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Schizophrenia and the Moving Body
transforming disembodiment into a measurable concept

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Abstract

Schizophrenia presents with a complicated clinical picture and causes immense suffering in the affected individuals and caregivers. In reaction to the lack of satisfying options for treatment and the ongoing academic dissent on the condition's origin, the interdisciplinary *embodiment approach* emphasizes bodily mediated, pre-reflective experiences in schizophrenia etiology and treatment and focuses on the role of the (moving) body within psychiatric research on schizophrenia psychopathology.
Schizophrenia is understood to be caused by a so-called *disembodiment*, which implies that it is not the psychotic symptoms which are essential for the understanding of schizophrenia, but rather the early and continuous disturbance of the pre-reflective, implicit functioning of the body in everyday life. *Disembodiment* is understood to manifest in symptoms on various experiential levels, such as basic self-disorders, motor abnormalities or a disturbed interbodily resonance, most of which are discussed phenotypic markers of schizophrenia vulnerability already, but are rarely studied in relation to each other. Scarcity of respective research or self-disorder and motor abnormality assessment in daily diagnostics might be due to the inconsistency of concepts and the lack of objective and sensitive assessment means for full-body movement and embodied interaction.

Filling this gap, the dissertation project aimed at operationalizing disembodiment. Measurable aspects of disembodiment were defined, the examination of anomalous self-experience (EASE) translated, a study protocol for objective movement assessment and analysis developed and a tool for an assessment of disembodied interaction proposed.
Within three mixed-methods studies, the abovementioned methodology was applied. In the first study, I quantified data-driven and theory-independent movement markers (MM), comparing simple gait of patients with schizophrenia and controls. In the second study, we analyzed balance characteristics of participants with schizophrenia. In the third study the MM were systematically related to changes in self- and body experience of respective patients.

Results show that MM extracted and quantified from basic walking can differentiate between people with schizophrenia and controls. Many MM are related to the integration and adjustment of body sides, limbs or the direction of movement. Furthermore, patients with schizophrenia show significant disturbances in static and dynamic balance which also are related to the integrative movement of body parts for an adaptive balance strategy. The MM are related to quantitative and qualitative measurements of changes in self- and body experience, or to SDs. Integration- and coordination-related MM significantly correlate with somatic depersonalization and loss of ipseity. Descriptions of specific anomalous self-experiences, such as hyperreflexivity, systematically increase with greater MM manifestation.

The findings emphasize that manifestations of disembodiment can be measured. They further imply that motor impairment and self-disorders, instead of individually being understood as endophenotypes of schizophrenia vulnerability, can be considered two manifestations of and their interrelation preliminary evidence for one underlying disturbance of schizophrenia, namely a disturbed pre-reflective and embodied consciousness.

Abbreviations

AIM	Abnormal involuntary movements
BPT	Body Psychotherapy
BMI	Body mass index
CD	Corollary discharge
CoP	Center of pressure
CoM	Center of mass
DMT	Dance and Movement Therapy
DW	Discriminant walker
EASE	Examination of anomalous self-experience
ECSP	European collaboration on movement and sensorimotor/psychomotor functioning in schizophrenia and other psychoses
FD	Fourier decomposition
GMA	General Motor Abnormalities
ISM	Interpersonal sensory matching
LDF	Linear discriminant function
LSA	Latent semantic analysis
MM	Movement markers
MoCap	Motion Capturing
MP	Movement profile
NSS	Neurological Soft Signs
PANSS	Positive and negative symptom scale
PCA	Principal component analysis
PCE	Perceptual crossing experiment
PAS	Perceptual awareness scale
SD	Basic self-disorder
ZITI	Institute of Computer Engineering, Heidelberg University
ZMP	Zero moment point

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1 Introduction

"[At times, my body and mind] did not fit anymore.
It was very strange, like when having new shoes that your feet have not yet gotten used to, but related to the whole body […].
It felt very unusual, strange and wrong. […]
I was in my body, but somehow not – mistakenly. […] The spirit was in the body, but it did not quite fit. Like, when you try – I don't know – to install Windows on an Apple computer […]."

SF03
study participant with schizophrenia
translated from German to English
by the author

1.1 Living with schizophrenia

Schizophrenia is a severe mental illness. It presents with a complicated clinical picture and causes immense suffering in the affected individuals and caregivers [1-5]. It affects around 1% of the world's population, is found in every culture and socioeconomic context and mostly emerges at a young age (18-35 years) [6, 7]. According to ICD-11 the illness is characterized by positive symptoms, such as persistent delusions, hallucinations, disorganized thinking and behavior, as well as by negative symptoms, including blunted affect, avolition, anhedonia, social withdrawal, and psychomotor disturbances [8-10]. Although the diagnosis *schizophrenia* has existed for over a century and pharmacological treatments have drastically improved, a cure or a satisfactory way of living with the illness seems as elusive as ever [1, 5]. While atypical neuroleptics mostly succeed in treating acute psychotic states by reducing positive symptoms, persistent negative as well as psychomotor symptoms are often unmet [1, 5, 11]. Three quarters of affected individuals present with recurrent symptoms with a considerable impact on their daily and social lives and full remissions are scarce [2, 3, 5, 12]. Furthermore, pharmaceutics, which have been the backbone of schizophrenia treatment since their introduction in the 1950s, have numerous limitations: Heterogeneous treatment responses and a number of disabling side effects lead to poor treatment adherence on the recipients' side as well as a trial-and-error-strategy with respect to treatment choice on the clinicians' side [5, 12, 13]. Most individuals pass through many hospitalizations and medication changes until they find a tolerable way to live with their illness [1, 5, 11]. Moreover, the lack of symptom remission, persistent deficits in cognitive abilities, poor physical health, and difficulties in forming and maintaining relationships lead to impaired occupational functioning and social isolation [6, 14]. Approximately 70 % of people with schizophrenia are unemployed [6]. They have smaller social networks and less satisfactory interpersonal relationships than healthy individuals or subjects with other diagnoses [15]. Consequently, it comes as no surprise that, each year, one in ten patients with schizophrenia will commit suicide [16].

1.2 The embodiment approach

Traditionally, cognitive sciences tend to separate mind and body [17, 18]. Therefore, schizophrenia has largely been regarded as an alteration confined to the individual's brain and research has focused on the malfunctioning of neural regions and brain circuitries involved in specific, mostly psychotic behavioral patterns [19, 20]. However, the lack of satisfying treatment options as well as an ongoing academic dissent on the condition's origin and symptom structure have paved the way for the development and acceptance of an innovative, interdisciplinary approach to the illness [21, 22]. Combining theory and practice from disciplines such as philosophy, psychology, psychiatry and neuroscience, the *embodiment approach* emphasizes bodily mediated, pre-reflective experiences in schizophrenia etiology and treatment and brings back into focus the role of the (moving) body within psychiatric research on schizophrenia psychopathology [23-25]. Acknowledging the integrative and holistic character of the human brain-body-environment system, the focus is shifted from higher-order cognitive processes ('theory of mind', 'meta-representation') [26] to the interplay between mind, body and environment in the diagnosis and treatment of the illness [20, 24, 27-29]. Known theories such as the vulnerability/stress model [30] or the concept of basic symptoms which emerge in prodromal stages long before any psychotic onset [31] are complemented by detailed analyses of the continuum reaching from divergent self-, body and world experiences to full-blown delusion and psychosis [32-34].

1.2.1 The embodied self

In order to grasp the idea of an implicit and embodied pre-reflective experience and its alteration through schizophrenia a little excursion into concepts of the self is required. Following contemporary perspectives in phenomenology, developmental psychology and cognitive neuroscience, we can distinguish (1) the *basic, pre-reflective or core self* from (2) the *extended, reflective or personal self* [33, 35-39].

(1) The basic, pre-reflective sense of self is an integral part of all our experiences. It is the implicit knowledge of "I am me, and I am the one looking at or touching the tree" [39-41]. Any sensation or action towards an object or another person implies a tacit self-awareness which does not require active introspection [35]. Phenomenologists also speak of "ipseity" when describing the unconscious first-person perspective of all our experiences [37, 39, 42]. Ipseity or the 'mineness' of all experiences is so basic, that it is even preserved in cases of memory loss, such as amnesia or dementia [35, 39]. Fuchs [39] differentiates three dimensions of the basic, pre-reflective sense of self: (a) *the primary bodily self*, (b) *the ecological self*, and (c) *the social self*.

   (a) The basic sense of self is no abstract, disengaged ego, but requires the implicit or unconscious usage and awareness of the body in everyday life [35]. Seeing or touching a tree always comprises the background feeling of the body, including interoception and proprioception [35, 40, 43]. The *primary bodily self* constitutes this pre-reflective awareness of the 'lived body', which is necessary for a general embodied affectability, a basic self-affection, and the so-called "feeling of being alive" [37, 39, 43]. It furthermore facilitates a fundamental temporal self-continuity and -coherence, rooted in a passive synthesis of inner time consciousness, which enables us to experience meaningful perceptual *Gestalts* (including the own self)

instead of fragmented points in time [39, 44]. With these two aspects it provides for an automatic and continuous attribution of sensations and experiences to one's own body and oneself [45].

(b) The proper development of ipseity not only contains self-affection but also involves the sensorimotor relation to the world mediated through the body with its habitual capacities and constraints [35, 39]. Being embodied, the *primary self* engages with a surrounding environment and becomes an *ecological self* [46], which is embedded in a 'lived space' that presents itself as horizon of possibilities, affordances, barriers or obstacles [35, 39, 45]. The development of the *ecological self* dates back to early prenatal stages (as early as 12 weeks in the womb), where the fetus is in diverse sensorimotor contact with its environment, evident through increasingly organized movement patterns and responses to tactile or auditory stimuli [39]. Through the continuous integration of proprioceptive, kinaesthetic and multisensory signals an early sense of sensorimotor self-coherence is formed, which is likely to include fundamental experiences of self-agency, that is, experiencing oneself as the source of spontaneity, activity and changes in the environment [ibid.].

(c) Through early embodied interactions (bodily-affective resonance), the infant learns to recognize itself in others and develops a *social* or *basic intercorporeal self* [35, 39, 47]. Already shortly after birth, newborns are able to imitate facial expressions of others, which means they experience the other's body as akin to their own [35]. Repetitive imitation enables a bodily resonance with the caregiver, which soon develops into shared affective states, emotional attunement or *interaffectivity* [35, 39]. Over time the child acquires an *implicit relational knowledge* [48], a pre-reflective understanding of how to interact with others, exchange emotions, capture attention, avoid rejection or overstimulation, and restore contact [39]. Thus, basic self-awareness not only requires an embodied interaction with the physical environment but also intercorporeality with others [35]. Researchers from cognitive science, who focus on enactive theory, refer to the "mastery of sensorimotor and self-other contingencies" when discussing the same phenomenon [49].

It seems important to note again, that all the above-mentioned dimensions of primary self-awareness are usually an unconscious and implicit background to our experience of the world. Their development dates back into prenatal life, further develops in the first year of life and does not require active self-reflection or social attribution [ibid.].

(2) In contrast, the *extended*, *reflective* or *personal self* refers to the ability to consciously recognize oneself as "me", differentiate oneself from others, and to grasp and define oneself over time [39]. The *reflective self* develops from the age of two, when children start to recognize themselves in the mirror [35, 39]. It is formed by the capacity to take over the perspective of others, contains internalized attitudes towards oneself or adopted roles offered by the community and is the basis of an autobiographical identity or narrative of oneself [35]. The *personal self* is thus intersubjective in nature: It emerges in constant interaction with others and requires complex shifts from egocentric to allocentric space and perspective [ibid.]. Despite its intricate, dialectic structure, the *personal self* remains based on the pre-reflective basic self in the sense that only a human being with an intact and coherent sense of ipseity is able to form and narrate stories about herself or an identity of herself [24, 35]. Thus, disturbances of basic self-experience will always affect the *personal self* as well [39].

1.2.2 Disembodiment and disembodied interaction

In embodiment research the “lived body” (*Leib*) is understood as a transparent medium or background to all our experiences [20, 29, 50]. Only through the pre-reflective, automatic and self-evident usage of the body, we can focus on reflexive and intentional actions: We can reach for a cup of tea without thinking about how far the arm needs to be stretched or how much force we need to apply to hold the cup [41].

On this basis, schizophrenia is understood as a fundamental disturbance of the pre-reflective, implicit functioning of the body; a so-called *disembodiment* [20, 34, 45, 51]. This includes an erosion of all abovementioned aspects of the basic, pre-reflective sense of self: (a) so-called basic self-disorders (SDs), (b) an associated disruption of implicit bodily functioning in both perception and action, and (c) a feeling of disconnection from others (reduced interbodily resonance) [1, 5, 28, 51].

(a) SDs can be understood as subtle perturbations of the *primary bodily self* – the unconscious feeling of being the owner or creator of one’s own experiences, thoughts and actions [33, 34, 52]. The pre-reflective immersion of the self in the body and subsequently, the self-evidence with which the ‘lived body’ mediates sensory perception, action, emotional expression (see b), and social interaction (see c) is increasingly lost [34, 40]. Many patients report a pervasive inner void or a lack of presence, sometimes dating back into childhood [34, 51, 53]. These feelings often are accompanied by an experiential disconnection from the own body as well as a range of abnormal bodily sensations, such as cenesthesias, boundary loss, and body schema centralization (see introductory citation on p. 3). Affected individuals no longer feel at home in their own bodies, which in intense states might result in increased mirror exposure or compulsive rituals, such as stereotypical movements with repetitive self-contact and self-stimulation (e.g. clapping/tapping hands) [1, 35, 54].

(b) Feelings of depersonalization are accompanied by a disturbance of the *ecological self*: a disruption of the implicit functioning of the body in everyday perception and performance [45, 55]. Meaningful actions or movement sequences, such as walking stairs, tying shoes or reading, are fragmented [20, 45, 56]. The loss of sensorimotor coherence results in a disautomation of movement acts, a hyper-reflexive awareness to and a pathological explication of normally tacit behavior [45, 51]. Unconscious sensorimotor processes suddenly become available for introspection and have to be prepared and produced deliberately, in a way that phenomenologists call a ”Cartesian” act of the mind on the body [35]. The term hyperreflexivity refers to a non-volitional and continuous self-observation, which in a vicious cycle further disrupts automatic actions and perception [39, 45, 51, 57, 58]. The following citation of a patient gives us an idea of the limitations these experiences cause in everyday life:

> “*If I do something like going for a drink of water, I’ve to go over each detail – find cup, walk over, turn tap, fill cup, turn tap off, drink it*” [59, p. 239].

Concerning perception the disruption of embodiment results in the deconstruction of familiar patterns or Gestalts [35, 60]. Single elements of perceptual units lose their related meaning and stand out separately, forming new idiosyncratic saliencies which take up attention and often leave patients incapable of concentrating [35, 45]. With growing alienation of perception and the fragmentation of its meaning, objects or environments become artificial, enigmatic, and uncanny [35, 61]. The act of perceiving

itself might become aware, rendering patients spectators of their own perceptive process:

> *"For me it was as if my eyes were cameras, and my brain was still in my body, but somehow as if my head were enormous, the size of a universe, and I was in the far back and the cameras were at the very front. So extremely far away from the cameras"* [61, p. 329].

Eventually, in acute psychotic states, subjects lose the sense of agency for their own perception, emotions and actions and experience existentially threatening delusions of imposed perception or alien control [35, 40].

(c) Altered self- and body experiences ultimately also affect the patients' embodied communication or *social self* [34, 35, 40]. A disturbed embodiment of self-experience is accompanied by a perturbation of interbodily resonance, meaning the pre-reflective, context-sensitive understanding of everyday interactions [35]. Many patients are increasingly incapable of making sense of felt emotions and of adequately expressing or following them with gestures or movement [1, 62]. This results in a fundamental alienation of intersubjectivity [20, 35, 61]. In cognitive science terms: A disturbed mastery of *sensorimotor contingencies*[1] always extends to the social domain, meaning a disturbed mastery of *self-other contingencies*[2] [49]. Embodied habituality and familiarity is also the basis of the so-called *common sense* [62]. Patients report that they question the meaning of everyday situations and given conditions and feel isolated and detached from others [35]. They present with pronounced interaction difficulties, such as reduced emotional expression, reduced synchrony, or inadequate gestures [15, 40, 63, 64]. The loss of "natural self-evidence" [65] and the basic sense of being-with-others in a shared experiential world leads to constant stress in complex social situations and increases tendencies of social withdrawal [35].

Against this background, it is not the psychotic symptoms which are essential for the understanding of schizophrenia, but rather the early and continuous destruction of basic self-awareness, rooted in a disruption of the implicit and automatic usage of the body in everyday life [33, 35]. A recent meta-analysis found evidence for the selective aggregation of SDs in schizophrenia spectrum disorder as compared to other mental disorders and healthy controls [52, 66]. SDs occur in patient groups with clinical and ultra-high risk for psychosis, gradually increase from prodrome to psychosis [67], and can predict a future diagnosis of schizophrenia spectrum disorder [68]. Hence, SDs are considered a "phenotypic marker of vulnerability to schizophrenia" [66, p. 107] or a generative condition for certain symptoms to arise [40]: As described above, productive symptoms can be understood as an interpretation of and a reaction to patients' intense changes in self-perception [33]. Also, negative symptoms, such as flat affect, a centralized body schema, and social and emotional withdrawal can be regarded as a direct consequence of a disembodied self-perception and affectivity [1, 54]: In an attempt to preserve at least core aspects of the self, patients withdraw attentional resources from the body periphery [35, 69]. Because social interaction becomes increasingly difficult, they start keeping to themselves [ibid.].

[1] Sensorimotor contingencies are defined as "the know-how of the regular ways in which changes in sensations depend on changes in movements" [49, p. 1].

[2] Self-other contingencies are defined as the understanding of "the regular ways in which changes in others' movements depend on changes in one's own movements" [49, p. 1].

1.3 Embodied therapies

Researchers committed to the embodiment approach not only systematically consider the lived body for the understanding of mental illnesses' etiology but also stress the need of targeting bodily experiences and movement in order to change emotions, cognition and behavior [5, 18, 70-72]. This becomes specifically significant in the case of severe mental disorders when verbal dialog can be difficult for the patient [12, 56]. Different from conventional psychotherapies, embodied therapies, such as Body Psychotherapy (BPT) or Dance and Movement Therapy (DMT), appreciate body motion and sensorimotor experiences as a source of information, knowledge and expression [70, 73-75]. Therapists mostly work with a non-verbal, practical and procedural knowledge for symbolic communication in order to achieve individual therapeutic goals [27, 76, 77]. While BPT mostly happens in a one-on-one context and combines nonverbal interventions with insight-oriented conversations, DMT primarily takes place in group settings and focuses on creative movement to improve emotional, cognitive, physical and social integration [5, 70, 78]. Embodied therapies have been shown to decrease depression and anxiety and increase quality of life as well as interpersonal, cognitive and psychomotor skills in general [79, 80]. In schizophrenia treatment, they have been particularly helpful with the reduction of persistent negative symptoms [1, 5, 81]. Specifically, patients' blunted affect and attention deficits were decreased [5]. Consequently patients scored higher on their subjective well-being [1]. Effect sizes were moderate and symptom reduction accounted for 20.65 %, which is relatively high in comparison to any other intervention targeting negative symptoms [5, 82, 83]. While it is highly valuable to find a way of addressing treatment-resistant symptoms, the underlying therapeutic mechanisms of embodied therapies remain a subject of discussion [5, 81].

1.4 Movement in diagnostics and staging

Diagnostic observations of movement abnormalities or sensori- and psychomotor functioning in individuals with schizophrenia are far from new. They have been described as early as the 19th century [84, 85]. Even though motor symptoms were reported in the preneuroleptic era, with the introduction of antipsychotic medication they lost their clinical and academic relevance; researchers and clinicians mostly ascribed respective symptoms to side effects of neuroleptic treatment [23, 86]. Today, with the rise of the embodiment approach, psychomotor symptoms are not only recognized as an important aspect but even considered a prognostic biomarker for neurodevelopmental alterations contributing to a vulnerability to schizophrenia [86-90]. Similar to SDs, motor abnormalities can be observed in up to 80% of all patients with schizophrenia, in 66% of first-episode, antipsychotic-naïve patients, and to a lesser degree in ultra-high risk individuals or unaffected first-degree relatives with a genetic risk for schizophrenia [23, 86, 89, 91, 92]. Since 2013 "abnormal psychomotor behavior" appears as a specifier of schizophrenia severity in the DSM-5 [93], since 2019 "psychomotor disturbances" are mentioned alongside positive and negative symptoms in the ICD-11 [10]. In 2017, the European collaboration on movement and sensorimotor/psychomotor functioning in schizophrenia

and other psychoses (ECSP) was established to foster systematic collaborations and define key principles and elements of research on movement disorders of schizophrenia [94].

1.4.1 Defining movement abnormalities

Despite the heightened interest in sensori- and psychomotor functioning of patients with schizophrenia, terms and definitions of the respective symptoms are far from clear. Not only do authors use a variety of umbrella terms for movement related symptoms, categorizations and descriptions of movement abnormalities vary greatly with different academic background, conceptual framework and assessment means of research teams [89]. Hirjak and colleagues [86] for example, classify four groups of so-called “genuine motor abnormalities (GMA)” : (1) neurological soft signs (NSS): observable impairments in e.g. sensory integration, motor coordination, balance, sequencing of complex motor acts and primitive reflexes [91, 95], (2) hyperkinetic abnormal involuntary movements (AIMS): dyskinesia, dystonia, akathisia or hyperkinesia, (3) hypokinetic AIMS: spontaneous parkinsonism, and (4) catatonic phenomena, which can present as hyperkinetic (e.g. mannerisms, stereotypy, excitement, perseveration) or hypokinetic (e.g. catalepsy, stupor, rigidity, immobility, mutism) movement disorder [89]. Pavlidou & Walter [96] speak of movement abnormalities and label six symptom categories: (1) Dyskinesia – AIMs, (2) parkinsonism, including akinesia, rigor and tremor, (3) akathisia, including restlessness and inner tension, (4) NSS (5) catatonia, including decreased, increased and abnormal movements, disturbances of volition and autonomous instability, and (6) psychomotor slowing, affecting fine and gross movements, such as writing or walking [89]. Some authors include deficits in gesture behavior or impairments in eye movement in the set of motor abnormalities associated with schizophrenia [97-99]. Different investigators pose different names for the same symptoms or syndromes: Depending on the underlying concepts, reduced movement is referred to as stupor, bradykinesia or avolition; involuntary movements are termed parakinesia or dyskinesia and rigidity is considered a sign of both, parkinsonism and catatonia [23].

1.4.2 Assessing movement abnormalities

Consequently, symptom definitions in rating scales for motor disturbances are confusing and overlapping. Some rating scales for NSS for example include items such as rigor or tremor which are also part of scales for parkinsonism, dyskinesia or catatonia [23, 100-104] Moreover, conventional assessment relies entirely on the subjective observation of the respective rater: Rating scales are prone to observer bias, depend on extensive rater training for a certain accuracy and are not designed to detect subclinical or subtle movement abnormalities [89, 105]. In contrast, instrumental assessment promises great advantages, as it lacks observer bias, is highly sensitive and creates results that are linearly related to the severity of respective motor symptoms (as opposed to ordinal outcomes of clinical ratings) [89, 94, 105]. Currently, there are various innovative, instrumental attempts to assess and quantify motor abnormalities of people with schizophrenia: They include the assessment of force variability in hand movement with an instrumental force transducer, the analysis of handwriting with a tablet and a respective software, accelerometers in smart phones to study tremor, specially designed gloves to study gesture disturbances, the mirror

game and a handle bar to record individual arm movement and nonverbal interaction with an artificial agent, pressure sensitive electronic foot switches for step and gait analysis, pressure-sensitive platforms for the measurement of postural sway, and actigraphy to assess restlessness and the overall activity of individuals [104, 106-117]. However, most studies applying instrumental assessment restrict their analysis to fine motor performance in individual movement, movement of the upper limbs, or static aspects of balance control and coordination [97, 116]. The few studies which evaluate gait or dynamic balance and coordination, as examples of full-body movement in people with schizophrenia, analyze highly reduced (stride length, cadence) or very broad (overall activity) variables [116, 118-120]. Even fewer studies find instrumental ways to study (dis-)embodied interaction in people with schizophrenia [117, 121].

All things considered, our current diagnostic system fails to include the objective assessment and evaluation of subtle and overt motor behavior [89, 97]. This impedes the systematic association of movement related symptoms with clinical and neurological parameters, or with the self-experience of patients. It also hinders the observation of the long-term development of movement abnormalities – e.g. in the progression from prodrome to psychosis -, as well as a comprehensive and unifying definition of a motor domain in schizophrenia.

2 Objectives of the dissertation

Although the embodiment paradigm and supportive evidence have helped in regarding the manifold and heterogeneous symptoms of people with schizophrenia from an integrative point of view and inspired innovative treatments (see e.g. [122]), they have not resulted in a fundamental change of diagnostics and assessment methods. Interestingly, despite localizing schizophrenia on an implicit or pre-verbal level, phenomenologists ask subjects to reason and reflect upon their symptoms (see e.g. [53, 123]) without systematically assessing the neurocognitive or sensorimotor underpinnings of changes in embodied self-experience [124-126]. Both, basic self-disorders as well as movement abnormalities are discussed as prognostic phenotypes of schizophrenia vulnerability [66, 90]. Sometimes, they are even considered two sides of the same coin or two poles of one underlying disturbance [52]. Yet, studies which systematically relate SDs to movement abnormalities are scarce [52, 127]. Furthermore, the embodied interaction between the person and others as well as her embeddedness in the social world is rarely considered. Reasons for this scarcity of research might be the above-mentioned inconsistency of concepts and terms as well as the lack of objective and sensitive assessment means for real-time full-body movement and embodied interaction.

Against this background, the primary objectives of the dissertation project were

(1) to gain an interdisciplinary overview of existing definitions of psycho- and sensorimotor symptoms in schizophrenia and so lay the foundation for a transdisciplinary definition of a motor domain in schizophrenia,
(2) to quantify theory-independent, subtle movement markers of people with schizophrenia,
(3) to analyze associations of movement markers with patients' self-experience as well as with conventional clinical and neurological measures
(4) and with this, to define and test empirical correlates (quantifiable measures) for the theoretical concept of disembodiment as underlying pathology of schizophrenia.

Aside from the primary objectives, which target a better understanding of schizophrenia and the experimental validation of its phenomenological definition, I aimed at implementing and developing innovative research methods (assessment and analysis), which, by empirically focusing on the lived body and its interaction as primary source of information, target at accessing tacit or embodied knowledge. Hence, further objectives of the dissertation project were

(5) the development, piloting and implementation of innovative experimental paradigms and assessment tools, which take into account the entire body and the social interaction of the individual,
(6) as well as the implementation and further development of algorithms for the analysis of the resulting complex data.

2.1 Research questions and dissertation procedure

To achieve the above-mentioned goals, the following overarching research questions were raised. They are outlined including the measures taken to address them. For the sake of coherence and clarity, I have chosen to first summarize my theoretical work, then turn to the methodological contributions of this dissertation project, and finally report results of the empirical studies based on the theoretical and methodological preparations. The research questions as well as the publication list are structured accordingly. Detailed hypotheses of each study as well as the theoretical and empirical rationale leading to their formation are outlined in the empirical section.

(1) *How are movement abnormalities, psycho- or sensorimotor symptoms of people with schizophrenia described by researchers from different academic fields (such as psychiatry, neuropsychology, phenomenology, sports research, biomedicine), concerning utilized terms, definition, and assumed etiology?*

The ECSP underlines the importance of a unified definition of movement abnormalities in schizophrenia for the development of standardized research procedures and treatment guidelines [94]. In order to gain an interdisciplinary overview, I started the dissertation project by conducting a systematic literature review on terms and definitions of movement abnormalities in schizophrenia (see section 3.2). While phenomenologists agree on a disturbed pre-reflective experience being the basis of the schizophrenic condition, there are different leading approaches to the exact nature of early implicit changes in affected individuals [45, 128, 129]. Collaborating with the phenomenologist Monika Knack, I supported the theoretical refinement of the underlying disturbance of schizophrenia by combining the approaches (see section 3.1, publication 1).

(2) *How can changes in full-body movement of people with schizophrenia be assessed and quantified in a detailed, sensitive and objective way?*
(3) *How can we measure and quantify changes of "interbodily resonance" [28] in nonverbal communication of people with schizophrenia?*

In their 2017 review, Walther and Mittal urge for novel and sensitive instrumentation development, screening, staging and targeted therapy of motor abnormalities in schizophrenia [97]. In order to arrive at greater detail, sensitivity and objectivity in the assessment of movement abnormalities and to be able to measure and interrelate limb movement of the entire body in complex movements, such as gate or balance, I further developed and piloted a study protocol, which utilizes optical, marker-based motion capture (MoCap) technology to assess real-time 3-dimensional movement of study participants (see section 4.3.1). For the objective analysis and quantification of movement characteristics, we adapted and further developed an algorithm which was invented by Troje and colleagues [130] for the decomposition and discrimination of movement patterns (see section 4.3.2).

As described above, Fuchs [55] and Schilbach [131] have proposed that many, if not all, psychiatric disorders entail disturbances of social abilities and reduced adaptive behaviors, which manifest in impairments of real-time embodied interactions. Hence, Froese and colleagues call for studies investigating mental disorders in a truly interactive manner, meaning within real-time social encounters [49, 132, 133]. To counteract the reduction of schizophrenia to an isolated clinical entity tied to a malfunctioning individual, we proposed

the perceptual crossing experiment (PCE) as translational tool for the systematic assessment of disturbed interbodily resonance or disembodied interaction (see section 4.4, publication 3).
To allow statements on a hypothesized disembodiment, the movement assessment was supposed to be systematically related to measures of changed self-experience. The examination of anomalous self-experience (EASE), a qualitative interview, which explores experiential anomalies of individuals with schizophrenia, is considered one of the most established assessment tools for basic self-disorders in schizophrenia [53]. However, at the time of my dissertation, the instrument only existed in English language. Within a great collaborative process, we translated the interview to German language (see section 4.1) and developed a semi-structured interview guide to ensure objectivity as well as replicability of the assessment (see section 4.2, publication 2).

(4) *How does full-body movement of people with schizophrenia differ from that of controls in complex movements, such as gait or balance?*
(5) *Which theory-independent movement markers for schizophrenia can be identified and quantified?*
(6) *How are the identified movement markers related to measures of anomalous self-experience (EASE), as well as to clinical (Positive and negative symptom scale – PANSS [134]) and neurological measures (Heidelberger NSS Scale [103])?*

Within three studies, we quantified movement characteristics of patients with schizophrenia and systematically related them to the patients' self-experience and clinical as well as neurological symptom load. In the first study, I applied the abovementioned study protocol and analysis method to compare movement patterns of patients with schizophrenia and healthy controls in gait (see section 5.1, publication 4). In the second study, I collaborated with Kevin Stein from the Institute of Computer Engineering (ZITI). We compared the performance of patients with schizophrenia to the one of healthy controls in static and dynamic balance tasks (see section 5.2). In the third study, I applied the translated version of the EASE interview as well as the self-constructed interview guide to assess changes in self- and body-experience of patients. Within a mixed methods design I quantitatively and qualitatively analyzed the interviews and related anomalous self-experiences to previously defined movement markers (MM). With this, the initially mentioned theoretical refinement was put into an empirical context (see section 5.3, publication 5).

Living up to standards in contemporary research, my dissertation project was highly interdisciplinary[3]. Most work was not done alone but in teams with members from different academic disciplines. To delineate my own contribution to each publication, I precede the respective sections with a short introduction of author inputs. Also, whenever I predominantly worked on something alone or am expressing my own opinion, I signify this by using "I". In the case of teamwork, I use "we" to value the significant contribution of my collaborators.

[3] According to Choi & Pak [135], interdisciplinarity synthesizes links between disciplines into a coherent whole, while transdisciplinarity transcends traditional boundaries of disciplines, also towards the outside of the academic context. As much as I would like to call my dissertation research transdisciplinary, it did not transcend non-academic boundaries. Hence, I chose to use the term interdisciplinary for the description of my work.

2.2 Publication list

Theoretical, methodological and empirical results are reported in the following publications:

1. Knack, M., **Martin, L**., & Fuchs, T. (2022). Fragmentierte Zeitlichkeit. Ein phänomenologisches Modell der Schizophrenie als Störung präreflexiven Erlebens. *Phänomenologische Forschungen*. (22/1). 129-154.

2. **Martin, L.**, De Haan, S. (2021). EASE Interviewleitfaden mit Beispielfragen. In Fuchs, T., de Haan, S., Ludwig, M. & Martin, L. (Hrsg.) *Selbst- und Welterleben in der Schizophrenie: Die phänomenologischen Interviews EASE und EAWE.* (Vol. 1). Stuttgart: Kohlhammer. S. 113-129.

3. Zapata-Fonseca, L., **Martin, L.**, & Fuchs, T. (2021). Operationalizing Disembodied Interaction: The Perceptual Crossing Experiment in Schizophrenia Research. Phenomenology and Mind, (21), 111-125.

4. **Martin, L.**, Stein, K., Kubera, K., Troje, N. & Fuchs, T. (2022). Movement Markers of Schizophrenia – a detailed Analysis of patients' gait patterns*. Eur Arch Psychiatry Clin Neurosci*. doi: 10.1007/s00406-022-01402-y.

5. **Martin, L.,** Melchert, D., Knack, M., & Fuchs, T. (2023). Relating movement markers of schizophrenia to self-experience—a mixed-methods study. *Frontiers in Psychiatry,* 14, 1212508.

Additional project-related publications include a book on assessment of self- and world-experience in schizophrenia as well as several conference contributions, some of which are exemplarily listed below.

Fuchs, T., de Haan, S., Ludwig, M. & **Martin, L.** (Eds.) (2021). *Selbst- und Welterleben in der Schizophrenie: Die phänomenologischen Interviews EASE und EAWE.* (Vol. 1). Stuttgart: Kohlhammer.

Therein: **Martin, L.**, Ludwig, M., Fuchs, T. (2021). Schizophrenie – eine Störung des basalen Selbsterlebens. In Fuchs, T., de Haan, S., Ludwig, M. & Martin, L. (Hrsg.) *Selbst- und Welterleben in der Schizophrenie: Die phänomenologischen Interviews EASE und EAWE.* (Vol. 1). Stuttgart: Kohlhammer. S. 17-33.

Martin, L., Stein, K., Kubera, K., Troje, N., Fuchs, T. (2022). Bewegungsmarker der Schizophrenie. Eine detaillierte Analyse von Gangmustern. Oral presentation within the symposium „Walk this way - Welche Informationen enthalten Ganganalysen über psychische Erkrankungen?" at the *DGPPN Congress*, Berlin, 23rd – 26th of November 2022

Martin, L., Stein K., Kubera, K., Troje, N., Fuchs, T. (2021). Full-body motor markers of schizophrenia – using MoCap to quantify disembodiment. Poster presented at the 8th MindBrainBody Symposium, virtual, 15th-18th of March 2021

Martin, L., Mombaur, K., Schubert, A., Koch, S.C., Tschacher, W., Fuchs, T. *(2018).* Schizophrenia and the moving body: motor markers of disembodiment. Poster presented at the *3rd international Mobile Brain/Body Imaging Conference.* Berlin, 12th – 14th of July 2018

3 The moving body in schizophrenia (theoretical work)

3.1 Schizophrenia as a fragmentation of embodied consciousness (publication 1)

Own contributions to the publication: Monika Knack and I went through a number of joint planning sessions, before she developed the phenomenological theory and wrote the first draft of the manuscript. In many discussion sessions, we specified and refined the theory. I contributed my experience and first results of the analysis of movement and pre-reflective experience in schizophrenia. Finally, I revised the manuscript several times with a specific focus on movement and embodied experience of people with schizophrenia.

As described in the introductory chapters, phenomenological analysis has shifted the focus from positive, psychotic symptoms of people with schizophrenia to an underlying disturbance of pre-reflective experience [20, 24, 28, 29]. However, phenomenologists disagree on the exact interpretation of the condition's basis: Some authors identify the core disturbance of the illness in a disruption of basal self-experience or ipseity [128], others underline the disruption of passive synthesis of inner time consciousness [129], and yet others emphasize the disruption of implicit bodily functioning [20, 45]. By focusing on the bodily mediation [45] and intentionality of pre-reflective experience [136], we managed to combine the leading approaches to the underlying illness of schizophrenia. Drawing on Husserl and Merleau-Ponty [29, 136], we conceptualize schizophrenia as a fragmentation of embodied, pre-reflective consciousness which manifests on all levels of implicit experience - feeling, thinking, perceiving including self-perception, moving, and interacting [41]. We use the term 'fragmentation' to take into account the time continuity of embodied, pre-reflective experience [41]. It is important to note that this, first and foremost, defines the schizophrenia as an impairment of embodied processes that constitute our consciousness before all deliberate reflection, and that spread to reflective parts of our consciousness in later stages of the illness [40, 41].

According to Husserl's "Phenomenologie des inneren Zeitbewusstseins" [136], pre-reflective processes do not exist in a timeless space, but are continuous and implicitly directional. This holds true for all experiential processes: When reading a sentence, we do not experience every word individually but in relation to previous and following words; when listening to music, we can only grasp the entire melody by experiencing the individual note embedded in previous and following notes; when moving, a movement is only graceful when it follows an intentional arch, in which the present movement is based on the past one and already indicates the next [137]. As per Husserl [136], the experiential time-continuum is enabled by the "intentionality of consciousness", a pre-reflective directedness of all our experience which is mediated by attentional processes. He defines conscious experience as a relational field of three components: (a) "Retention" – just past moments still retained, (b) "Urimpression" – the momentary impression, and (c) "Protention" – the open expectation of what is to come. The pre-reflective interplay of the three components enables the moment-to-moment integration or the experiential continuity of our consciousness. It is also called "passive synthesis", because it is crucial for consciousness but not actively or reflexively created [136, 138].

For the theoretical refinement of the pathology underlying schizophrenia, we specifically focused on the protention. As described above, from the very beginning of our lives we form implicit relational knowledge in constant embodied interaction with our surrounding [35]. The protention can be understood as the pre-reflective, hence unconscious and embodied expectation of likely outcomes. A functioning protention is mediated and enabled by attentional processes, which inhibit unlikely outcomes or inappropriate thoughts and actions. For implicit learning or habituation, "Urimpression" and protention are compared. If they match, protentional expectations are confirmed and solidified, if they do not match, the protention is adjusted and will be more appropriate next time. Hence, protention as implicit and embodied directedness and selector of probable events, enables effective habituation and learning, and thus a smooth embodied interaction with the world and others.

Accordingly, we hypothesized a porosity of the protention being the main aspect of the fragmentation of embodied, pre-reflective experience in schizophrenia. This porosity is accompanied by a slow degradation of perceptual Gestalts on all levels of consciousness:

(1) Diminishment of pre-reflective self-experience or ipseity: Understanding schizophrenia as a fragmentation of embodied, pre-reflective consciousness which is rooted in a disruption of protentional relations helps to take into account the time-continuity and processuality of self-perception: People affected by schizophrenia do not entirely lose their pre-reflective sense of self, but rather lack a basic continuity in their self-perception. The certainty that it is the same subject living one experience after the other is questioned. Because the protential-retentional connection of all previous, momentary and prospective sensorimotor, emotional and cognitive processes is disrupted, the overarching Gestalt of a continuous self is fragmented. Fuchs et al. give a vivid quote by one of their patients:
"I constantly have to ask myself "who am I really?" […] It is not easy when you change from day to day. As if you were a totally different person all of a sudden." [61, p. 329]

(2) Fragmentation of movement, perception, and thinking: Affected individuals are detached from the flow of their movement/acting, thinking, and perceiving, and must subsequently re-establish the processes reflectively or explicitly. Movements or actions become dehabitualized. They lose their relatedness, smooth transition, synchronization or "grace" [137]. Normally tacit sensorimotor processes become available for introspection and need to be produced and steered deliberately[4]. Likewise, pre-reflective, usually familiar perceptual patterns or Gestalts are deconstructed or fragmented to an overflow of details, and the flow of thinking is disrupted by unfitting and inappropriate thoughts. Here and in the following example, the mediating role of attention for the protention as inhibitor of unlikely outcomes or inappropriate thoughts and actions becomes especially evident.

(3) Loss of spontaneity and flexibility in social interaction: The porosity of the protention not only compromises the individual's self- and world-perception but also her social interaction. The pre-reflective and context-sensitive attunement to the social surrounding decays when protentional expectations (e.g. implicit expectations of facial or emotional reactions of a conversation partner) are continuously disrupted by unsuitable impulses or associations [35]. Actions or reactions of others become unexpected, strange, or even sinister. Affected individuals feel isolated and

[4] See 1.2.2 for further explanations and quotes of patients.

sometimes even ontologically different from others. Often, individuals compensate the fragmentation of pre-reflective, embodied experiences by a hyperreflexive awareness to their own appearance and actions.

In summary, disembodiment as the underlying disturbance of schizophrenia does not exist in timeless space. Like all experiential processes (and their psychopathological changes) it includes a temporal aspect. Hence, disembodiment may be understood best as a fragmentation of the implicit embodiment of consciousness, which – as described above - manifests early (considering the course of the illness) on different levels of pre-reflective experience (see also figure 1 in the following section). This refined conceptualization (a) enables the joint consideration of changes in self-awareness, movement and social interaction in schizophrenia research, and (b) particularly suits the analysis of full-body movement, since flexible body usage and smooth movement sequences are only possible when they involve pre-reflective intentionality (see above). The refined definition serves as the foundation of the dissertation project at hand.

3.2 Movement abnormalities in schizophrenia - a qualitative systematic literature review

Incongruous, overlapping and confusing definitions of movement abnormalities in schizophrenia prevent the comparability of scientific results and the systematic integration of respective symptoms into clinical routine [23]. Many reviews in current literature are restricted to one category of motor symptoms, such as catatonia or neurological soft signs, and do not compare results across disciplines [86, 95, 139].

In order to systemize terms and definitions of movement abnormalities in schizophrenia across disciplines, I conducted a systematic literature review, which followed the guidelines for systematic review studies in qualitative health research by Hasseler and colleagues [140]. This included the definition of search terms and of a sampling strategy, the systematic search of databases, a "hand search" of additional literature [141], and finally the systematic extraction of information[5].

The literature review had an explicitly interdisciplinary focus. Meaning, aside from medical, psychiatric, or (neuro-)psychological databases (PubMed, PsychINFO, Psyndex), I searched databases of sports research (SPORTDiscus), biomedical and biomechanical research (Physical Education Index, BIOSIS Preview), phenomenological theory and research (The Open Commons of Phenomenology), as well as generic scientific databases, such as Academic Search Complete, Google Scholar or the Cochrane Library. After the search, I "hand-searched" the literature's references for repeatedly cited authors and contacted professionals for recently published articles on the topic [141]. Following the theoretical sampling method of Grounded Theory, data collection was ended when theoretical saturation was achieved, meaning when newly found definitions and concepts of movement abnormalities reoccurred and no additional variation could be found [142, 143]. The database search took place between January and March of 2019 and was supported by a number of bachelor students[6] [144, 145]. The application of in- and exclusion criteria resulted in a total of 339 articles.

[5] Search terms as well as in- and exclusion criteria for literature can be found in appendix A.

[6] Two Bachelor theses resulted from the literature analysis [see 144, 145].

From the found literature I extracted terms, definitions and descriptions of movement abnormalities or motor symptoms in schizophrenia. With the help of open and axial coding [142], the data was systemized into categories of higher order, which were refined and named using so-called "generative questions" ([142, p.39] see appendix A). As is common in qualitative research, the identified categories were considered dynamic and variable throughout the entire writing process and were altered several times in exchange and collaboration with helping students and the first supervisor of this thesis [143]. The comparison and systemization process resulted in ten interdisciplinary symptom categories. Table 1 shows the symptom categories, including descriptions of their etiology and implications for future research and clinical practice.

Confirming the introductory statement, the systematic literature review resulted in the extraction of a variety of inconsistent and overlapping terms and definitions[7]. Authors not only disagree on specific terms but also on the etiology of the different movement abnormalities and come up with a variety of sometimes contradicting implications for further research or clinical practice. Because qualitative reviews always comprise interpretive aspects, the result categories are not exhaustive or statistically representative of all existing movement abnormalities and do not allow statements of general applicability. Nevertheless, they served as an ideal starting point for the analysis of movement abnormalities in schizophrenia.

First, the results clearly show that the majority of movement abnormalities are not medication related. This underlines that movement abnormalities are an intrinsic part of schizophrenia psychopathology and highlights the importance of their systematic analysis. Still, I decided to control for the influence of medication in all empirical analyses of the dissertation project (see publication 4).
Furthermore, some movement abnormalities are very well studied, while others are not. As already mentioned in the introduction, only a few studies analyze movement of the entire body (gait, balance). Rather, in psychiatric research, NSS have been at the center of scientific attention. The term refers to externally visible impairments in sensory integration, motor coordination, balance, sequencing of complex motor acts and primitive reflexes [91, 95]. In the literature, they are introduced as both, a sign for the risk of developing schizophrenia (trait factor) and as a monitoring measurement of disease progression (state factor) [146]. They are related to schizophrenia psychopathology (positive and negative symptoms) [147] and to poor cognitive and social functioning of patients [148, 149]. The most frequently reported category of NSS in patients with schizophrenia is motor incoordination [150-152]. It comprises the inability to perform rapid alternating movements as well as difficulties in simple coordination tasks, such as the tandem walk, finger-nose opposition, finger-nose tapping or rhythmic tapping [151]. Impaired motor or interlimb coordination has been found to discriminate best between high-risk children and controls as well as between patients with schizophrenia and a mood disorder [89, 151, 152].

[7] Exact extraction tables will be part of the upcoming publication and due to space limitations are not appended to the manuscript at hand.

Table 1. Interdisciplinary definitions of movement abnormalities

	EPS	Impaired acquisition of motor skills	Reduced and slowed movement *(Some authors consider this category a part of negative symptoms [153])*			Gait and posture related symptoms	Catatonia	Involuntary movement		Disorganized movement		Impaired nonverbal communication	disturbed eye move-ment	Body & movement perception
			Psychomotor poverty	Psychomotor slowing	Disturbed initiation			AIM	Excessive movement	NSS	Disauto-mation			
Defini-tion	Extrapyramidal side-effects (EPS) are movement disorders, which arise as side-effects of antipsychotic medication. There is acute (appearing close to med. intake) or chronic movement disorders [154]. EPS may present as abnormal paucity or excess of movement [87].	Impaired or slow motor learning, such as implicit and explicit sequence learning deficits [155], lead to delayed development of motor mile stones: standing, walking [156-158].	Psychomotor poverty encompasses a *quantitative* diminishment in overall motor activiy [70, 122, 153] as well as reduced speech, reduced spontaneous movement and various aspects of blunted affect & alogia as a result [159].	Psychomotor slowing encompasses the *qualitative* slowing of cognitive processes responsible of producing (planning, initiation, reaction) movement as well as the slowing of the execution of movement [160]: e.g larger reaction times in mirroring tasks, slow finger tapping test.	Disturbed initiation encompasses deficits in self-monitoring of action (proprioceptive and kinesthetic awareness) and as a consequence a diminished motivation or failure of willed action [161, 162].	Disturbances of gait and posture include increased postural sway, postural instability, deficits in postural control (balance), delayed development of postural control, slower gait, higher stride-to-stride variability [120, 163-165].	Catatonia is a group of motor, emotional and behavioral symptoms. Motor signs of catatonia include manneris (simple repetitive movement), rigor, stereotypies, catalepsy, grimacing & waxy flexibility [23, 87, 166-168]	Spontaneous dyskinesia comprises abnormal involuntary movements (AIM) of the orofacial, limb, trunk and respiratory musculature [169]	Excessive movements include hyperkinetic movements, hyperactivity, the feeling of inner restlessness as well as the behavioral motor restlessness [157].	Neurological Soft Sins comprise a number of subtle neurological abnormalities, which include deficits in fine and gross motor coordniation, sensory integration and motor sequencing [170]. They are considered endophenotypes of schizophr-vulnerability [90].	Some patients with schizophrenia experience a disruption of usually automatic actions (tying shoe laces, walking stairs) [20, 171]	Impaired nonverbal communication comprises reduced/unchanged facial expression, reduced/unfitting expressive gestures, deficits in gesture understanding, nonverbal perception/interpretation of behavior (decoding of socially relevant information) & less empathy [113, 172-174].	Most commonly reported deficits in eye movement are disorders of smooth pursuit and saccadic eye movement [175, 176]. Additionally a lack of or poor eye contact has been described [122].	Changes in Body perception range from impaired proprioception and nociception (impaired perception of fine touch, temperature, pain), to feelings of alienation or change (of movement, body parts, the entire body), the weakening of body-boundaries, or coenesthesias [45, 177, 178].
Etio-logy *What is causing the movement abnormalities of this category?*	EPS are the only movement abnormalities proven to be caused by meds.	An explanation attempt is a disruption of neural plasticity in motor areas [156].	Some name basal ganglia dysfunction [179-181] or abnormal functional connectivity (DLPFC and left inferior-temporal & middle temporal region [182].	Some researchers found associations with deficits in striatal-thalamic circuits [183, 184].	Some authors name the corollary discharge system [177] as basis for abnormal proprioceptive and kinesthetic perception.	Possible explanations involve decreased cerebellar-cortical connectivity or changes in cerebellar volume [91, 185].	Catatonia is associated with reduced activity of the SMA, the prefrontal cortext and the parietal cortex [186]	Explanations include morphological changes in the basal ganglia (caudate nucleus) or increased gray matter volumes in brain stem, inferior frontal gyrus etc. [91].	There might be a link between motor excitation/inhibition and basal ganglia dysfunction [157].	They might stem from morphological changes within the caudate nucleus, putamen and globus pallidus or from disconnections between cortical and subcortical areas [187, 188]	The disautomation of action seems to be linked to the disembodiment of self-experience [39, 45].	Reduced or changed nonverbal interaction is often ascribed to avolition and flat affect [189]. It can also be explained by the disembodiment of self-experience [39].	heightened fear/arousal in psychotic states, abnormal functioning of the mesolimbic dopamine system, or cerebellar dysfunction are named as cause of ocular signs [155, 190].	Impaired proprioception is related to a dysfunction of forward model circuitry, that allows the discriminating of self-generated from external movement [177]. Changes in body perception are ascribed to disembodiment of the self [39, 61].
Impli-cations *What does the definition imply for research and clinical practice?*	The use of second generation antipsychotics reduces EPS [191]. Low treatment compliance make the analysis of new coping strategies necessary [192].	The inclusion of anatomical and structural connectivity measures in future studies is required, specifically pre-frontal cortex and cerebellum [155].	Some researchers imply changes of functional deficits by sports participation or observation [162].	When assessing psychomotor performance in schizophrenia, both, general processing speed (cognitive) and motor speed should be assessed and related [193].	Reseracher s suggest to assess movement trajectories in relation to correspondi ng EEG [161].	Impaired gait parameters can be normalized by the usage of external cues [165] and better posture is associated with better self-esteem [194].	Catatonia is a complex concept and there is no agreement whether it is a discrete pathology or a dimensional cluster of symptoms [87].	A meta-analysis integrating multiple studies for brain changes underlying tard. dysk. is warranted [195]. Dysk. may predict psychosis onset [157].	Need for investigating choice reaction time paradigms, motor timing function, and stop signal reaction time in relation to brain structures (RDoc) [157].	Regular assessment of NSS can be useful for risk assessment and monitoring of disease progression [196, 197].	Embodied therapies can help patients to re-embody self-experience [171].	Embodied therapies have been found to improve flattening of affect [5, 81].	Changes in eye movem. are suggested to be trait markers of schizophrenia vulnerability and should be assessed by eye tracking [175, 198]	The self- and body or movement experience of the patients needs to be taken into account systematically [199].

On the basis of these findings, I chose to assess full-body movement in gait, to complement the movement assessment with a full-body balance task for the analysis of coordination difficulties, and to add the assessment of NSS as an established neurological measurement in the field of movement abnormality research. To navigate around the lack of conceptual clarity regarding movement abnormalities and to facilitate an objective assessment, I chose an innovative instrumental assessment and a strictly data-driven approach for the first step of the analysis: What differences of groups can be found based on the movement data alone, without any a priori hypotheses or underlying concepts of movement abnormalities? Only in the second step I compared groups based on hypotheses and related context- and theory-independent movement markers in gait as well as balance and coordination difficulties to existing concepts of movement abnormalities (see section 5).
The review also confirms the scarcity of studies which analyze observable motor symptoms in relation to self- and body perception. While it is beyond debate that posture and movement are in a constant bidirectional interplay with experience, cognition and emotion [200] – in fact, experience, cognition and emotion would not even be possible without body movement (see section 1.2.1) [28, 43] - and while it is clear that changes in movement ability have an impact on self-experience and well-being in patients with schizophrenia [119], disciplinary boundaries are rarely crossed when researching movement abnormalities. Self-experience is almost exclusively analyzed within phenomenological studies. Terms and definitions of symptoms and their etiology differ so much that they are hard to muster. In order to make phenomenological theory compatible with psychiatric evidence, I decided to systematically relate movement assessment with the thorough assessment of self- and body perception.

