal integration and help to explain repetitive unisensory behaviours in ASD, such as touching, that are similar to obsessive compulsive disorder (OCD)(Jiujias et al., 2017).

Repetition is a way to integrate time artificially and, while ASD shows low flow and high integration on the micro layer, addictive, obsessive and compulsive disorders show a different constellation of micro layer changes. Namely, high integration combined with high flow, rather than low flow as in ASD. This is clinically manifest in the impulsive nature of conditions such as impulse control disorders (Grant et al., 2005), substance use and addictive disorders (Chou & Ting, 2003; Jinha et al., 2017; Park & Hwang, 2009; Saunders, 2017; Wittmann et al., 2007) and OCD and eating disorders (Boisseau et al., 2012; Butler & Montgomery, 2005; Sohn et al., 2014). Whereas healthy 'Flow states' bring about a sense of timelessness when people are absorbed in an activity that offers them intrinsic reward and pleasure derived from their felt sense of masterful control (Csikszentmihalyi, 1975), pathological conditions of compulsion (Dixon et al., 2018; Dixon et al., 2019) or addiction (Chou & Ting, 2003; Jinha et al., 2017; Park & Hwang, 2009) are sometimes referred to as 'dark flow' states because the sense of timelessness is not associated with positive feelings of mastery or accomplishment but rather self-loathing or nullity. Abnormally high temporal flow on the micro layer tends to give preferential weight to the present at the expense of the future, meaning that the future 'time horizon' is contracted upon the present for impulsive or addictive behaviours (Wittmann & Paulus, 2008; Wittmann & Paulus, 2009). This highly flowing present-mindedness is clinically manifest in the impulsive loss of self-control (Jinha et al., 2017; Nigro et al., 2017) and drives certain behaviours that are present clinically in disordered addictions, obsessions, or compulsions (Boisseau et al., 2012; Butler & Montgomery, 2005; Hoffman et al., 2012; Jinha et al., 2017; Sohn et al., 2014; Wittmann et al., 2007),

However, impulsive flow in the micro layer need not be recursive or highly integrated. Early manifestations of impulsiveness in childhood may tend to be less recursive or object-focused, as in ADHD. Research has found a relatively pure time perception deficit and impaired time Processing mechanisms in ADHD (Barkley et al., 2001; Smith et al., 2002; Toplak & Tannock, 2005). A recent meta-analysis of time perception in ADHD (Nejati & Yazdani, 2020) has confirmed the findings of earlier reviews, such as by Allman and Meck (2012), in which children with ADHD showed deficits of delay (reward) discounting, time Perception, and coordination with clock-time or communicating with others about time(Barkley et al., 1997). The best intervals for probing time Perception deficits in ADHD are most likely those above 5 s (Nejati & Yazdani, 2020), but temporal processing deficits tend to show up in discrimination of intervals in the milliseconds range (Smith et al., 2002).

6 | MACRO AND MICRO DISORDERS OF TIME: BRINGING IT ALL TOGETHER FOR DIFFERENTIAL DIAGNOSIS

6.1 | Basic disturbances of time in different disorders

Figure 3 characterizes time for each of the eight quadrants of Figure 2 and associated psychiatric diagnoses. Healthy time across both micro and macro layers is smooth, flows at a generally pleasant rate, and places even structural weight on the past, present and future. Disordered time experience in the Macro layer distorts the structural relationship between the past, present and future and Flows either too fast or too slow. Time is smooth and Integrated in mania and depression (i.e. 'accelerated' in mania and 'dilated' in depression), whereas time in anxiety and dissociation/PTSD is less integrated, being 'turbulent' in anxiety (i.e. fast and disintegrated) and 'fragmented' in dissociation/PTSD (i.e. slow and disintegrated). Both depression and dissociation/PTSD Integrate too much past, whereas mania and anxiety are integrate too much future.

Disordered time construction in the micro layer distorts the transition between present moments so that time can become 'static', in the case of ASD, or 'disorderly' in the case of ADHD. Temporal Integration is also disintegrated or 'imprecise' in psychosis, as it is in ADHD, except that the present moment is decidedly longer. Disorders like OCD and addiction are 'recursive' or repetitive and so highly integrated like ASD, but also accelerated like ADHD, whereas ASD has a longer "now" like schizophrenia.