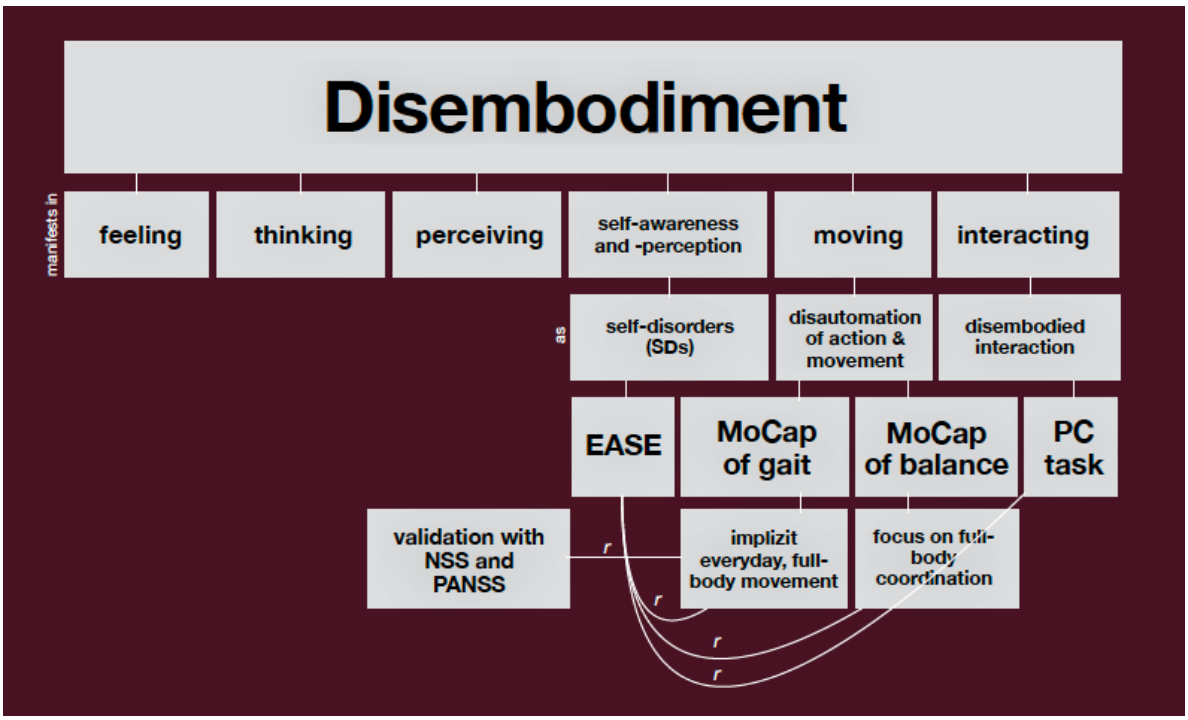

Fig.1 Operationalization of disembodiment. *r* stands for hypothesized correlations. If displaying associations with anomalous self-experience, the detection of subtle but significant changes in movement, coordination and embodied interaction are understood as evidence for disembodiment, as conceptualized in section 3.1. Both, subtle changes in gait and balance are hypothesized to be reflected in and hence preliminarily validated with increased NSS and negative symptoms.

Figure 1 gives an overview of the operationalization of disembodiment including respective assessment methods and hypotheses on variable interaction. Disembodiment, amongst other changes, is accompanied by an experiential disconnection from the own body and self (anomalous self-experiences), the disautomation of movement, and a disruption of interbodily resonance or interaction difficulties [39, 45, 50, 55]. Thus, I focused on self- and body-awareness, moving and interacting, as aspects of an embodied consciousness, which are easier to access on a pre-reflective level than feeling and thinking, which are traditionally conceptualized and assessed on rather reflexive levels. Although the EASE also assesses changes in the stream of thought, the discussion and definition of implicit and explicit parts of thoughts and emotions exceeds the scope of this thesis. Due to the lack of studies analyzing full-body movement, we chose to assess gait and balance (see more on that decision in section 4.3).
Finally, to take into account all sensorimotor, experiential and behavioral aspects of the abovementioned symptom categories, I use the term *movement abnormalities* as an umbrella term for all movement-related symptoms in schizophrenia throughout this thesis.

While the results of the review served as a solid foundation for the development of the empirical part of the dissertation project (study protocol, empirical studies), an update of the literature search is required for the publication of its results. This task is in progress and the respective manuscript in writing.

4 Operationalizing aspects of disembodiment (methodological work)

4.1 Measuring changes in self- and world experience: translating EASE and EAWE

On the basis of self-reports (within prodromal stages but also shortly before psychotic relapse), a collaboration of Danish, German, and Norwegian psychiatrists and phenomenologists lead to the publication of two semi-structured, qualitative interviews, which explore experiential anomalies of people with schizophrenia: The Examination of Anomalous Self-experience (EASE) incorporates all aspects of a disturbed sense of self (including body and movement perception); The Examination of Anomalous World Experience (EAWE) assesses changes in the experience of the own situatedness in the world and the relation to the surrounding and others [53, 123]. Both interviews have a strong descriptive, diagnostic and differential-diagnostic value, and a high reliability and validity [201-204]. They are particularly well-suited for capturing and examining subtle changes in perception and behavior before the onset of productive symptoms [205].
In fact, many EASE items were significantly influenced by Huber's concept of basic symptoms and its associated rating scale [31, 206][8]. Furthermore, similar to Nuechterlein and Dawson [30][9], many phenomenological psychopathologists conceive the basic disturbance of pre-reflective experience as a trait-like vulnerability to schizophrenia [35, 39, 51, 207]. The application of phenomenological interviews thus aligns with the increasing focus on interventions for early detection and prevention of the disorder [31, 33, 206, 208]. Respective interventions are unimaginable without a proper understanding of changed subjective experiences in pre-psychotic phases [33].
In addition, EASE and EAWE allow for psychoeducational and therapeutic support. The comprehensive and extended interviews offer affected individuals the chance to articulate, often for the first time, the frequently overlooked and hard-to-describe changes in their experiential worlds. This allows subjects to gain clarity and feel understood [33].

For the systematic assessment and analysis of these experiential changes within German-speaking research and practice, we translated both interviews to German language, and supplemented them with a historical and theoretical background as well as means for easy application (see following section and [205]). We hope that a subsequent systematic assessment, early detection and treatment of changes in the embodied experience of the self and the world is associated with a positive impact on the course of the illness for many high-risk individuals or people with schizophrenia [208].

[8] Within his influential approach, Huber [31, 206] summarized so-called basic symptoms, which appear in prodromal stages of the illness, up to five years before the onset of psychosis. They are based on the assumption of organic brain deviations in people with schizophrenia. Productive psychotic symptoms are considered to only arise secondarily in the presence of unfavorable living conditions or as coping mechanisms of the subtle changes [31, 33].
[9] Nuechterlein and Dawson [30] distinguish in their Vulnerability/Stress Model between "state" and "trait" characteristics: "State" characteristics are only significantly pronounced in specific stages of an illness (in schizophrenia: prodromal, manifest illness, remission), while "trait" characteristics consistently exhibit elevated levels of expression. "Trait" characteristics are seen as vulnerability factors for an illness in general, and like basic symptoms can be considered to reflect a general susceptibility to schizophrenia spectrum disorder [30].

4.2 An interview guide for German EASE interviews (publication 2)

Own contributions to the publication: I developed the interview guide (including recommendations on the interview procedure and rating, and the interviewer's attitude) on the basis of documented interviews (videos and documented questions) of Sanneke de Haan, a previous PHD student of Thomas Fuchs. Sanneke de Haan oversaw the development process and reviewed the manuscript several times.

Conducting EASE and EAWE interviews can be very intimidating. Merely the comprehension and memorizing of its many items requires a lot of effort and theoretical, phenomenological knowledge. Thus, the research group around Josef Parnas and Louis Sass offers consecutive training courses for the mastering of item understanding and interview techniques (see https://easenet.dk/ for details)[10]. Contributing to these courses, we developed an interview guide for the implementation of the EASE. It gives the interviewer an idea of interview contents and procedure, describes the course of the interview, and introduces a certain phenomenological interview attitude. Furthermore, it offers exemplary questions for each EASE item as well as suggestions for their evaluation and rating. Therefore, the guide not only responds to a potential insecurity of researchers or practitioners when applying the EASE, but also helps with the comparability of EASE interviews led by different interviewers as well as the systematic analysis of their results. In total, our interview guide consists of 150 questions for the 57 EASE items. It starts with a social interview for trust building and ends with an open comment section for the interviewee. Not all questions are asked in every interview. I applied the interview guide in all EASE interviews of the dissertation project.

4.3 Objective movement assessment and analysis

4.3.1 A new study protocol

As discussed above, despite great research interest in movement abnormalities, available assessment instruments for people with schizophrenia are either rating scales, which are always prone to observer bias, or instrumental tools, which do not assess detailed full-body movement [89, 104-117, 209]. In order to arrive at greater detail, sensitivity and objectivity in the assessment of movement abnormalities and to be able to measure and interrelate limb movement of the entire body in complex movements, I drew from assessment methods outside of the clinical realm.

The most detailed assessment of human motion has been done with motion capture (MoCap) technologies [210]. They are used in filmmaking, video game development, sports and medical application research. Various studies using MoCap show that motion patterns contain information about the identity of an individual as well as her actions, intentions, and emotions and that these motion patterns are central to human self-reference, interaction, emotional and social understanding [28, 211]. Apart from gestures and postures, the mere movement qualities of walking individuals unknown to their observers and abstracted to

[10] I attended a training for EASE conducting in 2019 and a rater training in 2020.

point-light displays (a number of luminous dots, which remove all identifying information, such as physicality, facial expression, attractiveness) reveal information about the walkers' gender, age and affective state (happy, sad etc.) [130, 212, 213]. Furthermore, humans present with individually different, time-invariant motor signatures that play a central role in their interaction behavior [121].
Providers offer different forms of MoCap technologies: Optical marker-based systems, such as Vicon or Qualisys, use cameras to track reflective markers attached to the moving bodies' skin. Inertia based systems, such as Xsens, track orientation, acceleration and velocity using inertial measurement unit (IMU) sensors. Prior to recruitment, I experimented with the accuracy of different MoCap techniques and found great bias in less detailed IMU based systems. Hence, I decided to search for subtle movement characteristics with detailed marker-based MoCap first and then transfer their mathematical and statistical evaluation to less detailed MoCap data.

At the time of protocol development, within the psychiatric context, only one other study had applied full-body, marker based MoCap to analyze movement patterns with relevance to diagnostics: Michalak and colleagues [214] compared gait patterns of patients with depression to those of healthy individuals and found a reduced walking speed, arm swing, vertical movement, a slumped posture of the upper body, and an increased lateral sway in patients, with effect sizes ranging between d = 0.8 and d = 1.3.
Conferring with Michalak and collaborating with Kevin Stein (see also section 5.2), I developed and piloted a study protocol, which allows for a detailed, real-time, 3-dimensional and full-body gait, balance and coordination analysis and – transferred to simpler MoCap techniques – can easily be integrated into daily clinical practice. For brevity's sake, the study protocol is located in appendix B.
Since phenomenology positions the schizophrenic disturbance on a pre-reflective level, the main challenge was to find movement tasks which are complex but habituated enough to exhibit subtle and implicit movement and coordination abnormalities and do not measure attentional or cognitive deficits in relation to movement or understanding deficits of the task. Also, being touched to search for bone landmarks during the MoCap marker placement or being filmed by 9 different cameras can be psychotically triggering. Hence, another challenge was to incorporate a sensitive and safe assessment environment and attitude which takes into account the vulnerability of participants with schizophrenia.

The study protocol for movement analysis comprises two experiments: (a) Assessment of gait in simple walking and within a dual task, (b) static and dynamic balance tasks as well as a complex sports task, which requires the coordination of all limbs.

(a) I chose to analyze gait first, because it is a habituated movement, implicit enough to not require much cognitive attention. Nevertheless, it requires a complex interplay of sensory, motor and balance processes, and a fine-tuning of all limbs [215]. It thus is most likely to exhibit pre-reflective, implicit movement characteristics and offers the possibility to analyze full-body interlimb coordination. Other, more creative movement tasks (climbing stairs, tying shoes) might have compromised replicability and revealed participants' physical limitations (e.g. back problems).
In order to occupy attentional resources and to augment possible differences between groups, I included a dual-task condition into the gait analysis.

(b) Patients with schizophrenia repeatedly demonstrate postural instability in static balance tasks, specifically in conflicting sensory conditions when eyes are closed and people have to rely on proprioceptive and haptic feedback [163, 185, 209]. Furthermore, balance, similar to gait, requires a proper proprioceptive and sensori-motor integration as well as the movement of the entire body and the coordination of all limbs. Therefore, we included the static balance test (five increasingly complicated static balance tasks, each with open and closed eyes [see 216, p. 62]) into the study protocol and complemented them by adding a dynamic balance as well as a full-body coordination sports task: tandem walk and star jump. The tandem walk is a widely applied test for dynamic stability, which is used e.g. by police to measure coordination inability due to intoxication or by neurologists to diagnose ataxia, the star jump is a coordination jump task known in German as "Hampelmann" (jumping jack) [216, 217].

The study protocol includes a great focus on explanation of the study procedure and all equipment and ample time for questions and pauses. It is designed to be conducted interdisciplinarily, with one person being experienced in the contact with vulnerable individuals. In our case, at least one psychologist and one biomechanic were present for all assessments. Furthermore, in our lab, 49 infrared-reflective markers were attached to the participants bodies[11]. Movement tasks were filmed with 8 Oqus500 cameras (Qualysis, Goeteborg, Sweden). The MoCap assessment of balance and coordination performance was complemented by the application of force plates. Details on force plate assessment are described in Stein's dissertation [216, e.g. p. 62]. An additional fixed video camera filmed the experiments from the front. As mentioned above, the study protocol can and should be applied to simpler MoCap techniques.

4.3.2 Data-driven movement analysis

For the data-driven analysis of gait, we applied and further developed an algorithm by Troje and colleagues [130], which allows the decomposition, description and modeling of human movement (captured with full-body MoCap). It has successfully been applied for gender discrimination [130], to discriminate between happy and sad walkers [214] or to analyze the effect of gait modification on mood [218]. In the following section, I will briefly outline the algorithm's computational steps and the amendments we made. Details are described in the paper of Troje et al. [211] and in publication 4 [89].

The algorithm applies statistical linear methods and pattern recognition to distinguish groups on the basis of their movements [130, 219]. As a first step, 15 joint centers are computed from the trajectories of the 49 reflective markers, stuck to the participants bodies. See Fig. 1 for a visualization of the joint center locations and the definition of the represented bone landmarks.

With the help of Fourier decomposition (FD), we reduced redundancy in the data and linearized the joint center locations. Modelling an individual gait with FD requires the movement to be periodic and repetitive. Troje's algorithm provides a measure for the average variance covered by the number of Fourier components in the chosen model: the *modelling power*. Non-periodic, irregular elements are reflected in a lower power, a higher

[11] The markerset is part of the study protocol in Appendix B.

power indicates a more periodic or rhythmic gait [89]. Complementing Troje's [211] computational framework, we computed and statistically compared the groups' modelling power in order to quantify their gait regularity (see publication 4).

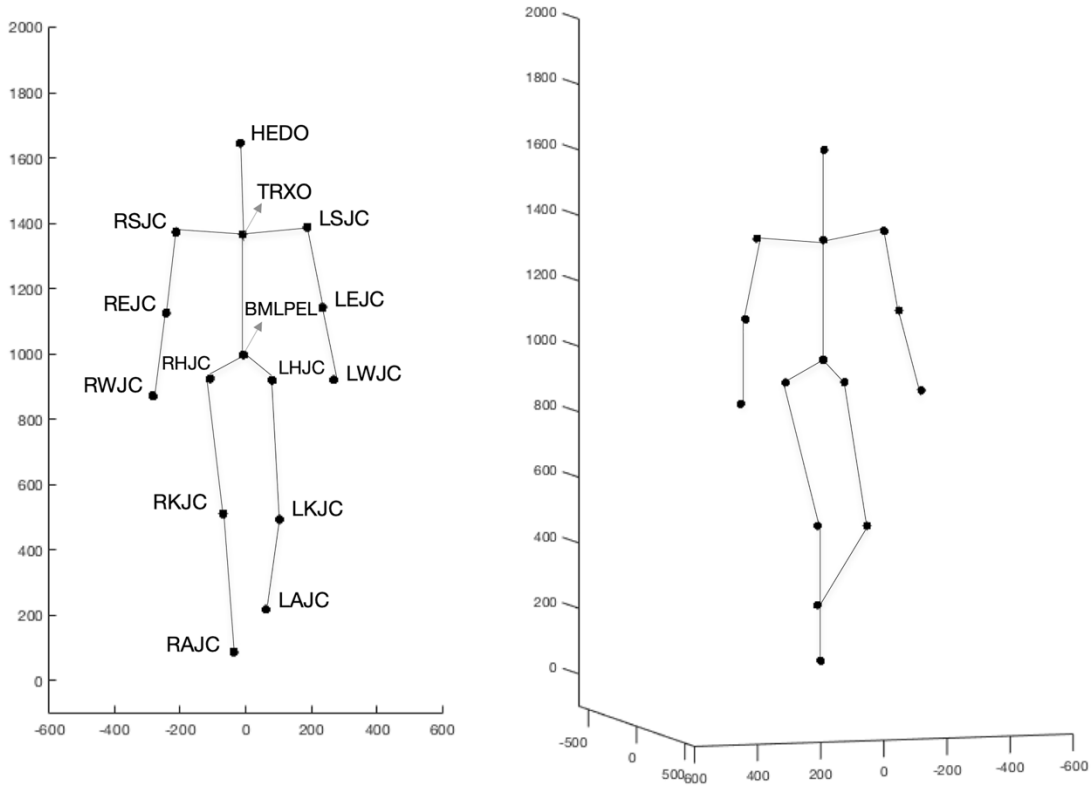

Fig.2 Visualization of the joint centers (JC). The figure is taken from [89]. Joint centers are located at the center of the head (HEDO), the sternum (TRXO), the shoulders (LSJC, RSJC), elbows (LEJC, REJC), wrists (LWJC, RWJC), the center of the pelvis (BMLPEL), hips (LHJC, RHJC), knees (LKJC, RKJC), and the ankles (LAJC, RAJC). The figure displays a film still of the average walker, derived from the entire sample. It can be viewed from the front (left picture) and rotated along all three axes (right picture). It is the basis for the discriminant walker, which is visualized as increments of the average walker.

For a reduction of the dimensionality of the linear walker space, we computed a principal component analysis (PCA) across all Fourier-decomposed walkers. This resulted in the decomposition of each walker into an average walker and a weighted sum of *eigenwalkers* (referring to *eigenvectors*, see [211]). In order to find core movement aspects (structural and dynamic aspects of group difference), so-called *classifiers*, we created a linear discriminant function (LDF) by regressing the group indicator (patients, controls) on the walkers' projections in the low-dimensional eigenwalker space [89, 130].
Unlike Troje, I was not interested in structural differences of participants' physicality (e.g. height, weight) but only in dynamic differences of the groups' movement. Hence, we controlled for height, weight and BMI in the assessment. Nevertheless, the group of individuals with schizophrenia displayed a significantly higher weight than the controls. Complementing the algorithm, we accounted for group differences in weight by repeating the LDF computation, regressing the weight on the eigenwalkers. By multiplying the second LDF (weight) with the transpose of the original LDF (groups), we extracted components that are explained by weight differences. We subtracted those components from the original

LDF and used the coefficients of the rectified LDF and the eigenwalkers of the PCA to create a so-called *discriminant walker* (DW) [89, 211].
The animated visualization of movement patterns, which were extracted by the LDF as group differentiating classifiers, can be viewed and tested online: https://www.biomotionlab.ca/martin2022/

Furthermore, unlike Troje, I was interested in the statistical comparison of the group differences or classifiers. LDF classifiers, however, remain on data-level, meaning they essentially represent moving dots in a 3-dimensional space. To quantify movement differences within one value for each participant, that can be compared statistically, amplitudes and visualizations of the DW were repeatedly examined and rated by different members of the research team [89]. Visible movement differences were gathered, categorized, mathematically described (put into formula) and computed for each participant on the basis of the FD data for one gait cycle [89].
Only after the comprehensive mathematical description of the groups' dynamic, full-body movement characteristics, meaning after working with the movement data only, I embarked on a hypothesis-driven statistical comparison of groups and a relation of the found differences to known concepts of movement abnormalities (see publication 4).

4.4 Measuring (dis-)embodied interaction: the perceptual crossing experiment (publication 3)

> *Own contributions to the publication: The publication is a result of a long collaboration which incorporated amongst many things, the joint planning of assessment, joint presentations, or a joint ethics proposal. To the publication I contributed phenomenological theory on schizophrenia psychopathology and embodied communication. I furthermore supported the systemization and phenomenological interpretation of PCE variables and revised and rewrote the manuscript several times.*

Shifting away from methodological individualism, the so-called second-person account to psychopathology focuses on the interaction between engaged individuals as the main phenomenon of interest and incorporates phenomenological evaluations for a better understanding of qualitative aspects of patients' experiences [25, 131, 220, 221]. The aim is to study real-time embodied interactions in such a way that participants feel engaged and take on an interactor rather than a passive observer role [132, 222]. Although constrained in comparison to group interactions, dyadic interaction allows the assessment of complex intra- and interpersonal aspects of the dynamic sensorimotor cycles in embodied social communication [28, 132].

The PCE, originally proposed by Lenay et al. [223], assesses real-time dyadic interactions in a minimalist, systematic and ecologically valid way [49, 224, 225]. In cognitive science with a focus on enactive theory, it is considered the ideal experimental paradigm for the isolation of sensorimotor and self-other contingencies (see section 1.2.2c), which are understood as the ability to detect and understand the other's responsiveness to one's own behavior [49, 132, 226-228]. The PCE has been used to investigate dyadic interactions

of various groups of people. For instance, individuals with autism displayed repetitive and restricted movement patterns (spending more time on searching for the other than on interacting) when participating in the PCE [228].

In the PCE pairs of individuals engage with each other via a computer interface, which reduces their embodied interaction to horizontal movement and tactile sensation (see Fig. 2) [132]. In practical terms, participants, not able to see or hear each other (they wear noise-cancelling headphones), move a mouse cursor with one hand from left to right in an invisible virtual space. They receive tactile feedback when their cursor touches an object in that space. Participants can encounter three different kinds of objects: (a) a static object; (b) the other person's cursor or avatar object (c) a moving object or shadow, that follows the other person's avatar at a constant distance [49, 132]. The task is to move around in the space and to click whenever one encounters an object, which is thought to be the other person [132, 225].

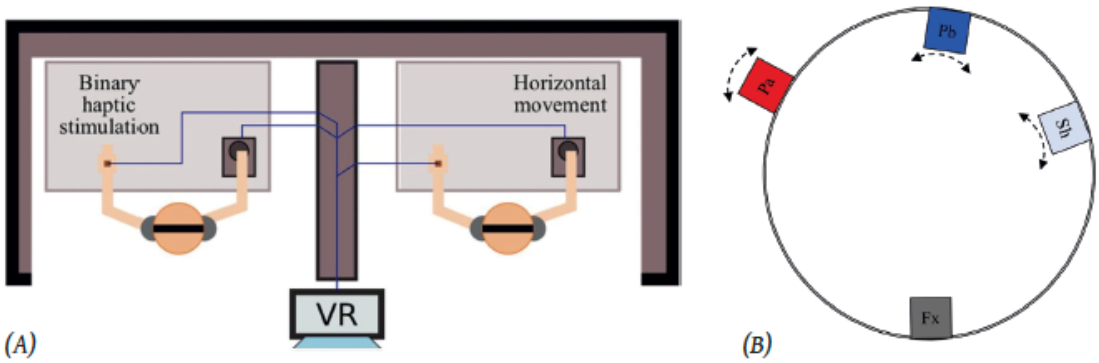

Fig 3. Perceptual Crossing Experiment. Taken from Zapata-Fonseca et al. [132] and adapted from Froese & Zapata-Fonseca [229]. (A) The physical setup: Participants interact exclusively via a Human-Computer Interface consisting of a trackball and a tactile stimulator. (B) The virtual setup: Participants are embodied as minimal avatars on an invisible one-dimensional circular space.

By being embodied as avatars and thus structurally coupled with the virtual environment through the human-computer interface, the basic self of the participant becomes embedded in a shared virtual space, which presents itself as a field of possibilities, affordances, barriers or obstacles, similar to the lived space of our everyday world [230, 231]. Like in real life, the different affordances of the virtual space can only be detected by movement and by considering what those movements evoke [132]: Objects can only be distinguished interactively in terms of the different patterns of sensorimotor responses they offer. Similar to gaze-crossings in real life, an overlap between both avatars in the virtual space is considered a perceptual crossing: while all three objects will elicit a vibration when encountered, only when both participants' avatars cross, both participants simultaneously get haptic feedback. A successful experiment requires a complex set of pre-reflective adaptive coordination processes. Participants must make sense of each other and achieve co-regulation between their patterns of movements. As described above (see section 1.2.2), in many cases, it is exactly this adaptive behavior during real-time embodied communication which is compromised in the disembodied interaction of people with schizophrenia [132].

Bridging cognitive sciences and phenomenological psychopathology, in publication 3 we proposed the PCE as an empirical set-up for the operationalization of interbodily resonance [47] as one of the main aspects of embodied interaction and one of the first to be disturbed in schizophrenia.

Table 2. Operationalizing (dis-)embodied interaction with the PCE

Variable	Definition	Phenomenological Correlate	Disturbance in Schizophrenia
Movement profile	Quantitative [232]: • Mean velocity • Variability of velocity (standard deviation) • Number of changes in direction Qualitative: • Self-report of the employed movements	Sense of bodily agency: Recognition of the own actions as such and acknowledgment of its effects on the environment. Motion flow: Integration of individual movements into meaningful behavior.	Disturbance of agency Quantitative: less and slow movement patterns prevail (lower mean velocity, diminished variablily of velocity) Qualitative: Is the indivual capable of initiating purposeful movements and ackknowlegdes them as their own?
Individual performance	Quantitative [233]: • Number of correctly detected encounters (accuracy of clicks) • Perceptual Awareness Scale (PAS) Qualitative: • Self-report of the experience of the presence of the other	Sensorimotor contingencies and Self-other contingencies: Detection of the presence of the other - the understanding of *"the regular ways in which changes in others' movements depend on changes in one's own movements"* [49].	Reduced engagement, ambiguity when crossing static objects, reduced detection and understanding of the other Quantitative: Less correct clicks (due to less and slow movement), lower scores on PAS Qualitative: reduced experience of the other
Learning effect	Quantitative [233]: • Changes in individual performance across trials (see variables above) Qualitative: • Self-report of the development of strategies	Transparency and degree of incorporation: Acquisition of a skill (dyadic interaction in the PCE) through sensorimotor mastery (Andrada, 2020). The focus of attention changes across trials. Initially, it is on how the device works. Afterward, it shifts towards the sensorimotor patterns and the interaction itself.	-
Interpersonal sensorimotor matching (ISM) (dyadic)	Quantitative: [234-236] • Amount of seconds spent together • Adaptation of movement profiles • Self-designed rapport questionnaire Qualitative: • Self-report of collaborativeness	Embodied (inter)affectivity: *"two cycles of embodied affectivity become intertwined, thus continuously modifying each partner's affective affordances and resonance" [28]*.	Diminished sensorimotor coupling (proxi for sensorimotor coherence) Quantiative: Crossing with as many objects as possible (overstimulation), minimizing activation of haptiv feedback (avoiding behavior), Asymmetry of MPs of the dyad, less ISM (e.g. no adaption of movement profiles, less amount of time spent together) Qualitative: Mismatch of self-reported collaborativeness

Note. The table was adapted from Zapata-Fonseca et al. [132]. The qualitative variables are obtained by implementing a semi-structured interview after participants finish a round of 10 or more trials. See publication 3 for details.

Table 2 summarizes quantitative and qualitative variables of the PCE, their phenomenological correlate and hypotheses on their properties in people with schizophrenia.

The PCE enables the quantification of disturbances in sensorimotor interactions, both on an intra- and interindividual level [132]. The application of the PCE with patient-control dyads as well as the systematic association of quantified interaction difficulties with individual movement abnormalities will help to define an empirical ground for the phenomenological concept of disembodiment [61].

We have started to assess patient-control dyads with the PCE. This work ought to be continued, the analysis of the resulting data with the abovementioned framework, the correlation of individual movement and interaction data, and the publishing of respective results is to be done.

5 Studying aspects of disembodiment (empirical work)

All studies have been carried out in accordance with the declaration of Helsinki (2013) and the code of ethics for doctors of the state chamber of physicians of Baden-Württemberg. Prior to participant recruitment, the studies were approved by the local ethics committee of the Medical Faculty of Heidelberg University (S-692/2018, see appendix C). Participants gave written informed consent prior to participation. Almost all individuals who participated in the overall dissertation project took part in all three studies. This enabled us to compare results across studies. In- and exclusion criteria as well as detailed sample characteristics are given in the respective publications.

5.1 Movement markers of schizophrenia (publication 4)

Own contributions to the publication: I designed the study, organized recruitment, conducted the data collection, analyzed the data and wrote the manuscript. The collaborators supported data collection and analysis and commented on the manuscript according to their specific expertise.

The first study comprises a detailed analysis of participants' full-body movement patterns in gait. Via the data-driven analysis and subsequent hypothesis-driven group comparisons, I extracted medication- and weight-independent limitations in posture, velocity, gait regularity, as well as sway, flexibility, and integration of body parts. The extracted movement limitations are based on the participants' movement only and are termed movement markers (MM) of schizophrenia.

The following hypotheses were tested:

- H1 The mere MoCap data will reveal significantly different movement characteristics for patients and controls, from which full-body movement markers (MM) can be extracted by controlling for confounding variables (medication load, weight).
- H2 Full-body MM are similar to but expand the movement characteristics of individuals with depression found by Michalak et al. [214].
- H3 Particularly interlimb coordination is affected.
- H4 Pronounced MM are associated with pronounced NSS (especially subscale motor coordination, and sensory integration)
- H5 Patients with pronounced negative symptoms display pronounced MM.

H2 relates our study to the one study applying a similar assessment set-up [see 214, or above]. Because impaired motor coordination (the inability to perform rapid alternating movements and difficulties in simple coordination tasks, such as finger-nose tapping or the tandem walk) is often reported in people with schizophrenia and even found to discriminate between high-risk children and controls, or between patients with schizophrenia and a mood disorder [150-152], I hypothesized interlimb coordination to be particularly affected (H3). As found in the systematic literature review, the most established neurological findings in the context of movement abnormalities in schizophrenia originate from studies on neurological soft signs (NSS). They are often related to psychopathological symptoms of schizophrenia, considered a sign for the risk of developing schizophrenia and used to

monitor disease progression [146, 148]. Hence, I chose the Heidelberger neurological soft signs scale [103] as a measure for neurocognitive symptom load and correlated the MM with NSS scores (H4). Furthermore, movement abnormalities of patients with schizophrenia are often found to be correlated with positive and negative symptoms: Increased positive syndrome scores are associated with reduced predictability of movements; higher negative syndrome scores are associated with low activity levels, slower and narrower movements [84]. Hence, I correlated resulting MM with the positive and negative symptom scale (PANSS) as a measurement for clinical symptom load [134] (H5).

I screened over 140 and finally included 50 participants (22 patients, and 28 controls). Due to drop out and propensity score matching, I analyzed the data of 40 participants (20 patients, 20 controls).

The study revealed three major findings: (1) Movement characteristics, extracted and quantified from basic walking, can differentiate between people with schizophrenia and controls, (2) many of the theory-independent MM are related to the integration and adjustment of body sides, limbs or the direction of movement, which definitely expands the range of movement characteristics Michalak et al. found in people with depression, and (3) most MM are associated with increased NSS, particularly with motor coordination and sensory-integration [89]. We could confirm all but one hypothesis. We could not find a significant association of the MM with positive or negative symptoms (H5). Auxiliary analyses (see publication 4) demonstrated the independence of the MM from the patients' medication load.
Table 3 shows the extracted MM. In the following, I briefly explain the expansive table:
For easy understanding, MM are organized into (1) postural markers, (2) kinematic markers, (3) markers related to velocity, and (4) relational markers which describe interlimb coordination. Patients not only displayed a slumped posture, they also walked slower, with smaller steps and with less and slower limb sway (arm, elbow, knee) than controls. Like patients with depression [214], they swayed more from side to side, which might indicate increased insecurity during gait. Interestingly patients' gait was less regular (less periodic or harder to model with FD) and varied more across moves. This is also reflected in the many relational markers. Patients adjusted or integrated the movement of limbs and body sides less while walking. The coordination of velocities or directions of limbs (goal directedness) was reduced, and limbs were used less flexible during gait.

Overall, the patients' gait can be described as slower, stiffer, and less organized, coordinated or integrated as the one of controls. It is important to note, that these differences were subtle, not visible with the naked eye. They could only be discovered by the detailed and objective analysis of the participants' movement data.

Table 3. Movement Markers of Schizophrenia

Movement Marker	Quantification (Movement Feature Acronym)	Manifestation in people with schizophrenia and controls	Relation to Neurological Soft Signs
Postural Markers			
Head Posture	Angle between head and clavicle. A bigger angle: more slumped posture/more hanging head (alphaHEAD)	Patients display significant bigger angles than controls, indicating their head is "hanging" more than the one of controls. Their posture is more slumped.	A slumped posture is positively correlated with the amount of NSS, especially with the subscales Motor Coordination and Sensory Integration. The higher the amount of NSS, the more slumped the posture of the participants.
Kinematic Markers			
Regularity/Pereriodicity of Gait	Modeling an individual gait with FD requires the walk to be periodic and repetitive. To quantify the periodicity of the groups' gait, we computed the participants' modeling power, a measure for the average variance covered by the number of Fourier components in the chosen model (in our case 2). Non-periodic or irregular elements are reflected in a lower power of the FD. A higher power indicates a more periodic or rhythmic walk. (Mpower)	Patients display a significantly lower mean modeling power than controls. It is harder to model their gait with periodic fourier decomposition. Their walk is less regular than the ones of controls.	The gait regularity is negatively correlated with the amount of NSS (subscales Motor Coordination, Sensory Integration, Complex Motor Tasks, Hard signs). The higher the amount of NSS, the more irregular the walk.
Variation of Regularity/Periodicity of Gait	Variation of the gait regularity within one walk: Standard Deviation of Average Power (see MPower) across 8 moves (SDPower).	Patients display a higher variation in their gait regularity. While the moves of controls can be modeled equally well, the moves of patients vary in their modeling power.	The variation of the gait regularity is positively correlated with the amount of NSS (subscales Motor Coordination, Sensory Integration, Complex Motor Tasks).
Stride Length	The average length of one stride (two steps) (MSL, MSTRL).	Patients walk with smaller strides and make significantly smaller steps	The step length is negatively correlated with the amount of NSS (subscale Motor Coordination, Sensory Integration, Right/Left Spatial Orientation). The higher the amount of NSS, the shorter the steps.
Arm Sway	3D/horizontal/forward Wrist Sway of left and right side and averaged across sides (AS3, WSL3, WSR3, AS2, WSL2, WSR2, AS1x, ASL1x, ASR1x) *or* changes in arm pit angle (URMLAx, URMRAx)	Patients display a lower arm sway. On average they move their arms less than controls. This applies to all quantifications of arm sway (3D, horizontal, AP, physicality independent).	Arm sway is negatively correlated with NSS (subscales Motor Coordination, Sensory Integration, Complex Motor Tasks). The higher the amount of NSS, the smaller the amount of arm movement. *Furthermore, there is a positive correlation with the subscale hard signs. This somewhat contradicts the other correlation patterns.*
Elbow Sway	3D Elbow Sway of left and right side and averaged across sides (ES3, ESL3, ESR3) or Changes of elbow joint angle (3D: URMLE3, URMRE3, AP: URMLEx, URMREx, or lateral: URMLEy, URMREy)	Patients display a lower elbow sway than controls. On average they move their elbows less than controls. Furthermore they display less movement in their lower arm, in all directions.	Elbow sway is negatively correlated with NSS, especially with the subscales Motor Coordination, Sensory Integration and Complex Motor Tasks. The higher the amount of e.g. Motor coordination Deficits the smaller the amount of elbow/lower arm movement. *Like the arm sway 3D elbow sway is positevly correlated with the subscale Hard Signs.*
Knee Sway	3D Knee Sway of left and right side and averaged across sides (KS3, KSL3, KSR3)	While walking, patients move their knees less in all directions than controls.	*We could not find a significant correlation with NSS.*
Lateral Body Sway	Mean amplitude of left and right shoulder in lateral direction (LBS) or changes of Thorax angle in lateral direction (URMTRy).	Patients display a larger lateral sway, lateral movement of the upper body while walking.	Lateral body sway (LBS) is positively correlated with NSS subscale Complex Motor Tasks, indicating a higher amount of difficulties with complex motor tasks when displaying more lateral sway while walking.

Velocity Markers			
Gait Velocity	Average speed across all 8 moves (MV).	Patients walk with less speed than controls.	The average speed is negatively correlated with the amount of NSS (subscale Motor Coordination). The higher the amount of NSS, the slower the walk.
Arm Sway Velocity	Wrist Sway multiplied by Cadence (3D: vWSL3, vWSR3, Horizontal: vWSL2, vWSR2)	Although patients don't walk with a lower cadence, they display a slower arm sway than controls for both sides (left and right).	The velocity of the arm movement is negatively correlated with NSS, subscale Motor Coordination, and overall NSS. The faster the movement, the smaller motor coordination deficits.
Elbow Sway Velocity	3D Elbow Sway multiplied by Cadence (vESL3, vESR3)	Patients display a slower 3D elbow sway than controls for both sides (left and right).	The velocity of the elbow movement is negatively correlated with NSS, subscale Motor Coordination, and overall NSS. The faster the movement, the smaller motor coordination deficits.
Relational Markers (Interlimb Coordination)			
Adjustment of Body Sides (left/right)	Ratio of wrist sway on left and right side in AP direction: A bigger ratio indicates a higher difference between the sides, one side moves more than the other (RatioWSLR1).	Patients display a higher ratio, indicating that one arm moves more than the other. The Ratio of controls is closer to 1, indicating that arms on both body sides are moved with the same amount.	The adjustment of body sides is positively correlated with the amount of NSS, especially Motor Coordination. The higher the ratio of the arms (the harder the adjustment), the bigger the amount NSS.
Goal Directed-ness of Movement	Difference of URM of Left/right upper arm (diffURMLA, diffURMRA) or shoulder (diffURMLS, ratioURMLS, diffURMRS, ratioURMRS) in AP and lateral direction. .	Patients display less movement in AP direction of the arms when related to movement in lateral direction. Patients also display more lateral movement of the shoulders, when related to AP movement, Controls move their shoulders more in AP or walking direction. Patients' movement seems less goal or forward directed. *The same pattern can be found for the lower Arms (e.g. diffURMLE).*	The goal directedness of the arm and shoulder movement is negatively correlated with the amount of NSS, especially Motor Coordination. The more goal directed the movement, the smaller the amount of NSS.
Flexibility of Limb Movement	Ratio/Difference of mean wrist and elbow sway of both sides (left/right) all directions (RatioWEd, DiffWEd) or difference of URM of left upper arm (arm) and left lower arm (elbow) in AP or lateral direction (diffLELAx, diffRERAx, diffLELAy, diffRERAy).	All Participants move their lower arms/wrirsts more than their upper arms/elbows but patients display less lower arm movement in relation to their upper arm movement. Their arm movement while walking is more rigid. A look at the physicality independent flexibility measures reveals that stiffness is apparent in both, AP and lateral movement of the arms.	The flexibility of the arm movement is negatively correlated with the amount of NSS (subscale Motor Coordination, Sensory Integration and Complex Motor Tasks). A higher flexibility is related to a smaller amount of NSS.
Adjustment/ Integration of Limb Movement	Ratio of leg and arm movement (RatioLAd, DiffLAd) or difference of shoulder and hip movement (DiffSHd). A higher ratio/difference indicates less adjustment of arm to leg or shoulder to hip movement.	Patients move their legs much more in relation to their arms than controls or their arms much less in relation to their legs. They don't adjust arm movement to steps. Furthermore, patients display less of an adjustement of shoulder and hip movement.	The adjustment of leg and arm movement and of shoulder and hip movement is positively correlated with the amount of NSS, especially Motor coordination. More adjustement of arm and leg or shoulder and hip movement (smaller ratio) is related to a smaller amount of NSS.
Adjustment/ Integration of Sway Velocites	Ratio of velocity of Elbow and Knee Sway (rationvLKE3, rationvRKE3). A smaller ratio indicates a better adjustment of sway velocities.	Patients and controls display differences in the adjustment of body part velocities. They move their knees 2.24 times as fast as their elbows, controls only 1.7 times as fast. This is in line with the fact that arms are used much less and in a stiffer way.	The adjustment of sway velocities between arms and legs is positively correlated with the amount of Motor Coordination Deficits and the amount of overall NSS, but negatively correlated with hard signs. The better the adjustment, the smaller the motor coordination deficits but the more pronounced the hard signs.

Note. The table is taken from [89]. One "move" is one way through the MoCap volume in the HCMR lab. We recorded 8 moves for each participant. The column "Movement Marker" (MM) refers to the concepts, which point towards schizophrenia. The column "Quantification" offers options of quantification that we found for the respective markers. It also displays the shortages of the feature names, which can be used to look up details of all defined features and their quantification in table 1 in the supplementary material and (upon request of the first author) in the respective Matlab script of publication 4. AP = Anterior-posterior

5.2 Balance in schizophrenia (collaboration with Kevin Stein)

In the second study, we compared static and dynamic balance capabilities of people with schizophrenia and controls. From the study protocol (see section 4.3.1 and appendix B), we analyzed the static balance test - five increasingly complicated static balance tasks, each one performed with full somatosensory information (eyes open) and with visual deprivation (eyes closed) [see 216, p. 62] - and one dynamic balance task: the tandem walk. While study design, participant recruitment and data assessment was done by the author of this thesis, data analysis was performed by Kevin Stein. Details of the analysis can be looked up in Stein's dissertation [216]. The joint publication of the study results is pending, the manuscript in writing.

The following hypotheses were tested [see also 216]:

- H1 Patients with schizophrenia will exhibit static balance deficits: lower success rate in static balance test, balancing for a shorter time (balance time).
- H2 Patients and controls will differ in Centre of Pressure (CoP) parameters when comparing successful trials.
- H3 Patients will exhibit dynamic balance deficits: balance time, Centre of Mass (CoM) dynamics, average angular velocity, posture control.
- H4 Loss of visual information will have larger effects on patients than on controls, both in the static and dynamic balance task (static: more falls, larger changes in CoP sway parameters, dynamic: recovery steps, step accuracy, step distance, CoM acceleration, normalized angular momentum, Zero Moment Point (ZMP) sway [237]).
- H5 We expect larger changes of balance behavior (balance strategy) in controls.
- H6 Balance deficits will be related to elevated PANSS scores.

Similar to the first study, the second study aimed at a detailed analysis of full-body movement in balance behavior and its changes in schizophrenia. Aside from obvious parameters of balance success (balance time and falls), our goal was to analyze subtle differences in successful static and dynamic balance trials. Stein [216] gives a detailed overview of stabilometric parameters and reasons for their selection in his dissertation (H1 & H2). Only a few studies analyze dynamic balance in people with schizophrenia. Jeon and colleagues [70], for example, found that individuals with schizophrenia fail the tandem walk at a higher rate by means of successful steps, distance without falling and walking speed [216]. Again, analyzed parameters remain superficial and broad. Stein analyzed slackline balancing in healthy individuals and defined detailed, full-body performance indicators for dynamic balancing [216]. The abovementioned parameters for dynamic balance in the tandem walk are chosen on the basis of his results (H3) [216]. Furthermore, previous studies found subtle medication-independent limitations in postural sway of respective patients [209], which increased in tasks containing unreliable somatosensory information, such as visual deprivation or conflicting visual information [185]. Hence, we hypothesized that a loss of visual information will increase balance deficits in the group of patients (H4), mainly because of the inability to adapt the own balance strategy to changing task requirements (H5). Again, movement performance is correlated with clinical symptom load (H6).

In total, 40 of 50 individuals were analyzed regarding their balance capabilities (20 patients, 20 controls). Because balance was dramatically limited in some, not all balance tasks could be analyzed for all participants.

Detailed results are summarized and plotted in Stein's dissertation [216]. As hypothesized, individuals with schizophrenia displayed significant limitations in static and dynamic balance performance. Patients' success rate of the static balance test as well as their balance time was significantly lower than that of controls. In successful trials, their sideways CoP sway distance was increased and CoP sway frequency was decreased. The combination of those two parameters (increased distance with decreased frequency) can be understood as a reduced CoP control in sideways direction [see216, p. 123]. Similarly, patients displayed larger CoM acceleration and larger ZMP sway when performing the tandem walk. Patients additionally performed more recovery movements during the tandem walk, which resulted in a larger utilized range of motion of the shoulder joints and larger normalized angular momentum. The deprivation of visual stimuli lead to performance decline of equal amounts in both groups, both in static and dynamic balance tasks. Hence, we can not confirm hypothesis 4. However, we found an inability in the patient group to adapt the own balance strategy to the specific task (H5). While controls started using their arms to compensate the restraint of recovery steps (in the tandem walk the feet need to stay placed in front of each other, touching each other), patients kept on doing recovery steps and mostly did not engage the arms for balance performance (mean shoulder and elbow angles, different mean posture). Like in the first study, we did not find a clear correlational pattern of balance deficits with PANSS scores and therefore can not confirm hypothesis 6.

Overall, balance was significantly limited in patients, both in static and dynamic tasks. During the tandem walk, patients needed to actively maintain balance already during the open eyes condition [216]. Controls only started to do balance movements with eyes closed. Additionally, patients lacked the capability to adjust their balance strategy. Again, these subtle differences are derived from the analysis of the movement data and are hardly detectable by mere observation.

5.3 Changes in self-experience and their relation to movement markers (publication 5)

Own contributions to the publication: I designed the study, organized recruitment, conducted the data collection, and wrote the manuscript. I performed the correlation analysis. The qualitative content analysis was done in collaboration with David Melchert. Further collaborators supported phenomenological interpretation of results and commented on the manuscript according to their specific expertise.

The third study applied a mixed methods approach, which involved the thorough assessment of patients' self-experience, its qualitative and quantitative analysis, and finally the systematic relation of changes in self- and body experience to the previously defined MM.

The following hypotheses were addressed:

- H1 The previously defined MM are correlated with changes in self- and body experience of patients: Specifically higher scores of the MM (a more severe impairment) are associated with higher ratings in the EASE subdomains 2 "Self-awareness and presence" and 3 "Bodily experiences".
- H2 Specific anomalous self-experiences (specific EASE items including but not restricted to "diminished sense of self", "distorted first-person perspective", "somatic depersonalization") are correlated with stronger MM manifestation.
- H3 Individual manifestations of MM (movement profiles) are reflected in the participants' qualitative descriptions of self- and body experience, in the sense that higher MM manifestations are associated with more and more intense descriptions of limitations in self- and body experience.

While both basic self-disorders (SDs) and movement abnormalities are discussed endophenotypes of schizophrenia psychopathology, they are rarely related [66, 90]. So far, only two studies empirically tested the association of basic self-disturbances and neurocognitive or sensorimotor symptoms in patients with schizophrenia: (1) Nelson and colleagues [127] could predict anomalous self-experience with source monitoring tasks (Action Memory Task, Word Recognition Test, Temporal Binding Task, Auditory Button-Press Task) in linear regression models. Tonna et al. [52] found an association between SDs and a specific postural pattern as well as a general disruption of the gait cycle. Hence, I correlated the previously defined MM with EASE total scores and with the five subdomains of the interview (H1). Because the interview subdomains are a collection of experiences, which share a common ground but are very heterogenous in their experiential nature [53], I added correlations with specific EASE items to the analysis (H2). I hoped this might shed light on the question which exact experience was related to the respective MM. Finally, because every quantitative analysis inevitably involves a massive data reduction [238], we complemented the correlation analysis with an in-depth qualitative content analysis of a subset of interviews [239, 240] (H3).

I interviewed 22 patients with schizophrenia. In order to be able to relate MM to self-experience, I analyzed the interviews of the same patients who qualified for the MM analysis

(see publication 4). The interviews of four participants (3 men, 1 woman) were analyzed qualitatively.

In the following, I summarize the study's key findings. First, confirming previous studies, I found many anomalous self- and body experiences in the study participants with a diagnosis of schizophrenia. Detailed textual examples of the experiential categories mentioned by all subgroup participants are given in publication 5.
Second, the correlation analysis suggests an association of changes in self- and body experience of patients with the theory-independent MM. Correlational trends appeared especially in the domain of (1) cognition, (2) self-experience and presence, and (3) bodily experience. Different than hypothesized (H1), we could not find statistically significant associations but only correlational trends.
Third, many MM were associated with specific anomalous experiences (H2). This accounts primarily for relational and adjustment-related MM. A stiffened, less coordinated and goal-directed gait, for example, was significantly correlated with subjective experiences of somatic depersonalization, or the disruption of the first-person perspective. Detailed results can be looked up in the correlation tables in publication 5.
Fourth, individual MM manifestations are not precisely reflected in the individual accounts of self- or body experience (H3). However, when looking at specific experiences, such as hyperreflexivity, we found trends of more and more intense descriptions of anomalous experiences with increasing MM manifestation. For the systematic relation of qualitative and quantitative data, we created movement profiles (MPs) for each subgroup participant (see figure 4 to 7) and quantified how frequent anomalous self- or body experiences were mentioned respectively (see table 4). Adding the results of the qualitative content analysis, we were able to relate frequency and intensity of the subgroup patients' anomalous self- and body experiences to their specific MM manifestation.

Overall, subtle changes in movement coexist with changes in self- and body experience in people with schizophrenia. Coordination and integration related MM are directly related to experiences of depersonalization and loss of ipseity. Specific anomalous experiences, such as hyperreflexivity are described more frequently and in greater intensity with higher MM manifestation.

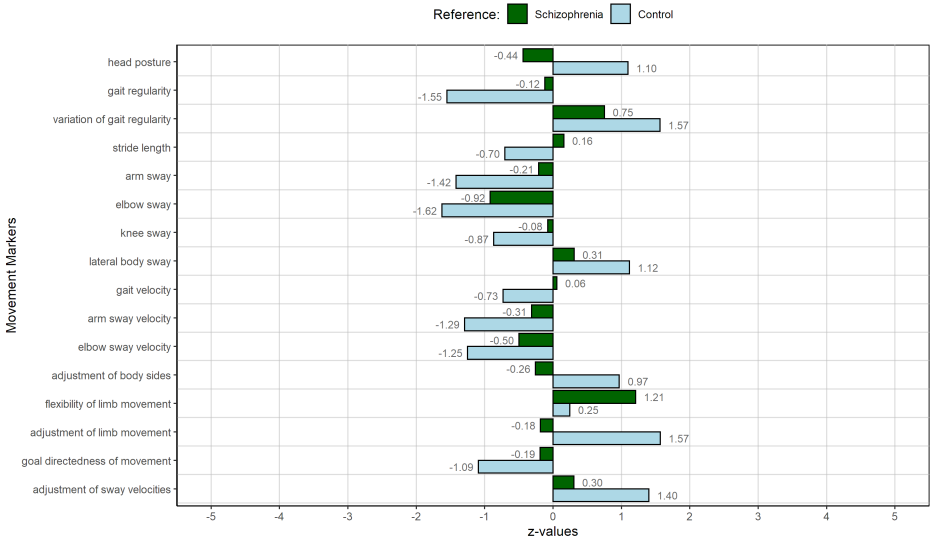

Fig. 4. MP of RM05: Figure taken from [40]. The person with the lowest MI, hence, the smallest deviation from the other patients, representing the prototypical patient of the schizophrenia sample. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

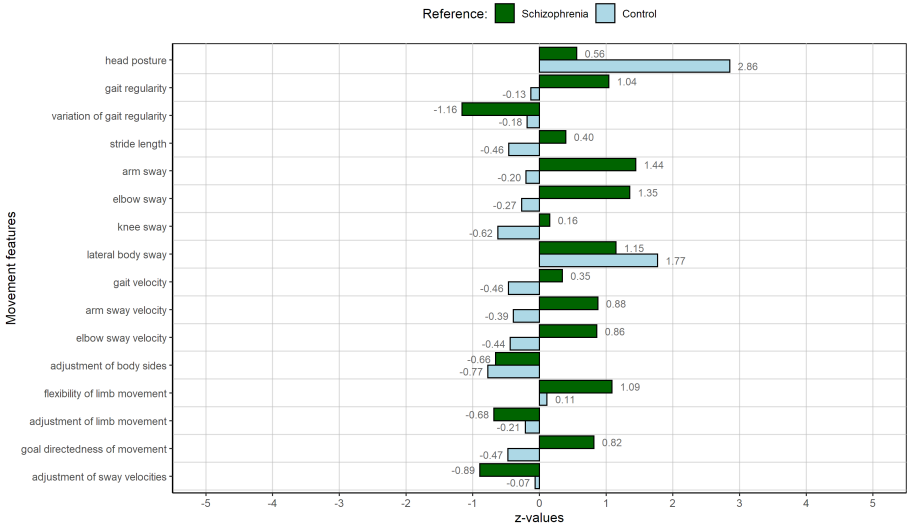

Fig. 5. MP of IH12: Figure taken from [40]. The female person with an average movement index, representing a medium deviation of the schizophrenia sample. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

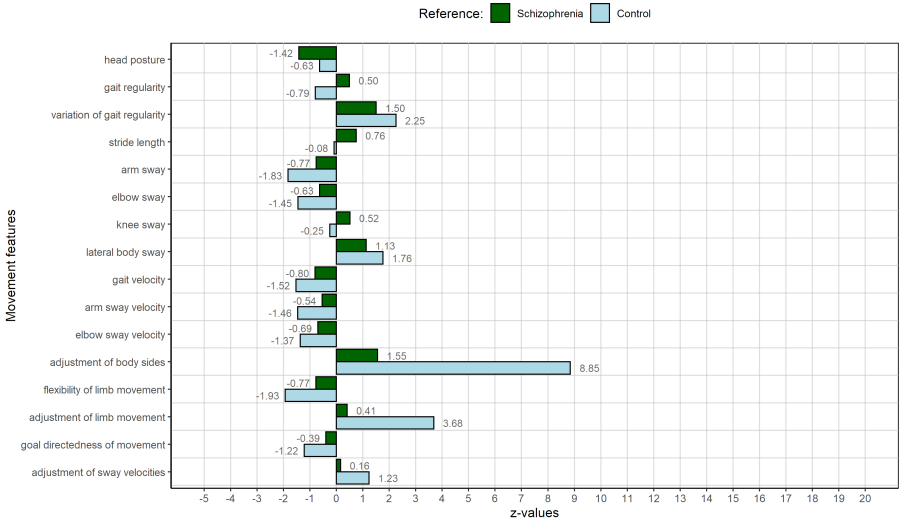

Fig. 6. MP of AB04: Figure taken from [40]. The male person with an average movement index, representing a medium deviation of the schizophrenia sample. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

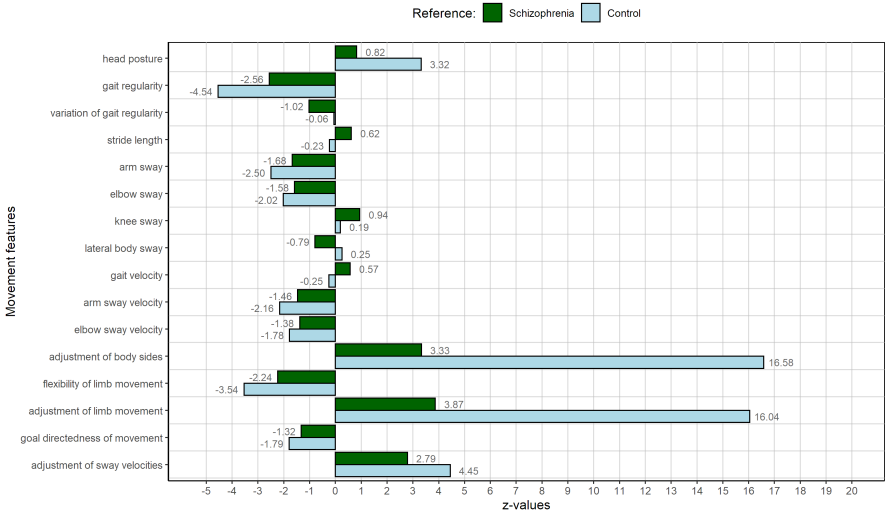

Fig. 7. MP of SF03a: Taken from [40]. The person with the highest movement index, representing a high deviation from the other patients or the most atypical movement profile regarding the patient group. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

Table 4: Frequencies of individual descriptions of anomalous self- and body experiences

	RM05	IH12	AB04	SF03a		
Category	**Frequency of category mentioning**				**Total**	**Brief description of category**
Self-experience						
Feeling of self-insecurity	**4**	**4**	**12**	**9**	**29**	Worrying about being yourself and being a person.
Feeling of anxiety	3	9	4	0	16	Includes panic attacks, psychic-mental anxiety, phobic anxiety, social anxiety, diffuse anxiety, and paranoid anxiety.
Distorted first-person perspective	0	1	1	0	2	Thoughts, perceptions, or feelings appear as deprived of the tag of mineness.
Feeling of a loss of control	**10**	**7**	**9**	**3**	**29**	The feeling of being dependent or to lose control.
Feeling of being absent/not present	1	0	2	2	5	The feeling of not fully participating in the world or not being entirely present in the world.
Feeling of being unlively/devitalized	**3**	**1**	**3**	**2**	**9**	A diminished vitality, diminished initiative, hypohedonia or (in extreme cases) the feeling of being a liveless, dead object/body.
Hyperreflexivity	**2**	**3**	**3**	**5**	**13**	The tendency to exaggeratedly monitor one's own sensations, emotions and thoughts; The attempt to volitionally steer otherwise tacit processes.
Mirror-related phenomena	0	0	0	1	1	An unusually frequent, and intense looking in the mirror or avoiding one's specular image or looking only occasionally but perceiving a facial or bodily change.
Sense of change in relation to age	0	0	1	0	1	A fundamental feeling of being considerably older or younger than the actual age, not related to social relations/interactions.
Fragmentation of experience	0	1	1	0	2	Stimuli and experiences, which usually tacitly appear to the subject as a unity, are perceived as fragmented.
Somatic depersonalization/bodily estrangement	0	0	0	1	1	Estrangement of the body and its movement.
Body experience						
Loss of body agency	0	0	3	0	3	The sense of losing control of one's own body movement.
Motor blocking	0	2	0	0	2	Sudden weakness (paresis), impediment or complete blockage of intended motor actions.
Disautomation	**1**	**1**	**2**	**1**	**4**	The tendency to exaggeratedly monitor one's own actions. Patients try to volitionally steer the otherwise tacit actions.
Rigidness/choppiness	0	0	0	1	1	Perception of own movements as rigid and choppy.
Feeling of lost body ownership	0	0	0	1	1	Disturbances in the sense of being the subject /owner of the movement or the body.
Psychophysical misfit and psychophysical split	0	0	0	2	2	The body or individual parts of the body are experienced as being isolated and separated from one another, as not being present at all or as not fitting to the owner.
Coenesthesias	0	1	1	0	2	Unusual bodily feelings, which cannot be explained medically; Also termed body hallucinations.
Motor slowdown	1	0	0	0	1	Own movement is perceived as being slowed down.
Thoughts linked to movements	0	0	1	0	1	Single or repetitive movements are perceived as related to thoughts.
	25	30	43	28		

Note. Table taken from [40]. Categories of self- and body-experience are marked bold, if they were mentioned by all of the four patients. Frequencies refer to the entire interview.

6 Discussion

6.1 Summary

This dissertation project sought empirical evidence for the phenomenological definition of schizophrenia as disembodiment, or a fragmentation of pre-reflective, embodied experience. For this, I adopted an interdisciplinary research approach in theory refinement, method development, and study planning. Results comprise a refined phenomenological conception of disembodiment, as well as an interdisciplinary overview on terms and definitions of movement abnormalities in schizophrenia (theory: research question 1), objective assessment and analysis methods for the quantification of movement abnormalities and a disturbed interbodily resonance as aspects of disembodiment (methodology: research question 2 and 3), and finally, theory-independent movement markers (MM), balance and coordination traits of people with schizophrenia as well as the detailed analysis of the markers' interaction with the anomalous self-experience of patients (empirical evidence: research question 4-6).

All parts of the dissertation project (theory refinement, method development, study results) comprise novel contributions to the international body of research on schizophrenia psychopathology: First, refining the underlying psychopathology of schizophrenia, we delineated its manifestation on the many levels of pre-reflective experience. Together with the interdisciplinary overview of movement related symptoms, this enabled me to systematically operationalize aspects of the complex concept of an underlying, pre-reflective disturbance in schizophrenia. So far, I am not aware of other interdisciplinary operationalization attempts of the phenomenological concept of disembodiment.
Second, focusing on the lived body, we further developed a data-driven approach which analyzes full-body movement and coordination (MoCap data) as a primary source of information, and suggested empirical correlates (variables) for disembodied communication. I am only aware of one other study applying an instrumental and data-driven approach for the classification of patients and controls based on individual and interactional movement: see [117] for details. However, this study applied an a priori definition of classifiers based on a stochastic model of hand motion as opposed to a definition on the basis of the collected data, and, similar to most studies on movement abnormalities in schizophrenia [89, 104-117, 209], it focused on fine motor performance of the upper body [117]. I am not aware of any studies offering the PC-task to participants with schizophrenia. Third, applying our study protocol and analysis method, we were able to define the first theory-independent movement markers of schizophrenia, which are derived from full-body movement data, correlate with neurological measures and show systematic interrelations with changes in self-experience of patients. They can serve as preliminary empirical evidence for manifestations of the phenomenological concept of disembodiment, defined as the disruption of bodily-mediated, pre-reflective experience.

In the following, I will discuss selected theoretical and empirical results in the light of current research and draw a final conclusion. Please refer to the publications for a detailed discussion of the individual study results.

6.2 Discussion of results

Applying innovative assessment and analysis methods, I successfully distinguished individuals with schizophrenia from controls, based solely on their full-body movement. Theory-independent MM not only differentiated patients from controls, they were also associated with anomalous self-experiences of patients and of similar nature to static and dynamic balance impairments in patients [89]. Interestingly, patients' sideways sway was increased in both gait and balance. In addition, patients displayed a reduction of arm sway, an impaired adjustment of arm to leg movement while walking, as well as a lack of arm usage in balance strategy and adaptability (see results of study 1 and 2) [40, 89, 216]. In line with the few studies evaluating gait or coordination disturbances in people with schizophrenia [116, 118-120], these MM and balance impairments are mostly related to the integration, adjustment and coordination of body parts [89, 216]. Also, the MM primarily correlated with NSS related to motor coordination and sensory integration [see 89]. Thus, our movement markers can be interpreted as subtle signs for motor coordination impairment, which is not only incerasingly found in schizophrenia patients compared to other diagnoses [150], but also longitudinally associated with an increased risk for psychosis and schizotypy in children [87, 152]. Accordingly, the dissertation provides encouraging evidence for the beneficiary effects of a systematic early assessment and continuous staging of MM in schizophrenia.

As mentioned earlier, not only movement abnormalities, but also basic SDs are discussed as prognostic phenotypes of schizophrenia vulnerability [52, 66, 90, 127]. Our theory-independent MM displayed correlational trends with anomalous experiences related to cognition and consciousness, self-experience and presence, and bodily perception. Coordination- and integration-related MM were correlated with anomalous experiences related to a loss of ipseity: A stiffened, less coordinated gait, for example, was related to the subjective experiences of somatic depersonalization, or the disruption of the first-person perspective. Specific anomalous experiences, such as hyperreflexivity, intensified with increased MM manifestation in the personal reports patients [40, 89].
Generally, our correlations are in line with the results of the only two previous studies, testing associations of SDs and neurocognitive or sensorimotor measures: While Nelson and colleagues [127] found association of SDs with source monitoring tasks, Tonna et al. [52] revealed relations between SDs and disturbances in gait and posture.
More specifically, the fact that adjustment- and integration-related MM were correlated with somatic depersonalization and a loss of ipseity supports our redefinition of disembodiment as an underlying disturbance of embodied experience, which manifests on various levels of pre-reflective consciousness (see fig. 1). Instead of understanding either motor impairment, or SDs, as endophenotypes of schizophrenia, I consider them two manifestations of and their interrelation preliminary evidence for a disturbed pre-reflective and embodied consciousness. In addition, the correlations are in line with previous phenomenological descriptions of disautomation and dehabitualization [137] and underline the necessity to consider temporal aspects and a pre-reflective directedness in the understanding and analysis of movement in schizophrenia: Following Husserl, Merleau-Ponty [29] emphasizes a *corporeal intentionality* for the exploration and understanding of the world [241]. As described in the introduction (see section 1.2.1), this requires an immersion of the self in the body and a consequent self-evident and flexible usage of the

lived body in daily life [241, 242]. Only when immersed and embedded in our lived body can we feel alive and attribute experiences to ourselves. Smooth movements, automatic actions and a constant adaption to the affordances of the surrounding come as a result. Citing Kraepelin, Fuchs examines graceful movements and concludes that the impression of elegance depends on the temporality of the intentional arch ([137], p. 165). As described in 3.1, it is the pre-reflective anticipation of suitable future movements (protention) as well as the constant interplay and adaption of protentional-retentional connections which facilitates unified movement patterns and smooth actions on the one hand, and enables the experience of a continuous self on the other [137]. Many patients with schizophrenia no longer succeed in self-evidently using their body and thus in initiating and maintaining a smooth sequence of actions [137]. Usually tacit sensorimotor processes come to the fore, disruptive movement inferences perturb the intentional arch of an action, and once learnt and automatic movement Gestalts are fragmented and disintegrated [137] (see publication 5 and the following section for individual descriptions). With this the self-referentiality, or the feeling of being "home" in one's body, is increasingly lost. Patients not only experience their movements as choppy, rigid and disintegrated, they also feel detached from their bodies and selves [61, 205]. This of course extends to the social domain, where psychomotor skills are no longer at the service of self-expression, seem hollow and sometimes unfitting [137]. The significant correlations of integration-related MM with experiences of somatic depersonalization and loss of ipseity stress the significant role of the implicitly directed, moving body in self-perception.
As a consequence, diagnostics of schizophrenia might not only benefit from systematically and objectively assessing MM but also from taking into account early and subtle changes in self-perception. The integration of a joint assessment of MM and anomalous self- and body experiences into clinical routine might help improving early risk detection as well as diagnosis of schizophrenia before psychotic onset. A focus on subtle coordination and integration deficits in movement and their relation to early experiences of depersonalization might be specifically promising.

Not only diagnostics, but also treatment of schizophrenia would benefit from a systematic staging of MM and associated changes in self-experience. While there is a great body of research which underlines the beneficiary effects of embodied therapies for people with schizophrenia [5, 81, 122], their therapeutic mechanisms are yet to be understood. Transferred to simpler MoCap techniques, MPs such as the ones in fig. 4-7 could be used to observe changes of individual MM manifestation throughout therapy. Together with the discussion of an altered self-experience, this might help in creating individualized movement therapy with specifically targeted interventions and in better understanding therapeutic changes in embodied therapies. In fact, Putzhammer and colleagues already managed to specifically target and change stride length differences between patients and controls in an earlier study [118].

Furthermore, in our third study (publication 5), all subgroup participants described experiences of hyperreflexivity, which – as mentioned above – intensified with greater motor aberration. Prompted for hyperreflexivity, one participant even provided us with detailed examples of experiential changes on all levels of pre-reflective, embodied experience – feeling, thinking, perceiving including self-perception and moving [see 40, section 4.2]. AB04 [see 40] revealed (a) experiences of fragmented perception in reading, (b) fragmented

movement when walking stairs, (c) an alienation of the own thoughts and actions, (d) a long-standing insecurity in self-perception and a feeling of worthlessness, and finally even (e) a questioning of his own situatedness in the social world as well as (f) a questioning of common sense (all quotes are taken from publication 5 [40]):

(a) "[*To understand] the whole sentence, the context, and then the next one after it, this mass, or something like that, that's too much.*"
(b) "*The stairs seem different heights to me. As if the levels are different, as if I had to climb higher to overcome the next stair than the other."*
(c) "*That sounds really weird. My thoughts are clearly mine because I think them. But I don't have the feeling that they are just mine."*
(d) "*For years I thought I had to die. […] You just have the feeling that you are worth nothing if you are supposed to be killed*."
(e) "*I stand there and then I don't know how to stand. And then someone starts walking and then I start walking too and then I think: Mh, the other person is long gone while I still think about the traffic lights*."
(f) "*Why do we have money and not exchange [things]? […] With the carbon dioxide [in mineral water]: why does it bubble? […].*"

The interrelation of hyperreflexivity with MM manifestation comes as no surprise. Many phenomenological analyses consider hyperreflexivity a complementary phenomenon to the experiential disconnection between self and body [61, 205]. While disembodiment, as conceptualized above, occurs on a pre-reflective level and thus eludes verbal discussion, hyperreflexivity involves the subject paying attention to or observing her self-experience in a *too* reflective manner [57]. Given our result of its interaction with individual MM manifestation and previous phenomenological descriptions of its direct relation to somatic depersonalization, I consider hyperreflexivity an early and direct way of coping with the disruption of pre-reflective, embodied experience, which does not reduce but rather further contributes to self-alienation and illness progression [57, 58, 124, 125, 243]. Being one conscious part of an otherwise pre-reflective process of self-objectification in schizophrenia, hyperreflexivity might be an important and accessible symptom for future research and comprehensive therapy to address aside from subtle MM in early, possibly even prodromal stages of the illness.

Finally, a substantial proportion of the human brain is devoted to the perception, generation and control of movement, as well as the integration of all three processes for nonverbal communication [105]. Thus, in the following I would like to discuss some results of the dissertation project in light of current neuropsychological research on schizophrenia.
Childhood coordination impairment in people with schizophrenia is hypothesized to be rooted in the early disruption of the comparison and integration of multisensory and sensorimotor signals [24, 152, 244], a process, which has also been emphasized for the development of a coherent sense of self [245-247]. Chen et al. [248] for example identified reduced functional connectivity between the primary sensorimotor area and the occipital lobe, indicating a disturbed integration in primary perception-motor processing as one reason for a reduced sense of self. This finding is supported by a considerable amount of studies focusing on the so-called "corollary discharge" (CD) mechanism in schizophrenia

research [52, 249-252][12]. Poletti et al. [253] demonstrate how early impairments of the CD mechanism result in childhood motor coordination impairment as well as a slow degradation of embodied situatedness and the sense of agency. The CD mechanism is thus suggested to represent a pathophysiological link between motor impairment and psychotic risk [250]. It is viewed as the neurological facilitator of an implicit sense of mineness and agency on the one hand, and of motor coordination, fluid and coherent motor action as well as stable psychomotor experiences on the other [253]. While this comes as a surprise for some neuropsychiatric researchers [253], it is almost obvious from a perspective that considers the initially described phenomenological conceptualization of the human being as an embodied subject, whose self-perception, movement and interaction with the world is only possible because it is mediated by the implicit, pre-reflective usage of the body. Hence, the CD mechanism can be understood as the neurological underpinning of embodiment, or of a coherent, embodied, situated and flexible interaction with the world [249, 250]. The consequences of its impairment in schizophrenia can be seen as further neurological proof for an underlying disturbance of embodied consciousness and for SDs and motor impairment being two manifestations thereof [253].
This understanding is substantiated by striking similarities between our phenomenological theory refinement and the definition of neurocognitive correlates for basic SDs by Nelson et al. [124, 125]. When redefining the underlying illness of schizophrenia, we emphasized a porosity of protention [41, 136], meaning the implicit and embodied directedness towards probable events[13]. Nelson [124, 125] argues that passivity phenomena, hyperreflexivity, and as, a consequence, positive symptoms result from source monitoring deficits, meaning a disruption of the CD mechanism. Similar to the comparison of the protention to all "Urimpressionen" [136], the CDs are used for an automatic prediction of expected, and comparison with actual sensorimotor outcomes [251, 254]. A disruption of the creation and recognition of CDs results in the missing suppression of sensations originating from self-generated actions. The consequence is the direction of attention to self- or body experiences that normally are blocked out for a smooth interaction with the world [124, 125]. Like we did in publication 1 [41], Nelson names disautomated actions and hyperreflexivity as a result [124, 125].
Future studies might benefit from adopting an interdisciplinary and holistic approach of researching schizophrenia which takes into account self-experience, full-body movement, embodied interaction and the neurological underpinnings of all mentioned processes. They

[12] The basic neural mechanism allows individuals to distinguish between self- and externally generated movements or sensations, based on their predictability [249 – 251, 253]. Self-generated actions or movements are highly predictable whereas other-generated signals are not [124]. When movements are predictable, they involve neural signals (efference copies), which are used to predict and suppress the sensory activity arising from the following proprioceptive or sensory input [40, 249, 250]. The neural feedback that is predicted on the basis of the efference copy is called CD [249, 251]. It creates a subjective experience of control over own acts when the predicted sensation matches the actual sensation [253]. Also, the CD mechanism is crucial for monitoring and integrating sensorimotor feedback [249, 253]. It contributes to perceptual stabilization, continuity and fluidity of movements, and enables motor sequencing and motor learning [253].

[13] Recapitulation for easier understanding: A functioning "Protention" is mediated by attention. Similar to a beam of light, it shines on and selects expected events and inhibits inappropriate or improbable reactions, meanings or thoughts [41]. According to our theory refinement, a perforation of the "Protention" leads to a fragmentation of thinking, perception, including basic self-perception and movement [41]. Actions lose their relatedness or smooth transition [137], normally tacit sensorimotor processes become available for introspection, usually familiar perceptual patterns or Gestalts fragment to an overflow of details, and the flow of thinking is disrupted by unfitting and inappropriate thoughts [41, 45, 243]. Often, individuals compensate the fragmentation of pre-reflective, embodied experiences by a hyperreflexive awareness to their own thoughts, appearance and actions (hyperreflexivity) [243].

might draw from such innovative research approaches as Mobile brain/body imaging (MoBi) [255]. The analysis of systematic interactions of CD impairment and all levels of pre-reflective consciousness, as conceptualized in publication 1, both in healthy individuals and in patients with schizophrenia, might play a central role.

6.2 Critical reflections and future directions

While the dissertation project shed light on various research questions, it leaves room for additional investigation and learnings. First of all, as is often the case in dissertations, I underestimated the amount of data and necessary time for its analysis. Hence, ample data remains to be analyzed and respective results to be published. Next steps comprise the correlation of the balance data with NSS and anomalous self-experience of patients, the analysis of MM manifestation in the dual task condition[14] and its comparison with simple gait, as well as the assessment and analysis of interaction difficulties with the PC task and their interrelation with individual MM.
In fact, by demonstrating the accuracy and efficacy of patient classifications involving biomarkers extracted from interactive motion, Słowiński and colleagues revealed the benefits of interactive assessment conditions for the testing of subtle movement abnormalities related to social communication [117]. While the authors underline the merits of applying artificial agents for "a high degree of control over the experimental condition" [117, p. 6], I appreciate exactly the opposite in the PCE: The minimalist set-up offers the possibility to assess real-time interactions of two real individuals and all corresponding interaction difficulties [49, 224, 225]. Hence, the systematic application of the PCE in a psychiatric context offers the possibility to research embodied interaction in a highly specific, systematic, effective and ecologically valid way, and should be focused on in future studies.

Despite being significantly less subjective than NSS ratings, the extraction of theory-independent MM presented in this thesis contains rating aspects as well as a dramatic reduction of the rich MoCap data. In the future, I would like to replicate movement characteristics found in study 1 (publication 3) applying innovative analysis methods, such as neural networks from machine learning (up to now mainly found in picture recognition and classification), as well as less reducing quantification methods: In contrast to our quantification approach, which defined indices based on single numbers for the MM, Słowiński et al. proposed distributions of values as movement features [117]. Because distributions contain more information than single values and hence allow for more accurate classification of individuals, it might be worth revisiting the MM quantifications with this approach in mind and to adopt it in future studies.

Moreover, in order to fully operationalize disembodiment as conceptualized above, I also need to specify measurements and correlates for pre-reflective aspects of feeling and thinking. While there is an ongoing debate on the nature and rise of emotions (emotions as feelings of bodily change [256] in contrast to emotions as appraisals of situations [257]), thinking or cognition are usually considered a rather reflexive construct, manifested in

[14] See study protocol, section 4.3.1 and appendix B.

processes such as memory or attention performance, and executive functioning [28, 258]. In publication 1, we illustrated how thinking and, as a consequence, speaking, against first intuitions, have a large pre-reflective part: Mostly, when thinking in or speaking our mother tongue, we do not need to consciously put together word after word, but rather follow a flow of thoughts that is easily verbalized [41]. We can concentrate on *what* we are thinking and want to say, without concentrating on *how* we think. In future studies, I would like to try to more precisely conceptualize and so operationalize implicit aspects of feeling and thinking, as well as their relations with the other levels of pre-reflective experience (see figure 1). A promising means of quantification in that context could be the concept of "forward flow" defined by Gray and colleagues and measured by latent semantic analysis (LSA) [259]. LSA [260] computes the semantic resemblance of two words by calculating their distance based on the frequency of their co-mentioning in other texts (0 = minimally different, 1 maximally different). Grey et al. combined free association techniques and LSA in order to create a quantitative measure for the implicit forward flow of our stream of thought (see [259] for details).

Finally, the main limitation of the dissertation project is the comparably small sample size of the empirical studies. As described in all empirical publications [40, 89], the sample size was a transdisciplinary compromise, which took into account previous studies, power calculations, the availability of the motion lab and the complexity and amount of the resulting data. Both MoCap and interview data are expansive and need a lot of preparation before being ready for analysis. One has to consider that one move of a participant through the MoCap volume contains the trajectories of 49 markers in 3 dimensions (x, y, z). I captured eight moves for each participant and filmed 50 participants in total. Thus, I ended up with 49 x 3 x 8 x 50 = 58.800 time series. Similarly, I interviewed 22 participants for about 3 hours each, which resulted in at least 40 pages of transcript for each person. Additionally, researching vulnerable individuals with schizophrenia in a clinical context is accompanied by inherent difficulties, such as drop-out rates, relapse, low study attendance and adherence, and mistrust towards instrumental assessment. While the replication of our preliminary evidence in bigger samples would put the MM and their relation to anomalous self-experiences on a more robust empirical ground, the existing publications show that journals recognized the innovative and possibly pioneering aspects of our research: By refining the term disembodiment and operationalizing aspects of it on different levels of pre-reflective consciousness, we have created a common ground for objective assessment methods and philosophical theory to converge and mutually enrich each other.

7 Conclusion

The quote which is taken from SF03's EASE interview and serves as a prelude to this dissertation gives us an idea of the extreme and fearful experiences of advanced disembodiment. Study participant SF03 not only experienced somatic depersonalization, but also his own movements as clumsy, rigid or choppy in daily life, and, compared to the other subgroup participants of study 3, presented with the highest MM manifestation (see MP in figure 7 and publication 5) [40].

The results of the dissertation project emphasize the benefits of a transdisciplinary conceptualization of schizophrenia, and the potential for improvement of contemporary diagnostics and treatment by the movement profiling of affected individuals [89, 253]. Movement profiles could include both single and interactive movement and could be applied for the systematic assessment and continuous staging of movement abnormalities, also in prodromal stages of the illness to predict psychotic onset. This would not only complement early and clinical diagnostic procedures, but also create the possibility for individually targeted and empirically informed embodied therapy. Also, I demonstrated throughout the dissertation project: in schizophrenia, subtle early and progressing changes in movement are accompanied by early and increasing changes in self-experience. Hence, modern therapy could not only benefit from the integration of movement assessment and treatment on the one hand, and from psychotherapeutic approaches, which focus on the verbalization and integration of anomalous self-, body- and world-experiences, on the other hand, but also from understanding the symptom categories as two manifestations of one underlying disruption of embodied consciousness.

This paradigm shift and the continuous consideration, assessment and relation of early and subtle changes on all levels of pre-reflective experience might lead to the long-awaited break-through on the way to a satisfactory treatment of schizophrenia.

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Publications

The full publication texts are appended on the next pages in the following order:

1. Knack, M., **Martin, L**., & Fuchs, T. (2022). Fragmentierte Zeitlichkeit. Ein phänomenologisches Modell der Schizophrenie als Störung präreflexiven Erlebens. *Phänomenologische Forschungen*. (22/1). 129-154.

2. **Martin, L.**, De Haan, S. (2021). EASE Interviewleitfaden mit Beispielfragen. In Fuchs, T., de Haan, S., Ludwig, M. & Martin, L. (Hrsg.) *Selbst- und Welterleben in der Schizophrenie: Die phänomenologischen Interviews EASE und EAWE.* (Vol. 1). Stuttgart: Kohlhammer. S. 113-129.

3. Zapata-Fonseca, L., **Martin, L.**, & Fuchs, T. (2021). Operationalizing Disembodied Interaction: The Perceptual Crossing Experiment in Schizophrenia Research. Phenomenology and Mind, (21), 111-125.

4. **Martin, L.**, Stein, K., Kubera, K., Troje, N. & Fuchs, T. (2022). Movement Markers of Schizophrenia – a detailed Analysis of patients' gait patterns*. Eur Arch Psychiatry Clin Neurosci*. doi: 10.1007/s00406-022-01402-y.

5. **Martin, L.,** Melchert, D., Knack, M., & Fuchs, T. (2023). Relating movement markers of schizophrenia to self-experience—a mixed-methods study. *Frontiers in Psychiatry,* 14, 1212508.

Monika Knack, Lily Martin, Thomas Fuchs

Fragmentierte Zeitlichkeit

Ein phänomenologisches Modell der Schizophrenie

Abstract

The variety of symptoms associated with schizophrenia are not easily unified under one coherent concept. Nevertheless, under the gaze of phenomenology, a disturbance of pre-reflexive experience has become increasingly apparent as the basis of the condition, which has so far been understood in two different ways: on the one hand, as a disturbance of basal self-experience, of my-ness or *ipseity* (Louis Sass, Josef Parnas, Dan Zahavi) and on the other hand, as a disturbance of the passive synthesis of inner time consciousness (Aaron Mishara, Shaun Gallagher, Thomas Fuchs). The present work introduces a link between the two approaches by regarding the basal self-experience grounded in an inner time consciousness. Schizophrenia is thus described as a disturbance of the temporal constitution of self-experience, which on the one hand causes self-alienation and on the other impairs the pre-reflexive, embodied performance of thinking, perceiving and moving. These analyses are then applied to the social dimension of the disorder, which manifests itself, among other symptoms, in the loss of spontaneous attunement with others.

Keywords: Schizophrenia, Phenomenology of Inner Time Consciousness, Protention, Schizophrenic Autism, Embodiment

Einleitung

Die Schizophrenie lässt sich in ihrer symptomatischen Vielfalt nur schwer unter einem kohärenten Konzept vereinen. Gerade dort, wo es darum geht, sich ihr nicht nur deskriptiv anzunähern, sondern die Symptome in ihrem strukturellen Zusammenhang zu verstehen, trifft man oft auf Widersprüchlichkeiten und divergierende Ansätze. Gleichwohl kristallisiert sich unter dem Blick der Phänomenologie eine Grundlage der Erkrankung heraus, die das breite Feld bündelt: Die Schizophrenie wird dabei als eine Veränderung präreflexiven Erlebens verstanden, welche jedoch bislang in zwei unterschiedlichen Weisen interpretiert wird: zum einen als partieller Verlust des basalen Selbsterlebens, der Meinhaftigkeit oder *Ipseität* der Erfahrung (Louis Sass, Josef Parnas, Dan Zahavi[1]) und

[1] Louis Sass, Josef Parnas, Dan Zahavi: „Phenomenological Psychopathology and Schizo-

zum anderen als Beeinträchtigung der passiven Synthese des inneren Zeitbewusstseins (Aaron Mishara,[2] Shaun Gallagher,[3] Thomas Fuchs[4]). Die vorliegende Arbeit unternimmt erstmals eine Verknüpfung der beiden Ansätze, indem sie das basale Selbsterleben in einem inneren Zeitbewusstsein fundiert sieht. Es ist demnach die *zeitliche Konstitution des Selbsterlebens*, welche in der Schizophrenie betroffen ist. Im Anschluss werden diese Analysen auf die soziale Sphäre der Erkrankung übertragen, die sich unter anderem im Verlust von spontaner Einstimmung (*attunement*) auf ein Gegenüber äußert. Die Schizophrenie lässt sich dabei in ihrem Kern als Beeinträchtigung präreflexiver Vorgänge verstehen, die von konstitutiver Bedeutung für das Selbst- und Fremderleben sind.

1. Präreflexives, leibliches Erleben

Die Schizophrenie als Veränderung präreflexiven Erlebens zu begreifen, bedeutet, sie als Beeinträchtigung von Vorgängen zu verstehen, die *vor* aller Reflexion die Grundlagen des Bewusstseins darstellen. Erst durch die präreflexive Situiertheit in der Welt, das heißt, durch die Allgegenwart von automatisierten und selbstverständlichen Vorgängen, ist eine Entlastung des intentionalen bzw. reflexiven Bewusstseins möglich.[5] So kann es sich selektiv bestimmten Tätigkeiten widmen, wie etwa dem Lösen eines Problems oder dem Erlernen einer neuen Fähigkeit. Präreflexive Vorgänge gehören demnach dem Hintergrund des Erlebens an; sie erlauben dem Subjekt, sich Unbekanntem und Neuem zuzuwenden, während das bereits Erlernte und Vertraute, wie etwa das Tippen dieses Textes auf der Tastatur, gedankenlos und automatisiert abläuft. Dies bedeutet jedoch nicht, dass sich präreflexive Vorgänge in vollkommener Abwesenheit des Be-

phrenia: Contemporary Approaches and Misunderstandings". In: *Philosophy, Psychiatry & Psychology* 18(1), 2011, 1–23.

[2] Aron Mishara: „Missing links in phenomenological clinical neuroscience: why we still are not there yet". In: *Current Opinion in Psychiatry* 20(6), 2007, 559–56.

[3] Shaun Gallagher: „Self-reference and schizophrenia: A Cognitive Model of Immunity to Error through Misidentification". In: Dan Zahavi (Hg.), *Exploring the Self: Philosophical and Psychopathological Perspectives on Self-experience.* Amsterdam/Philadelphia 2000, 203–239.

[4] Thomas Fuchs: „The Temporal Structure of Intentionality and its Disturbance in Schizophrenia". In: *Psychopathology* 40(4), 2007, 229–235; „Psychopathologie der subjektiven und intersubjektiven Zeitlichkeit". In: Thiemo Breyer, Thomas Fuchs, Stefano Micali & Boris Wandruszka. (Hg.), *Das leidende Subjekt. Phänomenologie als Wissenschaft der Psyche.* Freiburg/München 2014, 128–163; Thomas Fuchs & Zeno Van Duppen: „Time and Events: On the Phenomenology of Temporal Experience in Schizophrenia". In: *Psychopathology* 50(1), 2017, 68–74.

[5] Fuchs: „The Temporal Structure of Intentionality and Its Disturbance in Schizophrenia", 234.

wusstseins vollziehen. Sie werden vielmehr von ihm begleitet, das Bewusstsein wohnt ihnen bei, ohne sie jedoch aktiv zu steuern. Es sind deshalb gerade Vorgänge wie das Denken, Wahrnehmen und Bewegen, die präreflexiv fundiert sind. Sie werden zwar vom Subjekt initiiert, weisen jedoch stets eine gewisse Selbstständigkeit auf: Einen Gedanken müssen wir nicht erst bewusst zusammensetzen, bevor wir ihn denken können. Wir folgen vielmehr einem Fluss an Gedanken, die sich scheinbar ohne Konstrukteur zusammenfügen. Denken ist demnach, aller Intuition zuwider, in gewissem Sinn ein durchaus präreflexiver Vorgang. Er verläuft so selbstverständlich, dass wir uns gar nicht erst fragen, „wie" wir denn eigentlich denken, sondern nur „was". Ähnlich erscheint uns auch die Wahrnehmung als ein unhinterfragtes Geschehen, das selten Gegenstand unserer Reflexion wird. Lenkt man seine Aufmerksamkeit auf einen Gegenstand wie etwa eine Uhr, so muss man nicht erst Zifferblatt, Zeiger und Zahlen bewusst zusammenfügen, um Uhr und Uhrzeit zu erkennen. Vielmehr fügt sich ihre Gestalt mit einem Blick zu einer Einheit, sobald man sich ihr zugewendet hat. Ebenso verhält es sich in der Bewegung: Hat man den Entschluss zu einem Spaziergang gefasst, so bedarf es keiner Beachtung des Hebens und Senkens der Füße. Ja müsste man gar erklären, wie die Bewegung im Detail abläuft, dürfte man eher in Verlegenheit geraten.

Fuchs erklärt diese Selbstvergessenheit automatisierter Vorgänge damit, dass sie durch die wiederholte und gewohnheitsmäßige Ausübung Teil des impliziten Gedächtnisses bzw. *Leibgedächtnisses*[6] geworden sind. Die habitualisierten Bewegungen werden durch Einübung in den Leib „eingezeichnet", vollziehen sich schließlich selbstständig und sind damit kein expliziter, bewusster Gegenstand der Erfahrung mehr. Man könnte auch sagen: Die Bewegungen sind *leiblich* (*embodied*), insofern der Leib in der Ausübung kein äußeres Mittel, keine „Maschine" darstellt, die man zu steuern weiß, sondern, wie Husserl betont, ein präreflexives *Medium* der Erfahrung.[7] Helmuth Plessner gebrauchte für diese Unterscheidung auch die beiden Begriffe Leib (präreflexives Medium) und Körper (explizites Mittel).[8] Man kann sich seines Körpers zwar durchaus als Mittel bedienen, etwa dann, wenn man einen Tanz erlernt und die einzelnen Schritte wie ein Marionettenspieler anleitet; zum anderen wird der Leib jedoch, sobald man den Tanz einmal eingeübt hat, zum Medium des Tanzens. Von nun an muss man nicht mehr über die einzelnen Schritte nachdenken: Sie sind Teil eines automati-

[6] Thomas Fuchs: „Leiblichkeit und personale Identität in der Demenz". In: *Deutsche Zeitschrift für Philosophie* 66(1), 2018, 48–61, hier: 49.

[7] Maren Wehrle: „Being a Body and Having a Body. The Twofold Temporality of Embodied Intentionality". In: *Phenomenology of Cognitive Science* 19(3), 2019, 1–23, hier: 2.

[8] Helmuth Plessner: *Lachen und Weinen: eine Untersuchung nach den Grenzen menschlichen Verhaltens.* München 1950, 45.

sierten, leiblichen Ablaufes, der im Hintergrund der Erfahrung stattfindet. Das Subjekt kann sich nun z. B. dem mit dem Tanz Ausgedrückten zuwenden.

Zuletzt bleibt noch zu betonen, dass die begriffliche Trennung von Leib und Körper nur den Zweck der Veranschaulichung erfüllt. Streng genommen, müssen Leib und Körper als Verschränkung gedacht werden – als ein einziger „Körperleib".[9] Wie Plessner formuliert, ist ein Mensch „immer zugleich Leib […] und hat diesen Leib als diesen Körper".[10] Gemeint ist damit, dass unsere Leiblichkeit uns immer schon *bewusst* ist. Folglich stehen wir in einer gewissen Distanz, in einem *Verhältnis* zu unseren leiblichen Vorgängen. Die Besonderheit menschlichen Daseins besteht demnach darin, dass der Mensch „sein Erleben erlebt"[11] und dadurch das Bewusstsein der Relativität seines Tuns erlangt: Er könnte stets alles anders machen, als er es bisher getan hat. Selbst Personen, die ein Instrument gekonnt beherrschen suchen nach Möglichkeiten, das eigene Spiel zu verbessern, gehen demnach zwar in der gedankenlosen, leiblichen Bewegung ihrer Finger auf, hören sich jedoch zugleich selbst zu, sodass sie Unstimmigkeiten bemerken und ihr Spiel verfeinern können.

1.1 Schizophrenie als „Disembodiment"

Es ist nun gerade der eigene Leib, als präreflexives Medium der Erfahrung, welcher in der Schizophrenie nicht mehr „spürbar" wird. Zurück bleibt ein Körper, dessen man sich als explizites Mittel bedienen kann, freilich jedoch ohne sich selbst in ihm zu spüren: „Es fühlt sich so an, als ob dieser Körper nicht wirklich Ich bin, als wäre er vielmehr eine Maschine, die von meinem Gehirn kontrolliert wird, als wäre der Körper lediglich ein Anhängsel."[12] Die Person fühlt sich von ihrem eigenen Leib getrennt und muss ihn kontrollieren wie eine widerspenstige Maschine. Es ist dieser Verlust an leiblicher Situiertheit, der die Schizophrenie als Phänomen des „*entkörperten*[13] *Geistes*" („*disembodied spirit*"[14]) begreifbar

[9] Helmuth Plessner: „Lachen und Weinen: Eine Untersuchung menschlichen Verhaltens". In: Idem, *Ausdruck und menschliche Natur.* Gesammelte Schriften VII, hrsg. von Günter Dux, Odo Marquard & Elisabeth Ströker. Frankfurt am Main 1982, 205–384, hier: 240.

[10] Ebd., 238.

[11] Helmuth Plessner: *Die Stufen des Organischen und der Mensch: Einleitung in die philosophische Anthropologie.* Berlin/New York 1975, 292.

[12] Mads Gram Henriksen & Josef Parnas: „Ein klinischer und empirischer Blick auf Selbst-Sein und Verkörperung in der Schizophrenie". In: Thiemo Breyer, Thomas Fuchs, Stefano Micali & Boris Wandruszka (Hg.), *Das leidende Subjekt. Phänomenologie als Wissenschaft der Psyche.* Freiburg/München 2014, 188–204, hier: 194.

[13] Hier wird, um nah am englischen Orginal zu bleiben, der Begriff „Entkörperung" verwendet, welcher streng phänomenologisch gesehen, jedoch eher „Entleiblichung" heißen müsste.

macht. Eine betroffene Person berichtet, dass selbst die einfachsten Bewegungsabläufe, wie etwa das Treppensteigen, zu einer „geistigen Herausforderung" werden:

> *I* […] *constantly observed my walking and my movements… Climbing the stairs was also very extreme, when you need a bit of concentration and a feeling of balance. I really thought each step after the other, as it were, each movement.*[15]

Die Beschreibung beginnt mit der Beobachtung einer gewissen Desautomatisierung der Bewegung: Die Flüssigkeit eines Bewegungsablaufes kommt nicht mehr zustande.[16] Die Bewegungen erscheinen desorientiert, ungeschickt und verlieren an präreflexiver Sicherheit. Um dies zu kompensieren, versucht die Person schließlich, die Bewegungen gezielt „hervorzubringen".

Ebenso berichtet eine Person mit Schizophrenie, wie die Wahrnehmung präreflexiver Gestalteinheiten in verschiedene Assoziationen, Möglichkeiten und Details zerfällt, die das Bewusstsein schier überfluten[17]: „Ich muss mir die Dinge im Kopf zusammensetzen. Wenn ich meine Uhr anschaue, sehe ich die Uhr, das Uhrband, das Zifferblatt, die Zeiger usw., und dann muss ich das zu einem Ganzen zusammensetzen."[18] Analog zur Bewegung scheint die Wahrnehmung ihre unhinterfragte Funktionsweise zu verlieren. Sie erscheint fragmentiert, bei manchen Betroffenen sogar verschwommen oder unwirklich,[19] und muss fortan reflexiv von ihnen „gemeistert" werden, indem sie die Dinge „im Kopf zusammensetzen". Die Bündelung der Wahrnehmung wird folglich vom Subjekt selbst geleistet, anstatt selbstverständlicher Bestandteil der Erfahrungswelt zu sein. Man kann auch von einer „pathologischen Explikation" von eigentlich impliziten Wahrnehmungsgehalten sprechen, die mit einer Hyperreflexivität einhergeht.[20]

Ähnlich wie die Wahrnehmung entgleitet Betroffenen auch der Fluss des Denkens – das unmerkliche Übergehen eines Gedankens in den anderen. Dann müssen sie sich der eigenen Gedanken reflexiv vergewissern: „Sobald ihm ein Gedan-

[14] Giovanni Stanghellini: *Disembodied Spirits and Deanimated Bodies. The Psychopathology of Common Sense.* Oxford 2004.

[15] Thomas Fuchs & Sanneke de Haan: „The Ghost in the Machine. Disembodiment in Schizophrenia: Two Case Studies". In: *Psychopathology* 43(5), 2010, 327–333, hier: 330.

[16] Ebd.

[17] Daniel Sollberger: „Wider die Fragmentierung des Selbst". In: Daniel Sollberger, Hans-Peter Kapfhammer, Erik Boehlke et al. (Hg.), *Bilder der Schizophrenie.* Heidelberg 2015, 215–224, hier: 216.

[18] Thomas Fuchs: „Selbst und Schizophrenie". In: *Deutsche Zeitschrift für Philosophie* 60(6) , 2012, 887–901, hier: 894.

[19] Louis Sass, Elizabeth Pienkos, Borut Skodlar et al.: „EAWE: Examination of Anomalous World Experience". In: *Psychopathology* 50(1), 2017, 10–54, hier: 16.

[20] Fuchs: „Selbst und Schizophrenie", 894.

ke durch den Kopf ging, musste er seine Aufmerksamkeit zurücklenken und sein Bewusstsein untersuchen, um genau zu wissen, was er gedacht hatte."[21]

Der Betroffene ist seines Gedankenstroms entfremdet; er erlebt sein Denken erst im Nachhinein und muss ihm wortwörtlich *nach*-denken, um es zu erfassen. Einige Betroffene erleben ihr Denken deshalb auch als von außen gesteuert oder eingegeben und verlieren damit das Gefühl der Urheberschaft ihrer Gedanken.[22] Mit Lichtenberg könnte man auch sagen: „Es denkt in ihnen."[23] Sie können die Gedanken zwar noch in dem Sinne als die eigenen wahrnehmen, dass sie in ihrem mentalen Leben stattfinden; dennoch erscheinen sie ihnen fremd, als nicht selbst initiiert oder gesteuert. Doch selbst diese letzte Unterscheidung kann kollabieren, wenn die Betroffenen ihre eigenen Gedanken als Stimmen hören. Das heißt: Sie nehmen sie nicht bloß als von außen eingegeben, sondern als ihnen tatsächlich äußerlich wahr.

Die präreflexive, leibliche Sphäre der Erfahrung erfährt in der Schizophrenie folglich eine Entfremdung: Die Betroffenen werden aus dem Strom ihres Denkens, Wahrnehmens oder Handelns herausgelöst und müssen diese Prozesse fortan reflexiv oder explizit herstellen. Es ist ein Zerfall der alltäglichsten, selbstverständlichsten Dimension menschlicher Erfahrung. In diesem Sinne könnte man auch den Ausdruck einer Patientin des Psychiaters Wolfgang Blankenburg interpretieren, die Schizophrenie als „Verlust der natürlichen Selbstverständlichkeit"[24] bezeichnet.

1.2 Selbstverlust

Dieser Verlust betrifft nun auch die vielleicht grundlegendste Dimension präreflexiven Erlebens: Das eigene Selbsterleben. Mit seiner begrifflichen Einführung der Schizophrenie charakterisierte der Züricher Psychiater Eugen Bleuler sie zunächst als „Spaltung des Geistes".[25] Eine Möglichkeit, diese Spaltung zu interpretieren, besteht in einer Trennung des Subjekts von seiner Leiblichkeit.[26] Die Schi-

[21] Thomas Fuchs: „Psychopathologie der Hyperreflexivität". In: *Deutsche Zeitschrift für Philosophie* 59, 2011, 564–576, hier: 573.

[22] Ebd., 571.

[23] Orginalzitat: „‚Es denkt' sollte man sagen, so wie man sagt: ‚Es blitzt'. Zu sagen ‚Cogito' ist schon zuviel" (Georg Christoph Lichtenberg: *Schriften und Briefe.* Hrsg. von Wolfgang Promies. München Bd.1 1968 und Bd.2 1971, Aphorismus K76.

[24] Wolfgang Blankenburg: *Der Verlust der natürlichen Selbstverständlichkeit. Ein Beitrag zur Psychopathologie symptomarmer Schizophrenien.* Stuttgart 1971.

[25] Grc. *schizein* – spalten; grc. *phrēn* – Zwerchfell/Seele.

[26] Thomas Fuchs & Frank Röhricht: „ Schizophrenia and Intersubjectivity. An Embodied and Enactive Approach to Psychopathology and Psychotherapy ". In: *Philosophy, Psychiatry & Psychology* 24(2), 127–142, hier: 131 f.

zophrenie beschreibt damit eine Entkopplung vom eigenen basalen, leiblichen Selbst, die sich in einem Gefühl mangelnder Lebendigkeit oder Maschinenhaftigkeit, im Auftreten von ungewollten Gedanken und Bewegungen und schließlich in Erfahrungen der Fremdsteuerung äußert.[27] Zwei Betroffene beschreiben diese Entfremdung folgendermaßen:

> Ich bin gar nicht in der Lage, mein Selbst zu empfinden. Wer jetzt hier spricht, ist das falsche Ich. […] Je nach Augenblick entstehen und verschwinden unterschiedliche Selbst ganz ohne Regel. Es gibt keine Verbindung zwischen meinem jetzigen Ich und dem vorherigen.[28]
>
> *I constantly have to ask myself „who am I really?"* […] *It is not easy when you change from day to day. As if you were a totally different person all of a sudden.*[29]

Die Betroffenen beschreiben einen partiellen Verlust des Selbstgefühls; es handelt sich dabei nicht um eine vollkommene Auflösung des Selbst, sondern eher um eine zeitliche Fragmentierung. Was dabei verloren geht, ist folglich die grundlegende Kontinuität der Selbsterfahrung, das flüssige Übergehen eines Zustandes in den nächsten, die Einheit des Selbsterlebens über die Zeit trotz seiner Veränderungen. Dieser Umstand verweist auch darauf, dass das basale, leibliche Selbstgefühl, also die unhinterfragte Gewissheit, dass alle unsere Erfahrungen und Zustände von ein und demselben Subjekt erfahren werden, von der selbsttätigen Verknüpfung verschiedener „Selbstmomente" im Bewusstsein abhängt.[30] Das Selbst ist damit kein unveränderlicher „Zustand", kein „Ding" in uns, sondern ein kontinuierlich auf sich selbst bezogener *Prozess* – ein „Fluss" im eigentlichen Sinn des Wortes. Merleau-Ponty bringt es, an Husserl anschließend, auf die Formel: „Wir müssen die Zeit als Subjekt und das Subjekt als Zeit begreifen."[31]

Wir empfinden uns folglich als ein und dieselbe Person, weil alle mentalen Prozesse, Gemütszustände und leiblichen Empfindungen wie die Töne einer Melodie aufeinander bezogen sind.[32] Erst durch ihre wechselseitige (nach Husserl: protentional-retentionale, s. u.) Verknüpfung erscheint eine Melodie ebenso wie das Selbst als eine den einzelnen Momenten übergeordnete Gestalt. Das Selbst

[27] Ebd.

[28] Thomas Fuchs: „Zeiterfahrung in Gesundheit und Krankheit". In: *Psychotherapeut* 60, 2015, 102–109, hier: 105.

[29] Fuchs: „The Ghost in the Machine", 329.

[30] David Hemsley zeigt, wie die Fragmentierung des Selbsterlebens kognitionspsychologisch in einer Beeinträchtigung der Informationsverarbeitung begründet sein könnte. Ein Verlust der Kontinuität und Konsistenz der Informationsverarbeitung würde danach eine Schwächung des Selbsterlebens implizieren. Siehe David R. Hemsley: „The Disruption of the 'Sense of Self' in Schizophrenia: Potential Links with Disturbances of Information Processing". In: *Br. J. Med. Psychol.* 71(2), 1998, 115–124.

[31] Maurice Merleau-Ponty: *Phänomenologie der Wahrnehmung.* Berlin 1965, 480.

[32] Fuchs: „The Temporal Structure of Intentionality and Its Disturbance in Schiziophrenia", 231.

formiert sich ähnlich dem Wasserstrahl einer Fontäne, der trotz seines beständigen Werdens und Strömens als Prozessgestalt erkennbar bleibt.[33] Merleau-Ponty begreift das Selbstgefühl darüber hinaus nicht bloß in seiner zeitlichen Konstitution, sondern auch in seiner Leiblichkeit: Erst dadurch, dass die Fülle der leiblichen Empfindungen ebenso wie die Lage aller Glieder in einem „Körperschema"[34] integriert werden, wird eine einheitliche Selbstwahrnehmung möglich. Das Körperschema reicht dabei über die Grenzen des eigentlichen Körpers hinaus, insofern es zweckmäßige, räumliche Beziehungen zur Umgebung beinhaltet, die durch Habitualisierung erworben wurden. Die rechte Hand wird nicht bloß als z. B. leicht kühl, kribbelnd und in einer bestimmten Position erfahren, sondern auch als Hand, die das naheliegende Glas greifen und bewegen könnte.[35] Die Handlungsmöglichkeiten der Hand werden demnach in ihrer leiblichen Empfindung miterlebt. Das Körperschema wird damit zu einem Aktionsschema: Es ermöglicht und leitet die selbstverständliche „Handhabung" der Welt. Leibliche Selbstwahrnehmung bedeutet folglich eine Kontinuitätserfahrung, welche die leibliche Situiertheit in einem *Feld* innerhalb einer *Dauer* integriert.