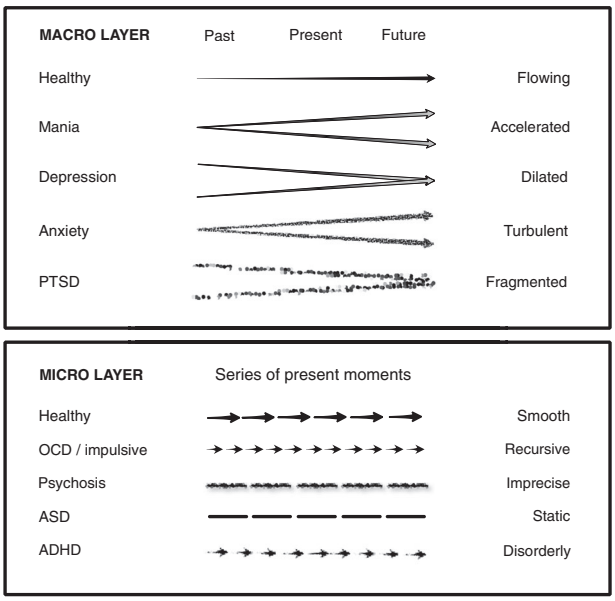

FIGURE 3 Varieties of disorder time. Graphic representation of the eight types of disordered time and corresponding categories of mental disorder. Clear lines or arrows in both layers represent highly integrated time, pixellated lines indicate low integration. Diverging arrows in the macro layer represent fixation on the future events, converging arrows represent fixation on the past events. Short arrows in the micro layer represent high flow, wide lines indicate low flow

6.2 | Dynamic nature of time disorders and relationship to symptoms

We are not suggesting that those diagnosed with particular psychiatric disorders always or exclusively experience time as characterized by the TTT in Figure 3 or as depicted in Figure 4. The layout of the taxonomy implies there can be a progression from one mode of time experience (macro) or constitution (micro) to another. This is especially so given the close inter-dependence of micro- and macro-layers and the fact that flow shapes integration (Vogel et al., 2018). Individuals can come in and out of the healthy zone during episodic illness and subsequent remission, and they can also move dynamically in and out of different 'time zones' (as per our 8-quadrant schema) depending on what symptoms they are experiencing currently. Individuals could also exhibit the secondary problems at an opposite extreme of temporal integration or flow in order to compensate for the primary time disorder.

For example, anxiety in response to a perceived threat (cf. high macro flow but low integration) could elicit compensatory addictive, obsessive, or compulsive behaviours that exert impulsive control (cf. high micro flow but high integration) over those unpleasant experiences. This may explain high comorbidity between conditions like generalized anxiety disorder (GAD) and OCD, their shared transdiagnostic features, and even their common aetiology in uncertainty intolerance or death anxiety (Gillett et al., 2018; Menzies et al., 2020). While the primary fear response may be at the root of OCD or eating disorders to substantiate them as anxiety disorders, their behavioural manifestation exhibits temporal distortions more reminiscent of other impulse control disorders that increase integration in the micro layer, leading to recursive behaviours of compulsion, obsession, addiction and so on (Grant et al., 2005).

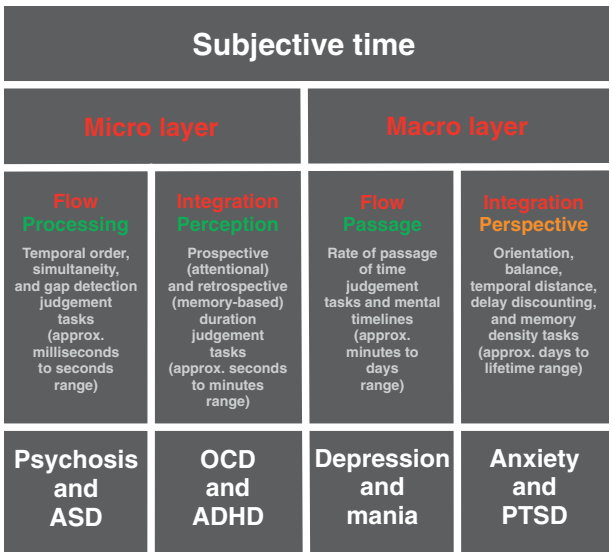

FIGURE 4 Testing for disordered time. Proposed primary tests for differential diagnosis or symptom tracking of each of the eight major categories of disorder identified with different disorders of time

Anxiety may not be the only disorder that commonly leads to impulsive compensatory behaviours. The same coping mechanism can arise in ASD (i.e. low micro flow but high integration) to increase Flow at the expense of Integration. From a predictive processing perspective, Perrykkad and Hohwy (2020a) propose that fidgeting, an endogenous non-goal-directed behaviour, helps individuals with ASD maintain expected rates of prediction error minimisation. Hohwy et al. (2016) propose the rate of prediction error minimisation translates into the rate of temporal flow, and so fidgeting can be viewed as a way of compensating for a 'static' time disorder in ASD by increasing flow through recursive, repetitive behaviours which may otherwise show up as compulsions, obsessions, or tics.