2. Intentionalität des Bewusstseins

Die Schizophrenie lässt sich, wie deutlich geworden ist, als Fragmentierung der präreflexiven Erfahrung charakterisieren: Das Erleben der Betroffenen ist durch wiederkehrende Situationen gekennzeichnet, in denen Wahrnehmungsgestalten ebenso wie Bewegungsabläufe in einzelne Bestandteile zerfallen. In akuten Stadien der Erkrankung kann dabei sogar die Selbstwahrnehmung ihre tragende Kontinuität vorübergehend einbüßen. Der Psychiater Emil Kraepelin bezeichnete diesen Verlust einer organisierten Einheit der Person auch treffend als „Orchester ohne Dirigenten".[36] Dies lässt sich als Verlust eines synthetisierenden Vermögens interpretieren, welches die präreflexive Sphäre als Kontinuitätserfahrung erst konstituiert.

Husserl folgend lässt sich dieses synthetisierende Vermögen der Intentionalität des Bewusstseins zuschreiben. Gemeint ist dabei keine reflexive Form der Intentionalität im Sinne einer expliziten oder bewussten Ausrichtung auf ein bestimmtes Ziel, sondern ein implizites, präreflexives Gerichtetsein.[37] Erst durch

[33] Merleau-Ponty: *Phänomenologie der Wahrnehmung*, 479.

[34] Ebd., 123.

[35] Komarine Romdenh-Romluc: „Merleau-Ponty's Account on Hallucination". In: *European Journal of Philosophy* 17, 2007, 76–90, hier: 79 f.

[36] Emil Kraepelin: *Klinische Psychiatrie.* Leipzig 1913, 668.

[37] Dan Zahavi: *Husserls Phänomenologie.* Tübingen 2009, 13.

ihre intentionale Ausrichtung werden verschiedene Bewusstseinsmomente zu einer Einheit integriert: Beim Lesen eines Satzes etwa ist man auf seinen Sinn ausgerichtet; würde man jedes Wort einzeln lesen, ohne es im intentionalen Kontext des Satzes zu verstehen, so erschiene es unauflösbar mehrdeutig. Erst durch die intentionale Ausrichtung des Satzes gewinnen die Worte ihre passende Bedeutung. In besonderer Weise kann man dieses Phänomen dann beobachten, wenn man einen Text in einer fremden Sprache liest: Selbst wenn einem viele der auftretenden Worte unbekannt sind, kann man ihren Sinn häufig aus dem Zusammenhang des Textes erkennen. Die einzelnen Wahrnehmungsmomente, also die verschiedenen Worte eines Satzes, werden folglich mittels der intentionalen Ausrichtung zu einer sinnvollen Einheit verknüpft. Nicht anders verhält es sich auch beim Denken und bei der Bewegung – es sind gerichtete Kontinuitätserfahrungen, nicht Abfolgen von Zuständen.

Husserl veranschaulicht diese intentionale Ausrichtung des Bewusstseins in seiner „Phänomenologie des inneren Zeitbewusstseins“[38] am Beispiel einer Melodie:[39] Würde man eine Melodie schlichtweg „Ton für Ton“ hören, so könnte man sie nie *als* Melodie, d. h. als eine den einzelnen Tönen übergeordnete Gestalt erfassen. Eine Melodie wird folglich nicht als Folge von Punkten in der Zeit erfahren, sondern als zeitlich ausgedehnte Gestalt, die vergangene ebenso wie kommende Töne miteinschließt. Sie ist mehr als die Summe ihrer Töne – sie ist die jeweilige intentionale Beziehung zwischen ihnen.[40]

Laut Husserl ist die gegenwärtige Wahrnehmung damit ein relationales Feld von gerade vergangenen, gegenwärtigen und erwarteten Momenten. Hört man einen Ton B, so steht dieser in unserer Wahrnehmung immer schon in Relation zum gerade vergangenen Ton A und dem erwarteten Ton C. Ton A und C sind einem dabei jedoch nicht als „Vorstellungen“ gegeben, wie es etwa in der Erinnerung oder Antizipation der Fall ist, sondern sie sind integrale Bestandteile der gegenwärtigen Wahrnehmung. Wir *nehmen* den gerade gewesenen Ton A als vergangenen und den kommenden Ton C als erwarteten Ton *mit wahr.*[41] Auf diese Weise wird der Ton in seiner zeitlichen Extension, seiner *Dauer* erfasst.[42] Die Wahrnehmung ist demnach ein konstitutiv relationaler Prozess. Husserl bezeichnet diese verschiedenen Bestandteile der Wahrnehmung auch als Retention

[38] Edmund Husserl: *Zur Phänomenologie des inneren Zeitbewusstseins (1893–1917).* Husserliana X, hrsg. von Rudolf Boehm. Den Haag 1966 (Hua X).

[39] Ebd., 23.

[40] Kai Vogeley, Christian Kupke: „Disturbances of Time Consciousness From a Phenomenological and Neuroscientific Perspective“. In: *Schizophrenia Bulletin* 33(1), 2007, 157–165, hier: 158.

[41] Zahavi: *Husserls Phänomenologie*, 85.

[42] Hua X, 24.

(Nachklingen des gerade Geschehenen), Urimpression (momentaner Eindruck) und Protention (offene Erwartung des Kommenden).[43] Durch die Protention entfaltet sich das Denken, Wahrnehmen und Handeln, wie im Wortsinn schon angedeutet, über den gegenwärtigen Moment hinaus, auf ein „Noch-Nicht" hin.[44] Während die Protention folglich ungefähr vorwegnimmt, was kommen könnte, so hält die Retention am gerade Gewesenen fest. Um diese zeitliche Extension aufrechtzuerhalten, erfordern beide Phänomene eine gewisse Spannkraft (*tendere* = lat. spannen), welche durch die Aufmerksamkeit (Attention) gewährleistet wird. Ist die Aufmerksamkeit, wie etwa im Schlafentzug, verringert, so kann es dazu kommen, dass man beim Sprechen plötzlich den Faden verliert: Die Spannung der Pro- und Re-*tention* nimmt ab und mit einem Mal weiß man nicht mehr, worauf man hinauswollte, oder kann sich an das gerade Gesagte nicht mehr erinnern.

Die präreflexive Verschränkung von Retention, Urimpression und Protention wird von Husserl auch als passive Synthese bezeichnet.[45] Sie ist deshalb „passiv", weil sie zwar für das Bewusstsein konstitutiv ist, jedoch selbst nicht aktiv, reflexiv oder bewusst hergestellt wird. Merleau-Ponty beschreibt das Zusammenwirken der drei Zeitkomponenten später auch als den „intentionalen Bogen"[46] gerichteter Handlung, welcher die Einheit des Erlebens erst ermöglicht. „Er ist es, der in der Krankheit seine Spannkraft einbüßt."[47]

2.1 Protention

Es ist nun gerade die Protention als offene Erwartung des Kommenden, welche die spezifische Gerichtetheit, die Intentionalität des Bewusstseins ermöglicht. Beim Lesen eines Satzes etwa hat man eine offene, protentionale Erwartung dessen, welche Worte folgen könnten. Nach Fuchs bildet die Protention dabei einen Kegel an Wahrscheinlichkeiten, in dem all jenes enthalten ist, was zu erwarten ist.[48] Außerhalb des Kegels liegt dabei das vollkommen Unerwartete und Unpassende, das keinen impliziten Bestandteil der Wahrnehmung mehr bildet. Metaphorisch gesprochen, bildet die Protention folglich einen Lichtkegel,

[43] Fuchs & Van Duppen: „Time and Events", 70.
[44] Fuchs: „The Temporal Structure of Intentionality and Its Disturbance in Schizophrenia", 231.
[45] Vogeley & Kupke: „Disturbances of Time Consciousness From a Phenomenological and Neuroscientific Perspective", 159.
[46] Merleau-Ponty: *Phänomenologie der Wahrnehmung*, 165.
[47] Ebd.
[48] Ebd.

der die ungewisse Finsternis des Kommenden beleuchtet. Sie erhellt dabei den Bereich des Kommenden, der als am wahrscheinlichsten erlebt wird. Andere Möglichkeiten verbleiben jedoch im Dunkeln. Streift man mit einer Taschenlampe durch eine dunkle Wohnung, um einem Geräusch auf die Spur zu kommen, so richtet man den Lichtkegel auf jene Ecken, in denen man das Geräusch erwartet. Man nimmt das Kommende damit in gewisser Hinsicht „ins Visier" und ist somit darauf vorbereitet. Ertönt das Geräusch nun aus einem bisher dunkel gebliebenen Winkel, so führt dies zu einem Schreck. Fuchs gibt dafür auch folgendes Beispiel: *„When you hear me saying: ‚Yesterday I walked across the …', you both retain these words and expect others follow, which would not be e. g. ‚… the butter' but rather ‚… the bridge' or something similar."*[49] Nimmt der Satz nun eine vollkommen unerwartete und gar zu sinnlose Wendung, indem er etwa auf „Butter", anstatt auf „Brücke" endet, so kann man von einer enttäuschten Protention sprechen. Eine solche Enttäuschung führt zu einer kurzzeitigen Perplexität. Die intentionale Ausrichtung wird durchkreuzt und muss sich reorientieren, sozusagen „die Weichen neu stellen" und einen anderen Möglichkeitsbereich anvisieren. Es sind diese Momente des Schrecks, der Überraschung, des Erstaunens, die den präreflexiven Vollzug unterbrechen, einen Riss in der implizit gelebten Zeit herbeiführen und reflexiv gemeistert werden müssen.[50] Sie fordern zum Umdenken auf, zu Dynamik und Flexibilität.

Die Protention ist damit eine unbestimmte, nicht auf ein konkretes Ereignis festgelegte, implizite Erwartung von Wahrscheinlichem.[51] Die protentionale Erwartung hat dabei einen konstitutiven Einfluss auf das Erleben des jeweils nächsten Ereignisses. Wir nehmen den gegenwärtigen Moment, also die Urimpression, nicht unvoreingenommen wahr, sondern immer auf Basis unserer Erwartungen. In Husserls Worten: „Das Jetzt ist konstituiert durch die Form der protentionalen Erfüllung."[52] So ordnen wir doppeldeutigen Worten wie etwa „Ball" (Kugel oder Fest) oder „Kiwi" (Vogel oder Frucht) beim Lesen eines Satzes spontan Bedeutungen zu, weil wir sie aus dem Kontext heraus in einer bestimmten Erwartung lesen.[53] Husserl fasst zusammen:

> So gibt es im Strom der Wahrnehmung keinen Punkt, der nicht seine Intentionalität hätte, und insbesondere die Urpräsentation [Urimpression] ist dabei beständig nicht bloß Auftre-

[49] Ebd., 230 f.

[50] Thomas Fuchs: „Zeiterleben in Gesundheit und Krankheit". In: *Psychotherapeut* 60(2), 2015, 102–109, hier: 103.

[51] Fuchs: „The Temporal Structure of Intentionality and Its Disturbance in Schizophrenia", 231.

[52] Edmund Husserl: *Die Bernauer Manuskripte über das Zeitbewusstsein (1917/18).* Husserliana XXXIII, hrsg. von Rudolf Bernet & Dieter Lohmar. Dordrecht 2001 (Hua XXXIII), 14.

[53] Shaun Gallagher: „The Past, Present and Future of Time-Consciousness: From Husserl to Varela and Beyond". In: *Constructivist Foundations* 13(1), 2017, 91–116, hier: 96.

ten von Urpräsenzen, die erst nachträglich Intentionalität annehmen würden, sondern beständiges Auftreten derselben im Modus der Erfüllung von Erwartungsintentionen [Protentionen].[54]

Die Urimpression als gegenwärtiger Eindruck ist folglich immer schon durch die protentionale Erwartung geprägt und geformt. Die Protention ist laut Husserl damit eine „Leerintention",[55] die sich durch den gegenwärtigen Eindruck „füllt". Dadurch wird aus der unbestimmten Erwartung eine bestimmte Impression, ein Ein-druck. Husserl betont damit, dass die Urimpression selbst schon intentional strukturiert ist. Ohne diese Vorprägung erschiene uns das Erlebte fragmentiert, zusammenhangslos und mehrdeutig.

Nun kann der intentionale Bogen nur realisiert werden, wenn der protentionale Kegel durch eine fortlaufende Aufmerksamkeit so eingeschränkt wird, dass störende und unpassende Assoziationen oder Wahrnehmungen *inhibiert* werden.[56] Um also beim Schreiben oder Sprechen nicht abzuschweifen und dadurch unentwegt den „Faden zu verlieren", bedarf es nicht nur einer bloßen Wahrnehmung von Wahrscheinlichem, sondern auch einer Inhibition unpassender Einfälle. Die „Spannkraft" der Aufmerksamkeit bildet demnach aus den Rändern des protentionalen Kegels eine Art „Schirm", von dem alles, was außerhalb des Kegels liegt, gewissermaßen abgewiesen wird. Das Bewusstsein ist folglich immer schon ein Selektionsprozess, bei dem unpassende und unwahrscheinliche assoziative Möglichkeiten „des-aktualisiert" werden.[57] Daniel J. Simons und Christopher F. Chabris gaben 1999 mit ihrer Studie „Gorillas in Our Midst"[58] dafür ein eindrückliches Beispiel: Den Zuschauenden eines Basketballspiels wurde aufgetragen, sich entweder auf die in weiß oder schwarz gekleideten Teams zu fokussieren und die Anzahl der abgegebenen Pässe zu zählen.[59] Beim konzentrierten Verfolgen bemerkten dabei viele der Probanden einen Gorilla nicht, der sich unter die Spielenden mischte. Selbst ungewöhnliche und aufdringliche Details des Wahrnehmungsfeldes können demnach übersehen werden, wenn die protentionale Aufmerksamkeit gänzlich auf etwas anderes gerichtet ist und alle „unpassenden" Assoziationen oder Reize abschirmt.

Anders verhält es sich jedoch bei weniger gerichteten und aufmerksamen Zuständen, wie etwa beim Tagträumen, bei kreativer Assoziation oder Schläfrig-

[54] Hua XXXIII, 4.

[55] Ebd., 5.

[56] Fuchs: „Psychopathologie der subjektiven und intersubjektiven Zeitlichkeit", hier: 141.

[57] Werner Janzarik: „Autopraxis. Desaktualisierung, Aktivierung und Willensthematik". In: *Nervenarzt* 75, 2004, 1053–1060.

[58] Daniel J. Simons & Christopher F. Chabris: „Gorillas in Our Midst: Sustained Inattentional Blindness for Dynamic Events". In: *Perception* 28(9), 1999, 1059–1074.

[59] Ebd, 1066.

keit.[60] Assoziationen werden dann ohne konkrete Bezugnahme oder weitgehend grundlos erfolgen. Der protentionale Kegel ist in diesen Zuständen weiter geöffnet als beim konzentrierten Schlussfolgern und beinhaltet fernliegende und ungewöhnliche Möglichkeiten. Eine Verminderung der Aufmerksamkeit führt folglich zu einer „Weitung" des protentionalen Kegels, während dieser durch Konzentration verengt werden kann. Ist der Bereich des „Möglichen" nun erweitert, so können freie Assoziationen und innovative, aber auch verworrene Gedankenketten entstehen. Beim eigentlichen Träumen erreicht diese Weitung ihren Gipfelpunkt. Die träumende Person ist trotz der Ungewöhnlichkeit der Ereignisse nicht irritiert, da die erhebliche Weitung des protentionalen Kegels selbst die unwahrscheinlichsten Ereignisse als möglich erfasst. Durch die Auflösung der aktiven Aufmerksamkeit lässt sich auch das Gefühl der Passivität beim Träumen erklären.[61]

2.2 Schizophrenie als Porosität der Protention

First, she only noticed difficulties in doing her housework. All the time something interfered, other thoughts, but also disturbing movements. […] *The movements occurred on their own accord, she didn't have control over them.*[62]

I could no more think what I wanted; constantly alien thoughts were pushing in between.[63]

Diese Beschreibungen des Kontrollverlustes, der Fremdsteuerung und Gedankeneingebung bei Menschen mit Schizophrenie können laut Fuchs nun als Beeinträchtigung der Protention, insbesondere des protentionalen Schirms, also der Inhibition interpretiert werden. Die Betroffenen erleben ganz unbeabsichtigte Bewegungsfragmente und thematisch unpassende Gedankeneinschübe, die ihre intentionale Aktivität unterbrechen. Man könnte auch sagen, dass der Schirm der Protention, der unwahrscheinliche und unpassende Assoziationen inhibiert, in der Schizophrenie porös und durchlässig wird. Deshalb unterbrechen oder gar durchbrechen unpassende, nicht inhibierte Fragmente den intentionalen Bogen und somit die Handlung oder den Gedankenablauf selbst. Anders als beim Träumen sind die Betroffenen in der Schizophrenie dabei keine passiven Beobachter ihrer mentalen Zustände. Die intentionale Aktivität beginnt, die Aufmerk-

[60] Fuchs: „The Temporal Structure of Intentionality and Its Disturbance in Schizophrenia", 232.

[61] Ebd.

[62] Thomas Fuchs: „From Self-Disorders to Ego-Disorders". In: *Psychopathology* 48(5), 2015, 324–331, hier: 327.

[63] Fuchs: „The Temporal Structure of Intentionality and Its Disturbance in Schizophrenia", 233.

samkeit verengt den Bereich des Möglichen, wird dann aber ständig unterbrochen: Immer wieder drängen sich unpassende, nicht intendierte Assoziationen in den Bewusstseinsstrom. Die Protentionen sind folglich nicht nur geweitet, sondern reißen immer wieder ab. Der Verlust der Inhibition von unpassenden Eindrücken und Assoziationen bedingt dabei eine Entfremdung der Wahrnehmung. Die einheitliche Wahrnehmung, die durch die protentionale Gerichtetheit ermöglicht wird, zerfällt in verschiedene Assoziationen und Details. Der Psychiater Eugene Minkowski beschreibt, wie sich einem Patienten die Bedeutung eines Satzes entzieht und in uneindeutige Fragmente zerfällt:

> *He becomes attached to a word, a letter, and does not attend to the meaning of the sentence. He examines whether all the „i"s have dots over them, whether there are accents where needed, whether all the letters have the same form.*[64]

Eine solche Überforderung und Überflutung durch Details, die das Wahrnehmen kohärenter Gestalten oder Sinnzusammenhänge erschwert, lässt sich auch in der künstlerischen Tätigkeit einiger Betroffener beobachten: Ein bekanntes Beispiel stammt dabei von dem von Schizophrenie betroffenen britischen Künstler Louis Wain (siehe Anhang: Abb. 1). Im Laufe der Schizophrenie wandelte sich sein anfangs realistischer Malstil zu einer abstrakten und ornamentreichen Variante. Dabei zeigt sich nicht nur ein Verlust von Perspektive und Wiedergabetreue, sondern auch eine Zunahme an Details. Die einheitliche Gestalt der Katze zersetzt sich in geschwungene Fellfragmente, ihre Tatzen, Augen, Pupillen usw. Der Verlust der Intentionalität der Wahrnehmung führt somit zu einer Überflutung durch Details, die ihrerseits zu Mustern und Ornamenten ausgestaltet werden. Nun lässt sich eine solche künstlerische Darstellung als solche nicht pathologisieren, insofern sie Ausdruck eines bestimmten Stiles ist; dennoch scheint Louis Wain einen eindrücklichen Einblick in die „überflutete Wahrnehmung" vieler von Schizophrenie Betroffener zu geben: Das Bewusstsein wird durch eine unstrukturierte Fülle an Details überfordert, denen kein Gegenstandscharakter und keine eindeutige Bedeutung mehr zukommt. Wie Fuchs betont, erfährt der Mensch mit Schizophrenie dabei in gewisser Hinsicht sogar „mehr" von der Wirklichkeit, da die Selektions- und Objektivierungsmechanismen geschwächt sind.[65] Eine intakte Protention vermittelt die Wirklichkeit nämlich

[64] Eugène Minkowski: „A Contribution to the Study of Autism: The Interrogative Attitude" (übers. von René Targowla & Salaheddine Ziadeh):. In: *Philosophy, Psychiatry & Psychology* 8(4), 2001, 271–278, hier: 273.

[65] Patient*innen zeigen im Vergleich zur Kontrollgruppe dementsprechend eine verbesserte Fähigkeit, einem beweglichen Ziel, welches seine Richtung unberechenbar ändert, durch Augenbewegungen zu folgen. Siehe L. Elliot Hong, Matthew T. Avila & Gunvant K. Thaker: „Response to Unexpected Target Changes During Sustained Visual Tracking in Schizophrenic Patients". In: *Exp. Brain Res*. 165(1), 2005, 125–131.

nicht als Flut von Bildern und Empfindungen, sondern als weitgehend „gezähmte" Wirklichkeit.[66]

Die Einbrüche in die Protention gehen jedoch nicht nur mit einem Überflutungserleben einher, sondern auch mit einem Gefühl des Kontrollverlusts oder sogar der „Fremdsteuerung".[67] Die plötzlichen und unpassenden Einbrüche in die intentionale Tätigkeit des Denkens und Handelns, nämlich in Form von Gedankeneingebungen und ungewollten Bewegungssequenzen, werden von den Betroffenen dabei als von außen stammend oder fremdbestimmt erlebt – ein Umstand, der nicht verwunderlich ist, da sich die Einbrüche nicht aus der aktiven, intentionalen Tätigkeit des Subjekts ergeben, sondern dieser entgegenstehen. Gänzlich unerwartete Gedanken oder Bewegungsfragmente, die die Betroffenen nicht selbst initiiert haben, empfinden sie als in ihr Bewusstsein als eingeschoben und befremdlich – im Extremfall sogar als fremde „Stimmen". Nicht selten erleben sich die Betroffenen dabei auch als „Maschinen" oder „Automaten", die durch fremde Agenten gesteuert werden. Durch die Einbrüche in ihre Protention sehen sie ihre eigene Selbstbestimmung und Handlungsfähigkeit (*agency*) in Frage gestellt. Inwiefern Protention und *agency* genau zusammenhängen, bedarf einer eingehenderen Analyse.

2.3 Protention und agency

Während Husserls Melodiebeispiel die Tätigkeit des Bewusstseins in einem Zustand beschreibt, der das Subjekt als passiven Zuhörer porträtiert, wählt Varela ein Beispiel, dass die Aktivität der Wahrnehmenden in den Vordergrund rückt: Beim Betrachten eines Kippbildes hat man zwei perzeptuelle Möglichkeiten, zwischen denen man hin und her wechseln kann, wenn man erstmal beide erkannt hat.[68] So erfährt man beim Wechsel der Auffassung des bekannten Kippbilds Kaninchen-Ente (siehe Abb. 2) eine gewisse Kontrolle über seinen Wahrnehmungsinhalt. Wendet man seine Aufmerksamkeit vom Kaninchen auf die

[66] Thomas Fuchs: *Psychopathologie von Leib und Raum. Phänomenologisch-empirische Untersuchungen zu Depressiven und Paranoiden Erkrankungen.* Darmstadt 2000, 169.

[67] Inwiefern die phänomenologischen Ansätze zur Protentionsstörung und das damit einhergehende Überflutungserleben, das Hervorstehen von Bedeutsamkeiten und das Gefühl der Fremdbestimmung mit neurologischen Befunden korrelieren, zeigen Barnaby Nelson et al. eindrücklich. Siehe: Barnaby Nelson, Thomas J. Whitford, Suzie Lavoie & Louis A. Sass: „What are the Neurocognitive Correlates of Basic Self-disturbance in Schizophrenia?: Integrating Phenomenology and Neurocognition Part 2 (Aberrant Salience)". In: *Schizophrenia Research* 152, 2014, 20–27.

[68] Francisko J. Varela: „Present-Time Consciousness". In: *Journal of Consciousness Studies* 6(2–3), 1999, 111–140, hier: 115.

Ente, so zeigt das perzeptuelle Bild erst für einen Moment Züge beider Gestalten auf, bevor sich die der Ente stabilisiert.

Man kann dieses Bild nun aktiv durch Konzentration aufrechterhalten oder es ohne Fixierung betrachten. Da es sich um eine multistabile Wahrnehmungsgestalt handelt, wendet sich das Bewusstsein bei der zweiten Option abwechselnd der Ente oder dem Kaninchen zu und schwingt wie ein Pendel zwischen beiden hin und her. Erst die *aktive*, aufmerksame Ausrichtung auf eine Wahrnehmungsgestalt kann nun eine Modulation des Kommenden bewirken.[69] In diesem Fall kann sie sogar über einen grundlegend verschiedenen Wahrnehmungsinhalt bestimmen, darüber nämlich, ob man eine Ente oder ein Kaninchen sieht. Erst die vom Subjekt aktiv geleistete attentionale Ausrichtung bestimmt also die Wahrnehmungsgestalt. Die enge Verknüpfung von Attention und Protention illustriert dabei auch den konstitutiven Zusammenhang des reflexiven und präreflexiven Vollzugs: Entscheidet man sich, etwas nachzulesen, so richtet man seine Aufmerksamkeit bewusst auf eine Textpassage und initiiert das Lesen, während das Erkennen der Worte ein präreflexiver Prozess bleibt. Dadurch, dass man seine Aufmerksamkeit aktiv initiieren, ausrichten und korrigieren kann, erfährt man *agency*, also die eigene Wirksamkeit. So hat man nicht schlichtweg eine Wahrnehmung, sondern man *nimmt* wahr, ist nicht bloß in Bewegung, sondern *bewegt* sich – man ist aktiv beteiligt an einem Vollzug, der gleichwohl auch präreflexive Komponenten behält.

Die Protention als „Sinn für das Mögliche" eröffnet dem Wahrnehmenden demnach ein direktes Gestaltungsmoment. Er erlebt das „Mögliche", wie Gallagher feststellt, als das „mir Mögliche", das sich auch in Husserls Begriff „Ich kann" finden lässt.[70] Die Protention eröffnet folglich ein Moment der Aktivität, denn auch wenn Denken, Wahrnehmen und Bewegen bis zu einem gewissen Grad präreflexive Vorgänge sind, so ist man doch direkt in sie involviert und erfährt sich so als denkendes, wahrnehmendes und bewegendes Subjekt. Eine Beeinträchtigung der Protention, in welcher nicht inhibierte Assoziationen in den Bewusstseinsfluss einbrechen, führt hingegen zu einer Passivierung und Entmächtigung des Subjekts.[71] Die Geschehnisse im Bewusstseinsfeld unterliegen nicht mehr der eigenen Kontrolle und Aktivität, sie zeigen eine bedrohliche Eigenmächtigkeit und Unvorhersehbarkeit.

[69] Gallagher: „The Past, Present and Future of Time-Consciousness", 93.

[70] Ebd., 110.

[71] Shaun Gallagher: „Self-reference and Schizophrenia: A Cognitive Model of Immunity to Error through Misidentification". In: Dan Zahavi (Hg.), *Exploring the Self: Philosophical and Psychopathological Perspectives on Self-Experience.* Amsterdam/Philadelphia 2000, 203–239, hier: 226.

3. Schizophrener Autismus

Als Eugen Bleuler erstmals den Begriff „Schizophrenie" prägte, führte er den „schizophrenen Autismus" als pathognomisches Symptom der Krankheit ein.[72] Der Begriff bezeichnet dabei jedoch etwas anderes, als das was man heute unter den Autismus-Spektrum-Störungen versteht. „Autismus" wurde von Bleuler nämlich in erster Linie als eine Loslösung von der äußeren und sozialen Realität definiert, die in einem Rückzug in ein inneres Fantasieleben münde.[73] Auch in der gegenwärtigen Forschung wird die soziale Dimension der Erkrankung miteinbezogen. So listet das phänomenologische Interview EAWE (*Examination of Anomalous World Experience*) den Verlust der nonverbalen Einstimmung (*lack of nonverbal attunement*), des Gemeinsinns (*social common sense*) und der spontanen emotionalen Verbundenheit (*spontanous emotional connection*)als charakteristische Symptome auf, die das soziale Erleben der Betroffenen bestimmen.[74] Sie erleben dies auch als Gefühl der Isolation (*detachment*) und der mangelnden Authentizität:

> *It's sometimes difficult for me to move and do things naturally. So when I take a drink from my glass, and I'm having dinner with people, I always have to pay attention to…who's picking up their glass after other people.*[75]

Aufgrund des Mangels an spontaner, präreflexiver und leiblicher Resonanz mit den anderen versuchen die Betroffenen soziale Situationen zu „algorithmisieren", indem sie diese gewissermaßen mit ethnologischer Genauigkeit beobachten. Eine Patientin beschreibt dies auch als Notwendigkeit, „den kleinen Anthropologen zu spielen".[76] Das sozial angemessene Benehmen, die spontanen Reaktionen und Verhaltensweisen des Alltags entgleiten den Betroffenen; stattdessen müssen sie auf explizite, aus den sozialen Situationen abgeleiteten Verhaltens*regeln* rekurrieren. Eine Patientin Blankenburgs berichtet:

> Was fehlt mir eigentlich? So etwas Kleines, so komisch, etwas Wichtiges, ohne dass man aber nicht leben kann. […] Jeder Mensch muss wissen, wie er sich verhält, hat eine Bahn, eine Denkweise. Sein Handeln, seine Menschlichkeit, seine Gesellschaftlichkeit, alle diese

[72] Robert G. T. Gipps & Sanneke de Haan: „Schizophrenic Autism". In: Giovanni Stanghellini, Andrea Raballo, Matthew Broome et al. (Hg.), *The Oxford Handbook of Phenomenological Psychopathology.* Oxford 2019, 812–827, hier: 813.

[73] Alessandro Salice & Mad Gram Henriksen: „The Disrupted ‚We'. Schizophrenia and Collective Intentionality". In: *Journal of Consciousness Studies* 22(7–8), 2015, 145–171, hier: 148.

[74] Sass; Pienkos; Borut et al.: „EAWE: Examination of Anomalous World Experience", 26 f.

[75] Ebd., 26.

[76] Stanghellini: *Disembodied Spirits and Deanimated Bodies*, 115.

> Spielregeln, die er ausführt: Ich konnte sie bis jetzt noch nicht so klar erkennen. Mir haben die Grundlagen gefehlt.[77]

Der Verlust der hier beschrieben wird, betrifft nun kein explizites *Know-how*, sondern die Fähigkeit, sich intuitiv und flexibel auf eine soziale Situation einzustimmen und somit ihre Anforderungen präreflexiv zu erfassen.[78] Binswanger beschrieb den schizophrenen Autismus deshalb auch als absolute Abhängigkeit von sozialen Normen und Regeln, die beinahe schon zwanghaft eingeübt werden.[79] Schizophrenie lässt sich folglich über die individuelle Symptomatik hinaus als Beeinträchtigung der präreflexiven Intersubjektivität beschreiben.[80] Die intuitive Synchronisation, das Einstimmen auf die Umgebung, das „richtige Timing"[81] erweisen sich damit als grundlegend präreflexive Erfahrungen, welche kaum bewusst erlernt werden können.

Um die Schizophrenie in einem kohärenten Bild zu integrieren, muss folglich auch die soziale Sphäre der Erkrankung konzeptuell eingegliedert werden. Die Betrachtung der individuellen Symptomatik hat den Verlust der Kontinuität der präreflexiven, leiblichen Erfahrungen in den Vordergrund gerückt. Die Einbeziehung der sozialen Dimension legt den Fokus nun auf den Verlust von sozialer Flexibilität, Spontaneität und Abstimmung – Fähigkeiten, die auch als *Wir-Intentionalität* bezeichnet werden.[82] Während Betroffene soziale Tätigkeiten mit einem festgelegten Ziel und Regelset oftmals mühelos ausüben können und somit durchaus über eine „*Joint Intentionality*"[83] verfügen, so fallen ihnen Tätigkeiten mit spontanen und unbestimmten sozialen Anforderungen schwer.

Die Fixierung auf starre, regelbasierte Verhaltensweisen lässt sich im Übrigen bereits auf der individuellen Ebene beobachten.[84] Eine betroffene Person berichtet: „*There is an absolute fixity around me.* […] *There is a kind of routine in me which does not allow me to envisage the future. The creative power in me is abolished.*"[85] Anstatt sich kreativ der Zukunft anzunehmen, sie als Gestaltungsraum zu nutzen, fühlt sich die Person in einer fixierten Routine eingeengt. Nach Minkowski fehlt den Betroffenen folglich die Fähigkeit, sich dynamisch und anforderungsgerecht auf ihre Umgebung einzustimmen, sich auf ein Ziel hin auszurich-

[77] Blankenburg: *Der Verlust der natürlichen Selbstverständlichkeit*, 42.
[78] Salice & Henriksen: „The Disrupted ‚We'", 163.
[79] Ebd., 149.
[80] Ebd.
[81] Laura Galbusera, Michael T. M. Finn & Thomas Fuchs: „Interactional Synchrony and Negative Symptoms: An Outcome Study of Body-Oriented Psychotherapy for Schizophrenia". In: *Psychotherapy Research* 28(3), 2016, 1–13, hier: 2.
[82] Salice & Henriksen: „The Disrupted ‚We'", 147.
[83] Ebd.
[84] Gallagher: „Self-reference and Schizophrenia", 226.
[85] Ebd.

ten.[86] Dieser Verlust an situationsgerechtem und flexiblem Verhalten soll im Folgenden ebenfalls als Beeinträchtigung der Protentionalität interpretiert werden.

3.1 Dynamik der Protention

Bisher wurde die „Beeinträchtigung der Protention" als phänomenologisches Erklärungsmodell für Schizophrenie herausgearbeitet. Nun soll ein selbstständiger Ansatz folgen, der den Mangel an Flexibilität und Spontanität in der Schizophrenie in dieses Modell eingliedert und es somit für die soziale Sphäre öffnet. Als Ausgangspunkt für die folgende Analyse soll das Verhältnis von Protention und Urimpression dienen: Die Protention wurde als konstitutive und modellierende Bedingung für die Urimpression eingeführt, welche mittels der protentionalen Ausrichtung die Flut an ambigen Eindrücken zu einer intentionalen Gestalt (Urimpression) zusammenfasst. Die Urimpression erfährt folglich stets eine protentionale Vorprägung, die, wie am Beispiel des Kippbildes demonstriert, auch durch das Subjekt selbst aktiv bestimmt werden kann.

Diese Überlegungen sollen nun durch einen mehrdimensionalen Ansatz ergänzt werden: Bislang wurde die Beziehung der verschiedenen Jetzt-Komponenten, also Retention, Urimpression und Protention zueinander betrachtet und aufgezeigt, wie das Jetzt sich als eine ausgedehnte Einheit formiert. Nun soll nicht mehr die Konstitution eines spezifischen Zeitmoments betrachtet werden, sondern der eigentliche „Fluss" der Zeit in seiner fortschreitenden, relationalen Verknüpfung. Die dabei dominierende Frage ist: Wie wird die Verknüpfung der verschiedenen Bewusstseinsmomente gewährleistet, sodass sie sich als übergeordnete Einheit, wie etwa als Melodie, formieren können? Husserl schreibt in den Bernauer Manuskripten:

> Das Kontinuum der protentionalen Akte ist in jeder Phase selbst ein Kontinuum. […] Die erfüllte Protention ist Erfüllung einer vorangegangenen leeren Protention, die selbst nur unselbständiges Stück eines weiteren Aktes ist, der eine Phase der Erfüllung hat. Im Fortgang besteht beständig sukzessive Deckung; das Volle, eintretend in die Leere, schafft einen modifizierten Akt. […] Die neue Protention ist in gewissem Sinne Modifikation der früheren, eine Abwandlung nämlich.[87]

Laut Husserl ist der protentionale Akt, wenn man ihn beschränkt auf ein spezifisches Zeitmoment betrachtet, stets unvollständig. Er befindet sich in einem Kontinuum, das mit jedem neuen Bewusstseinsmoment modifiziert wird. Dies lässt sich so verstehen, dass jede Urimpression, welche selbst strukturell eine er-

[86] Minkowski: „A Contribution to the Study of Autism", 275.
[87] Hua XXXIII, 9.

füllte oder enttäuschte Protention ist, die Basis für neue Protentionen bildet. Sie schafft durch die „sukzessive Deckung" mit der vorhergehenden Protention einen modifizierten Akt, folglich eine an die neuen Eindrücke angepasste protentionale Ausrichtung. Dazu wird die Urimpression mit den protentionalen Erwartungen verglichen: Liegt der Eindruck innerhalb des protentionalen Kegels, so kann man von einer erfüllten Protention sprechen. Umgekehrt von einer enttäuschten Protention, welche mit Überraschung oder Schreck einhergeht. Die neue Protention wird auf Basis dieses Vergleichs gebildet und ist folglich immer eine angepasste „Abwandlung" der vorhergehenden Protention.

Darauf aufbauend könnte man folgendes Modell entwerfen: Geschieht ein vollkommen unerwartetes Ereignis, so ist eine gänzlich neue Ausrichtung der Protention notwendig, und die vorhergehende wird verworfen. Geschieht jedoch etwas, das zwar vielleicht nicht als am wahrscheinlichsten, aber dennoch als möglich eingestuft wurde, so muss die bisherige Ausrichtung nur modifiziert werden. Ereignisse, die zuvor eher am Rand des protentionalen Kegels lagen, rücken nun eher in die Mitte. Die unterschiedlichen Grade der „Deckung" von Protention und Urimpression bilden folglich den Ausgangspunkt für eine neu modellierte protentionale Ausrichtung. Die Protention bietet damit zum einen die Grundlage für Flexibilität und Spontanität, insofern man unerwartete Ereignisse in den neu ausgerichteten protentionalen Kegel miteinbeziehen und somit seine Erwartungshaltung stetig anpassen kann. Zum anderen ergibt sich durch den Anpassungsprozess eine zur weiteren Zukunft hin fortschreitende Eingrenzung und Präzisierung des protentionalen Kegels, der den Bereich des „Wahrscheinlichen" immer eindeutiger festlegen kann.

Durch wiederholte Erfüllung dieser präzisierten Erwartungshaltung kann diese als leibliche Bereitschaft „eingekerbt" und sedimentiert werden, sodass sie zum Teil einer erfahrungsbasierten, *leiblichen* „Einstellung auf die Welt" wird. Von nun an wird sich die sedimentierte Erwartungshaltung aktualisieren, wenn man sich wieder in einer ähnlichen Situation befindet, und man ist bereits auf ein Ereignis eingestellt. In den ersten Anzeichen eines Ereignisses wird nun bereits sein Fortgang vorausgeahnt, so dass man präziser und rascher reagieren kann. Eine solche Sedimentierung protentionaler Erwartungshaltungen bildet schließlich die Grundlage für „Expertise", die sich als erfahrungsbasiertes *Knowing-how* vom expliziten Wissen (*knowing that*) unterscheidet.[88] Diese Sedimentierung von Erwartungshaltungen lässt sich auch als *leibliche* Protention beschreiben, insofern sich eine gewisse Einstellung oder Haltung verfestigt, die sich auch

[88] Vgl. Thomas Fuchs: „Verkörpertes Wissen – verkörpertes Gedächtnis". In: Gregor Etzel-Müller, Thomas Fuchs & Christian Tewes (Hg.), *Verkörperung. Eine neue interdisziplinäre Anthropologie.* Berlin 2017, 57–78.

in Form von leiblichen Ausdrucksformen, Bewegungsmustern und Erwartungszuständen (z. B. An- oder Entspannung) in der jeweiligen Situation äußert. Kehrt man etwa aus einem neuen Umfeld in den Kreis seiner Familie zurück, so aktualisiert sich sogleich eine gewisse „Haltung" oder „Rolle", die mit gewohnten Interaktions- und Ausdrucksweisen einhergeht, welche man im neuen Umfeld womöglich nicht mehr pflegt. Diese sedimentierten, leiblichen Haltungen sind dabei mitunter so tief in die leiblichen Protentionen eingekerbt, dass man sie sogar gegen seinen Willen wieder einnimmt. Das Pendant dazu auf der gesellschaftlichen Ebene bildet der „*Habitus*".[89] Die Protention hat demnach eine konstitutive Bedeutung für die Verleiblichung und damit für die Habitualisierung von Interaktionsweisen, sozialen Gepflogenheiten und Bewegungsabläufen. Sie entfaltet sich in den Haltungen und Gesten eines leiblichen Individuums, so dass man in all diesen Fällen auch von *leiblicher* Protention sprechen kann.[90]

Der Körper, diesmal als Organismus genommen, ist darüber hinaus als Bedingung für leibliche Protentionalität zu verstehen: Die protentionale und attentionale „Vorausspannung" ist, wie auch jede andere Form der „Spannung", mit einem gewissen Antrieb und Kraftaufwand verbunden, welcher ihre Ausrichtung auf die Zukunft erst ermöglicht. Diese konative Dynamik der Protention lässt sich laut Fuchs deshalb letztlich auf den vitalen Antrieb des Organismus zurückführen und damit auf seine Leiblichkeit.[91] Nicht verwunderlich scheint es demnach, dass gerade in Zuständen heftiger Müdigkeit, wie etwa im Schlafentzug, die „Spannkraft" des protentionalen Schirms nachlässt. Laut einer Studie von Petrovsky, Ettinger, Hill et al.[92] zeigten Personen nach einer Nacht Schlafentzug teilweise psychose-ähnliche Symptome wie perzeptuelle Störungen und kognitive Desorganisation.[93] Die „Ermüdung" des vitalen Antriebs des Organismus führt demnach zu einer Schwächung der Protention, die das Abbrechen von Gedankenketten und eine höhere Reizempfindlichkeit bedingen kann.[94] Die Protention und damit das Zeitbewusstsein überhaupt ist folglich an den Leib und seine vitale Konativität gebunden. Dies ergänzt die eher „kognitive" protentional-retentionale Struktur durch ein konativ-affektives Moment, welches ihre spontane und energetische Gerichtetheit erst ermöglicht.[95] Die konative Basis

[89] Pierre Bourdieu: *Sozialer Sinn.* Frankfurt am Main 1987.

[90] Elisabeth Behnke: „Bodily Protentionality". In: *Husserl Studies* 25, 2009, 185–217.

[91] Thomas Fuchs: „Temporality and Psychopathology". In: *Phenomenology and the Cognitive Sciences* 12(1), 2013, 75–104, hier: 78.

[92] Nadine Petrovsky, Ulrich Ettinger, Antje Hill et al.: „Sleep Deprivation Disrupts Prepulse Inhibition and Induces Psychosis-Like Symptoms in Healthy". In: *The Journal of neuroscience* 34(27), 2017, 9134–9140.

[93] Ebd., 9138.

[94] Ebd., 9137.

[95] Fuchs: „Temporality and Psychopathology", 78.

des Zeitbewusstseins kann dabei je nach leiblicher Verfasstheit durchaus schwanken und macht das Zeitbewusstsein damit zu einem veränderlichen und lebendigen Teil unseres Erlebens.

3.2 Protentionales Kontinuum

Die Relationalität der protentionalen Ausrichtungen zueinander eröffnet nun auch einen tieferen Einblick in die eigentliche Kontinuität der Zeiterfahrung: Das ausgedehnte Jetzt, welches aus Retention, Urimpression und Protention besteht, wurde bisher isoliert betrachtet und könnte somit den Anschein erwecken, dass es sich um eine unabhängige Zeiteinheit handelt. Wäre die Zeiterfahrung jedoch aus einer Vielzahl von unabhängigen, einander nicht überschneidenden Zeiteinheiten gebildet, bestehend aus Retention, Urimpression und Protention, so wäre die Kontinuität der Erfahrung nicht gesichert. Eine Melodie würde in einzelne Tonfolgen auseinanderfallen und nicht als Ganzheit erfahren werden. Erst dadurch, dass die einzelnen protentionalen Momente der Zeiteinheiten miteinander verknüpft sind, insofern sie Abwandlungen voneinander sind, entsteht eine Kontinuität in der Erfahrung. Man richtet sich folglich nicht mit jeder neu eintretenden Urimpression protentional von neuem aus, sondern man richtet eher nach, korrigiert, improvisiert und gewährleistet doch immer den Bezug zur vorherigen Erwartungshaltung.

Die Protention kann demnach als „Bindeglied" der einzelnen Bewusstseinsmomente verstanden werden, insofern sie zum einen in einem relationalen Kontinuum besteht, das immer schon an die vorherige Phase gebunden ist. Zum anderen weist sie in ihrer Struktur immer schon über die Jetzt-Einheit hinaus auf die mögliche Urimpression der nächsten Zeitphase hin. In ihrem überschreitenden Charakter gewährleistet die Protention die Kontinuität und Einheit der Erfahrung (Abb. 3): Die Urimpression erscheint uns dank ihr nicht wie ein gänzlich neuer Jetzt-Moment, sondern wird durch die protentionale Erwartung in die Einheit der Erfahrung eingegliedert. Auch die Retention ist in diesen relationalen Akt aufgenommen und damit ebenfalls konstitutiv für die Kontinuität der Erfahrung, indem sie das „gerade Gewesene" festhält.[96] Insofern die Retention jedoch das „Nachklingen" einer Urimpression ist, die sich wiederum als erfüllte oder enttäuschte Protention strukturiert, ist die Protention für die Kontinuität der Erfahrung primär. Sie ist konstitutiv für die Entstehung von eindeutigen und stabilen Urimpressionen, die schließlich zu Retentionen werden. Jede der Jetzt-

[96] Gallagher: „Self-reference and Schizophrenia", 222.

Konstituenten ist damit durch die Protention intentional ausgerichtet. Husserl betont:

> Und nun ist jede Phase des Prozesses eine Strecke Retention, ein Punkt Urpräsentation als erfüllter Protention und eine Strecke unerfüllter Protention. Dabei ist aber zu bedenken, dass in der Mitte des Prozesses jede Retention eine Retention früher erfüllter Protention und ihres Leerhorizontes sein müsste […].[97]

Auch die Retention ist demnach für die Kontinuität der Zeiterfahrung unerlässlich. Fällt jedoch die Protention weg oder ist sie beeinträchtigt, so sollte auch die retentionale Herstellung zeitlicher Kontinuität geschwächt sein. Dies insofern, als sie dann bloß noch ambige Urimpressionen als Inhalt hätte, welchen es an intentionaler Prägung mangelt. Eine Schwächung der protentionalen Ausrichtung bewirkt zudem, dass man zum passiven Zuschauer multipler Bewusstseinsmomente wird. Eine aktive Teilnahme wird verunmöglicht, wenn die Ausrichtung auf das Kommende und die in ihm enthaltenen Möglichkeiten wegfallen. Das Noch-Nicht in seiner Gestaltungsdimension fällt weg, stattdessen erscheint ein abruptes „Jetzt".[98]

3.3 Ein Erklärungsmodell des schizophrenen Autismus

Es ist gerade das Soziale, das ein außerordentlich hohes Maß an intuitiver Flexibilität, Spontanität und Anpassungsfähigkeit erfordert. Es gibt zunächst soziale Kontexte, in denen die Interaktionsmuster bereits festgelegt sind: Bei der Bestellung in einem Café variiert das eigene Verhalten kaum. Man greift auf bereits bekannte Phrasen, Verhaltensweisen und entsprechende Protentionen zurück, die man von vorherigen Café-Besuchen gewohnt ist und die einen gesellschaftlichen Standard erfüllen. Die meisten sozialen Interaktionen beruhen jedoch auf weniger eindeutigen Interaktionsmustern. Gerade in der Begegnung mit einer unbekannten Person, in einem nicht festgelegten Kontext, sind die Erwartungen an die Interaktion bloß vage fassbar. Der protentionale Kegel ist demnach weiter geöffnet und die Erwartung bezieht sich auf eine Vielzahl möglicher Interaktionsweisen. Die Reaktionen des Gegenübers auf das eigene Verhalten werden nun sorgfältig aufgefasst und protentional erwartet – sie werden „erspürt"[99] und nicht rational erkannt. Auf eine ironische Bemerkung erwartet man etwa ein Lä-

[97] Hua XXXIII, 14.

[98] Gallagher: „The Past, Present and Future of Time-Consciousness", 98.

[99] Robert Gugutzer: „Leibliches Verstehen: zur sozialen Relevanz des Spürens". In: Karl-Siegbert Rehberg (Hg.), *Soziale Ungleichheit, kulturelle Unterschiede: Verhandlungen des 32. Kongresses der Deutschen Gesellschaft für Soziologie in München.* Frankfurt am Main 2006, 4536–4546, hier: 4537.

cheln. Wirkt das Gegenüber jedoch, entgegengesetzt zur eigenen protentionalen Erwartung, eher verwirrt oder betreten, so korrigiert man diese Erwartungshaltung. Die Diskrepanz zwischen protentionaler Erwartung (des lachenden Gegenübers) und der tatsächlichen Urimpression (des verwirrten Gegenübers) erlaubt es, das eigene Verhalten intuitiv anzupassen und sich auf das Gegenüber einzustellen. Je länger man nun interagiert, desto treffsicherer wird der protentionale Kegel. In gewisser Hinsicht „verengt" er sich und es können Reaktionen und Möglichkeiten ausgeschlossen werden, die sich anfangs noch innerhalb des protentionalen Kegels befunden haben. Dies geschieht in einer interaktionalen Spirale (Abb. 4).

Durch die stetige Korrektur erlangt man schließlich eine „protentionale Sicherheit" in der Interaktion, die es erlaubt, schon in der unmerklichen Mimik des Gegenübers dessen Intention zu erahnen. So kann man etwa bei aufeinander eingespielten Personen beobachten, wie sie gegenseitig die Worte vorwegnehmen und ihre Mimik und Gestik beinahe simultan aufeinander abstimmen. Im Sprachgebrauch finden sich für solche Interaktionen oft musikalische Metaphern, wie „aufeinander eingespielt sein", „aufeinander eingestimmt sein" und „miteinander harmonieren".

Es ist dieses präreflexive „Eingestimmtsein" (*attunement*) auf die soziale Umgebung, welches in der Schizophrenie nicht gelingen möchte. Eine protentionale Tätigkeit, die stetig durch unpassende Impulse unterbrochen wird, bietet keine stabile Basis für die Urimpression. Diese strukturiert sich nicht mehr in Form einer protentionalen Erfüllung, sondern kommt unvorbereitet bzw. wird förmlich zum Widerfahrnis. Dadurch, dass die Verbindung zwischen protentionaler Erwartung und Urimpression aufgelöst ist, bildet die Urimpression auch nicht mehr die Basis für eine Anpassung der protentionalen Erwartung. Die Protention muss vielmehr von Neuem ausgerichtet werden, das Kontinuum protentionaler Akte wird durchbrochen und die Ausrichtung verliert an Flexibilität und Präzision. Was dabei verloren geht, ist die intuitive Abstimmung auf das Gegenüber,[100] die erst das Gefühl der Verbundenheit und Zugehörigkeit vermittelt. Der Verlust dieser präreflexiven Abstimmung mit ihrer sozialen Umgebung kann nun von den Betroffenen als Gefühl der Losgelöstheit und Isolation von sozialen Kontexten, gar als „ontologisches Anderssein"[101] erlebt werden.[102]

[100] Fuchs: *Psychopathologie von Leib und Raum*, 125.

[101] Salice & Henriksen: „Disrupted ‚We'", 162.

[102] Inwiefern der Verlust sozialen Resonanzvermögens neurokognitiv durch eine Schwächung des kontextuellen Verstehens und Wahrnehmens in der Schizophrenie zu erklären ist und damit auch mit dem Konzept der Beeinträchtigung der Bewusstseinsintentionalität übereinstimmt, zeigen Barnaby Nelson et al. Siehe Barnaby Nelson, Thomas J. Whitford, Suzie

Selbst bereits sedimentierte protentionale Ausrichtungen können so im Laufe der Zeit aufgelöst werden. Denn aufgrund der Beeinträchtigung protentionaler Erwartung erscheinen die Reaktionen des Gegenübers, die man sonst sicher vorwegnehmen konnte, befremdlich und unerwartet. Man könnte diesen Prozess auch als Deshabitualisierung beschreiben, als Erosion bereits sedimentierter Verhaltensweisen oder „Gewohnheitshierarchien".[103] Das implizite Beziehungswissen, welches Fuchs als ein musikalisches Gedächtnis für die Rhythmik und Dynamik der Interaktion mit anderen beschreibt,[104] erfährt in der Schizophrenie folglich einen Zerfall. Dieser Verlust an Sicherheit und Flexibilität in der Interaktion wird von den Betroffenen dabei durch einen hyperreflexiven, gar algorithmischen Vollzug kompensiert. Das Gefühl des spontanen Einklangs und der Resonanz mit anderen kann jedoch auf diese Weise nicht hergestellt werden, denn es beruht auf der Fähigkeit, sich präreflexiv auf seine Umgebung einzustimmen und auch die feinsten Dissonanzen aufzuspüren. Es ist das „Feingespür" für diese komplexe Dynamik, welches sich in keinem Algorithmus oder Regelset erfassen lässt.

Zusammenfassung

Das vorliegende phänomenologische Modell der Schizophrenie kann sicher noch ausgebaut werden. Dimensionen des basalen Selbst-Erlebens, der Leiblichkeit und der akuten Psychose wurden hier nur in Ansätzen angedeutet, obwohl ohne ihre eingehende Betrachtung eine Analyse der Schizophrenie nicht gelingen kann. Das Modell hat die Schizophrenie primär aus der Perspektive präreflexiver, leiblicher Vorgänge betrachtet, die das subjektive Erleben als *Kontinuitätserfahrung* konstituieren. Das Kontinuitätserleben wurde dabei auf die von Husserl beschriebene passive Synthese des inneren Zeitbewusstseins zurückgeführt, die im Bewusstsein die drei Komponenten der Retention, Urimpression und Protention vereint. Der Fokus wurde dabei auf die Protention als offene Erwartung des Kommenden gelegt. Sie ermöglicht eine implizite Wahrnehmung von Wahrscheinlichem, die in Abhängigkeit vom Grad der Aufmerksamkeit auch mit einer Inhibition unpassender Gedanken- und Bewegungsfragmente einhergeht.

Lavoie & Louis A. Sass: „What Are the Neurocognitive Correlates of basic Self-Disturbance in Schizophrenia?", 20–27.

[103] Lilo Süllwold & Gert Huber: *Schizophrene Basisstörungen.* Berlin/Heidelberg/New York 1986, 7.

[104] Thomas Fuchs: „Zwischenleibliche Resonanz und Interaffektivität". In: Harald J.Freyberger, Thomas H. Loew, Rainer Richter & Carsten Spitzer (Hg.), *Resonanz – Spiegelung – Attunement.* Stuttgart 2018, 211–221, hier: 216.

Anschließend wurde die Schizophrenie auf eine Porosität der Protention zurückgeführt, insofern die Inhibition von unpassenden Assoziationen geschwächt ist. Die nicht inhibierten Einbrüche in den Bewusstseinsstrom werden von den Betroffenen häufig als unkontrollierbar und fremdbestimmt erfahren, sodass das Gefühl der Urheberschaft (*agency*) geschwächt wird. Die resultierende Passivierung und Umkehrung des Erlebnisfeldes wurde auch als Inversion der Intentionalität beschrieben. Im Anschluss wurden diese Analysen auf die soziale Sphäre der Störung übertragen, wobei der Fokus auf den Verlust von spontaner Einstimmung (*attunement*) gelegt wurde. Die intuitive Beziehung zum Gegenüber wurde dabei als interaktionale Spirale protentionaler Akte spezifiziert. Eine Beeinträchtigung der Protention, wie sie in der Schizophrenie beschrieben wurde, führt dann dazu, dass das Kontinuum protentionaler Akte durchbrochen wird. Ähnlich wie im Zustand heftiger Müdigkeit, wo der Satz mitunter mitten im Sprechfluss abbricht, wird der interaktionale „Fluss" in der Schizophrenie unterbrochen und bedarf einer bewussten Rekonstruktion, die jedoch nicht zu einer spontanen, intuitiven Beziehung zum Anderen führt. Die Beeinträchtigung präreflexiven Erlebens bedeutet damit vor allem den Verlust der Vertrautheit, des Einklangs und der Verbundenheit mit sich selbst und mit anderen – einen doppelten Verlust, der die Schizophrenie zu einer Erfahrung radikaler Entfremdung werden lässt.

Anhang

Abb. 1: Gemälde von Louis Wain im Verlauf seiner Erkrankung

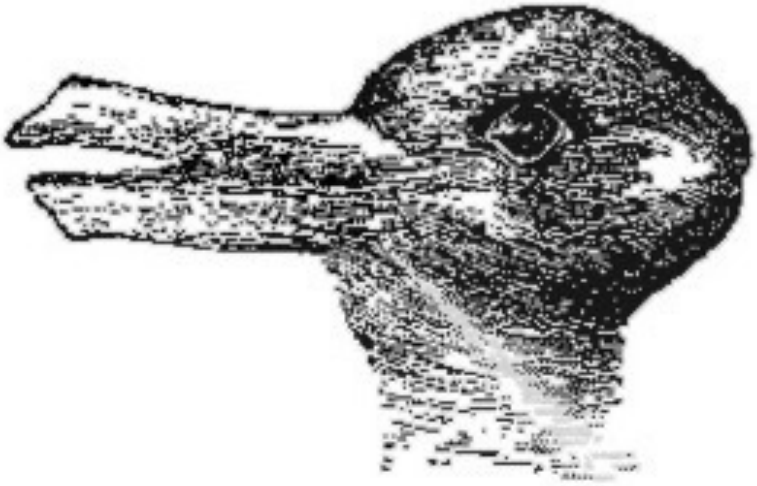

Abb. 2: Kippbild Ente-Kaninchen

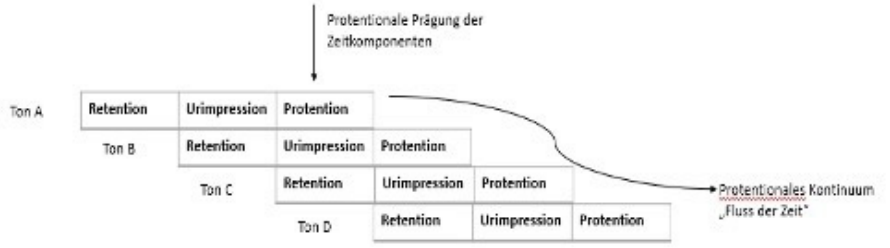

Abb. 3: Protentionales Kontinuum

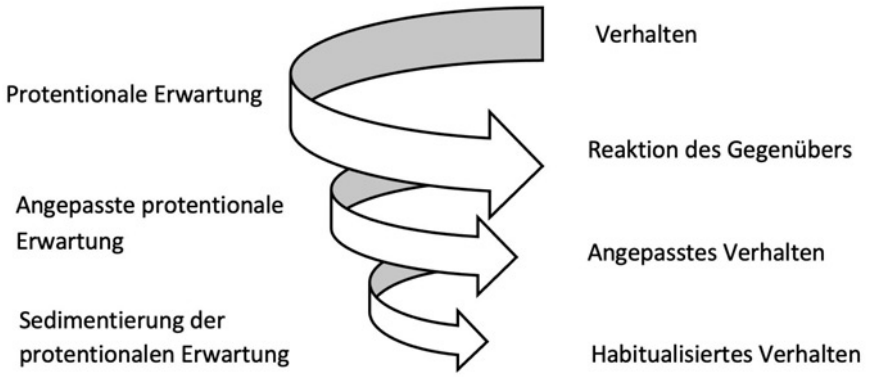

Abb. 4: Interaktionale Spirale

Thomas Fuchs
Sanneke de Haan
Max Ludwig
Lily Martin (Hrsg.)

Selbst- und Welterleben in der Schizophrenie

Die phänomenologischen Interviews EASE und EAWE

Verlag W. Kohlhammer

4 EASE-Interviewleitfaden mit Beispielfragen

Lily Martin und Sanneke de Haan

4.1 Allgemeine Hinweise

Dieser Interviewleitfaden sollte nur in Kombination mit und nach Lektüre des Originaltexts »EASE: Examination of Anomalous Self-Experience« von Parnas et al. (Parnas et al. 2005) sowie nach Besuch einer dreitägigen Schulung zur Interviewmethode verwendet werden. Die Beispielfragen stellen Gedanken- und Formulierungsstützen dar, die nicht nacheinander abgearbeitet werden müssen, und von deren Formulierung je nach Situation abgewichen werden kann und soll. Das zentrale Merkmal eines phänomenologischen Interviews ist, dass es sich von den Erfahrungen der Betroffenen leiten lässt. Im Idealfall werden diese Erfahrungen gemeinsam hermeneutisch exploriert (siehe hierfür auch die allgemeinen Hinweise bei Parnas (2005)).

4.2 Reichweite

Das Interview bezieht sich auf grundlegende Veränderungen oder Auffälligkeiten der Erfahrungen von Personen mit einer Störung aus dem schizophrenen Formenkreis. Erfahrungen in der Psychose können besprochen werden, stellen aber nicht den Schwerpunkt des Interviews dar. Von besonderem Interesse sind dementsprechend Veränderungen der Wahrnehmung oder Erfahrung von der frühen Kindheit an bis zum Auftreten der ersten Psychose bzw. Erfahrungen nach Abklingen der psychotischen Zustände. Die Zeitspanne, die im Interview besprochen wird, ist abhängig von der genauen Forschungsfrage und kann sich auf das ganze Leben der Betroffenen beziehen. Veränderungen von Wahrnehmung und Erfahrung können sowohl schlagartig als auch schleichend auftreten. Das primäre Interesse des EASE-Interviews gilt dabei nicht dem psychologischen Erleben dieser Erfahrungen, sondern einer Beschreibung ihrer Struktur (z. B.: Können Sie noch einmal genauer beschreiben, wie Sie das Vergehen der Zeit damals erfahren haben? anstatt: Wie hat es sich für Sie angefühlt, ständig »hinten nach« zu sein?)

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4.3 Ablauf des Interviews

Es empfiehlt sich, mit einem sozialen Interview zu beginnen, bevor man in die Fragen des tatsächlichen EASE-Interviews einsteigt: Wo ist die Befragte aufgewachsen? Wie steht sie zur ihrer Familie? Wie erging es ihr in der Schule?

Auf diese Weise entsteht eine lockere Gesprächsatmosphäre, bei der die Befragte selbst entscheiden kann, wie viel sie erzählen möchte. Darüber hinaus kann die Interviewerin einen ersten Eindruck der Person und erste Anhaltspunkte für die Erkrankung gewinnen. Schon während des sozialen Interviews können Betroffene Erfahrungen berichten, die auf der EASE-Itemliste zu bewerten sind. Es hängt von der Situation und dem Kontakt zur Befragten ab, ob man eine tiefergehende Exploration der beschriebenen Erfahrung direkt anschließt, oder ob man später noch einmal auf die Aussagen zurück kommt. Im Zweifel sollte man immer im Hinblick auf das Wohlbefinden der Befragten entscheiden.

Das EASE-Interview hat keine festgelegte Struktur. Der Ablauf des Gesprächs wird durch die Reihenfolge der Fragen bestimmt, wobei die Möglichkeit besteht, im passenden Moment Fragen aus verschiedenen Subdomänen vorzuziehen oder gar eine ganz neue Fragestruktur zu entwickeln. Die meisten Interviewerinnen beginnen jedoch mit der Ersten der fünf EASE-Domänen. Es hat sich als vorteilhaft erwiesen, mit eher »sachlichen« Themen wie Konzentration und Gedächtnis zu beginnen und dann über persönlichere und ggf. ungewöhnlichere Themen wie Selbstgewahrsein oder Leibwahrnehmung zu sprechen. Darüber hinaus passt das Berichtete häufig zu mehreren Items bzw. Domänen und kann deshalb mehrmals aus unterschiedlichen Blickwinkeln besprochen werden. Am Ende des Interviews empfiehlt es sich, noch einmal zu fragen, ob alle wichtigen Aspekte der persönlichen Erfahrung behandelt worden sind oder die befragte Person noch etwas hinzufügen möchte. Darüber hinaus kann man die Fragestellung der Studie wiederholen und die Person um eine persönliche Beantwortung dieser Fragestellung aufgrund ihrer eigenen Erfahrung bitten.

4.4 Vorgehensweise

Ziel ist es, Befragte so viel wie möglich spontan und selbst erzählen zu lassen. Deshalb empfiehlt es sich, mit offenen und allgemein gehaltenen Fragen zu beginnen (z. B. Wie nehmen Sie Ihren Körper wahr?) und erst im Anschluss die Aussagen der Befragten genauer zu explorieren (z. B. Was genau meinen Sie mit »unechten Gefühlen«? Könnten Sie mir von einer beispielhaften Situation erzählen?). Im Interviewleitfaden finden sich deshalb zunächst allgemeine Fragen zu den Subdomänen des EASE-Interviews und dann eine oder mehrere Fragen für die einzelnen Items. Der Interviewer sollte mit offenen Fragen beginnen und Betroffene so viel wie möglich selbst erzählen lassen. Die Beispielfragen können

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helfen, bestimmte einzelne Items genauer zu explorieren. Dabei ist es besonders wichtig, den Interviewten keine Antworten zu suggerieren oder vorzugeben. Darüber hinaus ist es hilfreich, das Besprochene in regelmäßigen Abständen zusammenzufassen und zu paraphrasieren (z. B. Wenn ich Sie richtig verstanden habe, kamen Ihnen Ihre Gedanken damals extra klar und bedeutungsvoll vor?). So können Befragte ihre Aussagen verdeutlichen oder ergänzen.

Die Beispielfragen für die einzelnen Items überlappen sich inhaltlich zum Teil sehr stark. Dies liegt daran, dass bestimmte EASE-Items sehr nah beieinander liegen und an unterschiedlichen Stellen des Interviews darüber gesprochen werden kann. Der Interviewer sollte die Items kennen und das eigene Interview flexibel anpassen, sodass es nicht zu vielen die Betroffenen ermüdenden Wiederholungen kommt.

Grundsätzlich empfiehlt es sich, immer nach Beispielen zu fragen. Besonders, wenn Interviewte abstrakte, allgemeine Formulierungen oder Fachbegriffe verwenden, sollte genau nachgefragt werden, was sie mit den jeweiligen Begriffen meinen. Befragte sollten ermuntert werden, eigene Beschreibungen oder Metaphern zu verwenden (so komisch sie auch klingen mögen). Es ist möglich, das Interview auf mehrere Termine zu verteilen. Dies sollte sich nach der Konzentrationsfähigkeit und Verfassung der Befragten richten.

In einem EASE-Interview werden oft Erfahrungen besprochen, die sehr schwer in Worte zu fassen sind. Es geht darum, *wie* Gedanken, Emotionen, der eigene Körper oder soziale Situationen erfahren werden; etwas, was normalerweise im Hintergrund abläuft, und worüber man selten nachdenkt oder spricht. Bestimmte Erfahrungen können außerdem sehr persönlich oder sogar schambesetzt sein. Dies kann ein offenes Gespräch erschweren und unterstreicht die Wichtigkeit einer guten Gesprächsatmosphäre. Dem gegenüber steht die Erleichterung der meisten Betroffenen, ihre Erlebnisse teilen zu können und zu erfahren, dass sie nicht die Einzigen sind, die auf diese Art und Weise erleben und empfinden. Häufig wird das Interview als hilfreich für die Einordnung der teilweise verstörenden Erlebnisveränderungen empfunden.

Weil es kaum Worte für bestimmte Erlebnisveränderungen gibt, verwenden Befragte häufig bildliche Sprache oder Metaphern. Bildliche Sprache kann jedoch buchstäblicher gemeint sein, als man es erwarten würde: Wenn ein Interviewpartner beispielsweise sagt, dass er bestimmte Gedanken »ständig im Hinterkopf« hat, kann es sein, dass er die Gedanken dort tatsächlich spürt (Item 1.8). Der Interviewer sollte bildliche Sprache und Metaphern deshalb stets genau explorieren.

4.5 Haltung der Interviewerin

Die Interviewerin hat eine stets offene Haltung, welche sich in den offen gehaltenen Fragen zeigt. Die Erfahrungen der Betroffenen sind maßgebend, sie sind

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also ernst zu nehmen. Wenn bestimmte Erlebnissen der Interviewerin sehr fremd vorkommen, sollte sie sie in keinem Fall als bizarr abtun, sondern durch stete Exploration versuchen, sie zu verstehen oder nachzuvollziehen. Es ist darüber hinaus von großer Bedeutung, die berichteten Erfahrungen nicht zu bewerten (z. B. bezüglich deren vermeintlicher Normalität bzw. Pathologie).

Voraussetzungen aufseiten der Interviewerin sind gute Fähigkeiten der Gesprächsführung sowie detaillierte Kenntnisse der Psychopathologie im Allgemeinen und des Schizophreniespektrums im Besonderen. Eine Vertrautheit mit phänomenologischen Analysen von Bewusstsein, Selbst, Intersubjektivität und dem Subjekt-Welt-Verhältnis sind hilfreich, um den Zielbereich des EASE-Interviews wirklich zu verstehen. Wie oben und in der Übersetzung des EASE-Interviews bereits erwähnt, sollte die Interviewerin eine dreitägige EASE-Schulung absolviert haben.

4.6 Auswertung

Damit man keine Items vergisst, empfiehlt es sich, die in diesem Band beigefügte Itemliste immer zur Hand zu haben. Es hat sich bewährt, Befragten während des Gesprächs die volle Aufmerksamkeit zu widmen und eine Auswertung der einzelnen Items erst im Anschluss an das Gespräch vorzunehmen. Das Interview sollte demnach aufgezeichnet werden (Video, Tonband). Dies hat den Vorteil, dass mehrere Personen ein »Rating« der Items vornehmen können und so die Objektivität der Auswertung erhöht werden kann.

Interviewer geben oft Beispiele, um die befragten Phänomene zu verdeutlichen. Dies ist zulässig. Befragte sollten daraufhin jedoch mindestens ein eigenes Beispiel beschrieben haben, bevor das Item als vorhanden bewertet werden kann. Ein einfaches »ja« reicht nie aus, um ein Item als vorhanden zu bewerten. Es gibt auch die Möglichkeit, die Häufigkeit und zeitliche Dauer von Erfahrungen im Rahmen einer Intensitätsbeurteilung der Items auf zwei Skalen von 1–3 zu bewerten (siehe hierfür den Quantifikationsvorschlag des EASE Ratings für die statistische Analyse in diesem Band sowie die ursprünglichen Aus- und Bewertungskriterien der einzelnen Items im original EASE-Interview von Parnas et al. (2005)).

4.7 Beispielfragen

4.7.1 Erklärung für Interviewpartner

Bei dem EASE-Interview geht es um Erlebnisse und Erfahrungen, die man bei bestimmten psychischen Erkrankungen haben kann, die aber meist nicht Gegen-

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stand der ersten klinischen Befragungen sind und in der Behandlung oft nicht zur Sprache kommen.

Es sind Erlebnisweisen, die eher »im Hintergrund« sind, die man vielleicht auch schon früher gehabt hat, und die man oft schwer beschreiben kann. Ich möchte Sie bitten, sie trotzdem zu beschreiben und zu versuchen Ihre ganz eigenen Ausdrücke dafür zu verwenden, auch wenn diese manchmal »komisch« klingen.

Es handelt sich um Erlebnisse oder Erlebnisveränderungen, die im Bereich des Denkens, der Gefühle, der Körperempfindungen liegen können oder ganz grundsätzlich die Erfahrung betreffen, wie man sich im eigenen Leben, in Beziehung zu anderen oder zur Welt fühlt. Diese Erlebnisse können während einer psychotischen Episode aufgetreten sein, können aber auch schon lange davor oder noch danach bestanden haben. Uns geht es in dem Interview nicht nur um die psychotischen Episoden, sondern besonders auch um Ihr grundsätzliches Erleben außerhalb dieser Krankheitsphasen. Wundern Sie sich nicht, wenn Ihnen die Fragen »komisch« vorkommen. Dann sagen Sie einfach, »nein, das spielt bei mir keine Rolle!« und dann gehen wir zum nächsten Thema über. Wenn Sie den Eindruck haben, etwas trifft auf Sie zu, dann sprechen wir etwas genauer darüber.

Ich nehme das Interview auf Band auf, um es später für die Auswertung noch einmal anhören zu können. Ist das in Ordnung für Sie? Die Aufnahmen dienen allein der wissenschaftlichen Verwendung, werden nicht an Dritte weitergegeben und anonym gespeichert.

Ein EASE-Interview kann etwas länger dauern. Das hängt ganz davon ab, wie viel Sie erzählen wollen oder können. Wenn es Ihnen zu viel wird, sagen Sie gerne Bescheid.

Das gesamte Interview ist freiwillig, Sie können es jederzeit unterbrechen, um Pausen bitten oder Rückfragen stellen, wenn Sie etwas nicht genau verstanden haben.

	Soziales Interview – ggf. vor Erklärung der EASE
	Ich würde das Interview gerne mit einer ganz offenen Frage beginnen: Wer sind Sie? Wie würden Sie sich/Ihre Person beschreiben? Können Sie mir etwas über Ihren Hintergrund erzählen? Wie sind Sie aufgewachsen? Haben Sie Geschwister? Wie erging es Ihnen in der Schule? Kamen Sie gut mit oder hatten Sie Schwierigkeiten? Weshalb sind Sie in die Klinik gekommen?
1	**Kognition und Bewusstseinsstrom**
	Der erste Bereich umfasst die Gedanken. Alles, was innerlich an Gedanken und Bildern in einem abläuft; Ihre Aufmerksamkeit, ob Sie sich im Allgemeinen gut konzentrieren können, den eigenen Gedanken gut folgen, die Zusammenhänge der Gedanken finden bzw. die Gedanken gut ordnen können; auch das eigene Gedächtnis. Gab es da schon einmal Veränderungen, ungewöhnliche Erfahrungen oder Schwierigkeiten (eine Art Durcheinander) bei Ihnen?

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1.1	Gedankeninterferenz
	Konnten Sie Ihre Gedanken immer gut nachvollziehen oder wurde Ihr Denken schon einmal unterbrochen, z. B. von anderen Gedanken, die nichts mit den ursprünglichen Gedanken zu tun hatten? Kamen oder kommen manchmal andere Gedanken dazwischen, sodass Sie den ursprünglichen Gedanken nicht zu Ende bringen können? Schießt manchmal ein anderer Gedanke dazwischen, sodass Sie nicht mehr richtig weiterdenken können?
1.2	Gedankenenteignung/Verlust der Gedanken-Ipseität
	Kamen oder kommen Ihnen Ihre Gedanken manchmal fremd vor? Sodass Sie sich fragen, wie diese Gedanken in Ihren Kopf gekommen sind, und ob es wohl Ihre eigene Gedanken sind? Hatten Sie schon einmal den Eindruck, dass bestimmte Gedanken gar nicht zu Ihnen gehören, dass es sich um fremde Gedanken handelt, die sie nicht steuern können? Oder hatten Sie schon einmal das Gefühl, dass Gedanken wie in einem Film abliefen, dem Sie wie von außen zuschauen, ihn aber nicht steuern können? (Wie ist es beim Lesen: Hatten Sie dabei schon einmal das Gefühl, jemand anderes könnte oder würde mitlesen?)
1.3	Gedankendrängen
	Erleben Sie manchmal viele (voneinander unabhängige) Gedanken gleichzeitig oder rasch aufeinanderfolgend? Geraten diese Gedanken dann durcheinander, ohne dass Sie es beeinflussen können? Liefen Ihre Gedanken manchmal beschleunigt ab oder wurden immer schneller, ohne dass Sie in der Lage waren, sie anzuhalten oder zu bremsen?
1.4	Gedankensperrung
	Kam oder kommt es manchmal vor, dass Sie den gedanklichen Faden verlieren? Subtyp 1: Blockade Haben Ihre Gedanken schon einmal plötzlich aufgehört? Passiert es manchmal, dass ein Gedanke verloren geht und Sie mit einer Leere im Kopf zurücklässt? Subtyp 2: Verblassen Rutschten Ihre Gedanken manchmal weg, verblassen oder verschwimmen, sodass Sie sie nicht zu Ende denken können? Subtyp 3: Kombination mit Gedankeninterferenz Wurde oder wird Ihr Denken manchmal von anderen Gedanken oder Erinnerungen unterbrochen, die danach in den Vordergrund treten und die alten Gedanken verschwinden lassen?
1.5	Stilles Gedankenecho
	Kam oder kommt es manchmal vor, dass Sie Gedanken wie nachgesprochen oder nachhallend erleben? Wiederholen sie sich dann wie ein Echo im Kopf?
1.6	Grübeln – Zwangsgedanken

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Grübeln Sie manchmal? Gab oder gibt es Gedanken, Vorstellungen, Erinnerungen oder Bilder, die Sie selbst unsinnig/nicht notwendig finden, die Sie aber nicht loslassen? Gedanken, die immer wieder kommen, über die Sie immer wieder nachdenken müssen?

Subtyp 1: Reines Grübeln
Kam oder kommt es manchmal vor, dass Sie z. B. abends den ganzen Tag noch einmal durchdenken, ohne dass es dafür einen Grund gibt/ohne dass etwas Besonderes passiert ist?

Subtyp 2: Sekundäres Grübeln
Machen Sie sich viele Gedanken über Ihr eigenes Verhalten, was Sie tagsüber alles gemacht und gesagt haben, oder was andere Leute gemacht und gesagt haben?
Kann es vorkommen, dass Ihnen das Verhältnis zu anderen Menschen fremd vorkommt und Sie darüber nachdenken, wie sie es einordnen sollen?

Subtyp 3: Echte Zwangsgedanken: ich-dyston
Hatten oder haben Sie manchmal Vorstellungen oder Gedanken, die Ihnen unsinnig, fremd, oder unwichtig vorkommen und die Sie gar nicht haben wollen, die aber trotzdem immer wieder auftauchen?

Subtyp 4: Pseudo-Zwangsgedanken: ich-synton
Hatten oder haben Sie manchmal Vorstellungen oder Gedanken, die Sie gar nicht denken möchten, weil Sie sich wegen ihres Inhalts schämen? Wovon Sie also meinen, dass man sie eigentlich nicht haben darf? Die Ihnen vielleicht auch Angst machen?

Subtyp 5: Rituale/Zwangshandlungen
Was machen Sie, wenn derartige Gedanken aufkommen?
Haben oder hatten Sie schon einmal Gedanken, die mit bestimmten Handlungen zusammenhängen? Handlungen, die Sie mehrmals wiederholen mussten? Gab oder gibt es Handlungen oder Rituale, die Sie immer in einer bestimmten Reihenfolge ausführen müssen?

1.7 Perzeptualisierung innerer Rede oder innerer Gedanken (Gedankenlautwerden)

Kam oder kommt es manchmal vor, dass Ihre Gedanken sich wie gesprochen anfühlen, im Kopf laut werden?

Subtyp 1: Innerlich
Hören Sie Ihre Gedanken manchmal wie durch eine Stimme gesprochen? Gab oder gibt es so etwas wie eine innere Stimme, die Ihre Erlebnisse begleitet?

Subtyp 2: Äquivalente
Sehen Sie Ihre Gedanken im Kopf manchmal wie aufgeschrieben, wie einen Text, ein Bild oder wie einen ablaufenden Film?

Subtyp 3: Innerlich wie beim Symptom 1. Ranges
Hatten Sie schon einmal Angst, Ihre Gedanken seien so laut, dass andere Leute sie hören könnten?

Subtyp 4: Äußerlich
Hatten Sie schon einmal das Gefühl, Ihre Gedanken würden von außen wiederholt, Ihre Gedanken würden im Raum widerhallen? Oder Sie könnten Ihre eigenen Gedanken von außen hören?

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(Ggf. Ist es bei solchen Gedanken immer klar, dass es Ihre eigenen Gedanken sind, oder kommen Ihnen diese Gedanken auch manchmal fremd vor?)

1.8 Verräumlichung der Erfahrung

Hatten Sie schon einmal das Gefühl, Ihre Gedanken seien irgendwo in Ihrem Kopf oder Körper lokalisierbar? Kam es Ihnen schon einmal so vor, als wären Ihre Gedanken oder innere Erlebnisse irgendwo im Raum oder würden Gestalt annehmen, wie Gegenstände?

1.9 Ambivalenz

Gab oder gibt es Situationen, in denen Sie sich schwer tun, Entscheidungen zu treffen, weil Sie innerlich hin und her gerissen sind? Kann das auch bei ganz harmlosen und alltäglichen Entscheidungen vorkommen?
Kann sich diese Ambivalenz auf alltägliche Situationen auswirken, sodass Sie z. B. beim Einkaufen nicht wissen, was sie einkaufen sollen, oder morgens nicht wissen, was Sie anziehen sollen? Gab oder gibt es Situationen, in denen Sie so hin- und hergerissen sind, dass sie sich blockiert fühlen und mit Ihrer Handlung oder Entscheidung nicht mehr weiterkommen (auch in eigentlich unwichtigen Situationen)?

1.10 Unfähigkeit zur Unterscheidung von Modalitäten der Intentionalität

Gibt es Situationen oder Erinnerungen, von denen Sie nicht recht wissen, ob Sie sie erlebt oder sich nur vorgestellt oder sie geträumt haben?

1.11 Störung der Initiative oder Intentionalität des Denkens

Hatten oder haben Sie manchmal Schwierigkeiten, Ihr Denken oder Handeln in Gang zu bringen? Das Gefühl: »ich will etwas tun, aber ich komme nicht so richtig in die Gänge. Ich schaffe es nicht anzufangen, was ich eigentlich will?«
Oder dass Sie die Reihenfolge alltäglicher Handlungen, wie das Kochen, nicht mehr zusammenbekommen?

1.12 Aufmerksamkeitsstörungen

Subtyp 1: Fesselung durch Details
Gab oder gibt es Situationen, in denen Sie von besonderen Details in Ihrer Umgebung gefesselt sind? Sodass Sie Ihre Aufmerksamkeit nicht mehr losreißen können?

Subtyp 2: Unfähigkeit, die Aufmerksamkeit zu teilen
Hatten oder haben Sie manchmal Schwierigkeiten, sich auf etwas zu konzentrieren, wenn Sie gleichzeitig von anderen Reizen abgelenkt werden, etwas anderes hören oder sehen?
Z. B. die Schwierigkeit, sich auf eine Person zu konzentrieren, wenn viele Leute durcheinanderreden? Oder die Schwierigkeit, sich auf das Lesen zu konzentrieren, wenn gleichzeitig ein Radio oder ein Fernseher läuft?

1.13 Störung des Kurzzeitgedächtnisses

Wie ist Ihr Gedächtnis? War oder ist es manchmal schwer, ein Buch zu lesen oder einen Film zu sehen, weil Sie im Verlauf den Anfang wieder vergessen?

1.14 Störung des Zeiterlebens

Subtyp 1: Störung im subjektiven Zeiterleben
Gab oder gibt es Veränderungen in Ihrem Zeiterleben?
Lief oder läuft alles für Sie manchmal schneller oder langsamer?

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Subtyp 2: Störung der existenziellen Zeit (Zeitlichkeit)
Hatten oder haben Sie manchmal das Gefühl, dass es nur noch das Hier und Jetzt, also die Gegenwart gibt? Dass die Zukunft gar nicht mehr erreichbar oder blockiert ist?

1.15 Diskontinuierliches Bewusstsein des eigenen Handelns

Haben Sie schon einmal kleine Lücken, Brüche oder Aussetzer in Ihrem Gedächtnis oder Bewusstsein erlebt? Z. B. Momente, in denen Sie nicht wussten, wie Sie irgendwo gelandet sind oder was Sie gerade wollten?

1.16 Missverhältnis zwischen Ausdruck und Ausgedrücktem

Haben Sie grundsätzlich das Gefühl, dass das, was Sie sagen, zeigen und ausdrücken dem entspricht, was Sie sagen und ausdrücken wollen? Passt das, was Sie sagen und ausdrücken auch zu Ihren inneren Gefühlen und Gedanken?

1.17 Störung der expressiven Sprachfunktion

Können und konnten Sie immer die richtigen Worte finden, um sich auszudrücken? Oder haben Sie manchmal das Gefühl, dass Ihnen Worte fehlen? Haben Sie manchmal das Gefühl, dass das, was Sie sagen, nicht richtig »herauskommt«?

2 Selbstgewahrsein und Präsenz

Im zweiten Bereich des Interviews geht es um das grundlegende Gefühl, anwesend und (in der Welt) präsent zu sein; und um das Gefühl, »man selbst« zu sein. Gibt es hier Veränderungen oder Schwierigkeiten bei Ihnen?

2.1 Vermindertes basales Selbsterleben

Hatten oder haben Sie manchmal das Gefühl, nicht richtig anwesend oder »wie in einer anderen Welt« zu sein?
Hatten oder haben Sie manchmal das Gefühl, ganz anders als andere Menschen zu sein (z. B. bezogen auf Ihre Weltsicht), keine Identität oder keinen Kern zu haben oder anonym, nicht-existent zu sein?
Erleben Sie manchmal so etwas wie eine innere Leere/Haltlosigkeit?
Oder das Gefühl, nur eine Rolle auf einer Bühne zu spielen, z. B. weil andere Menschen es von Ihnen erwarten?

Seit wann bestehen diese Gefühle?

Subtyp 1: Früh im Leben
Haben Sie diese Gefühle schon seit Ihrer Kindheit?

Subtyp 2: Seit Adoleszenz
Haben sich diese Gefühle in der Pubertät entwickelt?

2.2 Verzerrte Erste-Person-Perspektive

Subtyp 1: Meinhaftigkeit, Subjektivität
Haben Sie immer das Gefühl, dass Ihre Gedanken, Handlungen oder Gefühle zu Ihnen gehören? Oder gab es auch schon einmal ein Gefühl von Entfremdung, so als ob Handlungen, Gedanken und Gefühle nicht von Ihnen selbst ausgehen würden (unpersönlich, anonym, mechanisch)?

Subtyp 2: Erlebte Distanz
Hatten oder haben Sie manchmal das Gefühl, sich selbst zu beobachten/beobachten zu müssen, wie von außen, als wären Sie von sich selbst getrennt? Denken

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und beobachten Sie mit, was Sie gerade tun?
Hindert Sie diese ständige Selbstbeobachtung manchmal daran, spontan auf andere zu reagieren?

Subtyp 3: Verräumlichung des Selbst
Erleben Sie sich selbst oder Ihren Kern, manchmal räumlich, an einem bestimmten Punkt im Körper oder im Raum (z. B. ausgedehnt)?

2.3 Psychische Depersonalisation (Selbstentfremdung)

Hatten oder haben Sie manchmal das Gefühl, sich selbst fremd zu sein, nicht richtig Sie selbst zu sein oder sich nicht richtig zu spüren?

Subtyp 1: Melancholiforme Depersonalisation (state)
Hatten oder haben Sie manchmal den Eindruck, dass sie ihre Gefühle nicht richtig spüren können, weniger fühlen oder weniger involviert sind als sonst?

Subtyp 2: Unspezifische Depersonalisation
Hatten oder haben Sie irgendwelche anderen Erfahrungen von Entfremdung sich selbst gegenüber?

2.4 Verringerte Präsenz

Hatten oder haben Sie manchmal das Gefühl, dass Sie mit der Welt oder mit anderen Menschen nicht richtig mitgehen können, dass die Dinge nicht zu Ihnen durchdringen, sie nicht richtig erreichen oder berühren?

Subtyp 1: Nicht affiziert sein
Haben Sie schon einmal die Erfahrung gemacht, nicht an der Welt beteiligt zu sein, nicht so richtig »eintauchen« zu können, sich nicht so richtig für die Dinge zu interessieren? Blieben Sie unberührt von den Dingen, die um Sie herum passierten?

Subtyp 2: Distanz zur Welt
Hatten oder haben Sie manchmal das Gefühl, einen besonderen Abstand zu ihrer Umgebung und zu anderen Menschen zu haben?
Gab oder gibt es ein Gefühl von Distanz zwischen Ihnen und der Welt, wie eine Wand aus Glas oder eine Barriere zwischen Ihnen und dem Geschehen?

Subtyp 3: Wie Subtyp 2 plus Derealisation
Hat sich auch Ihre Wahrnehmung der Welt verändert? Kommen Ihnen z. B. Farben blasser oder grauer vor? Sieht alles leer, tot oder mechanisch aus?

2.5 Derealisation

Im Anschluss an 2.4: Bezieht sich das auch auf andere Aspekte der Umwelt?
Kam oder kommt Ihnen die Umgebung manchmal verändert vor? Scheinen Raum, Gegenstände, und Menschen fremd, sonderbar verändert, unwirklich?

Subtyp 1: Fluide globale Derealisation
Erschien oder erscheint Ihnen die Welt manchmal wie ein Traum, unklar, mehrdeutig oder fremd und bedeutungslos?

Subtyp 2: Intrusive Derealisation
Gab oder gibt es bestimmte Situationen oder Gegenstände in Ihrer Umwelt, die Ihnen sehr bedeutungsvoll erscheinen, sich gar aufdrängen (als ob sie etwas Be-

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sonderes zu sagen hätten)? Hatten oder haben Sie manchmal das Gefühl, bestimmte Dinge treten hervor, springen Ihnen ins Auge?

2.6 Hyperreflexivität, vermehrte Reflexivität

Haben Sie es schon einmal erlebt, dass Sie sich selbst (ständig) beobachten oder infrage stellen, dass Sie (ständig) mitdenken und reflektieren: »Was tue ich jetzt gerade«? Oder »Wer bin ich eigentlich?«
Befragen und beobachten Sie sich auch in Gesprächen oder sozialen Situationen? Ist es dadurch schwierig, spontan zu sein?
Ist dieses »sich selbst Beobachten« eine bewusste Entscheidung oder können Sie nicht anders?

2.7 Ich-Spaltung

Hatten Sie schon einmal das Gefühl einer Spaltung oder einer fehlenden Einheit, so als ob es zwei oder mehrere Seiten von Ihnen gäbe?

Subtyp 1: Ich-Spaltung vermutet
(befragte Person ist nebelhaft und unklar, Interviewer oder Interviewerin vermutet Ich-Spaltung.) Beispiel (Parnas et al. 2005): Nachdem er in ein Einzelzimmer gebracht und allein gelassen wurde, bekam er den Gedanken: »Nun sind wir zwei alte Kerle allein zusammen.« Dieser Gedanke überraschte ihn.

Subtyp 2: »Als ob«-Erleben
(befragte Person spricht in »als ob«-Ausdrücken über eine Spaltung.)

Subtyp 3: Konkretes verräumlichtes Erleben
Könnten Sie beschreiben oder zeigen, wo sich die verschiedenen Teile in Ihnen oder im Raum befinden oder befunden haben?

Subtyp 4: Wahnhafte Ausgestaltung
Waren oder sind Sie davon überzeugt, dass diese Teile in der Tat auf diese Weise räumlich in Ihnen lokalisiert sind? Haben Sie auch danach gehandelt bzw. handeln Sie danach?

2.8 Dissoziative Depersonalisation

Subtyp 1: »Als ob«-Phänomen
Hatten oder haben Sie manchmal das Gefühl, als stünden Sie neben (oder außerhalb von) sich selbst und könnten sich beobachten?

Subtyp 2: Dissoziative visuelle Halluzination
Können Sie sich selbst von dieser Außenposition (neben, unter, über sich selbst) regelrecht sehen?

2.9 Identitätskonfusion

Hatten Sie jemals das Gefühl, jemand anders zu sein? Also nicht Sie selbst, sondern jemand, den Sie kennen, oder auch jemand ganz anderes?

2.10 Empfundene Veränderung in Bezug auf das chronologische Alter

Haben Sie immer das Gefühl gehabt, so alt zu sein wie Sie tatsächlich sind? Oder fühlen Sie sich manchmal älter oder jünger, als Sie tatsächlich sind?

2.11 Empfundene Veränderung in Bezug auf das Geschlecht

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Haben Sie das Gefühl, das »richtige« Geschlecht zu haben? Oder hatten Sie auch schon einmal das Gefühl, »eigentlich anders« zu sein?

Subtyp 1: Gelegentliche Angst, homosexuell zu sein
Glauben Sie manchmal, homosexuell zu sein, oder von anderen Leuten als homosexuell betrachtet zu werden?

Subtyp 2: Gefühl, gegengeschlechtlich zu sein
Haben Sie manchmal das Gefühl, dem anderen Geschlecht anzugehören?

2.12 Verlust des »Common Sense«/Ratlosigkeit/Verlust der natürlichen Selbstverständlichkeit

Hatten Sie schon einmal für längere Zeit den Eindruck, Ihnen gehe das sichere oder selbstverständliche Gefühl davon verloren, wie die Dinge in der Welt ablaufen, wie man sich im Alltag oder in sozialen Situationen verhält? Dass Sie sich gefragt haben, wie man eigentlich einen gewöhnlichen Tagesablauf hinter sich bringt? Also ein Gefühl von Unsicherheit, wie das Leben eigentlich normalerweise abläuft.
Haben Sie sich öfter schon einmal darüber gewundert, wieso die Dinge sind, wie sie sind, und nicht anders? Wieso bestimmte Verhaltensweisen normal sind und andere nicht?

2.13 Angst

Litten oder leiden Sie manchmal an Ängsten?

Subtyp 1: Panikattacken mit autonomen Symptomen
Hatten oder haben Sie manchmal plötzlich aufkommende Angstgefühle oder Panik, ohne zu wissen weshalb?
Geht diese Angst mit körperlichen Empfindungen einher (Zittern, Schwitzen, Herzklopfen, Beklommenheit, Schwindel, Hyperventilation)?

Subtyp 2: Psychisch-mentale Angst
(befragte Person verneint körperliche Symptome.)

Subtyp 3: Phobische Angst
Hatten oder haben Sie Angst vor bestimmten Gegenständen oder Tieren, oder an bestimmten Orten (große Plätze, enge Räume)?

Subtyp 4: Soziale Angst
Hatten oder haben Sie Angst bei der Begegnung mit anderen oder in sozialen Situationen?

Subtyp 5: Diffuse, frei flottierende durchgängige Angst
Oder ist es eine andauernde, unmotivierte Angst, eine Angst ohne Grund, die immer da ist oder war?

Subtyp 6: Paranoide Angst
Fürchteten Sie, von anderen bedroht zu werden? Fühlen Sie sich verfolgt oder beobachtet (auch außerhalb der Psychose)? Hatten oder haben Sie manchmal das Gefühl, die Dinge, die in Ihrer Umgebung passieren, beziehen sich auf Sie?

2.14 Ontologische Angst

Erfahren Sie manchmal eine tiefgreifende Unsicherheit im Kontakt mit der Umwelt oder speziell anderen Menschen? Haben Sie manchmal das grundlegende

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Gefühl, sich verteidigen oder verbergen zu müssen? Oder haben Sie manchmal das Gefühl, etwas Schreckliches könne passieren?

2.15 Verringerte Transparenz des Bewusstseins

Haben Sie manchmal das Gefühl, nicht bei vollem Bewusstsein zu sein, wie in Watte eingepackt oder benommen zu sein, als stünde etwas zwischen Ihnen und der Welt, und zwar ohne, dass Sie Alkohol oder Drogen genommen hätten?

2.16 Verringerte Initiative

Kostet es Sie manchmal viel Mühe oder Kraft, mit etwas zu beginnen? So sehr, dass leichte oder kleine Handlungen zu schwer oder anstrengend erscheinen und Sie sie erst gar nicht beginnen?

2.17 Hypohedonie

Gab oder gibt es Zeiten, in denen Sie unfähig waren oder sind, Lust oder Spaß zu erleben? Kann es vorkommen, dass Sie kein Interesse mehr an Aktivitäten haben, die Ihnen vorher Spaß gemacht haben (Essen, Sex, Hobbys, Sport, soziale Ereignisse)?

2.18 Verringerte Vitalität

Fühlen Sie sich häufig geistig oder körperlich erschöpft?
Hatten oder haben Sie vermehrt das Gefühl, grundsätzlich keine Energie oder keinen Elan zu haben? Haben Sie z. B. Schwierigkeiten, aus dem Bett zu kommen, oder grübeln Sie viel?

Subtyp 1: State
Ist dieses Gefühl durchgängig vorhanden oder geht es auch wieder weg?

Subtyp 2: Trait
Hat dieser Mangel an Energie Ihr ganzes Leben bestimmt und tut er das noch?

3 Leiberleben

Der dritte Bereich des Interviews umfasst Erfahrungen und Erlebnisse bezüglich des eigenen Körpers: Fühlt sich Ihr Körper wie eine Einheit an, können Sie über Ihren Körper verfügen, oder hat er sich vielleicht schon einmal fremd, nicht ganz eigen angefühlt?
Hatten oder haben Sie manchmal irgendwelche besonderen körperlichen Empfindungen oder unklare Schmerzen?

3.1 Morphologische Veränderungen

Gab oder gibt es bei Ihnen manchmal sonderbare Veränderungen in Ihrem Körpererleben? Z. B. dass sich Ihre Glieder zu groß oder zu klein anfühlen?

Subtyp 1: Spüren von Veränderung
Können Sie dieses Gefühl beschreiben? Geht es auch wieder weg?

Subtyp 2: Wahrnehmung von Veränderung (Illusionen von Veränderungen)
Haben Sie diese Veränderungen tatsächlich am Körper wahrgenommen oder gesehen? Sahen z. B. Ihre Hände wirklich größer aus?

3.2 Spiegelbezogene Phänomene

Wie ist es, wenn Sie in den Spiegel schauen? Haben Sie sich schon einmal im Spiegel angesehen und gedacht »das bin gar nicht ich; diese Person sieht ko-

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misch, irgendwie verändert aus«?

Subtyp 1: Suche nach Veränderung
Hatten Sie Phasen, in denen Sie immer wieder in den Spiegel schauen mussten, um nachprüfen, ob sich z. B. an Ihrem Gesicht etwas verändert hat?
So etwa wie: »Wie sehe ich aus? Bin ich immer noch ich selbst?«

Subtyp 2: Wahrnehmung von Veränderung
Haben Sie dann auch tatsächliche Veränderungen gesehen oder wahrgenommen?

Subtyp 3: Andere Phänomene
Gab es eine Zeit, in der Sie oft in den Spiegel schauen mussten, um zu überprüfen, ob Sie wirklich »da« waren?
Oder haben Sie schon einmal vermehrt Fotos von sich selbst angesehen, um etwas über sich selbst herauszufinden?

3.3 Somatische Depersonalisation (Leibliche Entfremdung)

Haben Sie schon einmal die Erfahrung gemacht, dass Ihr Körper oder Teile des Körpers taub, fremd, oder weit weg erschienen; als ob er oder sie nicht richtig zu Ihnen gehörten?
Oder hatten Sie schon einmal das Gefühl, Ihre Körperteile bildeten keinen richtigen Zusammenhang?

3.4 Psychophysische Fehlpassung und psychophysische Spaltung

Hatten oder haben Sie manchmal das Gefühl, Ihr Körper gehöre oder passe nicht so richtig zu Ihnen? (z. B. zu groß, zu klein oder auf irgendeine Weise unbequem)

3.5 Leibliche Desintegration

Hatten Sie schon einmal oder haben Sie manchmal das Gefühl, dass Ihr Körper verschwinden oder sich auflösen könnte? So als würde er auseinanderfallen oder der Zusammenhang zerbrechen?

3.6 Verräumlichung (Vergegenständlichung) von Leiberlebnissen

Hatten oder haben Sie manchmal das Gefühl, Ihr Körper oder einige Körperteile seien wie Dinge oder Gegenstände im Raum?
Beeinflusst dieses Gefühl Ihre Beziehung zu Ihrem Körper oder den entsprechenden Körperteilen?
Oder können Sie manchmal innerliche, körperliche Prozesse spüren (Kreislauf, Organe)?

3.7 Zönästhetische Erlebnisse

Hatten oder haben Sie manchmal sonderbare, rätselhafte Körperempfindungen oder Schmerzen? Z. B., dass etwas in Ihrem Körper Sie reizt, drückt, vibriert oder kribbelt (Stromgefühl)?
Fühlt sich Ihr Körper manchmal sonderbar leicht oder schwer an (Schwebegefühl)?

3.8 Bewegungsstörungen

Wie nehmen Sie Ihre eigenen Bewegungen wahr? Gab oder gibt es dort manchmal Veränderungen oder Störungen?

Subtyp 1: Pseudobewegungen des Körpers

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Hatten Sie schon einmal das Gefühl, Körperteile oder Ihr ganzer Körper bewege sich, ohne dass dies wirklich der Fall war/ohne dass andere Personen diese Bewegung sehen konnten?

Subtyp 2: Motorische Interferenz
Ist es schon einmal vorgekommen, dass Sie Bewegungen ausführen mussten, obwohl Sie das gar nicht wollten?

Subtyp 3: Bewegungsblockade
Ist es schon einmal vorgekommen, dass Sie eine Handlung ausführen wollten (z. B. nach einem Glas greifen), Ihr Körper aber nicht so richtig wollte, dass es einfach nicht ging? (Stockung, Blockade, Steckenbleiben in einer Bewegung)

Subtyp 4: Empfinden motorischer Lähmung
Hatten Sie oder haben Sie manchmal das Gefühl, wie gelähmt zu sein oder langsam gelähmt zu werden?
Kann es in solchen Momenten sein, dass Sie sich tatsächlich nicht mehr bewegen können?

Subtyp 5: Desautomatisierung von Bewegung
Wie steht es mit alltäglichen Bewegungen (Zähne putzen, Fahrrad fahren, sich den Mantel zumachen)? Handlungen, die normalerweise automatisch oder nebenbei ablaufen, ohne dass man sich darüber Gedanken machen muss? Laufen diese Bewegungen automatisch und flüssig ab oder hatten Sie schon einmal Schwierigkeiten, diese alltäglichen Handlungen auszuführen? Brauchen Sie dann viel Aufmerksamkeit oder Anstrengung, um sie durchzuführen?

3.9 Mimetisches Erleben (Resonanz zwischen eigenen und fremden Bewegungen)

Gab oder gibt es manchmal Situationen, in denen Sie das Gefühl hatten, Ihre Bewegungen werden von anderen oder Dingen in Ihrer Umwelt imitiert oder nachgemacht? Das Gefühl, andere würden das Gleiche machen wie Sie? »Wenn ich eine Bewegung mache, dann machen die anderen das auch ausgerechnet im gleichen Moment.«
Wie wirkt sich dieses Gefühl dann auf Sie aus (Gefühl der eigenartigen Verbindung, Stoppen der Bewegung)?

4 Demarkation/Transitivismus

Der vierte Bereich dreht sich um die Grenzen zwischen einem selbst und anderen bzw. der Umwelt.
Hatten oder haben Sie manchmal Schwierigkeiten, sich richtig abzugrenzen?

4.1 Verschmelzung mit dem Anderen

Hatten oder haben Sie manchmal das Gefühl, mit anderen Menschen zu verschmelzen, sodass sich die Grenze zwischen Ihnen und der anderen Person auflösen? Das Gefühl, andere würden Sie durchdringen, in Sie eindringen, sich mit Ihnen vermischen oder Ähnliches? War dies unangenehm oder bedrohlich? Gab es schon einmal die Situation, dass Sie jemandem angeschaut haben und plötzlich Angst vor seinem Blick bekamen: »Diese Person saugt mich auf, jetzt kann ich nicht mehr standhalten, jetzt gehe ich mir verloren?«

4.2 Verschmelzung mit dem eigenen Spiegelbild

Kann es vorkommen, dass Sie in den Spiegel blicken oder Fotos ansehen und sich unsicher sind, wer wer ist? »Stehe ich hier oder im Spiegel?«

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4.3	Bedrohlicher Körperkontakt
	Subtyp 1: Unangenehmes, Angst auslösendes Gefühl Ist es schon einmal vorgekommen, dass Sie sich vom Körperkontakt mit anderen Menschen bedroht fühlen, so als ob Ihre Identität dadurch irgendwie verloren gehen könnte? Subtyp 2: Gefühl des Verschwindens, der Vernichtung Hatten Sie schon einmal das Gefühl sich aufzulösen, wenn jemand Ihnen sehr nahekam oder Sie berührte?
4.4	Beeinflussungsstimmung
	Haben Sie manchmal das Gefühl, der Welt ausgeliefert zu sein, eingeschränkt, beeinflusst zu sein? Oder haben Sie manchmal das ungute Gefühl, gleich könnte etwas Schreckliches passieren, ohne dass Sie genau sagen können, was?
4.5	Andere transitivistische Phänomene
	Hatten oder haben Sie manchmal das Gefühl, Ihnen fehle eine »Barriere« der Welt gegenüber, als seien Sie zu offen, zu transparent oder zu durchlässig? Oder haben Sie umgekehrt eine besonders dicke Schicht, die Sie gegenüber Einflüssen der Umgebung schützt?
5	**Existenzielle Reorientierung**
	Der letzte Bereich umfasst Ihre Grundeinstellungen zum Leben, Ihre Weltanschauung. Hatten oder haben Sie Zeiten, in denen Sie sich besonders für religiöse oder philosophische Themen oder weltanschauliche Fragen interessieren?
5.1	Primäre eigenbezügliche Phänomene
	Gab es Situationen, in denen Sie das Gefühl hatten, äußere Ereignisse oder Menschen stünden in Beziehung zu Ihnen oder es hätte eine bestimmte Bedeutung, dass Handlungen gerade jetzt und genau so passieren? Beispielgedanke: »Wenn dieses und jenes gerade dann passiert, wenn ich hier bin, möchte mir irgendjemand etwas damit sagen, oder es hat eine besondere Bedeutung für mich.« – »Das will doch etwas heißen.«
5.2	Empfinden von Zentralität
	Hatten oder haben Sie manchmal das Gefühl, irgendwie im Mittelpunkt zu stehen? Oder gar das Zentrum des Universums zu sein? (Damit ist nicht gemeint, dass Sie alle angeschaut haben, wenn Sie sich z. B. in der Schule gemeldet haben, sondern der Eindruck in alltäglichen Situationen, etwa auf der Straße: »Alle drehen sich nach mir um«, oder bei der Arbeit: »Ich muss allen helfen.«)
5.3	Gefühl, als sei das Erfahrungsfeld des Subjekts die einzig vorhandene Realität
	Hatten oder haben Sie manchmal den Gedanken, dass nur das existiert, was Sie gerade sehen?
5.4	»Als ob«-Gefühle von außergewöhnlicher kreativer Kraft, außergewöhnlicher Einsicht in verborgene Dimensionen der Realität oder außergewöhnliche Einsicht in den eigenen Geist oder den Geist anderer.
	Hatten oder haben Sie manchmal das Gefühl, Sie hätten außergewöhnliche Kräfte oder Eigenschaften? Sie könnten Dinge tun, die andere Leute nicht kön-

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	nen? Oder Sie hätten eine besondere Einsicht in die Welt, wüssten Dinge, die andere Menschen nicht wissen?
5.5	»Als ob«-Gefühl, dass die erfahrene Welt nicht wirklich real sei, existiere, als wenn sie nur scheinbar, illusionär oder täuschend sei.
	Haben Sie die Welt schon einmal für eine Illusion gehalten; als ob sie nicht wirklich existiere, nur ein Schauspiel, ein Traum oder eine Bühne wäre?
5.6	Magische Ideen, verknüpft mit der Erfahrungsweise des Subjekts
	Hatten oder haben Sie manchmal das Gefühl, dass es von Ihnen abhängt, was in der Welt geschieht, dass Sie die Ursache von äußeren Ereignissen sind oder sie auf irgendeine Weise beeinflussen können?
5.7	Existenzielle oder intellektuelle Veränderung
	Gab oder gibt es Zeiten, in denen Sie sich intensiv mit Themen, wie z. B. Mystik, übernatürliche Phänomene, Esoterik, tiefgründige philosophische Theorien, Religion o. ä beschäftigt haben/beschäftigen? Haben Sie sich schon immer für diese Themen interessiert oder gab es Momente, in denen Sie sich plötzlich intensiv mit einem Thema beschäftigt haben, das Sie vorher weniger interessiert hat?
5.8	Solipsistische Grandiosität
	Hatten Sie schon einmal oder haben Sie manchmal das Gefühl, Zusammenhänge besser zu verstehen als andere Menschen, besser zu verstehen, worum es im Leben eigentlich geht? (z. B. andere Menschen führen einen oberflächlichen Lebensstil, sind nicht so klug)
	Abschluss
	Fragen, Ergänzungen
	Gibt es Themen oder Dinge, die nun nicht zur Sprache gekommen sind, von denen Sie denken, dass Sie noch relevant oder wichtig sind, damit wir Ihre Erfahrung gut verstehen können?
	Forschungsfrage
	Sie kennen die Fragestellung der Studie. Wie würden Sie aufgrund Ihrer Erfahrungen diese Frage beantworten?