Time distortions must be seen as dynamic rather than static, meaning they can change over time along the different dimensions or trajectories of our eight-quadrant schema with its different 'time zones'. The blending of these 'time zones' in some disorders (e.g. dissociation), how co-morbidity shapes trajectories through or topologies within the TTT state space, and how compensatory mechanisms serve as attractors within the state space are all areas for future development with more fine-grained analyses and data aimed directly at testing the model.

6.3 | Clinical testing of time disorders

Based on the above analyses, we tentatively propose a testing framework to isolate time disorders within the eight diagnostic groups in the TTT above. These proposals are not definitive as there is much work to be done ascertaining their predictive power and diagnostic specificity. There are also many paradigms that sit underneath each methodology, so a more detailed analysis needs to be undertaken.

As a starting point, however, Figure 4 suggests that processing tests of micro flow such as temporal order and simultaneity judgements may suit psychosis (Lalanne et al., 2010; Martin et al., 2013; Martin et al., 2014; Stanghellini et al., 2015; Thönes & Oberfeld, 2017) and ASD (Casassus et al., 2019). Perception tests of micro integration such as prospective and retrospective duration judgements may suit OCD (Gu & Kukreja, 2011) and ADHD (Barkley et al., 1997; Nejati & Yazdani, 2020; Smith et al., 2002; Toplak & Tannock, 2005). On the macro layer, Figure 4 suggests passage tests of flow such as rate of passage and mental timelines (including metaphors and movement) may suit depression (Stanghellini et al., 2017; Thönes & Oberfeld, 2015) and mania (Bschor et al., 2004; Moskalewicz & Schwartz, 2018). Perspective tests of macro integration such as orientation/balance and temporal distance may suit anxiety (Kooij et al., 2018; McKay et al., 2016; Rinaldi et al., 2017) and dissociation or PTSD (Kihlstrom, 2005; Lanius et al., 2002; Sword et al., 2014).

Early intervention in psychiatry could harness these testing approaches to add depth and nuance to clinical phenotyping through phenomenological psychopathology, as suggested by Nelson et al. (2020). The phenomenological approaches related to tests on the macro layer (i.e. passage and perspective) could also be combined with psychophysical measures of temporal processing and time perception to forge a powerful combination of subjective and objective data. Doing this in a transdiagnostic way would also accord with a transdiagnostic staging approach to emerging psychopathology (McGorry & Nelson, 2016).

7 | CONCLUSION

Psychiatric disorders show various affective, sensory, and cognitive changes as manifested in various surface-level symptoms. There is yet a deeper dimension, though, concerning mainly abnormalities in the experience or perception of time as outlined in both phenomenology and psychology. What may be especially helpful for clinical use, as Nelson et al. (2020) argue, is if phenomenological domains can be dimensionalized (although not diluted in the process) in order to link them to clinical symptoms and stages for early intervention (Fernandez, 2019).

Converging recent models of subjective time, we here propose a step towards using time disorders in the differential diagnosis of various psychiatric conditions. Based on phenomenological, psychological and clinical evidence, we propose a clinical taxonomy along the dimensions of flow and integration of time on micro and macro layers. Extreme degrees in either direction (extremely high or low flow or integration on either micro or macro layer) can be observed in different psychiatric conditions including psychosis, ASD, anxiety, obsession/compulsion, PTSD, ADHD, depression, and mania. We postulate that such basic temporal changes may strongly affect behaviour in these subjects including their perception, emotion, and cognition. Psychopathological symptoms may represent more basic changes in the constitution of time (and space) entailing what recently has been described as 'spatiotemporal psychopathology' (Northoff, 2016a, 2016b, 2018b; Stanghellini et al., 2017).

A key aspect of the future research will be exploring neural mechanisms and correlates of the time disorders proposed above. Ideally, this will allow triangulation of temporal (and spatial) features shared across neural, clinical, and psychological/phenomenological domains, a methodology Northoff et al. (2019) characterize as the 'common currency' approach. This permits an 'apples with apples' comparison between different psychiatric disorders with respect to their changes in time experience/processing. This may improve understanding of both shared and differential features in time distortions and symptoms of various psychiatric disorders as a key requisite for their proper differential diagnosis and early intervention (Damiani et al., 2019; Northoff, 2018a, 2018b; Northoff, 2020; Northoff et al., 2018; Northoff et al., 2020).

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