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OPERATIONALIZING DISEMBODIED INTERACTION: THE PERCEPTUAL CROSSING EXPERIMENT IN SCHIZOPHRENIA RESEARCH[1]

abstract

Embodied and phenomenological approaches to neuropsychiatry have proven to be promising for assessing social cognition and its impairments. Second-person neuroscience has demonstrated that the dynamics of social interaction make a difference when it comes to how people understand each other. This article presents the Perceptual Crossing Experiment (PCE) as a paradigm for studying real-time dyadic embodied interactions in the context of schizophrenia. We draw on the phenomenological concept of interbodily resonance (IR) and show how the PCE can be used to accurately model and assess IR. We then turn to disembodied interaction in schizophrenia and finally propose the PCE as a translational tool for systematically assessing the hindered IR that individuals with schizophrenia suffer from. We offer an experimental approach to phenomenology which could be informative for the development of more embodied interventions aiming to remedy the profoundly disrupted social life that patients with schizophrenia live with.

keywords

social interaction, perceptual crossing, schizophrenia, (inter)bodily resonance, embodied interaction

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1. Introduction

In recent years, the field of neuropsychiatry has pointed out the necessity to adopt tools capable of evaluating the bodily, situated, and interpersonal aspects of psychopathology (Froese *et al.*, 2020; Fuchs & Schlimme, 2009; Schilbach *et al.*, 2013). Some researchers have proposed that many, if not all, mental disorders entail disturbances of the social dimension, shown as difficulties to communicate with others, to make sense of what others do, and to adapt to the dynamics of social interactions present in everyday life (Fuchs, 2010; Schilbach, 2016; Vogeley, 2018).

This shift away from methodological individualism has also incorporated phenomenological evaluations, in which assessments of qualitative aspects of patients' sensorimotor experiences and social surroundings are required to get a better understanding of psychopathology (Fuchs, 2007, 2019; Krueger, 2020; Krueger & Aiken, 2016; Myin-Germeys *et al.*, 2009).

This so-called second-person account of psychopathology takes the interaction between engaged individuals as the main phenomenon of interest (Fuchs, 2015a, 2015b; Ratcliffe, 2015; Schilbach, 2016; Vogeley, 2018). The interpersonal space of patients gains uttermost relevance for the prevention, diagnosis, treatment, and prognosis of mental disorders (Fuchs, 2019; Myin-Germeys *et al.*, 2016). Granted that mental disorders cannot be fully understood without looking at the interactive engagement between people, then an empirical framework also considering the interpersonal level is required.

Embodied approaches to social cognition have developed diverse experimental set-ups to assess the interaction dynamics present in any social encounter. The aim is to study real-time embodied interactions in such a way that the involved individuals feel engaged and take an *interactor* rather than a passive observer role (Auvray & Rohde, 2012; Schilbach *et al.*, 2013). Accordingly, social interaction has been actively researched in real-time dyadic situations such as gaze cueing tasks, structured conversations, psychotherapy sessions, emotional expression workshops, body-oriented psychotherapy, and movement improvisation tasks (Abney *et al.*, 2014; Galbusera *et al.*, 2018; Galbusera *et al.*, 2019; Michael *et al.*, 2015; Ramseyer & Tschacher, 2014; Schilbach *et al.*, 2013).

Although constrained, a dyadic model of interaction is already complex enough to study real-life situations like mother-baby coupling or therapist-client encounters (Montague *et al.*, 2002; Ramseyer & Tschacher, 2011; Trevarthen & Aitken, 2001). A dyadic setup allows quantitative and systematic research of manifold behavioral patterns, elicited by an encounter between two interacting subjects. The dyad becomes the unit of analysis, allowing the assessment of both *intra*- and *inter*-individual aspects brought forth during social interactions.

In this work, we primarily present and refer to the Perceptual Crossing Experiment (PCE),

an empirical paradigm capable of assessing real-time dyadic interactions in a systematic and ecologically valid way (Auvray *et al.*, 2009; Froese *et al.*, 2014; Froese *et al.*, 2020; Hermans *et al.*, 2020; Zapata-Fonseca *et al.*, 2018). After a thorough description of the PCE, we draw on the phenomenological concept of interbodily resonance (IR) (Fuchs & Koch, 2014) and show how it can be captured accurately by the paradigm. Accordingly, we propose an operationalization of IR into observable and testable variables. Afterward, we offer a brief account of schizophrenia as a disorder of embodied interaction, in which the subjective experience of body, time, and environment is altered, and IR therefore profoundly hindered. Finally, we suggest the implementation of the PCE to study disembodied interaction in people with schizophrenia, aiming to build a bridge between the phenomenology of social impairments and the experimental study of embodied social interaction.

2. The Perceptual Crossing Experiment

The Perceptual Crossing Experiment (PCE) is a two-person empirical setup that isolates the interactive aspect of the detection of sensorimotor contingencies (SMC). These can be understood as the sensorimotor affordances and responsive patterns that dynamically change depending on the own active exploration of an environment (Buhrmann *et al.*, 2013; O'Regan & Noe, 2001). Given its dyadic character, the PCE has also been proposed as a tool for assessing self-other SMC, (soSMC), that is, "*the know-how of the regular ways in which changes in others' movements depend on changes in one's movements*" (Froese *et al.*, 2020, p. 1).

Moreover, and despite its minimalist character, the PCE has already been used to investigate various features of dyadic interactions in different groups of people, including adolescents and patients with high-functioning autism (Auvray *et al.*, 2009; Barone *et al.*, 2020; Deschamps *et al.*, 2016; Froese *et al.*, 2014; Froese *et al.*, 2020; Hermans *et al.*, 2020; Zapata-Fonseca *et al.*, 2018). For instance, it has been shown that people suffering from autism were able to solve the task, namely, they could accurately detect the social contingencies. However, when looking at the movement patterns, they showed a significant difference in comparison to the control individuals: they moved rather repetitive and restrictive, likely spending more time on searching than on interacting (Zapata-Fonseca *et al.*, 2019; Zapata-Fonseca *et al.*, 2018).

In the PCE, pairs of physically separated participants can only engage with each other via a haptic human-computer interface (HCI) that reduces their embodied interaction to a minimum of horizontal left to right movement and haptic feedback. Participants are seated at separate desks so that they cannot see each other; the mutual auditory perception is also avoided as they wear noise-canceling headphones (Figure 1A). The task of the game is to move horizontally (left-right) within the unidimensional space and to mark those moments, in which an encounter with the partner has presumably occurred. They are told to help each other to achieve the goal of finding the other and establish an interaction.

Through the technological mediation, both participants are embodied as minimal avatars on an invisible line that wraps around after 600 units of space. Within the space, there are also distracting objects, namely a static and a moving one (see Figure 1B). Participants are to interact as embedded and embodied avatars by using their own HCI:

- They can move a trackball that controls the displacement of their avatar within the shared invisible space.
- And they can feel a vibration in the hand for as long as their avatar overlaps any of the other objects, that is, whenever a *perceptual crossing* occurs.

As shown in Figure 1B, each participant can encounter different kinds of objects within the virtual communal space. In total, three types of objects can be crossed with:

- A static one that is fixed at an arbitrary location.
- The other person's avatar, and
- A moving object that *shadows* the other person's avatar but at a constant distance.

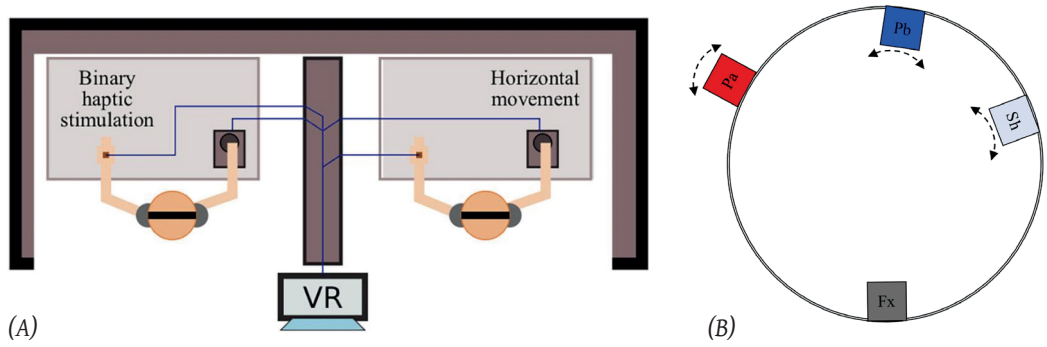

Figure 1. Perceptual Crossing Experiment. *(A) The physical setup: Participants interact exclusively via a Human-Computer Interface consisting of a trackball and a tactile stimulator (modified from Froese & Zapata-Fonseca, 2017). (B) The virtual setup: Participants are embodied as minimal avatars on an invisible one-dimensional circular space. Each participant can encounter three different objects: one located at a fixed position (dark grey square; Fx), another that corresponds to the participant's avatar (red or blue squares; Pa and Pb), and a shadow that moves exactly as the participant's avatar but at a constant distance of it (light gray square, Sh). For the sake of simplicity, (B) shows only the perspective of Pa.*

Only when both participants' avatars are crossing simultaneously, both participants are getting haptic feedback at the very same time.
Crucially, all three objects will elicit an on-off vibration if encountered. Figure 2 shows *perceptual crossings* that are to be distinguished only by the qualities they offer, *i.e.*, by their different possibilities for *(inter)*action, also known as affordances (Gibson, 1979). The static object would be at a certain point in space all the time, so it is inanimate: it does not move. On the contrary, the moving object is animate, but it is not reactive as it merely follows the other person's avatar at a constant distance; that is why this moving object is also called a shadow

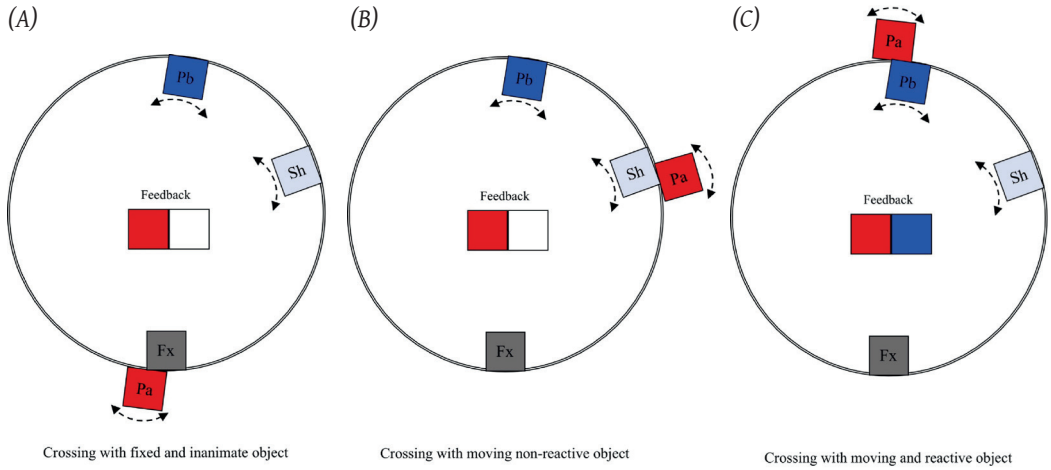

Figure 2. Different types of encounters in the Perceptual Crossing Experiment. *(A) and (B) are situations of one-directional coupling: Pa (red) interacts with two non-reactive objects, either inanimate (Fx) or animate (Sh); in this situations Pa (red) receives stimulation but Pb (blue) remains unaware of that and therefore no responsiveness to the former can be created. (C) shows a mutual encounter, defined as the overlap between participants' avatars (perceptual crossing); consequently, both Pa and Pb receive the tactile feedback simultaneously.*

because even if it is crossed, the *owner* of such shadow will never feel any vibration, making reactivity impossible. So only the avatar of the other person can change its behavior and therefore be both animate and reactive according to the encountered contingencies.
The PCE as an experimental set-up fulfills various requirements needed to establish meaningful embodied interactions. Being affected by *crossings* (haptic sensation) triggers a bodily resonance at physiological and proprioceptive levels, for example, arousal and motor reflexes, as well as back and forth movements to *palpate* the different objects in the environment and finally be able to detect the presence of the other, which in turn influences the perception and evaluation of the affordances that are in the *landscape* (animate, inanimate, reactive and their combinations) and implies a corresponding action readiness at a behavioral level. Like in real life, the different affordances can only be detected through movement and by considering what those movements elicit: there is a need to move and create movements and therefore to establish a sensorimotor coupling between interactants.
Notice that the experience of the body, both as a physical object and as a lived subject, is fundamental for the PCE framework. Because of the immersion in a shared environment, the subject's body is detected by another participant, and at the same time, her body allows her to be embedded and actively present. The embodied subject can *palpate* and *be palpated*, so her actions are perceptions as well. It is only through such embodied duality that the interaction can be realized. Both recognizing one's own creation of movement patterns and detecting reactivity to them become crucial to succeed in the recognition of the presence of the other.
It is also necessary to develop a sensitivity to different sensorimotor patterns resulting from the ongoing interactions not only between participants but also with the distracting objects that are always present in the environment. Therefore, the interaction is co-constructed by the moving and the feeling of the two embodied subjects that are co-present both in time and space.
In sum, the PCE entails an active and bodily based interaction between two subjects, who are simultaneously engaged with the environment through dynamic sensorimotor couplings. Such description is fully compatible with that of IR as we will see in the next section.

3. Inter-bodily Resonance

Inter-bodily resonance (IR) consists of a dynamic intertwinement of *expressions* and *impressions* between two people (Fuchs & Koch, 2014). Both interpersonal and intrapersonal levels are described so that the internal and relational properties can be distinguished. Individuals are regarded as embodied subjects being actively engaged within the environment through dynamic sensorimotor cycles (see Figure 3, adapted from Fuchs & Koch (2014)). In enactive terms, they may be seen as brain-body-environment systems constantly changing their states and situated within a shared environment (Froese *et al.*, 2013).
As shown in Figure 3, each subject experiences a relationship between perception and action, or *affection* and (*e*)*-motion*. If I can be affected, and literally *moved through my body* (intra-bodily resonance), then I am simultaneously capable to be reactive, showing emotional expressions, and making movements considering what the other embodied subject does (bodily feedback). Thus, a circular process unfolds over time, and participants become engaged interactors instead of detached observers (Fuchs & Koch, 2014).
In other words, IR comprises an ever-changing sensorimotor interpersonal system, in which one person's bodily activity (expression) turns into the other person's bodily perception (impression), and vice versa. Such interactive experience comprises the integration of time, the body, and the other:

- *Time* is captured by the fluctuating patterns of interaction within the environment and between embodied subjects. It is only through this dynamic character that cycles of sensorimotor patterns can unfold and become self-sustaining.

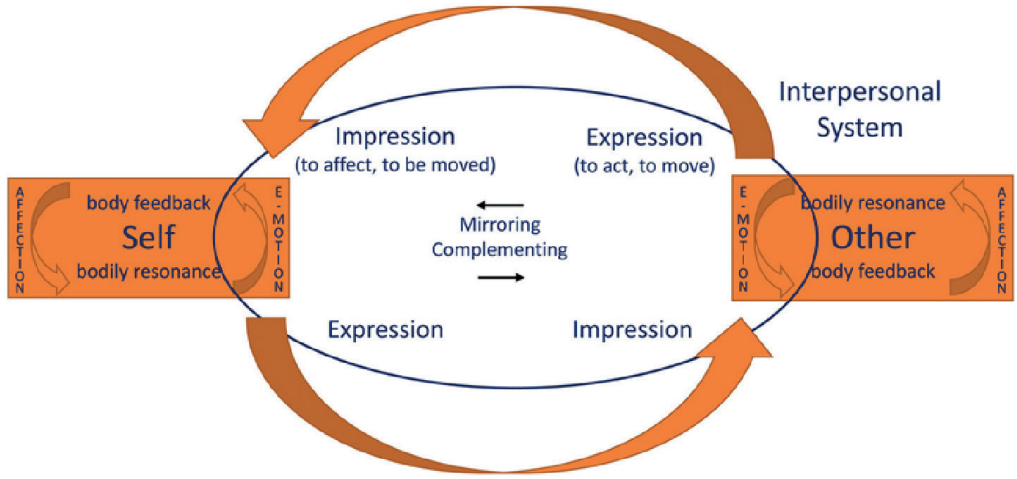

Figure 3. Illustration of the different components and interactive cycle of inter-bodily resonance. *Adapted from Fuchs & Koch (2014). Inter-bodily resonance is a dyadic interaction in real-time between two embodied subjects. Each individual is an intrapersonal system that through sensorimotor cycles is constantly related to itself and the environment.*

- The *Body* is depicted as a sensorimotor resonant system that allows bodily expressions through movements, and bodily impressions leading to being affected and reactive. An action-perception loop is formed, in which to act is to perceive, and vice versa (Froese & Fuchs, 2012).
- The *Other* refers to the embodied subject with whom the interaction is taking place. A reciprocal intertwinement of bodily expressions and impressions allows the feeling of being connected (Fuchs, 2017). Even if the global perceptual field of each subject is a shared environment, a clear demarcation between *Self* and *Other* is always present.

IR thus comprises a fluctuating sensorimotor interpersonal system, in which embodied subjects can move and be moved. They can *express* themselves through *(e-)motions*, and at the same time get *impressions* from the other embodied subject, allowing bodily *affections* to arise (Fuchs & Koch, 2014). This time-dependent and shared situation permits a bidirectional communication, sustained by both intra-individual and dyadic sensorimotor cycles. The unit of analysis is shifted from the isolated individual to the dynamics and properties at the dyadic level.

3.1. Empirical definition of Inter-bodily resonance and its relation to the PCE

From a phenomenological point of view, the task of the PCE experiment includes the recognition of the other's presence within a shared space, in which participants are, through technological mediation, *literally connected* and able to *feel each other*. They can enact meaningful sensorimotor loops, such as staying still after crossing with the other or moving back and forth to convey animacy. These allow them to eventually experience the presence of the other as a sense of embodied intersubjectivity.

Analogous to IR, we now present the integration of time, the body, and the other in the context of the PCE:

- *Time* is implied in the real-time interactions that evolve within and between trials. A flow of sensorimotor patterns that constitute the process of interaction is always present, which will enable the finding and understanding between participants. Both individual and dyadic behaviors unfold over time.

- *The Body* with its movement is the means through which participants interact. The PCE interactions are based on hand movements and the corresponding vibrations such that a sensorimotor cycle enables the interaction. Only through regulation of this sensorimotor engagement, the required communicative and interactive patterns can be achieved.
- *The Other* must be recognized as such to succeed in the game. The technological mediation in the PCE allows participants to intermittently interact with each other and with the other objects. There is a shared world, in which dyadic coupling and mutual communication are possible.

During the PCE, participants have partial control of their perceptual field as they move. In a sense, the participants *are* their movements, and the co-regulation of their movements is the only way of succeeding at the task. The interactants can find each other through *to-and-fro* movements that increase the frequency of the vibrations that are being felt simultaneously by both (see Figure 2C). Eventually, this flexible and adaptive responsiveness indicates the presence of the other. The presence of one participant completes the perception that the other is (co-)creating to actually recognize her partner and therefore establish a complementary social interaction.

Thus, the PCE is a suitable tool for operationalizing IR as it focuses on the interactive process itself and can consider the co-constitution of mutual communication between embodied subjects whose sensorimotor loops are continuously being adapted, both at an intra- and interpersonal level. *Table 1* shows the defined variables measured by the PCE and their corresponding phenomenological terms.

Furthermore, the dynamics taking place during everyday dyadic encounters resemble what happens during interactions in the PCE (Froese & Zapata-Fonseca, 2017). Both in everyday social interactions and during the PCE there is a modulation of the interaction within the dyad. While being constrained by the respective perceptual field, the interaction does not occur between isolated individuals, for the other is always part of the field as well (Fuchs, 2019). Following this second-person methodology, we turn now to the case of schizophrenia as a disorder, in which impaired and disembodied interaction prevails. Schizophrenia can be considered as a social impairment when focusing on the diminished sense of interbodily resonance and on the difficulties that patients have when trying to make sense of the environment and interactions with other people.

4. Disembodied interaction in schizophrenia

According to phenomenological psychopathology, patients with schizophrenia show disturbances in their embodiment, that is, the otherwise fluid oscillation between the modes of the body-as-subject and the body-as-object is disrupted, if not lost (Fuchs, 2010). The related alterations include impaired awareness of oneself or one's own body, a discontinuity of action-perception cycles of everyday performance, and impairment of intercorporeality with other people (Fuchs & Röhricht, 2017; Sass & Parnas, 2003).

The weakened sense of bodily self is manifested as a loss of vital contact with oneself and reality (Minkowski, 1970), sometimes described by patients as being detached from others, "*surrounded by invisible walls"* and feeling foreign to the world (Fuchs & Röhricht, 2017, p. 130). Additionally, there is existential insecurity, in which the own body, the own self, and the environment feel unfamiliar, and *"things can no longer be taken for granted"* (Fuchs & Röhricht, 2017, p. 131).

Patients with schizophrenia also suffer from a loss of sensorimotor coherence. This means a disintegration of automatic, fluid performance: everyday activities such as gait or lacing the shoes may become impaired or fragmented, often requiring deliberate movements and hyperreflective attention like a *"Cartesian action of the mind on the body"*. An example was

Variable	**Definition**	**Phenomenological Correlate**
Movement profile	Quantitative (Zapata-Fonseca *et al.*, 2019): • Mean velocity • Variability of velocity (standard deviation) • Number of changes in direction Qualitative: • Self-report of the employed movements	Sense of bodily agency: Recognition of the own actions as such and acknowledgment of their effects on the environment. Motion flow: Integration of individual movements into meaningful behavior.
Individual performance	Quantitative (Froese *et al.*, 2020): • Number of correctly detected encounters (accuracy of clicks) • Perceptual Awareness Scale (PAS) Qualitative: • Self-report of the experience of the presence of the other	soSMC: Detection of the presence of the other, *i.e.*, the "*know-how of the regular ways in which changes in others' movements depend on changes in one's movements*" (Froese *et al.*, 2020, p. 1).
Learning effect	Quantitative (Froese *et al.*, 2020): • Changes in individual performance across trials (see variables above) Qualitative: • Self-report of the development of strategies	Transparency and degree of incorporation: Acquisition of a skill (dyadic interaction in the PCE) through sensorimotor mastery (Andrada, 2020). The focus of attention changes across trials. Initially, it is on how the device works. Afterwards, it shifts towards the sensorimoto0r patterns and the interaction itself.
Interpersonal sensorimotor matching (dyadic)	Quantitative: (Hermans *et al.*, 2020; Kojima *et al.*, 2017; Zapata-Fonseca *et al.*, 2016) • Amount of seconds spent together • Adaptation of movement profiles • Rapport questionnaire Qualitative: • Self-report of collaborativeness	Embodied (inter)affectivity: *"two cycles of embodied affectivity become intertwined, thus continuously modifying each partner's affective affordances and resonance"*(Fuchs & Koch, 2014, p. 9).

Table 1. Measured variables with the PCE. *The qualitative variables are obtained by implementing a semi-structured interview after participants finish a round of 10 or more trials. soSMC: Self-other sensorimotor contingencies.*

described by a patient as *"I could not perform any movement without having to think about how would I do it"* (Fuchs & Röhricht, 2017, pp. 131,132; Sass & Parnas, 2003). A reduced capability to recognize familiar motor or sensory patterns ensues: single elements of the perceptual field stand out separately (Fuchs, 2019) and the *hypersalient* details become an overwhelming source of information that hinders tacit motor processes. As a result, the perception of the world is no longer transparent but opaque (Froese *et al.*, 2013), and reacting to it becomes increasingly difficult.

Of special relevance for the present work is the dysfunctional intercorporeality that manifests itself as a reduced interbodily resonance and a *"fundamental alienation of intersubjectivity"* (Fuchs & Röhricht, 2017, p. 133). Patients start to feel isolated and detached from the world, and one's own as well as the behavior of others come to be observed from a distant or third person point of view instead of being based on second-person embodied interactions. There is a severely disrupted *"basic sense of being-with-others in a shared life-world"* (Fuchs & Röhricht, 2017, p. 133; Sass & Parnas, 2003).
Such weakened embodied communication and lack of social resonance might be shown as impaired performance in detecting soSMC and difficulties for establishing an interpersonal matching during a real-time interaction (see Table 1 for details on the variables). Therefore, we propose the implementation of the PCE for schizophrenia research.

4.1. Disembodied interaction in the PCE

So far, we have argued that the PCE is an empirical set-up that enables us to quantify parts of the complex process of inter-bodily resonance. The PCE allows the assessment of social interaction including a sense of embodiment grounded in sensorimotor loops, as well as a sense of bodily agency in the form of responsiveness to the different affordances offered within a shared space. Both embodied subjects can initiate and control their own actions, while always remaining in contact with their bodies thanks to the human-computer interface (HCI) (Braun *et al.*, 2018; Tsakiris *et al.*, 2007). Additionally, the technologically mediated environment leads people to rely on the interaction itself from the very beginning of the trials, which corresponds to a second-person approach to psychopathology.
It is worth recalling the crucial role of bidirectional interactions and the adaptation to affordances in the PCE: they become the only way for efficiently distinguishing between the objects presented to the players. Once a trial begins, the environment turns into a dynamic one, in which different sensorimotor contingencies exist so that participants need to develop a perceptual knowledge about the available affordances for interaction and eventually reach an understanding of the sociality that is taking place.
In other words, the PCE relies on sensorimotor interactions that are influenced by adaptive coordination and imply time dependency, both at individual and dyadic levels of description. To be successful in the task, participants must make sense of each other and achieve a co-regulation between their patterns of movement. It is precisely this kind of adaptive behavior during real-time embodied interactions that is compromised in patients with schizophrenia.
To implement the PCE in the context of schizophrenia, it becomes crucial to operationalize disembodied interaction. Accordingly, we consider the following variable categories:
1) the sense of bodily agency (SBA), 2) the accuracy on detecting self-other sensorimotor contingencies (soSMC), and 3) interpersonal sensorimotor matching (ISM).

1) The SBA can be derived from the movement profile (MP) variable shown in Table 1. In the PCE it is possible to look at the active or passive character of the participants' movements (Kojima *et al.*, 2017). If a disturbance of agency is present, rather less and slow movement patterns would prevail (lower mean velocity and diminished variability of it – quantitative aspects of MP). If the individual is capable of initiating purposeful movements and acknowledges them as being created by herself (the qualitative aspect of MP), then it can be said that the agency is preserved.
2) The accuracy of detecting soSMC can be inferred from the amount of correctly assigned clicks and its subjective correlates (shown in Table 1 as individual performance). The animate and reactive object (the partner's avatar) is the only one capable of explicitly signalizing that one's own actions are indeed causing *impressions* and *expressions* on the partner. However, there might be a sense of ambiguity when crossing the static object because it is not the active movement (*expression*) that is causing the *impression*, but

rather a mere location in certain spatial coordinates (Di Paolo *et al.*, 2008). Therefore, accurate detection of soSMC requires not only sensitivity from a passive standpoint but also an active engagement to distinguish between reactive and non-reactive objects.

3) A diminished sensorimotor coupling (a proxy of sensorimotor coherence) might be observable as a predilection either for overstimulation (crossing with as many objects as possible) or for avoiding behavior (minimizing the activation of the haptic feedback). Additionally, a dysfunctional asymmetry between the MP of the dyad could be indicative of a lacking integration of sensorimotor loops measured by the dyadic variable ISM, mentioned in Table 1. The type of movements in terms of exploration or interaction, as well as the adaptive range of such movements (movement profile in Table 1), seem to be appropriate variables to propose potential socio-motor signatures that could resemble the disembodied interaction present in schizophrenia (Zapata-Fonseca *et al.*, 2019).

Importantly, these PCE variables should not be understood as having additive effects. That is, the disembodied interaction in schizophrenia can be manifested in different ways and at different levels. It is only through statistical hierarchical modeling, as suggested in Froese *et al.* (2020), that an integration of the variables and the respective interpretation is possible.

Given that the PCE focuses on the exploration of *prereflective* relational aspects of social interaction, *theorizing* or *mind-reading* are far from being useful for establishing a meaningful and embodied interaction. Given that people with schizophrenia frequently suffer from *hyperreflexivity*, it is expected that they might adopt such an observer's perspective. This detachment might also trigger difficulties for the other embodied subject involved in the interaction. For instance, a patient's behavioral movement might resemble static or animate nonreactive objects (the so-called shadows), which are characterized by absent responsiveness. As rather passive subjects, patients with schizophrenia might project a reduced vitality, hindering the detection of soSMC by the interactive partner. Furthermore, patients with schizophrenia might need more time and rounds to get familiar with the task in comparison with controls. For to successfully solve the task a certain level of intuitive behavior is required and it is precisely this implicit learning that is disrupted, leading to hyperreflexivity.

As a complement to the discussed objective variables, a hybrid assessment of behavioral variables and phenomenological descriptions of the interaction is warranted. The inclusion of qualitative questionnaires about the interactants' experience of *being-with-the-other* has shown to be very useful already. For instance, an integrative analysis of both quantitative and qualitative variables of the PCE was recently conducted, and it was found that "*a clearer perception of the other was not associated with correctness of recognition as such, but with both participants correctly recognizing each other*" (Froese *et al.*, 2020, p. 1).

Finally, given the embodied foundation of the PCE, as well as its engaging and dynamic character, it is possible to research a learning effect through repeated sessions of embodied interactions (Froese *et al.*, 2020; Hermans *et al.*, 2020). Such property could provide insights on how training of minimal embodied dyadic interaction might eventually have a countereffect on or even change the disembodiment suffered by patients with schizophrenia, analogous to well-established body-related interventions (Daly & Gallagher, 2019; Hildebrandt *et al.*, 2016; Martin *et al.*, 2016; Mastrominico *et al.*, 2018). It has been acknowledged that *"intercorporeality may serve as a remedy for the disembodiment in schizophrenia"* (Fuchs & Röhricht, 2017, p. 138). This would be in line with the TESIS study, a randomized controlled trial of embodied group therapy in patients with schizophrenia and autism, which showed that shared body sensitivity training and interaction could improve in particular flat affect, but also other negative symptoms (Martin *et al.*, 2016).

5. Summary

In the present article, we endorsed an embodied and phenomenological approach to psychopathology: mental disorders are understood as different modes of *being-in-the-world*, instead of mere brain disorders (Fuchs, 2007). Thus, we have drawn special attention to the bodily actions and the social dimension of human beings. By considering schizophrenia as a disorder of embodied interaction, we aimed to build a bridge between embodied cognitive sciences and phenomenological psychopathology.

Accordingly, we presented the Perceptual Crossing Experiment (PCE) as a sound paradigm to systematically study dyadic embodied interactions in real-time. We then introduced the theoretical notion of inter-bodily resonance and aimed to operationalize it in terms of the PCE. Based on these theoretical and empirical concepts, we showed how the PCE can capture the subjective experience of one's own body, the temporal context, and the relation to the other. Because of the inherent complexity of sociality, a minimal embodied cognition setup like the PCE yields the opportunity to consider both the individual phenomenology and the multi-scale dynamics that occur between individuals in a manageable experiment.

Consequently, we proposed the implementation of the PCE to study schizophrenia, aiming at a better understanding of the difficulties that schizophrenic patients face every day in the interactions with others. Frequently they experience these interactions as a burden, leading them to withdraw from the social world. Already in 1911 Bleuler introduced the term schizophrenic autism defining it as a detachment from the outer world associated with a predominance of an inner life (Bleuler, 1958). More recently, schizophrenic autism has been defined as a "disturbance of the *prereflective selfworld relation*" (Henriksen *et al.*, 2010, p. 365). Given that the PCE evaluates the *prereflective* relational aspects of social interaction and the fact that it is indeed sensitive to the modes of interaction deployed by patients with autism, it renders then plausible to observe disruptions in the movement trajectories of patients with schizophrenia as well.

The goal of applying the PCE to the study of schizophrenia is to provide a more naturalistic assessment of the disorder in its social context, grounded on the crucial role of embodied interactions. Moreover, the PCE offers a temporal resolution to deal with processes happening at pre-reflective levels, otherwise elusive to quantitative research. This contribution is expected to provide both embodied cognitive sciences and phenomenological psychopathology with a valuable tool for an integrative assessment of schizophrenia as a disorder of intersubjectivity.

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ORIGINAL PAPER

Movement markers of schizophrenia: a detailed analysis of patients' gait patterns

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Abstract

Motor abnormalities occur in the majority of persons with schizophrenia but are generally neglected in clinical care. Psychiatric diagnostics fail to include quantifiable motor variables and few assessment tools examine full-body movement. We assessed full-body movement during gait of 20 patients and 20 controls with motion capture technology, symptom load (PANSS, BPRS) and Neurological Soft Signs (NSS). In a data-driven analysis, participants' motion patterns were quantified and compared between groups. Resulting movement markers (MM) were correlated with the clinical assessment. We identified 16 quantifiable MM of schizophrenia. While walking, patients and controls display significant differences in movement patterns related to posture, velocity, regularity of gait as well as sway, flexibility and integration of body parts. Specifically, the adjustment of body sides, limbs and movement direction were affected. The MM remain significant when controlling for medication load. They are systematically related to NSS. Results add assessment tools, analysis methods as well as theory-independent MM to the growing body of research on motor abnormalities in schizophrenia.

Keywords Motion capture · Motor abnormalities · Movement · Controlled trial · Embodiment

Abbreviations

GMA	Genuine motor abnormalities
NSS	Neurological soft signs
UHR	Ultra high risk
CPM	Center for Psychosocial Medicine
HMR	Heidelberg center for motion research
MoCap	Motion capture
FD	Fourier decomposition
LDF	Linear discriminant function
MM	Movement markers
MF	Movement features
URM	Utilized range of motion

Introduction

Genuine motor abnormalities (GMA) can be observed in up to 80% of all patients with schizophrenia and in 66% of first-episode, antipsychotic-naive patients [1–5]. To a lesser degree, they have been observed in individuals considered at ultra-high risk (UHR) and in unaffected first-degree relatives with a genetic risk for schizophrenia [3, 6, 7]. Some researchers accordingly consider GMA a prognostic biomarker for neurodevelopmental alterations contributing to a vulnerability to the illness [3, 8]. However, acquiring a comprehensive overview of GMA related to schizophrenia is difficult. Descriptions and categorizations vary largely with the conceptual framework and the assessment means of the respective researchers [3, 9–12]. Hirjak et al. [3] for example, categorize four groups of GMA: (a) neurological soft signs (NSS)—externally observable impairments in sensory integration, motor coordination, balance, and sequencing of complex motor acts [1, 13], (b) hyperkinetic abnormal involuntary movements (AIMS), such as dyskinesia, dystonia, akathisia or hyperkinesia, (c) hypokinetic AIMS, such as

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spontaneous parkinsonism, and (4) catatonic phenomena, which can present as a hyperkinetic (e.g. mannerisms, stereotypy) or a hypokinetic (e.g. stupor, rigidity, immobility) movement disorder.

Pavlidou and Walter [9] in turn, name six distinct categories of GMA: (a) Dyskinesia—AIMS, (b) parkinsonism (c) akathisia—including restlessness and inner tension, (d) NSS (e) catatonia, and (f) psychomotor slowing, affecting fine and gross movements, such as writing or walking. The lack of conceptual clarity also applies to GMA rating scales which, additionally, rely on raters' subjective observation. They are thus prone to observer bias, depend on rater training for accuracy and are not designed to detect subclinical abnormalities [4, 6, 14–19].

The most established neurobiological findings on GMA originate from studies on NSS [3, 10, 20]. Besides being a sign for the risk of developing schizophrenia (trait factors), they can be used to monitor disease progression (state factors) [20, 21]. They are not only related to psychopathological symptoms of schizophrenia [22] but also to poor cognitive and social functioning of patients. Cuesta and colleagues found strong associations of NSS with impaired performance in attention tasks, speed of processing, verbal and visual memory in first-episode patients [23, 24]. The most frequently reported NSS category in patients with schizophrenia is motor incoordination, comprising the inability to perform rapid alternating movements and difficulties in simple coordination tasks, such as the tandem walk or finger-nose tapping [25–27]. Impaired motor or interlimb coordination has been found to discriminate best between high-risk children and controls, and between patients with schizophrenia or a mood disorder [26, 27].

Recently formed task forces, such as the European collaboration on movement and sensorimotor/psychomotor functioning in schizophrenia and other psychoses (ECSP), attempt a consensus on GMA definitions and underline the great advantages (e.g. sensitivity, linearly related results) of an increased implementation of instrumental assessment [6, 19]. Additionally, researchers from different academic backgrounds have begun experimenting with modern technology to create innovative paradigms for the systematic assessment of GMA in schizophrenia. They include accelerometers in smartphones to study tremor, pressure sensitive foot switches for step analysis, or actigraphy to assess restlessness and overall activity of individuals [28–39]. Despite disturbances in interlimb and motor coordination being one of the motor symptoms most specific to schizophrenia, most studies focus on fine motor performance or movement of the upper limbs [10, 39]. Very few studies examine full-body movement, and if they do, they analyze highly reduced (stride length, cadence) or very broad (overall activity) variables [39–41]. The most detailed assessment of human motion has been done with motion capture (MoCap) technologies [42], showing that the mere movement qualities of anonymized walkers (abstracted to point-light displays) reveal information about their gender, age and affective state [43–47]. To our knowledge, within the psychiatric context full-body MoCap has only been applied in one study to analyze movement patterns with relevance to diagnostics: Michalak et al. [48] compared gait patterns of patients with depression to controls and found a reduced walking speed, arm swing, vertical movement, a slumped posture of the upper body, and an increased lateral sway in patients. Effect sizes ranged between $d = 0.8$ and 1.3.

Taken together, despite various instrumental attempts to quantify GMA [18, 28–39], current diagnostics fail to systematically include the objective evaluation of subtle and overt motor behavior [10]. Available assessment means do not analyze detailed full-body movement or interlimb coordination. Hence, with our study, we aimed at

(a) piloting an assessment protocol, which allows for a detailed, three-dimensional, full-body gait analysis, and
(b) defining theory-independent full-body movement markers (MM) for schizophrenia.

To navigate around the lack of conceptual clarity regarding GMA and to facilitate a truly objective assessment, we chose a data-driven approach for the first step, and only in the second step related its results to existing symptom definitions. We are not aware of any other study on schizophrenia applying such an approach. The following hypotheses were addressed:

H1 The mere MoCap data will reveal significantly different movement characteristics for patients and controls, from which full-body Movement Markers (MM) can be extracted by controlling for confounding variables (medication load, weight).

H2 Full-body MM are similar to but expand the movement characteristics of individuals with depression found by Michalak et al. [48].

H3 Particularly interlimb coordination is affected.

H4 Pronounced MM are associated with pronounced NSS (especially subscale motor coordination, and sensory integration).

H5 Patients with pronounced negative symptoms display pronounced MM.

Methods

The study was conducted as part of the collaborative research project "Schizophrenia and the Moving Body" [Center for Psychosocial Medicine (CPM), Heidelberg Center for Motion Research (HCMR), BioMotionLab]. It was embedded in a series of studies on movement of

individuals with schizophrenia and conducted in accordance with the declaration of Helsinki [49]. The ethics committee of Heidelberg University's Medical Faculty approved the study before recruitment start.

Recruitment procedure

Participants with a diagnosis of schizophrenia were consecutively (2019–2020) recruited from one of four wards (three in-patient, one out-patient ward) of the CPM. Included patients were (1) able to consent, (2) between 18 and 60 years old, (3) diagnosed with a schizophrenia spectrum disorder (ICD-10: F20.0-F20.9) prior to study inclusion by senior psychiatrists unrelated to the study and (4) stable on antipsychotic medication for at least 2 weeks. Exclusion criteria were: (1) acute psychosis (ICD-10: F23), (2) diagnosis with a catatonic or schizoaffective subtype (ICD-10: F20.2, F25.0-F25.9), (3) history of brain trauma, neurological or internal diseases, heavy fractions or prostheses (4) visible tremor, (5) strong visual impairment (6) alcohol/substance abuse or dependency within the past 12 months or a substance-induced psychosis (ICD-10: F19.5), (7) an IQ < 70, (8) an SAS score above 4, (9) pronounced language barriers. Controls were recruited through postings and the University's website. Exclusion criteria resembled the patients' ones with one addition: history of psychosis or schizophrenia, personal or in first-degree relatives. All participants gave informed consent prior to participation, were clinically assessed at the CPM and then motion captured at HCMR. A priori power analyses (g*power) suggested a total sample size between 23 and 55 for the detection of medium to large effects ($d = 0.5$–0.8), when assuming an alpha-level of $p < 0.05$. Because previous studies [48] found large effect sizes, we targeted a sample size of at least 40 participants.

Clinical assessment

Patients were assessed with the Positive and Negative Syndrome Scale (PANSS) [50], the Heidelberger NSS Scale [17], the Brief Psychiatric Rating Scale (BPRS) [51], and the Simpson-Angus Scale (SAS) [52, 53] (parkinsonoid). Controls were assessed with the Heidelberger NSS Scale.

Movement assessment

Lab equipment and functionality were explained to prevent psychotic triggers. A set of 49 infrared-reflective markers was attached to the participants skin and skintight sportswear (see C-Motion [54] for the detailed marker set). 8 Oqus500 cameras (Qualisys, Goeteborg, Sweden) tracked participants' movements. An additional fixed video camera filmed the experiment. Participants were requested to walk back and forth on a path (7 m × 0.70 m) marked with white tape. They performed a series of other movement, balance and coordination tasks (details and results are discussed elsewhere). Walking was chosen, because it is a habituated full-body movement not requiring much cognitive attention but a complex interplay of sensory, motor and balance processes, and a fine-tuning of all limbs. To ensure a natural, "un-performed" walk, participants were asked to walk for a while to "find their most comfortable speed" (at least 3 min) before the actual recording began without further notice. At least 50 steps (8 times through the MoCap volume) were recorded.

Data analysis

Data were first analyzed algorithm-driven and then following a one-factorial, controlled between-group design. We performed three steps of analyis using different software for the various types of data: (1) By matching the groups for certain characteristics, we aimed at minimizing the influence of confounding variables (see Sect. 2.2.1). (2) We then quantified all visible group differences in movement (movement features, see Sect. 2.2.2), and (3) finally defined movement markers for schizophrenia from the pool of movement features (see Sect. 2.2.3).

Step 1: Sample characteristics and propensity score matching

Sample characteristics were analyzed and groups matched in R (Version 4.0.2) [55]. Daily medication load was converted into olanzapine equivalents (OPZ) following the classical mean dose method by Leucht and colleagues [56]. To match an equal-sized subgroup of controls to the available patients, we performed propensity score matching with five variables inherently correlated with gait: (a) gender, (b) age, (c) height, (d) weight, (e) BMI. We chose logistic regression for the estimation of propensity scores and created a matched sample using the one-to-one approach [57–59]. Except for the variable gender (exact matching), we chose nearest-neighbor matching. Matching was successful in reducing covariate imbalance for all variables except weight and, consequently, BMI. Hence, we based all further analysis on the matched and reduced sample and controlled for weight within the data-based exploration of movement patterns and the auxiliary analysis. See the supplementary material for details on matching.

Step 2: Data-driven analysis of movement patterns (movement features)

The MoCap data were analyzed with Qualisys Track Manager (Version 2018) and Matlab (Version R2020a). To avoid artifacts in the motion data, first and last centimeters of the

walks were excluded from the analysis. For the quantification of movement features, we followed Troje's [44, 60] computational framework. Due to space limitations, we can only give an overview of the algorithm. See [44] for a detailed description of the single computational steps. First, we computed the locations of 15 joint centers from the 49 marker trajectories. See Fig. 1 for a visualization of the joint center locations and [61–64] for the definition of the bone landmarks. With the help of Fourier Decomposition (FD), the joint center locations were linearized and redundancy was reduced.

We then computed a principal component analysis (PCA) across all Fourier-decomposed walkers to reduce dimensionality of the linear walker space [44, 47] (ten principal components, see [44, p. 10] for the decision on the amount of components of the PCA). To create linear classifiers, we computed a linear discriminant function (LDF), regressing the class indicator (patients, controls) on the walkers' projections in the low-dimensional Eigenwalker space. To account for group differences in weight, we repeated the LDF computation, regressing the weight on the Eigenwalkers. By multiplying the second LDF (weight) with the transpose of the original LDF (patients, controls), we extracted components that can be explained by weight differences. We subtracted those components from the original LDF. Using the coefficients of the rectified LDF and the Eigenwalkers of the PCA, we created a discriminant walker (DW), an animated visualization of the set of movement patterns that the LDF extracted as classifiers [44]: see https://www.biomotionlab.ca/martin2022/. LDF classifiers, however, remain on data-level, meaning they essentially refer to moving dots in space. To quantify visible movement features, which could be compared statistically, amplitudes and visualizations of the DW were repeatedly examined and rated by different members of the research team. Visible differences were gathered, categorized and computed for each participant on the basis of the FD data for one gait cycle. We aimed at a comprehensive mathematical description of the groups' dynamic, full-body movement differences (no structural differences: e.g. body size or hip width). Hence, for some movement differences, we propose multiple quantification options (movement features), which either follow Troje or Michalak [44, 48, 65]

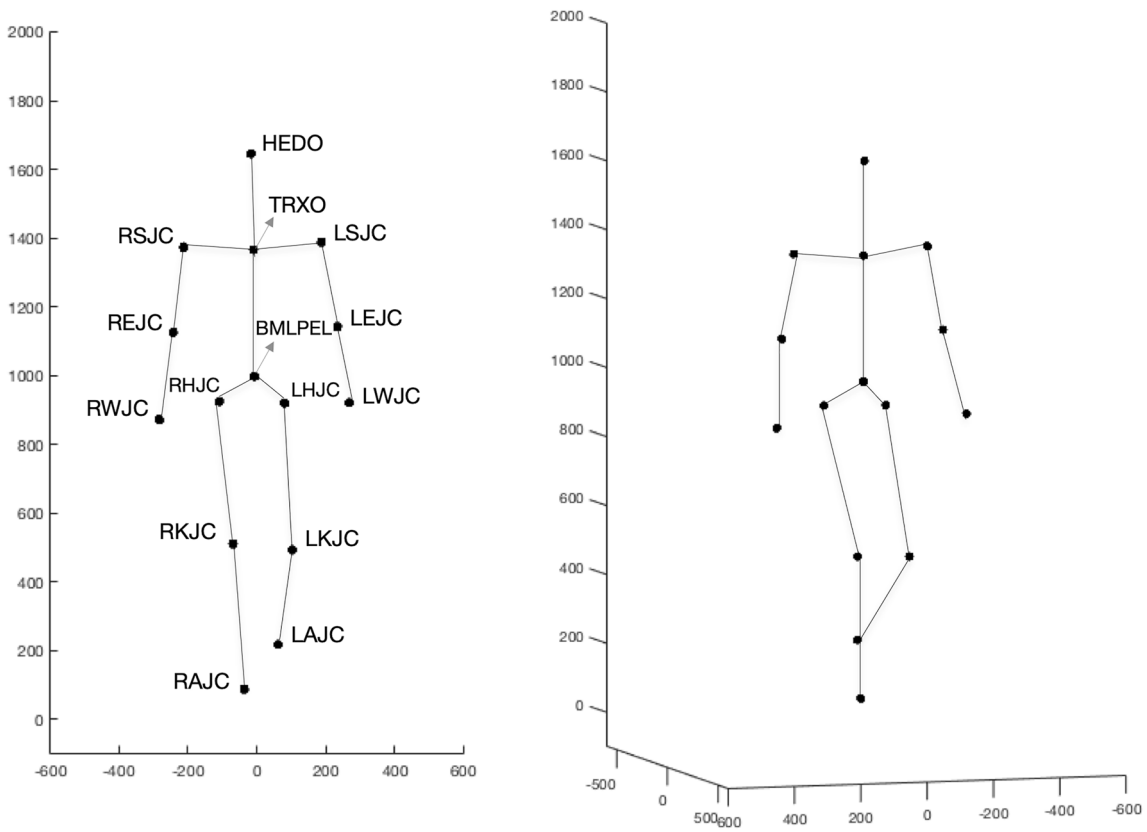

Fig. 1 Visualization of the joint centers (JC). They are located at the center of the head (HEDO), the sternum (TRXO), the shoulders (LSJC, RSJC), elbows (LEJC, REJC), wrists (LWJC, RWJC), the center of the pelvis (BMLPEL), hips (LHJC, RHJC), knees (LKJC, RKJC), and the ankles (LAJC, RAJC). The figure displays a film still of the average walker, derived from the entire sample. It can be viewed from the front (left picture) and rotated along all three axes (right picture). It is the basis for the discriminant walker, which is visualized as increments of the average walker. Axes: x = walking direction, y = lateral direction, z = vertical direction

by capturing body parts' amount of movement in space, or biomechanical recommendations, by quantifying the extent of motion in a respective joint ("Utilized Range of Motion" (URM)). See Table 1 in the supplementary material for computational details on all movement features.

Step 3: Determination of movement markers (MM) and correlations with clinical scales

Group comparisons of movement features and correlations were computed with IBM SPSS (Version 27.0.0.0). To determine MM for schizophrenia, all movement features were tested for significance. First, we computed *t* tests (two-sided, independent groups). We applied Bonferroni correction ($p < 0.0003 = 0.05/154$) for multiple testing but due to the explorative nature of our study also acknowledged initially significant variables not withstanding the correction. We again controlled for the weight of participants in an ANCOVA. In an auxiliary analysis, we assessed the influence of the medication load, by (a) correlating significant movement features with OPZ, and (b) splitting the patient group into a high and low dosage group and comparing significant movement features with second *t* tests. Movement features which proved significant in the main *t* tests and the ANCOVA and non-significant in the auxiliary analysis were defined as MM. Furthermore, we chose movement features which could be summarized for both body sides. Finally, we correlated the defined MM with the clinical scales PANSS, BPRS and NSS. Correlations with PANSS and BPRS, being schizophrenia-specific, were calculated for the patient group only. We correlated the MM with the conventional three factor model of the PANSS (Positive, Negative, Global) [50] as well as with the five-factor model of van der Gaag et. al (Positive, Negative, Disorganized, Excitement, Emotional Distress) [66, 67]. Correlations with NSS were calculated for the entire sample. We correlated the MM with gait specific items of the NSS scale (Station and Gait, Tandem Walk) as well as with its five subscales (Motor Coordination, Sensory Integration, Complex Motor Tasks, Right/Left Spatial Orientation, Hard Signs) [17].

Results

Sample characteristics

We screened over 140 and included 50 participants (22 patients, 28 controls). Due to drop out and propensity score matching, we analyzed the data of 40 individuals: 20 patients, 20 controls. See Table 1 for detailed sample characteristics.

Table 1 Demographics of the matched sample

	Control ($N=20$)	Patient ($N=20$)	Total ($N=40$)
Gender			
Male	14 (70.0%)	14 (70.0%)	28 (70.0%)
Female	6 (30.0%)	6 (30.0%)	12 (30.0%)
Diverse	0 (0%)	0 (0%)	0 (0%)
Age (years)			
Mean (SD)	38.2 (11.1)	39.0 (11.8)	38.6 (11.3)
Weight (kg)			
Mean (SD)	80.7 (15.3)	91.4 (16.1)	86.1 (16.4)
Height (cm)			
Mean (SD)	178 (9.22)	177 (9.87)	177 (9.43)
BMI			
Mean (SD)	25.4 (3.62)	29.0 (3.36)	27.2 (3.89)
Handedness			
Right	18 (90.0%)	17 (85.0%)	35 (87.5%)
Left	2 (10.0%)	3 (15.0%)	5 (12.5%)
Nationality			
German	17 (85.0%)	19 (95.0%)	36 (90.0%)
Other	2 (10.0%)	1 (5.0%)	3 (7.5%)
Many	1 (5.0%)	0 (0%)	1 (2.5%)
Mother tongue			
German	15 (75.0%)	18 (90.0%)	33 (82.5%)
Other	5 (25.0%)	2 (10.0%)	7 (17.5%)
Family status			
Unwed	12 (60.0%)	17 (85.0%)	29 (72.5%)
Married	5 (25.0%)	2 (10.0%)	7 (17.5%)
Widowed	0 (0%)	0 (0%)	0 (0%)
Divorced	3 (15.0%)	1 (5.0%)	4 (10.0%)
Years of education			
Mean (SD)	17.5 (2.61)	14.7 (4.19)	16.3 (3.54)
Missing	0 (0%)	7 (35.0%)	7 (17.5%)
Job			
In training	6 (30.0%)	1 (5.0%)	7 (17.5%)
Employed	11 (55.0%)	7 (35.0%)	18 (45.0%)
Self employed	3 (15.0%)	0 (0%)	3 (7.5%)
Retired	0 (0%)	2 (10.0%)	2 (5.0%)
Unemployed	0 (0%)	7 (35.0%)	7 (17.5%)
On sick leave	0 (0%)	2 (10.0%)	2 (5.0%)
Other	0 (0%)	1 (5.0%)	1 (2.5%)
Olanzapine equivalents			
Mean (SD)	0 (0)	17.2 (8.30)	–
Years of illness			
Mean (SD)	0 (0)	12.6 (11.5)	–
Number of psychoses			
Mean (SD)	0 (0)	5.05 (4.86)	–

Despite propensity score matching, the groups differed significantly concerning their weight and BMI. Covariate balance was ensured by comparing group means and calculating variance ratios. There were no significant group differences in any of the other variables

Data-based movement markers

Results of the group comparison are shown in Table 2. Due to space limitations, it only contains movement features, which display significant group differences (see results of all t tests in Table 2 of the supplementary material). Features which withstood Bonferroni correction are marked bold.

(a) *Basic features* patients and controls walked with significantly different speed (Mean velocity) resulting from a smaller stride or step length, not from a significantly different cadence (CA, SF see Table 2 supplementary material). They differed significantly in modeling power (Mean Power), indicating a less regular walk in the patient group, and varied more in their modeling power across moves (Standard Deviation of Power). It generally seems harder to model patients' walk with FD.

(b) Of all postural features (see Tables 1 and 2 in the supplementary material), only the angle between clavicle and head (head angle) was significantly different between the groups. Heads of patients "hang" more than those of controls.

(c) *Sway of body parts* patients displayed a significantly reduced 3D, horizontal and anterior–posterior (AP) arm sway, a significantly reduced 3D elbow and knee sway, and a significantly increased lateral body sway..

(d) *Interplay of limb movement (interlimb coordination)* patients displayed a significantly increased ratio of left and right arm or wrist movement, indicating lesser adjustment of the two body sides. Furthermore, we found significant differences in relational movement of the wrists and elbows (Ratio Wrist Elbow, Difference Wrist Elbow). Patients not only move wrists and elbows less in general, but they also move their wrists much less in relation to their own elbows, indicating stiffer arm movements. Similarly, we found significant differences in the relational movement of the arms and legs (Ratio Leg Arm, Difference Leg Arm) and shoulders and hips (Ratio Shoulder Hip, Difference Shoulder Hip). Patients do not adjust arm to leg movement (significantly more leg movement in relation to arm movement) or shoulder and hip movement to each other. Controls use their hips flexibly, patients walk with rather stiff hips, in a pendulum-like manner (twice as much lateral shoulder than hip movement).

(e) *Utilized range of motion* we found significant differences between the groups of URM in AP and lateral direction, both of the upper and lower, left and right arm (URM Left Arm AP − URM Right Elbow lateral). Analyzing physicality-independent, biomechanical measures, we can confirm the finding that patients generally use upper and lower arms less than controls. Furthermore, the 3D angle inside the elbow changes significantly less for patients within one gait cycle (URM Left and Right Elbow 3D), indicating a rather stiff usage of the arms. We also could replicate significant differences in LBS by looking at changes in the lateral movement of the thorax in relation to the entire body (URM Thorax lateral).

(f) *Relational URM* calculating the ratio of arm movement in AP and lateral direction, we found that movement in walking direction is more dominant in controls than in patients (Ratio URM Left and Right Arm, Difference URM Left and Right Arm). The strong expression of the control group's arm movement in walking direction can be interpreted as a goal directedness of the arms or as less "unnecessary" movement in lateral directions. This result is supported by similar group differences concerning the shoulders: patients move their shoulders more in lateral direction, controls move them almost with the same amount in AP and lateral direction (Ratio URM Left and Right Shoulder, Difference URM Left and Right Shoulder). Furthermore, patients show smaller differences in AP and lateral movement of their upper and lower arms. They move their arms in a stiffer or less flexible way (Ratio Left Elbow Left Arm AP − Difference Right Elbow Right Arm lateral). This result replicates and refines the finding of a decreased URM in the elbow joint of patients.

(g) All sway velocity measures are significantly different between the groups.

(h) Patients display significantly more pronounced ratios of knee and elbow velocities.

Effect sizes are considerably large ($d = 0.6$–1.5). None of the auxiliary correlations and t tests were statistically significant (see Tables 3 and 4 in the supplementary material) indicating that movement features are indeed independent of medication. Applying the definition rules mentioned above (see also the auxiliary ANCOVA—Table 5 in the supplementary material), we defined 16 full-body MM for schizophrenia. Table 3 summarizes the MM, their manifestation within the groups and ways to quantify them (movement features). Except for a decreased vertical body sway, we found similar MM in patients with schizophrenia, which Michalak and colleagues [48] found in individuals with depression. Additionally, we found a reduced step length, a reduced regularity of gait and various MM indicating a reduced ability to integrate the movement of body sides and limbs. Following Bonferroni adjustment, significance was maintained for the regularity of the gait, the arm and elbow sway, the flexibility of arm movement, the goal directedness of the shoulder movement and arm and elbow sway velocities. Hence, we can confirm H1 to H3.

Table 2 Significant Results of first t test

Features	*M*		95% CI		$t_{(38)}$	*p*	Cohen's *d*
	Patient (*N* = 20)	Control (*N* = 20)	LL	UL			
a) Basic features							
Mean velocity	1.084	1.209	− 0.223	− 0.027	− 2.571	0.014*	− 0.813
Mean stride length	1.215	1.330	− 0.202	− 0.029	− 2.696	0.010*	− 0.853
Regularity of walk							
Mean power	**0.993**	**0.995**	**− 0.002**	**− 0.001**	**− 3.971**	**0.000*****	**− 1.256**
Standard deviation of power	0.0008	0.0005	0.0001	0.0003	2.899	0.006**	0.917
b) Postural features							
Head angle	**12.867**	**5.301**	**3.854**	**11.274**	**4.127**	**0.000****	**1.309**
c) Sway of body parts							
Wrist sway left 3D	**261.246**	**418.665**	**− 240.747**	**− 74.091**	**− 3.824**	**0.000*****	**− 1.209**
Wrist sway right 3D	**217.250**	**384.860**	**− 240.966**	**− 73.872**	**− 4.652**	**0.000*****	**− 1.471**
Arm sway 3D	**239.248**	**401.762**	**− 234.735**	**− 90.294**	**− 4.555**	**0.000*****	**− 1.441**
Wrist sway left horizontal	247.086	396.892	− 230.792	− 68.818	− 3.745	0.001**	− 1.184
Wrist sway right horizontal	**203.823**	**366.547**	**− 234.778**	**− 90.670**	**− 4.572**	**0.000*****	**− 1.446**
Arm sway horizontal	**225.55**	**381.719**	**− 226.952**	**− 85.577**	**− 4.475**	**0.000*****	**− 1.415**
Arm sway left AP	**240.210**	**392.976**	**− 232.807**	**− 72.724**	**− 3.864**	**0.000*****	**− 1.222**
Arm sway right AP	**169.308**	**363.490**	**− 239.992**	**− 94.371**	**− 4.648**	**0.000*****	**− 1.470**
Arm sway AP	**218.259**	**378.233**	**− 230.592**	**− 89.355**	**− 4.586**	**0.000*****	**− 1.450**
Elbow sway left 3D	141.424	202.882	− 95.531	− 27.385	− 3.651	0.001**	− 1.155
Elbow sway right 3D	**126.004**	**185.913**	**− 88.892**	**− 30.926**	**− 4.185**	**0.000*****	**− 1.323**
Elbow sway 3D	**133.714**	**194.397**	**− 90.415**	**− 30.952**	**− 4.132**	**0.000*****	**− 1.307**
Lateral body sway	41.841	32.612	3.143	15.317	3.070	0.004**	0.971
Knee sway left 3D	299.171	323.829	− 48.540	− 0.776	− 2.090	0.043*	− 0.661
Knee sway right 3D	289.709	321.029	− 55.098	− 7.541	− 2.666	0.011**	− 0.843
Knee sway 3D	294.440	322.429	− 51.227	− 4.751	− 2.438	0.02*	− 0.771
d) Relational sway of body parts							
Relation of body sides							
Ratio wrist sway left right AP	1.753	1.255	0.0176	0.979	2.098	0.043*	0.664
Relation of body parts							
Ratio left wrist elbow	1.781	2.063	− 0.502	− 0.062	− 2.595	0.013*	− 0.821
Difference left wrist elbow	119.822	215.783	− 149.110	− 42.811	− 3.655	0.001**	− 1.156
Ratio right wrist elbow	1.663	2.054	− 0.625	− 0.156	− 3.375	0.002**	− 1.067
Difference right wrist elbow	**91.246**	**198.947**	**− 155.360**	**− 60.041**	**− 4.575**	**0.000*****	**− 1.447**
Ratio wrist elbow	1.738	2.062	− 0.526	− 0.123	− 3.260	0.002**	− 1.031
Diff wrist elbow	**105.534**	**207.365**	**− 147.872**	**− 55.789**	**− 4.477**	**0.000*****	**− 1.416**
Ratio leg arm	3.479	1.929	0.379	2.721	2.679	0.011*	0.847
Difference leg arm	394.516	282.596	39.225	184.616	3.117	0.003**	0.986
Ratio shoulder hip	1.878	1.172	0.170	1.241	2.666	0.011*	0.843
Difference shoulder hip	15.437	1.007	4.931	23.929	3.075	0.004**	0.972
(e) Utilized range of motion (URM)							
URM left arm AP	9.753	15.027	− 8.276	− 2.271	− 3.556	0.001**	− 1.124
URM right arm AP	**8.641**	**13.647**	**− 7.538**	**− 2.473**	**− 4.001**	**0.000*****	**− 1.265**
URM right arm lateral	1.529	2.043	− 0.880	− 0.147	− 2.835	0.007**	− 0.896
URM left elbow AP	19.342	30.572	− 17.228	− 5.231	− 3.790	0.001**	− 1.199
URM right elbow AP	**15.601**	**28.653**	**− 18.722**	**− 7.381**	**− 4.660**	**0.000*****	**− 1.474**
URM left elbow lateral	3.617	6.254	− 4.310	− 0.964	− 3.191	0.003**	− 1.009
URM right elbow lateral	**2.154**	**5.072**	**− 4.103**	**− 1.732**	**− 4.980**	**0.000*****	**− 1.575**
URM left elbow 3D	3.988	6.485	− 4.339	− 0.654	− 2.743	0.009**	− 0.867

Table 2 (continued)

Features	*M*		95% CI		$t_{(38)}$	*p*	Cohen's *d*
	Patient (*N* = 20)	Control (*N* = 20)	LL	UL			
URM right elbow 3D	3.618	6.956	− 5.251	− 1.425	− 3.533	0.001**	− 1.117
URM thorax lateral	1.964	1.559	0.128	0.681	2.965	0.005**	0.938
URM left shoulder lateral	1.972	1.656	0.001	0.631	2.032	0.049*	0.643
URM right shoulder lateral	1.958	1.590	0.053	0.682	2.369	0.023*	.749
URM left shoulder AP	**1.308**	**1.757**	**− 0.669**	**− 0.229**	**− 4.127**	**0.000****	**− 1.305**
URM right shoulder vertical	.394	0.298	0.002	0.189	2.057	0.047*	.651
URM right hip 2D	1.197	1.584	− 0.748	− 0.026	− 2.168	0.037*	− .686
URM right hip AP	3.506	4.487	− 1.864	− 0.097	− 2.247	0.031*	− .711
URM left hip vertical	.351	0.437	− 0.171	− 0.002	− 2.067	0.046*	− .654
f) Relational utilized range of motion (URM)							
Relation of movement in AP and lateral direction of the same body part							
Ratio URM left arm	4.518	6.212	− 3.083	− 0.303	− 2.466	0.018*	− .780
Diff URM left arm	7.406	12.466	− 7.820	− 2.300	− 3.712	0.001**	− 1.174
Diff URM right arm	7.112	11.604	− 7.0166	− 1.967	− 3.602	0.001**	− 1.139
Diff URM left elbow	15.725	24.318	− 13.393	− 3.792	− 3.624	0.001**	− 1.146
Ratio URM left shoulder	**0.685**	**1.152**	**− 0.668**	**− 0.266**	**− 4.704**	**0.000*****	**− 1.488**
Diff URM left shoulder	**− 0.664**	**0.101**	**− 1.090**	**− 0.441**	**− 4.776**	**0.000*****	**− 1.510**
Ratio URM right shoulder	0.867	1.330	− 0.729	− 0.197	− 3.520	0.001**	− 1.113
Diff URM right shoulder	− 0.262	0.337	− 0.966	− 0.231	− 3.302	0.002**	− 1.044
Relation of movement of different joints							
Difference left elbow left arm AP	9.589	15.545	− 9.441	− 2.471	− 3.459	0.001**	− 1.094
Ratio left elbow left arm lateral	**1.502**	**2.468**	**− 1.459**	**− 0.472**	**− 3.964**	**0.000*****	**− 1.253**
Difference left elbow left arm lateral	1.270	3.693	− 3.719	− 1.128	− 3.787	0.001**	− 1.198
Ratio right elbow right arm AP	1.717	2.125	− 0.672	− 0.145	− 3.136	0.003**	− .992
Difference right elbow right arm AP	**6.960**	**15.006**	**− 11.674**	**− 4.418**	**− 4.490**	**0.000*****	**− 1.420**
Ratio right elbow right arm lateral	1.459	2.625	− 1.809	− 0.523	− 3.673	0.001**	− 1.161
Difference right elbow right arm lateral	**0.625**	**3.029**	**− 3.479**	**− 1.329**	**− 4.528**	**0.000*****	**− 1.432**
Difference left shoulder hip lateral	− 1.247	− 2.424	0.126	2.226	2.267	0.029*	0.717
Difference right shoulder hip lateral	− 1.169	− 2.329	0.075	2.244	2.165	0.037*	0.685
Ratio left shoulder hip vertical	1.393	0.814	0.080	1.077	2.350	0.024*	0.743
Difference left shoulder hip vertical	0.055	− 0.118	0.045	0.302	2.724	0.010*	0.862
Ratio right shoulder hip vertical	1.352	0.804	0.005	1.092	2.041	0.048*	0.646
Difference right shoulder hip vertical	0.029	− 0.120	0.018	0.279	2.303	0.027*	0.728
g) Velocities of body parts							
Velocity left wrist 2D	222.366	362.129	− 216.566	− 62.960	− 3.684	0.001**	− 1.165
Velocity right wrist 2D	**182.898**	**333.890**	**− 218.867**	**− 83.116**	**− 4.503**	**0.000*****	**− 1.424**
Velocity left wrist 3D	235.064	382.036	− 226.148	− 67.795	− 3.758	0.001**	− 1.188
Velocity right wrist 3D	**194.879**	**350.584**	**− 224.663**	**− 86.747**	**− 4.571**	**0.000*****	**− 1.445**
Velocity left elbow 3D	126.523	184.208	− 89.630	− 25.741	− 3.656	0.001**	− 1.156
Velocity right elbow 3D	**112.640**	**168.498**	**− 82.801**	**− 28.917**	**− 4.197**	**0.000*****	**− 1.327**
Velocity left knee 3D	266.733	294.250	− 53.233	− 1.800	− 2.166	0.037*	− .685
Velocity right knee 3D	258.404	291.409	− 58.005	− 8.005	− 2.673	0.011*	− .845
h) Relational velocities of body parts							
Ratio velocity left knee elbow	2.244	1.731	0.156	0.870	2.908	0.006**	.919
Ratio velocity right knee elbow	2.482	1.846	0.224	1.047	3.126	0.003**	.988

* $p < 0.05$, ** $p < 0.01$, ***$p < 0.001$. LL = Lower Level, UL = Upper Level, AP = anterior–posterior, 3D = 3 dimensional, 2D = horizontal

Definitions and calculations of the movement features are shown in Table 1 in the supplementary material. All t-tests (also non-significant results) can be viewed in the supplementary material (Table 2). We applied Bonferroni adjustment for multiple testing: $p < 0.0003 = 0.05/154$. Results, which remained significant after Bonferroni adjustment are marked bold

Table 3 Movement markers of schizophrenia

Movement marker	Quantification (movement feature acronym)	Manifestation in people with schizophrenia and controls	Relation to neurological soft signs
Postural markers			
Head posture	Angle between head and clavicle. A bigger angle: more slumped posture/more hanging head (alphaHEAD)	Patients display significant bigger angles than controls, indicating their head is "hanging" more than the one of controls. Their posture is more slumped	A slumped posture is positively correlated with the amount of NSS, especially with the subscales Motor Coordination and Sensory Integration. The higher the amount of NSS, the more slumped the posture of the participants
Kinematic markers			
Regularity/periodicity of gait	Modeling an individual gait with FD requires the walk to be periodic and repetitive. To quantify the periodicity of the groups' gait, we computed the participants' modeling power, a measure for the average variance covered by the number of Fourier components in the chosen model (in our case 2). Non-periodic or irregular elements are reflected in a lower power of the FD. A higher power indicates a more periodic or rhythmic walk. (Mpower)	Patients display a significantly lower mean modeling power than controls. It is harder to model their gait with periodic Fourier decomposition. Their walk is less regular than the ones of controls	The gait regularity is negatively correlated with the amount of NSS (subscales Motor Coordination, Sensory Integration, Complex Motor Tasks, Hard signs). The higher the amount of NSS, the more irregular the walk
Variation of regularity/periodicity of gait	Variation of the gait regularity within one walk: Standard Deviation of Average Power (see MPower) across 8 moves (SDPower)	Patients display a higher variation in their gait regularity. While the moves of controls can be modeled equally well, the moves of patients vary in their modeling power	The variation of the gait regularity is positively correlated with the amount of NSS (subscales Motor Coordination, Sensory Integration, Complex Motor Tasks)
Stride length	The average length of one stride (two steps) (MSL, MSTRL)	Patients walk with smaller strides and make significantly smaller steps	The step length is negatively correlated with the amount of NSS (subscale Motor Coordination, Sensory Integration, Right/Left Spatial Orientation). The higher the amount of NSS, the shorter the steps
Arm sway	3D/horizontal/forward Wrist Sway of left and right side and averaged across sides (AS3, WSL3, WSR3, AS2, WSL2, WSR2, AS1x, ASL1x, ASR1x) *or* changes in arm pit angle (URMLAx, URMRAx)	Patients display a lower arm sway. On average they move their arms less than controls. This applies to all quantifications of arm sway (3D, horizontal, AP, physicality independent)	Arm sway is negatively correlated with NSS (subscales Motor Coordination, Sensory Integration, Complex Motor Tasks). The higher the amount of NSS, the smaller the amount of arm movement. *Furthermore, there is a positive correlation with the subscale hard signs. This somewhat contradicts the other correlation patterns*
Elbow sway	3D Elbow Sway of left and right side and averaged across sides (ES3, ESL3, ESR3) or Changes of elbow joint angle (3D: URMLE3, URMRE3, AP: URMLEx, URMREx, or lateral: URMLEy, URMREy)	Patients display a lower elbow sway than controls. On average they move their elbows less than controls. Furthermore they display less movement in their lower arm, in all directions	Elbow sway is negatively correlated with NSS, especially with the subscales Motor Coordination, Sensory Integration and Complex Motor Tasks. The higher the amount of e.g. Motor coordination Deficits the smaller the amount of elbow/lower arm movement. *Like the arm sway 3D elbow sway is positevly correlated with the subscale Hard Signs*

Table 3 (continued)

Movement marker	Quantification (movement feature acronym)	Manifestation in people with schizophrenia and controls	Relation to neurological soft signs
Knee sway	3D Knee Sway of left and right side and averaged across sides (KS3, KSL3, KSR3)	While walking, patients move their knees less in all directions than controls	*We could not find a significant correlation with NSS*
Lateral body sway	Mean amplitude of left and right shoulder in lateral direction (LBS) or changes of Thorax angle in lateral direction (URMTRy)	Patients display a larger lateral sway, lateral movement of the upper body while walking	Lateral body sway (LBS) is positively correlated with NSS subscale Complex Motor Tasks, indicating a higher amount of difficulties with complex motor tasks when displaying more lateral sway while walking
Velocity markers			
Gait velocity	Average speed across all 8 moves (MV)	Patients walk with less speed than controls	The average speed is negatively correlated with the amount of NSS (subscale Motor Coordination). The higher the amount of NSS, the slower the walk
Arm sway velocity	Wrist Sway multiplied by Cadence (3D: vWSL3, vWSR3, Horizontal: vWSL2, vWSR2)	Although patients don't walk with a lower cadence, they display a slower arm sway than controls for both sides (left and right)	The velocity of the arm movement is negatively correlated with NSS, subscale Motor Coordination, and overall NSS. The faster the movement, the smaller motor coordination deficits
Elbow sway velocity	3D Elbow Sway multiplied by Cadence (vESL3, vESR3)	Patients display a slower 3D elbow sway than controls for both sides (left and right)	The velocity of the elbow movement is negatively correlated with NSS, subscale Motor Coordination, and overall NSS. The faster the movement, the smaller motor coordination deficits
Relational markers (interlimb coordination)			
Adjustment of body sides (left/right)	Ratio of wrist sway on left and right side in AP direction: A bigger ratio indicates a higher difference between the sides, one side moves more than the other (RatioWSLR1)	Patients display a higher ratio, indicating that one arm moves more than the other. The Ratio of controls is closer to 1, indicating that arms on both body sides are moved with the same amount	The adjustment of body sides is positively correlated with the amount of NSS, especially Motor Coordination. The higher the ratio of the arms (the harder the adjustment), the bigger the amount NSS
Goal directedness of movement	Difference of URM of Left/right upper arm (diffURMLA, diffURMRA) or shoulder (diffURMLS, ratioURMLS, difffURMRS, ratioURMRS) in AP and lateral direction	Patients display less movement in AP direction of the arms when related to movement in lateral direction. Patients also display more lateral movement of the shoulders, when related to AP movement, Controls move their shoulders more in AP or walking direction. Patients' movement seems less goal or forward directed. *The same pattern can be found for the lower Arms (e.g. diffURMLE)*	The goal directedness of the arm and shoulder movement is negatively correlated with the amount of NSS, especially Motor Coordination. The more goal directed the movement, the smaller the amount of NSS

Table 3 (continued)

Movement marker	Quantification (movement feature acronym)	Manifestation in people with schizophrenia and controls	Relation to neurological soft signs
Flexibility of limb movement	Ratio/Difference of mean wrist and elbow sway of both sides (left/right) all directions (RatioWEd, DiffWEd) or difference of URM of left upper arm (arm) and left lower arm (elbow) in AP or lateral direction (diffLELAx, diffRERAx, diffLELAy, diffRERAy)	All Participants move their lower arms/wrirsts more than their upper arms/elbows but patients display less lower arm movement in relation to their upper arm movement. Their arm movement while walking is more rigid. A look at the physicality-independent flexibility measures reveals that stiffness is apparent in both, AP and lateral movement of the arms	The flexibility of the arm movement is negatively correlated with the amount of NSS (subscale Motor Coordination, Sensory Integration and Complex Motor Tasks). A higher flexibility is related to a smaller amount of NSS
Adjustment/integration of limb movement	Ratio of leg and arm movement (RatioLAd, DiffLAd) or difference of shoulder and hip movement (DiffSHd). A higher ratio/difference indicates less adjustment of arm to leg or shoulder to hip movement	Patients move their legs much more in relation to their arms than controls or their arms much less in relation to their legs. They don't adjust arm movement to steps. Furthermore, patients display less of an adjustment of shoulder and hip movement	The adjustment of leg and arm movement and of shoulder and hip movement is positively correlated with the amount of NSS, especially Motor coordination. More adjustment of arm and leg or shoulder and hip movement (smaller ratio) is related to a smaller amount of NSS
Adjustment/integration of sway velocities	Ratio of velocity of Elbow and Knee Sway (rationLKE3, rationRKE3). A smaller ratio indicates a better adjustment of sway velocities	Patients and controls display differences in the adjustment of body part velocities. They move their knees 2.24 times as fast as their elbows, controls only 1.7 times as fast. This is in line with the fact that arms are used much less and in a stiffer way	The adjustment of sway velocities between arms and legs is positively correlated with the amount of Motor Coordination Deficits and the amount of overall NSS, but negatively correlated with hard signs. The better the adjustment, the smaller the motor coordination deficits but the more pronounced the hard signs

One "move" is one way through the MoCap volume in the HCMR lab. We recorded 8 moves for each participant. The column "Movement Marker" (MM) refers to the concepts, which point toward schizophrenia. Due to the exploratory nature of our study, we chose to ignore p-value correction for the determination of MM. The column "Quantification" offers options of quantification that we found for the respective markers. It also displays the shortages of the feature names, which can be used to look up details of all defined features and their quantification in Table 1 in the supplementary material and (upon request of the first author) in the respective Matlab script

AP anterior–posterior

Table 4 Correlations of movement markers with clinical symptom load

Movement markers								
	Gait velocity (MV)	Stride length (MSTRL)	Head posture (alphaHEAD)	Regularity of gait (MPower)	Variation of gait regularity (SDPower)	Arm sway (AS3)	Elbow sway (ES3)	Knee sway (KS3)
Clinical Scales								
PANSS: pos	− 0.192	− 0.255	0.326	− 0.411	0.288	− 0.352	− 0.316	− 0.233
PANSS: neg	0.024	− 0.111	0.229	− 0.304	0.257	− 0.393	− 0.282	− 0.165
PANSS: glob	− 0.177	− 0.140	0.178	− 0.307	0.332	− 0.356	− 0.196	− 0.206
VDG: positive	− 0.210	− 0.173	0.147	− 0.411	0.233	− 0.346	− 0.283	− 0.198
VDG: negative	− 0.024	− 0.143	0.247	− 0.271	0.324	− 0.399	− 0.301	− 0.177
VDG: disorganisation	− 0.032	− 0.010	0.412	− 0.346	0.331	− 0.336	− 0.187	− 0.008
VDG: excitement	− 0.247	− 0.179	0.161	− 0.389	0.208	− 0.388	− 0.304	− 0.180
VDG: emotional distress	− 0.145	− 0.255	− 0.004	− 0.270	0.179	− 0.266	− 0.147	− 0.339
PANSS: total	− 0.117	− 0.165	0.243	− 0.349	0.314	− 0.390	− 0.268	− 0.210
BPRS	− 0.292	− 0.323	0.112	− 0.276	0.333	− 0.288	− 0.193	− 0.366
NSS: station and gait	**− 0.402****	**− 0.441*****	**0.567*****	**− 0.518*****	**0.474****	**− 0.622*****	**− 0.564*****	**− 0.366***
NSS: tandem walk	− 0.186	− 0.164	**0.511*****	− 0.275	**0.377***	**− 0.405***	**− 0.327***	− 0.078
NSS1: motor coordination	− 0.303	− 0.307	**0.370***	**− 0.425****	**0.349***	**− 0.528****	**− 0.439****	− 0.286
NSS2: sensory integration	− 0.294	**− 0.343***	**0.499****	**− 0.325***	**0.472****	**− 0.443****	**− 0.371***	− 0.228
NSS3: complex motor tasks	− 0.147	− 0.131	0.231	**− 0.351***	**0.329***	**− 0.380***	**− 0.332***	− 0.117
NSS4: R/L spatial orient	− 0.181	**− 0.375***	0.060	− 0.013	0.023	− 0.147	− 0.198	− 0.254
NSS5: hard signs	0.064	0.197	− 0.189	**0.336***	− 0.200	0.292	**0.337***	0.199
NSS: total	**− 0.319***	**− 0.358***	**0.394***	**− 0.387***	**0.389***	**− 0.516****	**− 0.440****	− 0.288
	Lateral body sway (LBS)	Adjustment of body sides (RatioWSLR)	Goal directedness of movement (diffURMLS)	Flexibility of limb movement (RatioWEd)	Adjustment of limb movement (RatioLAd)	Arm sway velocity (vWSL3)	Elbow sway velocity (vESL3)	Adjustment of sway velocity (rationLKE)
PANSS: Pos	− 0.148	− 0.382	0.281	− 0.220	− 0.088	− 0.346	− 0.276	0.041
PANSS: Neg	− 0.317	− 0.315	0.381	− 0.375	0.018	− 0.304	− 0.190	0.058
PANSS: Glob	− 0.147	− 0.234	0.372	− 0.394	0.019	− 0.348	− 0.210	− 0.017
VDG: positive	− 0.072	− 0.354	0.259	− 0.235	− 0.082	− 0.394	− 0.315	0.043
VDG: negative	− 0.292	− 0.318	0.402	− 0.369	0.006	− 0.320	− 0.209	0.051
VDG: disorganisation	− 0.282	− 0.272	**0.497***	− 0.386	0.021	− 0.346	− 0.217	0.091
VDG: excitement	− 0.052	− 0.147	0.239	− 0.350	0.124	− 0.387	− 0.296	0.071
VDG: emotional distress	− 0.042	− 0.225	0.135	− 0.260	− 0.008	− 0.212	− 0.093	− 0.118
PANSS: total	− 0.218	− 0.313	0.376	− 0.369	− 0.006	− 0.352	− 0.231	0.023
BPRS	− 0.123	− 0.370	0.353	− 0.243	− 0.124	− 0.309	− 0.210	− 0.100

Table 4 (continued)

	Lateral body sway (LBS)	Adjustment of body sides (RatioWSLR)	Goal directedness of movement (diffURMLS)	Flexibility of limb movement (RatioWEd)	Adjustment of limb movement (RatioLAd)	Arm sway velocity (vWSL3)	Elbow sway velocity (vESL3)	Adjustment of sway velocity (ratiovLKE)
NSS: station and gait	0.198	**0.361***	− 0.267	**− 0.573*****	**0.433****	**− 0.491****	**− 0.451****	**0.436****
NSS: tandem walk	0.151	0.215	− 0.239	**− 0.451****	0.266	**− 0.324***	− 0.285	0.307
NSS1: motor coordination	0.228	**0.405***	**− 0.456****	**− 0.548****	**0.435****	**− 0.407***	**− 0.362***	**0.376***
NSS2: sensory integration	0.187	0.269	− 0.168	**− 0.464****	0.258	− 0.293	− 0.261	0.234
NSS3: complex motor tasks	**0.337***	0.198	**− 0.471****	**− 0.371***	0.248	− 0.255	− 0.247	0.237
NSS4: R/L spatial orient	− 0.287	0.022	− 0.057	0.002	0.050	− 0.090	− 0.150	0.152
NSS5: hard signs	0.269	− 0.021	− 0.144	0.105	− 0.191	0.304	0.300	**− 0.334***
NSS: total	0.228	**0.356***	**− 0.449****	**− 0.518****	**0.372***	**− 0.364***	**− 0.340***	**0.336***

Correlations follow Pearson and are two-tailed. Correlations of PANSS and BPRS were calculated for the patient group only, correlations of NSS were calculated with the entire sample. For space-saving reasons, for each MM one quantification option (movement feature acronym) was chosen. NSS1 to NSS5 are subscales of the Heidelberger NSS Scale. "Station and Gait" as well as "Tandem Walk" are two items of the respective scale which are directly related to walking

VDG van der Gaag, *Orient*. Orientation

Significant correlations are marked bold

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Correlations with clinical scales

Table 4 displays the correlations of the MM with the clinical scales. We can confirm H4. Almost all MM (except Lateral Body Sway and Knee Sway) are significantly correlated with total NSS scores and especially with the subscales *Motor Coordination, Sensory Integration* and *Complex Motor Tasks.* The correlations indicate that a stronger manifestation of the respective MM is associated with a stronger manifestation of NSS in general, specifically with coordination and integration related NSS. Furthermore, all objectively measured MM (except Lateral Body Sway and Goal Directedness of Movement) are significantly related to the subjectively rated NSS item "Station and Gait". Again, and in all cases, a stronger manifestation of the respective MM is related to more disturbances in station and gait. Contrary to this, only some specific MM are correlated with the NSS item "Tandem Walk": Head Posture, Variation of Gait Regularity, Arm and Elbow Sway, Flexibility of Limb Movement and Arm Sway Velocity.

We can not confirm H5: none of the correlation patterns with the positive, negative, global (PANSS) and overall symptom load (BPRS) are significant. This holds true when looking at van der Gaag's five-factor model of the PANSS [67]: Except for the MM Goal directedness, which is positively related to the patients' disorganisation, none of the correlations become significant. The positive correlation of the patients' goal directedness with the disorganisation subscore contradicts the correlation patterns with NSS scores indicating a stronger manifestation of disorganisation when movements are more goal directed. Some MM display a correlational trend with the PANSS and BPRS. e.g. in the sense that less of an arm sway is related to an increase in positive, negative, disorganisational, excitement related and overall symptoms (e.g. $r_{AS3,\ PANSS:Pos}$). Correlations of integration related features with the symptom load do not show a systematic pattern. Furthermore, we could not find a systematic difference between the interaction of the MM with positive or with negative symptoms.

Discussion

Our study revealed three major results. First, movement features extracted and quantified instrumentally from basic walking are able to differentiate between individuals with a diagnosis of schizophrenia and without. Second, the MM of schizophrenia are mainly related to the integration and

adjustment of body sides, limbs or the direction of movement. Third, most of the MM are associated with increased NSS, particularly motor coordination and sensory-motor integration.

Our theory-independent MM are in line with results of the few previous studies analyzing posture and gait disturbances in people with schizophrenia [39–41, 48, 68, 69]: Cristiano et al. [69] identified forward head tilt as the most common postural feature in early and late-stage schizophrenia and found associations of postural changes with disease severity. Similarly, we identified the head posture as only significant posture marker and found associations of an increased "hanging" of the head with higher levels of NSS items "Station and Gait", "Tandem Walk" and NSS subscales "Motor Coordination" and "Sensory Integration". Like Putzhammer and colleagues [41], we identified a significantly decreased gait velocity in patients compared to controls, which can be ascribed to a shorter stride length, not to a decreased cadence. Similarly to Lallart and colleagues [40], who compared the stride-to-stride variability of patients and controls in a "walk alone" and in dual-task conditions and found significant differences in the dual-task conditions only, we did not find group differences concerning the variation of cadence in simple walking. An increased intraindividual variability in kinematic indices such as peak velocity and peak acceleration was also found by Jahn et al., who developed a device to analyse repetitive pronation/supination for subtle kinematic changes [70, 71]. Although pronation/supination, which is generally considered to be a typical NSS for schizophrenia [71], refers to fine motor performance of the hands, Jahn's finding corresponds to our finding of an increased variation in gait regularity across moves (walks through the MoCap volume). Together with Lallart's finding, it suggests that schizophrenia is characterized not merely by motor retardation but particularly by motor variability [71].

The fact that gait regularity was the only MM in our study which varied across moves might be related to the simplicity of our movement task. A dual-task condition was part of the above-mentioned additional movement tasks and will be analyzed in forthcoming publications. The striking differences of Lallart's participants' stride-to-stride variability while dual-tasking raises the assumption that the identified MM might be augmented by a dual-task. Additionally, Boks et al. [26] identified impaired motor coordination as most specific to patients with schizophrenia when comparing them to patients with a mood disorder; and Schiffman and colleagues [27] identified coordination deficits at the age of 10–13 as predictors of schizophrenia spectrum disorder at the age of 31–33. Although Schiffman and Boks as well restricted their analysis to fine motor performance and did not examine full-body movement, their results coincide with the many relational markers and variability differences we found. The relational features are particularly interesting, because they touch on the idea derived from embodied cognition that a disorganized mind is related to a disorganized body in the sense of a missing intrabodily and sensorimotor integration. Within the field of embodied cognition, the search for underlying brain alterations of schizophrenia is complemented by the analysis of interplay between mind, body and environment [72–74]. Schizophrenia is understood as a form of disembodiment, a missing integration and adjustment of sensorimotor loops, which results in an alienation of somatosensory perception, a lack of emotional expression, and a dissolution of the Gestalt units of movement and action [75, 76]. Successive movements (like one step after the other in walking) are described to lose their relatedness, smooth transition and "grace" [77, 78].

Tsakiris et al. [79] review studies on the sense of body-ownership ("It is my body, which is moving") and the sense of agency ("I control my movements") as two basic aspects of an embodied self-experience: while multisensory afferent signals suffice to create a sense of body ownership, it takes the integration of efferent motoric (self-initiated movement) and subsequent afferent sensory signals (multisensory integration) to create a sense of agency and finally a coherent experience of one's own embodied self. On one hand, the fact that most MM are not only correlated with deficits in "Motor Coordination" but also with deficits in "Sensory Integration" can be seen as further evidence for disembodiment or a lack of multisensory integration in the patients [76]. On the other hand, the consistent relations of the MM with NSS total scores, which not only include motor but also sensory NSS, correspond to the transidagnostic nature of NSS and raises the question if our MM are of transdiagnostic value as well. NSS have been observed in other severe neuropsychiatric conditions such as bipolar disorder, Alzheimer disease or HIV-associated cognitive disorder and are understood by some researchers as signs for neurocognitive impairment in general [20, 80, 81]. While the fact that Michalak et al. [48] did not identify movement patterns related to the adjustment of limbs or body sides in patients with depression suggests the possibility of using MM for the prediction and differential diagnosis of schizophrenia, it remains to be tested if and which MM can be found in patients with other neuropsychiatric diagnoses.

Finally, relating the MM to gait specific NSS items allows for a preliminary validation. While almost all MM were associated with the item "station and gait", only specific MM (Head Posture, Variation of Gait Regularity, Arm and Elbow Sway, Flexibility of Limb Movement and Arm Sway Velocity) were related to the NSS rating of the tandem walk. This makes sense, since the Tandem Walk—other than simple walking—is a highly coordinated, less habituated

movement, which requires a straight posture, flexible limb and dextereous arm usage.

Limitations and future directions

This was an exploratory study with a relatively small sample size. Non-significant correlations of MM with clinical scales might be a consequence. Hertzog [82] reviews the precision of estimates in pilot studies and appraises samples of 10–20 as sufficient for clinical contexts, given the possibility to specify expected group differences in an a priori power analysis. Our sample size was an interdisciplinary compromise taking into account previous studies, power calculations and the availability of the motion lab. The replication of this study with a larger sample might lead to a systematic association of MM with positive and negative symptoms. Another reason for non-systematic relations of MM with PANSS scores could be the ongoing controversy in the literature about which factor model of the PANSS yields the most useful research results [83].

By conducting a data-driven, comprehensive mathematical description of the groups' dynamic movement differences, we arrived at a very large amount of movement features, which overlap and correlate. To correct for multiple statistical testing we applied the Bonferroni correction. Streiner and Norman [84] discuss different correction types and arrive at the conclusion that the conservative Bonferroni method might lead to an overcorrection in explorative studies which aim at defining promising leads. Hence, we followed the researchers' advice against correction in the definition of "areas", in our case MM, that need follow-up in later studies [84]. In future analyses, we aim at a substantiation of the MM by conducting a factor analysis on the movement features and a multiple regression analysis.

Due to uncertainties concerning the reaction of vulnerable participants to the instrumental assessment, we exclusively examined individuals with a stable second-generation antipsychotic. To control for medication, we did auxiliary statistical analyses. Previous studies found no differences regarding GMA in never-medicated individuals and participants taking second-generation antipsychotics [41] and demonstrated that NSS vary in the course of the illness with psychopathological symptoms [21]. This includes a decline under neuroleptic treatment and speaks against an induction of GMA by medication. However, to entirely rule out the influence of medication on the identified MM, it would be beneficial to examine never-medicated or UHR individuals. This, and the longitudinal measurement of MM might answer the question to what extent behavioral MM can serve as predictors of a transition from a prodromal state to an acute psychosis or as indicators of disease progression. Since recent studies suggest that GMA gradually intensify on a continuum from prodrome to acute psychosis and that NSS improve with medication [1, 3, 20, 21] and since we found significant correlations of our MM with NSS, it is highly probable that a similar continuum can be established for the objectively assessed MM of this study and that the MM are primal symptoms of schizophrenia, which are independent of medical side effects.

Future studies should also assess the neuropathology underlying the identified MM. Recent neuroimaging studies support the hypothesis that GMA are linked to a disrupted "cortico-cerebellar-thalamic-cortical circuit" [1, 3, 10, 85]. However, studies on the neurological mechanisms underlying full-body gait disturbances in schizophrenia are scarce. On the way to defining a distinct motor domain for schizophrenia the present study should be expanded with a portable, neurological assessment, ideally guided by the current Mobile brain/Body imaging (MoBi) approach [86].

Finally, to integrate instrumental assessment into daily clinical practice, less expensive MoCap techniques (e.g. Kinect) should be explored. Prior to recruitment, we experimented with and found great bias in tools which base the motion tracking on inertial measurement units. Hence, we decided to establish subtle MM first and then transfer their mathematical and statistical evaluation to less detailed MoCap data. A greater accessibility and comprehensibility of MoCap data and its analysis might serve a systematic integration of motion assessment into clinical practice, generate great amounts of data and provide the missing link of GMA to the patients' subjective experience.

Conclusion

Long-standing negligence of the moving body in schizophrenia research has left us with a diagnostic system heavily weighing positive and cognitive symptoms and underestimating motor abnormalities. The systematic and continuous assessment and staging of MM as well as their correlation with self-experience and subjective well-being could substantially improve early and differential diagnosis of schizophrenia. At length, not only diagnostics but also treatment of schizophrenia would benefit from a systematic staging of MM. While various studies underline the overall beneficiary effects of embodied therapies [75, 87–89], their underlying mechanisms are far from clear. With the help of external cues, Putzhammer et al. [41] could dissolve stride length differences between patients and controls. This is highly encouraging evidence for the beneficiary effect of identifying individual MM of patients and treating them with specifically targeted therapy.

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Declarations

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

Animations Visualization of discriminant walker: https://www.biomotionlab.ca/martin2022/

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Relating movement markers of schizophrenia to self-experience—a mixed-methods study

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Introduction: Basic self-disorders on the one hand and motor symptoms on the other hand are discussed as endophenotypes of schizophrenia psychopathology. However, the systematic interaction between motor symptoms and the self-experience of patients is rarely studied.

Methods: In a previous study we defined motor markers of schizophrenia via a data-driven analysis of patients' gait patterns. In this study, we related the movement markers to measures of basic self-disorder obtained with EASE interviews. We substantiated the correlations with a qualitative content analysis of the interviews of a subset of four patients. We related qualitative and quantitative data on an intra- and interpersonal level.

Results: Our results suggest an association between the previously defined, theory-independent movement markers and basic self-disorders, specifically in the domain of cognition, self-experience and bodily experiences. While movement marker manifestation was not precisely reflected in the individuals' descriptions of anomalous self- and body experience, we found clear trends of more and more intense descriptions with increasing movement marker scores, when looking at specific experiences, such as hyper reflexivity.

Discussion: These results foster an integrated view of the patient and could stimulate therapeutic approaches aiming at an improvement of self- and body-experience of patients with schizophrenia.

KEYWORDS

self-disorders, movement markers, schizophrenia, examination of anomalous self-experience (EASE), mixed-methods

1. Introduction

Schizophrenia is among the most incapacitating psychiatric conditions and manifests in a variety of symptoms which scientists struggle to subsume under one coherent concept (1). Although basic self-disorders (SDs) have been reported as a characteristic feature since the first definition of schizophrenia, they have only been discussed as the pathogenetic core of schizophrenic psychoses within the past two decades (2–9). SDs are observed in the majority of people with schizophrenia and often occur in prodromal stages of the illness, long before positive symptoms arise and schizophrenia is diagnosed (8). Recent reviews found strong evidence for SDs being a phenotypic marker of vulnerability to the illness: SDs not only selectively aggregated within schizophrenia spectrum disorders (SSD) but also occurred in patient groups with clinical high risk and ultra-high risk for psychosis (7, 8). Moreover, SDs

gradually increase from non-psychotic disorders over clinical and ultra-high-risk patients to patients with SSD (8), and elevated SD levels in adolescence can predict the diagnosis of SSD later in life (10). A recent meta-analysis concludes that SDs are not just another symptom domain occurring in parallel with other symptom clusters but rather a generative condition of altered experience that is necessary for certain symptoms to arise (delusion, hallucinations, and social withdrawal) [(7), p. 1013].

Basic self-disorders are subtle but specific disruptions of the so-called minimal self—the tacit, pre-reflective feeling of being the owner or creator of one's experiences, thoughts, and actions (11–13). The minimal, basic, or core self describes the integral first-person perspective of our consciousness: "I am the one looking at the tree," without having to make this certainty explicitly conscious by active introspection (12). Phenomenologists also speak of "ipseity" when describing the unconscious feeling of mineness of all our experiences (13). Moreover, seeing or touching the tree always comprises the background feeling of the body, or the implicit awareness of being an *embodied* subject of action, including interoceptive, proprioceptive, and kinesthetic awareness as well as a basic auto-affection or "feeling of being alive" (11, 13, 14). Neuropsychological research supports the assumption that an intact basic sense of self arises from two components: (a) the sense of body ownership and (b) the sense of body agency. While multisensory afferent signals are considered sufficient to generate a sense of ownership, recent studies suggest that efferent motor signals (self-initiated movement) and afferent sensory feedback (sensorimotor integration) are necessary to generate a sense of agency and an integrated bodily self-experience (15–17). Hence, correctly attributed body and movement experiences are considered essential prerequisites for the emergence of an integrated sense of self (17).

SDs in schizophrenia present as a subtle feeling of alienation, inner emptiness or inanimation, and loss of natural self-evidence (3, 9, 18, 19). The affected no longer feel at home "in their own bodies and worlds (3, 20, 21). The self-evidence with which the body mediates sensory perception, action processes, emotional expression, and social interactions is primarily disturbed or increasingly lost (3, 12, 19). Subtle feelings of depersonalization are accompanied by altered body and movement perception (disautomation of movement sequences, hyper-reflexive self-observation) and pronounced interaction difficulties (reduced emotional expression in gestures and facial expressions, lack of non-verbal resonance) (22). Against this background SDs are often subsumed under the term of *disembodiment* (3, 12, 23). In acute psychotic states, the subtle experiences can increase to an existentially threatening "ego dissolution" (22). People lose the sense of agency for their own emotions or actions, leading to delusions of manipulation or alien control (positive symptoms) (9, 24, 25).

In 2005, a collaboration between Danish, German, and Norwegian psychiatrists and phenomenologists lead to the publication of the Examination of Anomalous Self-Experience (EASE), a semi-structured, qualitative interview, which explores experiential or subjective anomalies of individuals with schizophrenia. The interview was constructed by Parnas et al. on the basis of self-reports of patients, has a strong descriptive, diagnostic and differential-diagnostic value, and is now considered the most established assessment tool for SDs (26). With its 57 items, which are structured into five subdomains: (1) cognition and stream of consciousness, (2) self-awareness and presence, (3) bodily experiences, (4) demarcation/transitivism, and (5) existential reorientation—it incorporates all aspects of a disturbed basic sense of self. Fuchs et al. focus on a disruption of pre-reflective bodily self-awareness and the implicit sensorimotor functions of the body and thus consider a disembodiment and anomalous bodily and self-experiences (EASE domain 2 and 3) as the core disturbance of schizophrenia and SDs (3, 20, 24, 27–30).

Most people with schizophrenia not only present with altered body and movement perception but also with externally observable general motor abnormalities (GMAs), such as neurological soft signs (NSSs), abnormal involuntary movements (AIMs), or psychomotor slowing [see Ref. (31–33) for an overview]. In fact, subtle impairments in motor coordination, sensory integration, balance, and sequencing of complex motor acts (all NSS) are among the most established findings in schizophrenia research (11, 31, 34). Similar to SDs, GMA have been observed in up to 80% of people with SSD and can be found in individuals with a high risk of psychosis as well as in first-degree relatives with a genetic risk for the illness. Hence, they can be considered a sign or an endophenotype for schizophrenia vulnerability (31, 35). Despite their high prevalence, there is no single definition of GMA. Categorizations of associated symptom clusters vary with conceptual frameworks and assessment instruments of the respective studies and researchers (31, 35, 36). In a previous study, we identified theory-independent movement markers (MMs) of people with schizophrenia: *via* data-driven analysis of full-body motion patterns in gait, we extracted medication- and weight-independent limitations in posture, velocity, regularity of gait as well as sway, flexibility, and integration of body parts. Specifically, the adjustment of body sides, limbs, and movement direction were affected [see Ref. (31) for study details].

While it is beyond debate that postures or movement are in a constant bidirectional interplay with cognition and emotion (37–39) and that subtle or intense changes in movement ability and behavior are related to changes in self-experience and subjective wellbeing of patients (40), the systematic interaction between motor symptoms and the self-experience of patients with schizophrenia is rarely studied. Only recently, there have been attempts to systematically relate phenomenological concepts, such as SDs, to underlying neurocognitive mechanisms (41, 42) or GMA (11). Tonna et al. (11) identified postural patterns (motor rigidity or instability) and a general disruption of the gait cycle as a marker for the underlying neurodevelopmental disturbance in early-onset schizophrenia and found associations of the specific motor pattern with subjective bodily experiences (mainly the loss of bodily integrity, cohesion, and demarcation). As a result, the researchers hypothesized motor symptoms and SDs to be "two poles of the same underlying perturbation of the structure of consciousness, [. . .] first and foremost rooted in motor enactment" [11, p. 12].

Taking into account the role of the moving body in the development of a coherent sense of self [sense of body ownership and agency; see above and (15)], in the following study, we aimed at relating the previously identified MM to subtle changes in

the self- and body experience of the participants measured by the phenomenological examination of anomalous self-experience (EASE). By adding an in-depth, qualitative analysis of a subset of EASE interviews, we chose a mixed-methods approach, which aims at relating qualitative and quantitative data. We are not aware of any resembling study.

We addressed the following hypotheses:

H1. The previously defined MMs are correlated with SD measurements: Specifically, higher scores of the MM (a more severe impairment) are associated with higher ratings in the EASE subdomains 2 "Self-awareness and presence" and 3 "Bodily Experiences."

H2. Specific anomalous self-experiences, (specific EASE items, including but not restricted to "diminished sense of self," "distorted first-person perspective," "somatic depersonalization") are correlated with stronger MM manifestations.

H3. Individual manifestations of MM (movement profiles) are reflected in the participants' qualitative descriptions of self- and body experience, in the sense that higher MM manifestations are associated with more and more intense descriptions of limitations in self- and body experience.

2. Materials and methods

The study was part of the collaborative research project "Schizophrenia and the Moving Body" (Center for Psychosocial Medicine (CPM), University Hospital Heidelberg; Heidelberg Center for Motion Research (HCMR), University of Heidelberg; BioMotionLab, York University). It was conducted in accordance with the Declaration of Helsinki (2013) and the code of ethics for doctors of the state chamber of physicians of Baden-Württemberg and approved by the local ethics committee of the Medical Faculty of Heidelberg University (S-629/2018).

2.1. Recruitment and assessment

Participants with a diagnosis of schizophrenia were recruited between 2019 and 2020 among patients who were admitted to one of four wards of the CPM. All patient files of the wards were screened according to the following selection criteria: Inclusion: (1) able to consent, (2) between 18 and 60 years old, and (3) diagnosed with a schizophrenia spectrum disorder (ICD-10: F20.0 – F20.9) prior to study inclusion by senior psychiatrist unrelated to the study, (4) stable on antipsychotic medication for at least 2 weeks; exclusion: (1) acute psychosis (ICD-10: F23), (2) diagnosis of a catatonic or schizoaffective subtype (ICD-10: F20.2, F25.0-F25.9), (3) history of brain trauma, neurological or internal diseases, heavy fractions, or prostheses, (4) visible tremor, (5) strong visual impairment, (6) alcohol/substance abuse or dependency within the past 12 months or substance-induced psychosis (ICD-10: F19.5), (7) IQ < 70, (8) SAS score above 4, and (9) pronounced language barriers. With the help of flyers and through personal approach by the leading physicians, eligible patients were referred to the study. Since the control group is not actively analyzed in this publication but only functions as a point of reference, recruitment procedure and selection criteria of the control group are described elsewhere (31). All participants, who met the inclusion criteria, were informed in great detail about the course of the study and gave informed consent prior to participation. They were interviewed at the CPM using the EASE (26) and then invited to the HCMR to take part in the movement assessment. EASE interviews were conducted by the first and the last author (LM and TF) with the help of a semi-structured interview guide (43) and audio-taped [Check (21) for details on EASE documentation and analysis]. Both interviewers were trained in the usage of the interview within official workshops conducted by the interview's author group. Details of the movement assessment are given in another publication (31). Depending on the participants' schedules, the assessments took place on the same day or on different days. After completion of the study, participants were reimbursed with an expense allowance of 10 € per participation hour.

2.2. Data analysis

MMs of Schizophrenia were defined in a previous study by an algorithm-driven analysis of the MoCap data comparing patients and controls. See Martin et al. (31) for a detailed description of the respective analysis. While walking, patients with schizophrenia displayed (1) a hanging *head posture,* (2) a reduced *gait regularity*, (3) an increased *variation of gait regularity*, (4) a reduced *stride length*, (5) *arm sway*, (6) *elbow sway,* (7) and *knee sway*, (8) an increased *lateral body sway*, (9) a reduced *gait velocity*, (10) *arm sway velocity*, (11) and *elbow sway velocity*, (12) less *adjustment of body sides*, (13) less *goal directedness of movement*, (14) less *flexibility of limb movement*, (15) less *adjustment of limb movement*, (16) and a decreased *adjustment of sway velocities*. Calculations for the publication at hand were done using the free software environment for statistical computing and graphics R (Version 4.0.2) and RStudio (Version 1.2.5019) (44) as well as IBM SPSS (Version 27.0.0.0).

After defining sample characteristics, we performed five steps of analysis.

2.2.1. Interview rating and inter-rater reliability

All interviews were rated according to an adapted rating scale by the first author of this article (45). To ensure a certain level of objectivity, half of the interviews (randomly chosen) were rated by a second rater who was not involved in the study but trained in EASE rating. Rater training took place over the course of 2 days at CPM and was conducted by the last author (TF). The second rating was used to calculate inter-rater reliabilities (IRRs). IRRs were calculated following a tutorial by Hallgren (46). We computed intra-class correlations (ICCs) for the overall EASE score and for all five subdomains, respectively. Except for subdomain four, the ICCs of the individual subdomains were sufficient: (1) cognition and stream of consciousness: $ICC_1 = 0.84$, (2) self-awareness and presence: $ICC_2 = 0.85$, (3) bodily experiences: $ICC_3 = 0.66$, (4) demarcation/transitivism: $ICC_4 = -0.20$, and (5) existential reorientation: $ICC_5 = 0.61$. The low ICC of subdomain four can be explained by a misunderstanding of the second rater, which led to a complete omission of ratings in subdomain four. Because the

overall IRR was considerably high ($ICC_{Total} = 0.89$), a satisfactory amount of objectivity can be assumed. Therefore, the EASE scores of the first rater were used in all further steps of the analysis.

2.2.2. Correlations with EASE scores

We correlated the defined MM (31) with EASE total scores and with the five subdomains of the interview. Correlations followed Pearson (47) and were two-tailed. Normal distribution of the variables was determined with the Kolmogorov–Smirnov test (48, 49). The EASE subdomains are a collection of experiences, which share a common ground but are very heterogenous in their experiential nature. Hence, to get an idea of the correlations' origin (which exact experience is related to the respective measurable MM?), we also correlated the MM with specific EASE Items. Following Streiner and Norman (50), who advice against overcorrecting with the Bonferroni method in explorative studies, which might find promising leads, we deliberately chose not to apply a correction method for multiple testing. Therefore, we understand the following results as a preliminary base for further hypothesis generation. Furthermore, due to the explorative nature of our study, we understood non-significant but moderate correlations (above 0.3) as pointing toward a correlational trend.

2.2.3. Movement index and movement profiles

Because every quantitative analysis inevitably comprises a data reduction, we decided to enrich the correlational clusters with idiosyncratic qualitative information. To enable an in-depth analysis of the qualitative interview data and relate the textual information to the quantitative MM, we extracted a subsample of four patients. Since a targeted selection of particularly interesting interviews is associated with the risk of a confirmation bias, we determined a selection criterion based on the quantitative movement data: The *movement index* (MI) was computed on the basis of the abovementioned 16 MM. It is defined as the patient's mean of absolute z-deviations across all 16 MM and can be interpreted as the individual's prototypicality of movement markers within the schizophrenia sample. To be exact, we first transferred all individuals' MM values to absolute z-values, indicating the deviation of the respective patient's MM manifestation from the mean values of the other patients. Absolute values were used to prevent positive and negative values from averaging out in the following step. Then, we calculated the individuals' mean across all 16 transferred MM (MI = mean of the absolute MM z-values). Using the MI, we identified three patients who covered the entire spectrum of MM manifestation: (a) the person with the lowest movement index and, hence, the smallest deviation from the other patients, representing the prototypical patient of the schizophrenia sample, (b) one person with an average movement index, representing a medium deviation of the schizophrenia sample, and (c) the person with the highest movement index, representing a high deviation from the other patients or the most atypical movement profile regarding the patient group. Because we used absolute z-values, the abovementioned deviation includes both negative and positive differences of MM manifestation to the schizophrenia sample. However, the selection procedure provided a subsample containing exclusively male patients. To reflect the entire sample's gender distribution within the subsample, one more female patient with an average MI was selected. To get an overview of the manifestation of the 16 individual MM within the subsample individuals and make the quantitative data relatable to the qualitative interview data, we created four *movement profiles* (MPs). For this, we computed and plotted two z-values of each MM for each of the four subsample patients using the mean of and thus relating the movement markers to the (a) schizophrenia sample and (b) the control group. While (a) allowed the assessment of the prototypicality of schizophrenia-characteristic MMs, (b) represented a more disease-oriented dimension regarding the deviation from the control group. Finally, we identified remarkable movement markers of subsample patients, which exhibited z-scores higher or lower than 1 regarding the control group. These remarkable movement markers were related to the individuals' categories of subjective self- and body experiences, hence the qualitative data from the EASE interviews.

2.2.4. Qualitative analysis of interview data

The qualitative analysis of the subsample's interview data followed a consensual research approach (51, 52). It was implemented by an analysis committee (first, second, and fourth author of the publication coming from the fields of psychology and psychiatry) who within regular focus groups aimed at a consensus on the suitability of procedures as well as the analysis of the interview data. For the interpretation of the interview data, we invited an independent expert (third author, phenomenologist) to ensure a certain level of interpretation objectivity. We used the software MAXQDA 2020 (53) for all qualitative analysis steps. After the transcription of the interview audio-files [guidelines of McLellan et al. (54)], we conducted a qualitative content analysis following Kuckartz (55). The transcripts of the interviews can be found in the Supplementary material. All identifying names and places were anonymized. To account for the diverse expressions and descriptions of individual experiences and to make the qualitative analysis as reproducible as possible, we deliberately chose to ignore the factorial and item structure of the original EASE interview and to analyze the interviews "as a whole." To enable an open and unbiased analysis of the textual material, we chose to search for salubrious and pathological expressions of self- and body experience rather than SDs specifically. We performed five steps of qualitative analysis: (1) deductive development of the main thematic categories and codes of self- and body experience using theory and literature (15, 20, 26, 56–61); (2) coding of the interview material; (3) compilation of all text passages coded within a category; (4) inductive enrichment of the main thematic categories and formation of lacking categories using the interview material; and (5) coding of the complete material with the final category system. Coding was continued until data saturation was reached, hence until found categories recurred and no novel variations were found.

2.2.5. Relating interview data to MMs

As stated above, only remarkable MMs (exhibiting SDs > +/- 1 than the control mean) were related to the qualitative data. The integration of qualitative and quantitative data was done on two

levels: (a) On an intrapersonal level, we related the number of coding of a respective experiential category as well its subjective severity (taken from the individual descriptions) to the individual's MM manifestations (intensity of manifestation and kind of MM). (b) On an interpersonal level, we searched and compiled trends: Are more and more intense descriptions of aberrations in self- and body experience related to higher manifestations in remarkable MMs?

3. Results

3.1. Sample characteristics

We interviewed 22 patients with schizophrenia. Due to rigorous inclusion criteria and dropouts, we analyzed the interview data of 20 patients only−14 men and 6 women. See Table 1 for detailed sample characteristics.

TABLE 1 Sample characteristics.

	Patients with schizophrenia ($N = 20$)
Gender	
Male	14 (70.0%)
Female	6 (30.0%)
Age (Years)	
Mean (SD) [Min, Max]	39.0 (11.8) [20.0, 59.0]
Body Weight (kg)	
Mean (SD) [Min, Max]	91.4 (16.1) [60.9, 125]
Height (cm)	
Mean (SD) [Min, Max]	177 (9.87) [156, 197]
BMI	
Mean (SD) [Min, Max]	29.0 (3.36) [23.2, 36.2]
Handedness	
right	17 (85.0%)
left	3 (15.0%)
Nationality	
German	19 (95.0%)
Other	1 (5.0%)
Mother tongue	
German	18 (90.0%)
Other	2 (10.0%)
Family status	
single	17 (85.0%)
married	2 (10.0%)
divorced	1 (5.0%)
Years of education	
Mean (SD) [Min, Max]	14.7 (4.19) [9.00, 26.0]
Missing	7 (35.0%)
Job	
In training	1 (5.0%)
Employed	7 (35.0%)
Self employed	0 (0%)
Retired	2 (10.0%)
Unemployed	7 (35.0%)
On sick leave	2 (10.0%)
Other	1 (5.0%)
Olanzapine equivalents	
Mean (SD) [Min, Max]	17.2 (8.30) [5.00, 32.3]
Years of illness	
Mean (SD) [Min, Max]	12.6 (11.5) [0.0800, 38.5]
Number of psychotic episodes	
Mean (SD) [Min, Max]	5.05 (4.86) [1.00, 20.0]

3.2. Correlations of MM with self-experience

Tables 2, 3 display the correlations of the MM with the patients' SD measurements by the EASE. Table 2 gives an overview of correlations with EASE total and subscores, and Table 3 displays correlations with certain single EASE items.

3.2.1. Correlations of MM with EASE total and subscores (H1)

Except for LBS, we could not find statistically meaningful correlations of MM with overall SDs or any of the EASE subscales. An increased lateral body sway (LBS) was associated with higher ratings in cognition or self-awareness disturbances. The association of a higher LBS with changes in self-awareness (EASE subscore 2) is statistically significant on an alpha-level of 0.05.

However, we found many correlational trends: While some MM moderately correlated with subscale 3 (stride length, adjustment of body sides, flexibility of limb movement, and adjustment of limb movement), many also displayed a moderate correlational trend with deficits in *self-awareness and presence* (gait velocity, lateral body sway, adjustment of body sides, and flexibility of limb movement). Furthermore, many MMs were associated with disturbances in *cognition and consciousness* (EASE subscale 1: gait velocity, stride length, variation of gait regularity, and lateral body sway). This seems logical, because, as stated above, not only SDs and movement but also movement and cognition are in a constant bidirectional interplay with each other.

We expected the MM to mainly be correlated with the amount of *anomalous bodily experiences (EASE subscale 3) and disturbances in self-awareness and presence (EASE subscale 2)*. Taken together, despite the lack of statistically significant correlations, most kinematic MM displayed a correlational trend with either the SD total score, or one or many of the first three subscores of the EASE. For instance, the gait velocity was inversely correlated with the amount of SDs in general ($r = -0.379$), with disturbances in *cognition and consciousness* ($r = -0.436$) as well as with

TABLE 2 Correlations of movement markers with the patients' self- and body experience: EASE subscores.

		Movement markers							
	EASE Subscores	Head posture	Gait regularity	Variation of gait regularity	Stride length	Arm sway	Elbow sway	Knee sway	Lateral body sway
Examination of Self-Experience (EASE)	**Total**	−0.319	0.080	0.295	−0.263	−0.247	−0.099	−0.189	0.331
	1. Cognition	−0.336	0.182	0.442	−0.376	−0.224	−0.205	−0.272	0.324
	2. Self-Awareness	−0.253	0.058	0.109	−0.069	−0.153	0.056	−0.019	**0.462***
	3. Bodily Experiences	−0.205	−0.022	0.057	−0.327	−0.256	−0.185	−0.212	0.013
	4. Demarcation	−0.271	0.155	−0.050	−0.094	−0.003	0.061	−0.214	−0.132
	5. Existential Reorientation	0.001	−0.181	0.413	−0.030	−0.230	−0.069	0.011	0.151
	EASE Subscores	Gait velocity	Arm sway velocity	Elbow sway velocity	Adjustment of body sides	Goal directedness of movement	Flexibility of limb movement	Adjustment of limb movement	Adjustment of sway velocities
	Total	−0.379	−0.085	0.010	0.199	−0.169	−0.369	−0.015	−0.174
	1. Cognition	−0.436	−0.001	0.010	0.083	−0.184	−0.121	−0.198	−0.205
	2. Self-Awareness	−0.304	−0.038	0.066	0.338	−0.286	−0.416	0.080	−0.167
	3. Bodily Experiences	−0.223	−0.070	0.001	0.417	−0.223	−0.388	0.303	0.039
	4. Demarcation	−0.044	−0.101	−0.060	−0.112	0.100	−0.133	−0.065	−0.058
	5. Existential Reorientation	−0.175	−0.209	−0.069	−0.242	0.285	−0.263	−0.147	−0.145

Higher EASE values signify increased disturbances in self- and body experience. Correlations follow Pearson and are two-tailed. Statistically significant correlations are marked bold. *$p < 0.05$, **$p < 0.01$.

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TABLE 3 Correlations of movement markers with the patients' self- and body experience: EASE single items.

		Movement markers							
	EASE Items	Head posture	Gait regularity	Variation of gait regularity	Stride length	Arm sway	Elbow sway	Knee sway	Lateral body sway
Examination of self-experience (EASE)	**2.1: Dim. sense of basic self**	−0.337	−0.081	0.15	0.29	−0.125	−0.153	0.39	−0.216
	2.2: Dist. first-person perspective	−0.092	−0.411	0.24	−0.275	**−0.492***	−0.330	−0.144	0.25
	2.3: Depersonalization	−0.090	−0.095	−0.055	0.1	−0.150	0.04	0.11	−0.026
	2.4: Diminished presence	−0.112	−0.228	−0.304	−0.002	−0.093	−0.004	−0.046	0.07
	2.6: Hyperreflexivity	−0.022	−0.072	−0.260	−0.182	−0.003	0.05	−0.121	0.35
	3.1: Morphological change	−0.044	−0.056	−0.253	−0.047	−0.135	−0.129	−0.221	−0.196
	3.3: Somatic Depersonalization	−0.117	−0.121	0.11	−0.294	−0.224	−0.228	0.02	−0.150
	3.4: Psychophysical misfit	0.15	−0.275	−0.011	−0.136	−0.440	−0.478	−0.086	−0.097
	3.5: Bodily disintegration	−0.357	0.18	0.02	−0.291	−0.037	−0.011	0.01	0.11
	3.6: Spat. of bodily experiences	0.2	0.2	0.1	−0.057	0.1	0.2	0.23	0.41
	3.7: Cenesthetic experiences	−0.141	0.16	0.08	−0.350	0.04	0.17	−0.262	0.24
	3.8: Motor disturbances	−0.260	0.31	0.17	−0.381	0	−0.003	−0.377	0.11
	EASE Items	Gait Velocity	Arm sway velocity	Elbow sway velocity	Adjustment of body sides	Goal directedness of movement	Flexibility of limb movement	Adjustment of limb movement	Adjustment of sway velocities
	2.1: Dim. Sense of basic self	0.21	−0.035	−0.043	0.19	−0.096	−0.086	0.22	0.13
	2.2: Dist. First-person perspective	−0.402	−0.336	−0.249	**0.450***	−0.268	**−0.619****	0.34	0.21
	2.3: Depersonalization	0.08	−0.061	0.06	0.34	−0.123	−0.375	0.27	0.09
	2.4: Diminished presence	−0.023	−0.144	−0.089	0.08	0.02	−0.224	0.15	0.07
	2.6: Hyperreflexivity	−0.145	0.12	0.15	0.32	−0.438	−0.174	0.16	−0.119
	3.1: Morphological change	0.11	−0.047	−0.047	0.25	−0.033	−0.164	0.32	0.09
	3.3: Somatic depersonalization	−0.199	−0.016	−0.017	**0.580****	−0.363	−0.315	0.44	0.24
	3.4: Psychophysical misfit	−0.067	−0.272	−0.307	0.46	−0.057	−0.428	**0.557***	0.41
	3.5: Bodily disintegration	−0.170	0.23	0.25	0.25	**−0.516***	−0.113	−0.008	−0.093
	3.6: Spat. Of Bodily Experiences	−0.240	0.24	0.23	0.52	−0.465	−0.043	−0.171	−0.062
	3.7: Cenesthetic experiences	−0.354	0.08	0.19	−0.094	−0.138	−0.126	−0.224	−0.382
	3.8: Motor disturbances	−0.419	0.02	0.03	0.02	0.06	−0.016	−0.147	−0.265

Higher EASE values signify increased disturbances in self- and body experience. Correlations follow Pearson and are two-tailed. Statistically significant correlations are marked bold. Shortages: 2.1 Dim. Diminished, 2.2 Dist. = Distorted, 3.6 Spat. = Spatialization.
*$p < 0.05$, **$p < 0.01$.

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disturbances in *self-awareness* in particular ($r = -0.304$). A higher manifestations of the respective movement marker—a slower walk—were related to increased SDs regarding cognition, self-awareness, and body perception. We could not find moderate correlations of SDs with the sway of specific limbs (arm, elbow, and knee sway). These MM might be too specific to display a correlation with overall experiences of self-disturbance in such a small sample size. The fact that we could find moderate correlations with the overall gait velocity but not with specific limb velocities supports this notion.

Looking at the relational MM, we can find a clear correlational trend with changes in body perception: Most relational MMs are moderately correlated with the amount of anomalous bodily experiences (adjustment of body sides, flexibility of limb movement, and adjustment of limb movement). Many of them are also moderately correlated with disturbances in self-awareness and presence. The adjustment of left and right arm movement (adjustment of body sides), for example, is not only positively correlated with EASE subscore 3 (*anomalous bodily experiences: r* $= 0.417$*.)* but also with subscore 2 (amount of disturbances in *self-awareness and presence*: $r_{\text{RatioWSLR1,EASE : Self-Awareness}} = 0.338$). Both associations make sense since a higher value in the respective MM stands for less of an adjustment between the body sides. Hence, increased disadjustment was related to increased SDs considering self-awareness and body perception. Other relational MMs, such as the flexibility or the adjustment of limb movement, show the same correlation properties. Considering the small sample size of 20 patients, the abovementioned correlations are comparably high. All correlational patterns but the one of the postural marker (head posture) are in line with our hypothesis. Correlations of head posture with EASE total and subscore 1 are moderate and point toward a correlational trend but contradict hypothesis 1 in the sense that, e.g., increased disturbances of cognition are related to a more upright posture.

3.2.2. Correlations of MM with specific EASE items (H2)

We expected specific anomalous experiences to be associated with higher MM manifestations. We found six statistically significant associations: (1) a reduced arm sway was related to feelings of a distorted first-person perspective (significant inverse correlation: $r = -0.429^{*}$), (2/3) lacking adjustment of body sides while walking was correlated with disturbances in the first-person perspective ($r = 0.450^{*}$) as well as with experiences of somatic depersonalization ($r = 0.580^{**}$; significant positive correlations; higher values in the adjustment ratio stand for less of an adjustment), (4) a reduced goal directedness of the gait was related to experiences of bodily disintegration (significant inverse correlation: $r = -0.516^{*}$), a (5) reduced flexibility of limb movement was related to disturbances in the first-person perspective (significant inverse correlation: $r = -0.619^{**}$), (6) and a reduced adjustment of limb movement during gait was related to descriptions of psychophysical misfit (significant positive correlation: $r = -0.557^{*}$, see explanation of adjustment variable above).

In addition to the statistically significant correlations, we found many correlational trends: In general, almost all MMs were associated with one or many specific anomalous self- or bodily experiences. Mostly, people who displayed increased MM also reported at least one anomalous bodily experience, such as somatic depersonalization, psychophysical misfit, bodily disintegration, coenesthetic experiences, or general motor disturbances.

Furthermore, half of the MM were at least moderately correlated with the experience of a distorted first-person perspective. Other anomalous experiences, such as feelings of general depersonalization, were moderately associated with a reduced adjustment of body sides and less flexibility in the limb movement. In addition, increased experiences of hyperreflexivity were moderately associated with many relational MM (lateral body sway, adjustment of body sides, and goal directness of movement). Overall, the adjustment-related MM (adjustment of body sides, goal directedness of movement, flexibility of limb movement, and adjustment of limb movement) displayed the most correlational trends with specific self- and body-related anomalous experiences. Again, the correlations of specific anomalous experiences with head posture contradicted our hypotheses. Increased anomalous experiences were associated with more upright walking.

TABLE 4 Movement index, demographic, and medical data of the subsample.

	Patient			
	RM05	IH12	AB04	SF03a
Movement index	Low	Middle	Middle	High
Gender	Male	Female	Male	Male
Age (years)	30	46	25	24
Mass (kg)	98,6	90,3	105	93,4
Height (cm)	178	175,6	189	178,5
BMI	31,12	29,28	29,39	29,31
Handedness	Left	Right	Right	Right
Olanzapine equivalents	30,64	6,53	13,5	5,32
Years of illness	2,25	26,5	6,5	9,5
Number of psychoses	2	3	6	5

3.3. Self- and body experience of subgroup patients

Table 4 gives an overview of the subgroup's demographic data.

The final categories of the coding system and detailed case vignettes of the individual interviews can be found in the Supplementary material. Due to space limitations, we focus on reporting pathological experiences and give textual examples for those experiential categories, which were mentioned by all patients. Table 5 explains and summarizes the experiential categories mentioned by the four subgroup patients. Patient quotes were translated from German by the first and second author.

All patients describe various examples of existential *feelings of self-insecurity,* which surface in social or work situations or are expressed as the feeling of being fundamentally different to other people. *RM05* even suspects that his self-doubts marked the

TABLE 5 Descriptions and frequencies of the pathological categories mentioned by the subsample.

Category	RM05	IH12	AB04	SF03a	Total	Brief description of category
	Frequency of category mentioning					
Self-experience						
Feeling of self-insecurity	**4**	**4**	**12**	**9**	**29**	Worrying about being yourself and being a person.
Feeling of anxiety	3	9	4	0	16	Includes panic attacks, psychic-mental anxiety, phobic anxiety, social anxiety, diffuse anxiety, and paranoid anxiety.
Distorted first-person perspective	0	1	1	0	2	Thoughts, perceptions, or feelings appear as deprived of the tag of mineness.
Feeling of a loss of control	**10**	**7**	**9**	**3**	**29**	The feeling of being dependent or to lose control.
Feeling of being absent/not present	1	0	2	2	5	The feeling of not fully participating in the world or not being entirely present in the world.
Feeling of being unlively/devitalized	**3**	**1**	**3**	**2**	**9**	A diminished vitality, diminished initiative, hypohedonia or (in extreme cases) the feeling of being a liveless, dead object/body.
Hyperreflexivity	**2**	**3**	**3**	**5**	**13**	The tendency to exaggeratedly monitor one's own sensations, emotions and thoughts; The attempt to volitionally steer otherwise tacit processes.
Mirror-related phenomena	0	0	0	1	1	An unusually frequent, and intense looking in the mirror or avoiding one's specular image or looking only occasionally but perceiving a facial or bodily change.
Sense of change in relation to age	0	0	1	0	1	A fundamental feeling of being considerably older or younger than the actual age, not related to social relations/interactions.
Fragmentation of experience	0	1	1	0	2	Stimuli and experiences, which usually tacitly appear to the subject as a unity, are perceived as fragmented.
Body experience						
Somatic depersonalization/bodily estrangement	0	0	0	1	1	Estrangement of the body and its movement.
Loss of body agency	0	0	3	0	3	The sense of losing control of one's own body movement.
Motor blocking	0	2	0	0	2	Sudden weakness (paresis), impediment or complete blockage of intended motor actions.
Disautomation	**1**	**1**	**2**	**1**	**4**	The tendency to exaggeratedly monitor one's own actions. Patients try to volitionally steer the otherwise tacit actions.
Rigidness/choppiness	0	0	0	1	1	Perception of own movements as rigid and choppy.
Feeling of lost body ownership	0	0	0	1	1	Disturbances in the sense of being the subject /owner of the movement or the body.
Psychophysical misfit and psychophysical split	0	0	0	2	2	The body or individual parts of the body are experienced as being isolated and separated from one another, as not being present at all or as not fitting to the owner.
Coenesthesia	0	1	1	0	2	Unusual bodily feelings, which cannot be explained medically; Also termed body hallucinations.
Motor slowdown	1	0	0	0	1	Own movement is perceived as being slowed down.
Thoughts linked to movements	0	0	1	0	1	Single or repetitive movements are perceived as related to thoughts.
	25	30	43	28		

Note: Categories of self- and body experience are marked bold, if they were mentioned by all of the four patients. Frequencies refer to the entire interview.

beginning of his illness: *"I talked about this a lot with my mother. She said, it already started in elementary school. There, a teacher wrote about me: 'He is able to do a lot but does not dare to do it'. This describes me very well; Until today, I somehow always think, what I do is not good enough."* His self-questioning leads to a feeling of otherness and loneliness: "*I feel clearly different from other people.*" In his first job, confronted with stressful situations and work pressure, the insecurity escalated into a persistent conviction that people in his work environment would speak badly of him and that he would therefore never find a job again. Similarly, IH12

experiences a multitude of problems in social and work-related situations that have a common basis of self-insecurity: *"I think I did something wrong at work. And then I keep thinking about it. [. . .] Still, there is something I do wrong every day. [. . .] At least one thing."* Due to the feeling of not being right or doing things the right way, she too often reassures herself by asking for advice about the smallest things (e.g., which company stamp to use). The feelings interfere with daily life to such a degree that she feels compelled to devise a coping routine: *"That's why I always go to church on Sundays, simply because I keep making mistakes, and just to let go of that and know that I'm going to start all over again."* AB04 presents with the most and strongest descriptions of self-insecurity. In the course of the conversation, they surface as deep uncertainties about what is right or wrong, whether he is right or wrong as a person and which parts of him, including thoughts and perceptions, are healthy or sick: "*My thinking and my behavior are very different from people who are not so sick. [. . .] I can't at all say whether I feel [the thoughts] normally, or whether it is already, uh, abnormal, because it was so long ago that I wasn't sick that I forgot how it should be. And now I don't really know whether that's right, or isn't that right?".* This existential uncertainty is associated with (a) the alienation of the own self, its thoughts, and actions and leads to a (b) profound feeling of worthlessness and even the questioning of the own right to exist: (a) *"That sounds really weird. My thoughts are clearly mine because I think them. But I don't have the feeling that they are just mine. [. . .] Something is added to the normal structure of thoughts."*; (b) "*For years I thought I had to die. [. . .] You just have the feeling that you are worth nothing if you are supposed to be killed."*

Furthermore, all patients experience a loss of control. Loss of control manifests as cognitive phenomena such as pressured thinking, decision ambivalence, or concentration problems and sometimes is associated with body-related phenomena or even has an influence on social interaction. SF03a summarizes his experience from child- and adulthood as follows: "*As a child I said to my mother: The thoughts don't stop. I can't stop thinking. [. . .] It is such a rush of thoughts, such a storm. [. . .] I can no longer filter properly. I can no longer classify the thoughts, allocate the right meaning to them. [. . .] When the thoughts flow in on you, then I would say the filter is broken. There is a processor on the computer, a task scheduler, which assigns to the various processes what is important, what will be carried out first. That one is broken in the brain."* AB04 compulsively and unintentionally broods over the course of the day: *"I don't go to bed and think: now you're thinking about today again. Not like that, it comes automatically."* The pressure he experiences through his thoughts is evident as an electrical feeling in his head: *"I have no rest with my thoughts. Many people, I think, can sometimes relax, just think about nothing for a moment or only think about simple things [. . .] And with me it's always [makes loud electric noises with his tongue]."* The feeling is so intense and regular that he initially thought every patient with schizophrenia experiences this sort of pressure. After reporting his sensation to another patient, he was surprised that the other did not experience the phenomenon at all. Naturally moments of loss of control impact daily life. RM05 describes how he sometimes loses track of conversations due to disappearing, fading and suddenly dissipating thoughts or even finds himself somewhere on the street without remembering how he got there: *"[During conversations] I hop from topic to topic. In one moment I think about my e-mail account, in the next I wonder if I closed the window, then a completely different topic comes up. My thoughts are erratic. [. . .] Sometimes the other person looks at me and asks: äh, how did you get there now?"*

Another feeling that is prevalent in all subgroup patients is the *feeling of being unlively or devitalized*. It often is accompanied by a *feeling of being absent or not present* and is expressed in descriptions of being lost in thought, of a gray and unlively environment, strong anhedonia, and an intense lack of initiative or energy. RM05, for instance, sinks into thoughts that come automatically and feel very lively. He then appears absent-minded and subsequently has to be actively brought back into the conversation by other people who snap their fingers and say his name several times. AB04 confirms the question of whether the world sometimes seems dead and gray to him and adds: "*Everything works, but it works like a movie, where you are totally powerless, somehow totally second row, like that."* In addition, he described strong feelings of anhedonia: "*The whole time you just had the thought: I have to die, I have to die, I have to die. And then everything somehow passes you by, the whole rest. [. . .] You can't enjoy anything anymore, and so on. [. . .] I didn't take a shower for weeks, I didn't go out, and everything. Nothing at all."* For SF03a, the feeling of being absent escalates into an objectification of the environment. He reports that he usually does not perceive lively objects in the environment with which he can interact. Instead, he feels as an observing subject detached from the world: *"That corresponds a bit to the Cartesian image of man, from Descartes, where you perceive yourself as detached from the world. And just watch. And then the world consists only of things and not of tools."* As a result, he increasingly withdraws, lacks initiative, and feels fundamentally devitalized: "*Sometimes I feel an emptiness inside. Before I got to [name of psychiatric department], I wasn't interested in anything, enjoyed nothing. I just didn't want to do anything. I just laid in bed and did nothing. [. . .] I was completely disinterested and lacking in drive. [. . .] I even found it difficult to answer the ringing phone next to the bed, which I knew my mother would call to help. But to pick up the phone myself and then talk, somehow I couldn't muster the energy for it."*

Additionally, all patients report hyperreflexivity, meaning the tendency to exaggeratedly monitor one's own sensations, emotions, and thoughts (1, 13, 20). AB04 reflects intensively on various aspects of the environment, questioning otherwise tacit aspects of everyday life. *"Why do we have money and not exchange [things]? [. . .] With the carbon dioxide [in mineral water]: why does it bubble? [. . .]."* His intense hyperreflexivity is not only related to a *loss of common sense* but also to a fragmentation of his cognition, body perception, and movement (see also descriptions of *disautomation* below). For instance, when reading texts, he is able to understand single words but has difficulties to grasp the content of the entire sentence or text: *"I read a sentence, the second sentence, then I have already forgotten the first one, then I skip one because it is so exhausting for me and so I go through the whole text. [. . .] [To understand] the whole sentence, the context, and then the next one after it, this mass, or something like that, that's too much." Or,* when standing at traffic lights, he reflects: *"I stand there and then I don't know how to stand. And then someone starts walking and then I start walking too and then I think: Mh, the other person is long gone while I still think about the traffic lights."* The effects of hyperreflexivity

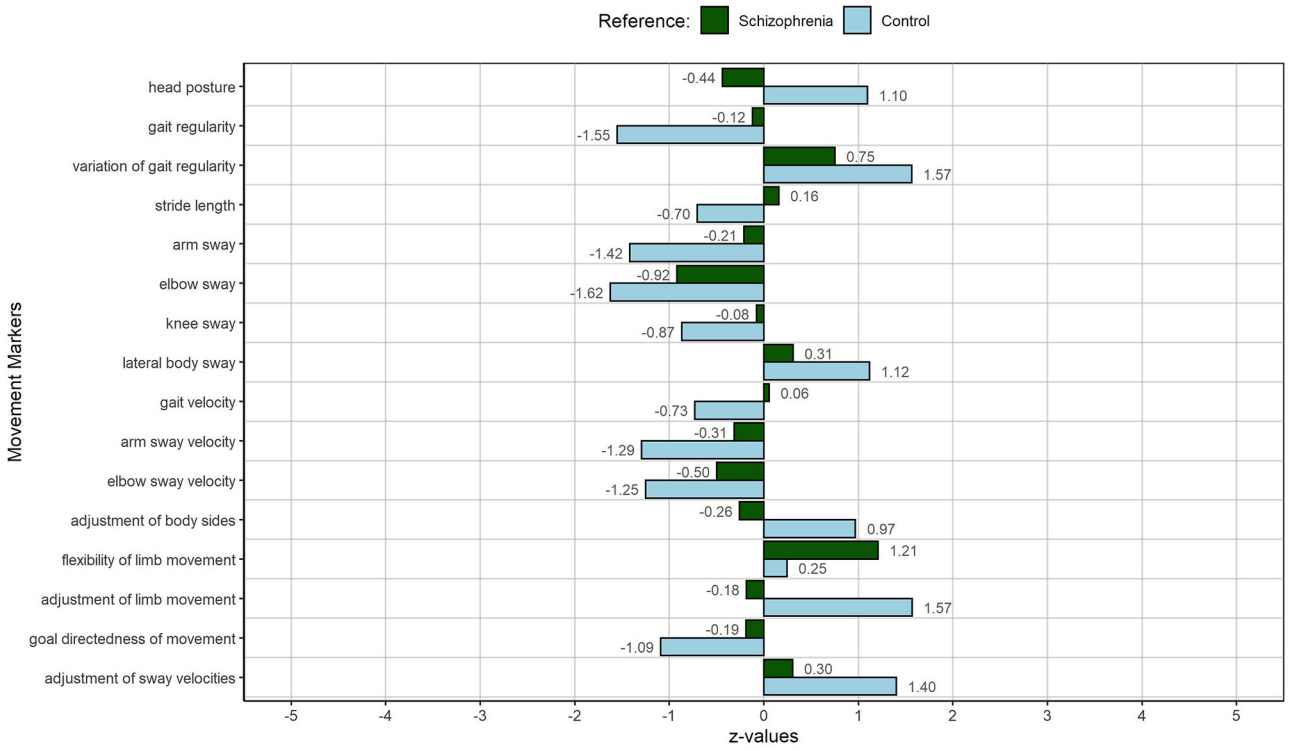

FIGURE 1
MP of RM05: The person with the lowest MI, hence, the smallest deviation from the other patients, representing the prototypical patient of the schizophrenia sample. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

seem to have the greatest effect on SF03a. This is also reflected in the frequency of category mentioning (see Table 5). In daily live, he (a) continuously reflects on social interactions and (b) sometimes even stops perceiving his environment due to intense reflection: (a) *"[When shopping] I always get out of the way of people, worry a lot about being in the way or so. I am very careful with this."*, (b) *"I am always told that I sometimes stroll through the area, lost in thought. That is true. Sometimes I don't notice when people greet me because I'm so in my thoughts. [. . .] I really like to think when I walk, and then it can happen that I just walk somewhere [without noticing]."* Similarly to AB04, SF03's hyperreflexivity is connected to a fragmentation of movement perception: *"How do I experience my movements? Yes, a little awkward at times. That I don't know how to move properly, like that."* It once even escalated in the alienation from his own body perception, when he experienced an intense *psychophysical misfit* and with this a *somatic depersonalization or a bodily estrangement*. *"[. . .] Somehow, body and mind were now totally separate and that was a very strange bodily feeling. [. . .] That was very unusual, like having new shoes that your feet have not yet got used to but related to the whole body. [. . .] I was yet in the body, but yet not. [. . .] The spirit was in the body, but it didn't quite fit. Like, when you try - I don't know - to put Windows on an Apple computer or something."*

Finally, all subgroup patients report phenomena of *disautomation*, a category of experiences which is closely intertwined with hyperreflexivity. RM05, for instance, not only perceives his own movements as very slow but also experiences the loss of the natural self-givenness in routine actions, such as tying his shoe laces: *"Sometimes I find myself having to think about how to tie the knot. That I thought to myself: Okay, now you have to think about it somehow, even though you really don't have to."* Similarly, IH12 experiences physical black-outs while making music, and SF03a perceives his movements as clumsy, rigid, or choppy. AB04 experiences disautomation phenomena most frequently. He reflects on the heights of stairs and reports that he no longer is able to climb stairs automatically without introspection: *"The stairs seem different heights to me. As if the levels are different, as if I had to climb higher to overcome the next stair than the other. Strange. And yet, it is the same [height] everywhere. [. . .] All over the world it is the same [the height of the stairs], if you consider how close we go over them. It's the same everywhere, stairs are always the same, otherwise you would stumble."* For all subgroup patients, the own movements become an object of intense reflection (hyperreflexivity) and hence do not take place automatically anymore.

3.4. Movement profiles and their relation to self- and body experience (H3)

3.4.1. Intrapersonal comparison of MM manifestation and self- and body experiences

Considering his MM pattern, RM05 represented the prototypical patient in our study. Except one MM (flexibility

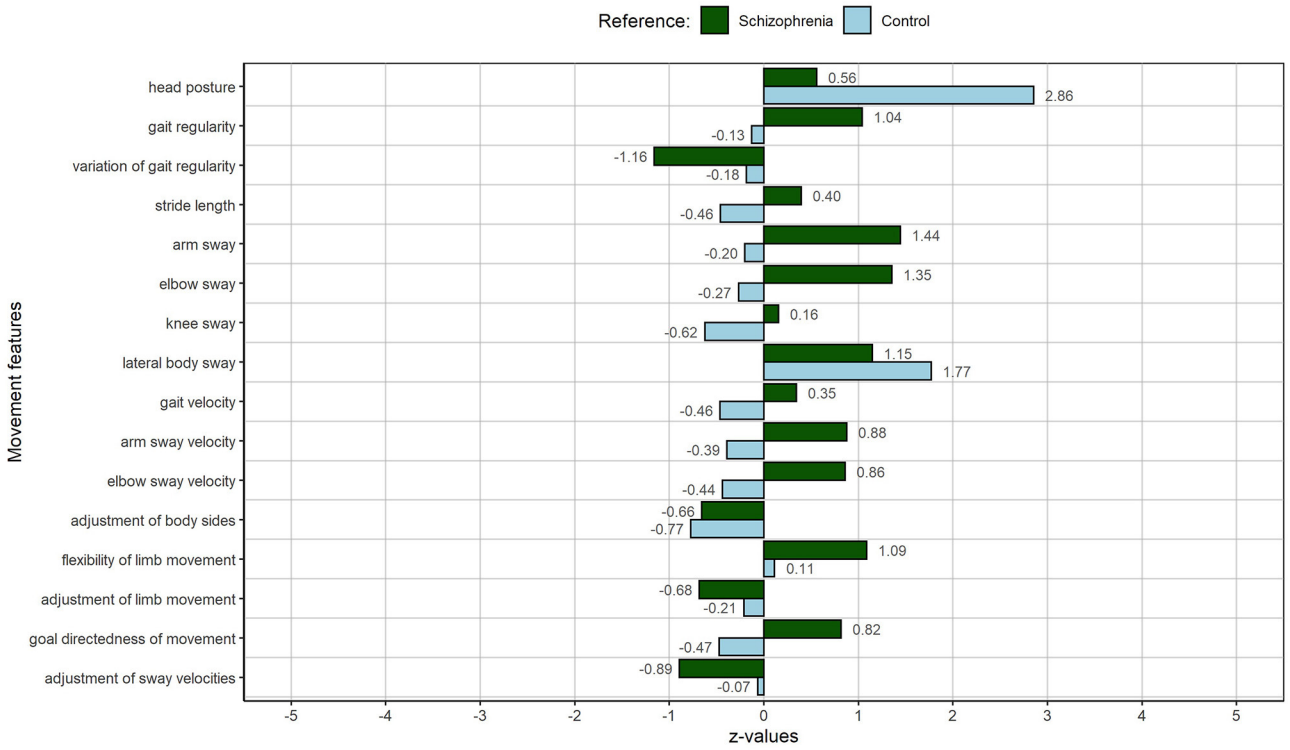

FIGURE 2
MP of IH12: The female person with an average movement index, representing a medium deviation of the schizophrenia sample. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

of limb movement), which differs from other patients more than one SD, his movement pattern is close to the schizophrenia mean (deviation in the range of −1 to 1 SD). Compared to the mean of the study's control sample, the following MMs exceed a deviation of +/− 1 SD and hence are considered remarkable: head posture, gait regularity, variation of gait regularity, arm and elbow sway, lateral body sway, arm and elbow sway velocity, the adjustment of limb movement, the goal directedness of movement, and the adjustment of sway velocities. See Figure 1 for the exact SD values. Compared to the average control individual, RM05 walks with an increasingly slumped posture, his gait is less regular and varies more in its regularity, his arms and elbows sway less and slower while walking, and his gait is characterized by more sideways sway. Finally, during gait, the movements of his limbs and sway velocities are less adjusted (higher values in the ratios stand for less of an adjustment).

Compared to the other subset patients, RM05 presents with the lowest number of mentioned SD experiences (see Table 5). This is in line with his MM manifestation, due to which he was selected as the prototypal patient regarding his gait pattern (Figure 1). Overall, his own movement perception corresponds to the manifestation of the MM in his gait. Compared to the average control person, he presents with a reduced arm and elbow sway velocity, which is in line with his statement, that he generally moves more slowly than others. Furthermore, he experiences hyperreflexivity and disautomation in usually tacit actions, such as tying shoelaces. Although not specifically mentioned in relation to gait, disautomation is also reflected in RM05's gait: His experiences can be linked to a reduced adjustment of limbs and body sides during walking as well as to his reduced gait regularity. The reduced arm and elbow sway, the increased lateral body sway, and the loss of goal directedness can be interpreted in the same light. We can hypothesize that experiences of hyperreflexivity are intertwined with a fragmentation of successive movements, which lose their relatedness, smooth transition, and "grace" (31). In the case of RM05, less movement or a certain stiffness in limbs and diminished goal directedness during gait might be an indication of that connection. Naturally, such experiences contribute to the experience of loss of control, which, RM05 in comparison with the other subgroup patients mentions a lot.

IH12 and AB04 were selected to represent a medium deviation of MM manifestation of the schizophrenia sample. While AB04 represents a rather adverse medium deviation and hence a more pathological movement pattern than the other patients with schizophrenia, IH12 represents a rather favorable medium deviation, a healthier movement pattern than the average patient with schizophrenia. Compared to the average patient with schizophrenia in our study, AB04 presents with a slumped gait posture, an increased variation of gait regularity, an increased lateral body sway, and a decreased adjustment of limb movements (high values = less of an adjustment). IH12, in contrast, presents with an increased gait regularity compared to the other patients with schizophrenia and a decreased variation of gait regularity,

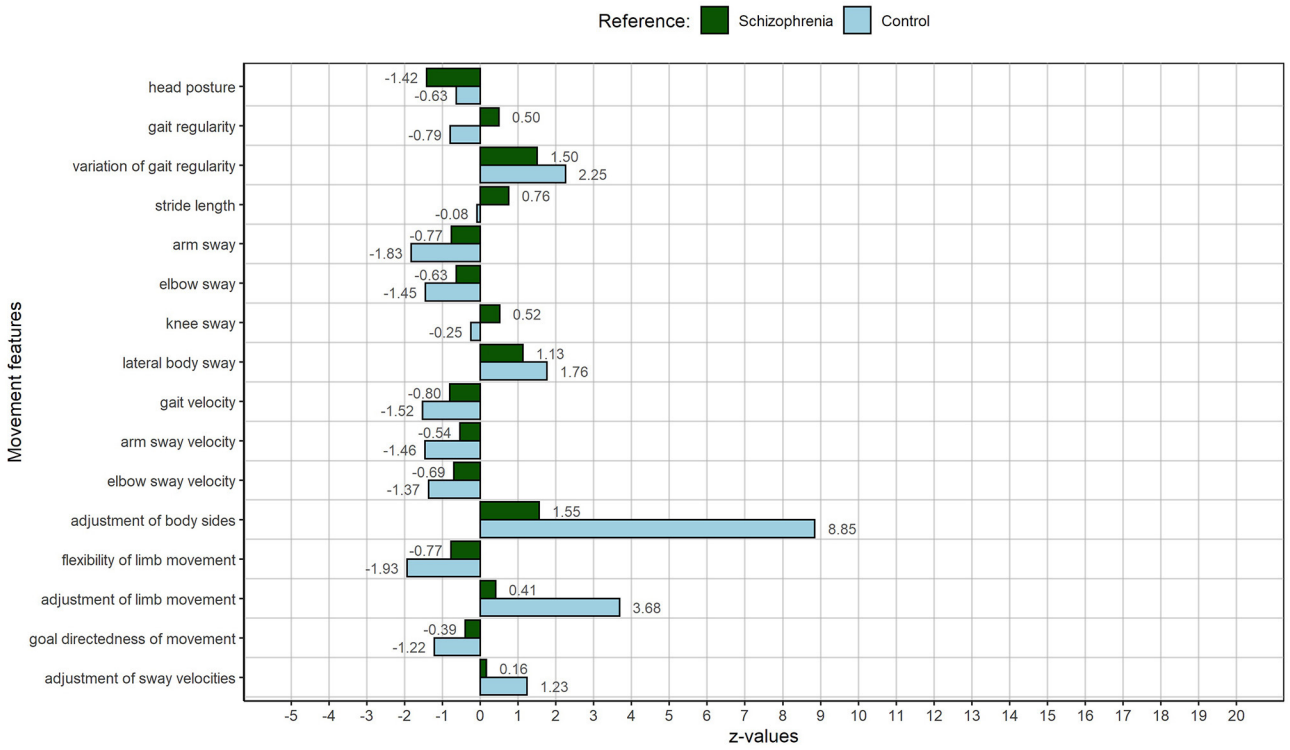

FIGURE 3
MP of AB04: The male person with an average movement index, representing a medium deviation of the schizophrenia sample. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

hence with an overall more regular gait pattern. She displays more arm and elbow sway and a higher flexibility of limb movement than the average patient with schizophrenia in our study. Only her lateral body sway is increased in relation to the other patients.

This also applies when comparing IH12 to the average control individual of our study. Regarding most MM, she deviates very little from the average control person. Only her head posture and lateral body sway during gait are affected. See Figure 2 for the exact SD values. Compared to the average control individual of our sample, IH12 presented with a definitely increased bowing of the posture and an increased lateral body sway while walking. In addition, considering the total number of mentioned self- and body experiences, IH12 is located in the middle of the schizophrenia range. However, the total numbers of Table 5 only take into account pathological categories which are named a lot considering the statement that IH12 presents with a rather favorable movement pattern. Especially various descriptions of anxiety increase the number of mentioned pathological self- and body experiences. Likewise, the relation of MM and descriptions of anomalous experiences are not as straightforward as for RM05.

On the one hand, the increased hanging of the head and the lateral body sway—as a sign of a reduced frontal direction of the gait—can be associated with descriptions of hyperreflexivity and disautomation by IH12. As stated above, hyperreflexivity is the tendency to excessively monitor own actions. It can lead to disautomation of usually tacit actions and movements. The constant downward directedness of the gaze can be associated with a monitoring of the own steps and hence has an influence on the head posture during the gate and the directedness of it. On the other hand, it is remarkable that subjective experiences of severe anxiety, loss of control, feelings of being devitalized, experiences of disautomation, and motor blocking seem to have little effects on IH12's MM manifestation. We hypothesize that the variety of body- and movement-oriented hobbies (tennis, swimming, playing instruments, and singing), which she describes in the interview, have beneficial effects on her body and movement perception as well as her actions and movements.

As stated above, AB04 represents a rather adverse medium deviation of MM manifestation from the other patients. Compared to the average control participant, however, AB04 presents with many strong movement limitations during gait: higher variations of gait regularity, less arm and elbow sway, increased lateral body sway, slower overall gait, and slower movement of the limbs while walking. Especially adjustment-related MMs are impaired: He presents with a dramatically decreased adjustment of body sides, a decreased adjustment of limb movement, and his limb movement is less flexible than that of an average control person. See Figure 3 for exact SD values.

The number and intensity of remarkable MM are in line with the overall amount and content of SD descriptions by AB04. With a total number of 43 (see Table 5), he mentions the most pathological self- and body experiences during the course of the interview. Descriptions of hyperreflexivity and disautomation are directly linked to gait (standing and walking at traffic lights, and climbing stairs) and are reflected in an overall slower gait, slower movements

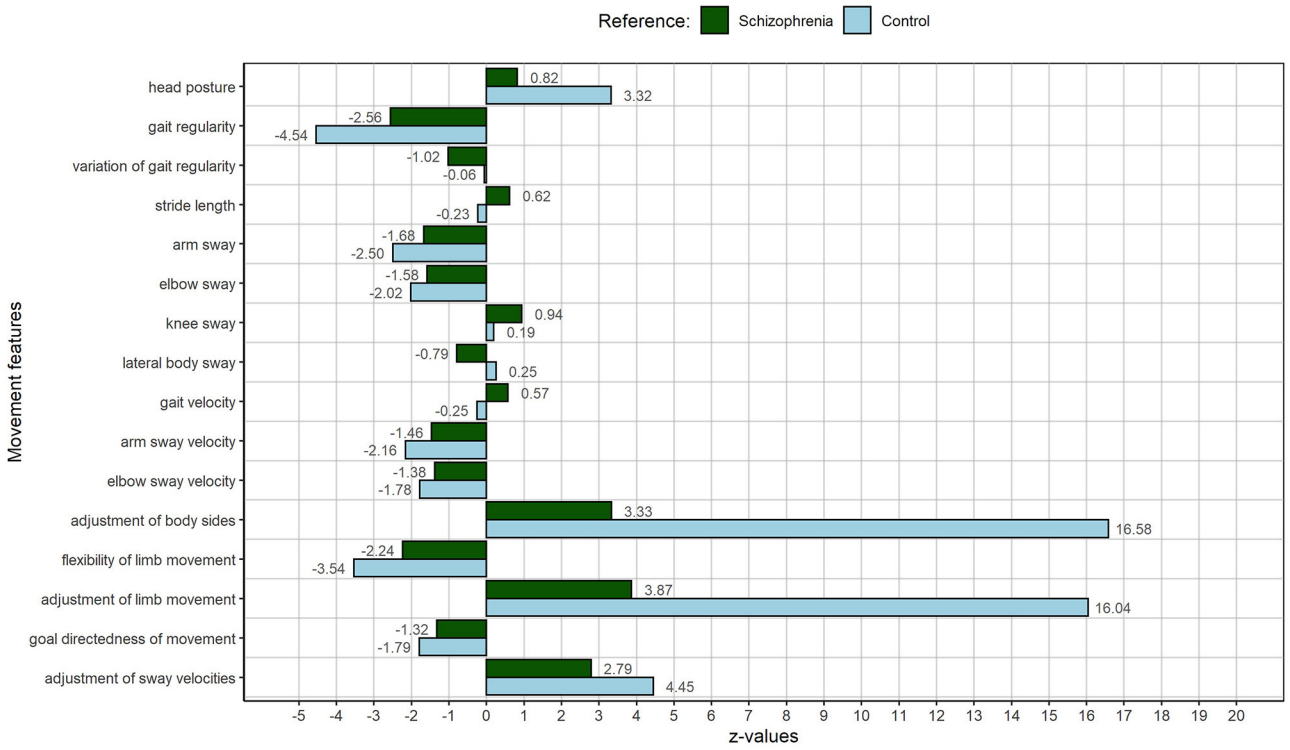

FIGURE 4
MP of SF03a: The person with the highest movement index, representing a high deviation from the other patients or the most atypical movement profile regarding the patient group. The figure displays deviations of individual MM from the schizophrenia sample (green) and the control sample (light blue).

of the limbs as well as in a dramatically decreased adjustment of body sides and limb movement, as well as less limb flexibility during gait. MM and experiences are not only directly linked, and they also relate content wise: AB04 describes to be slower than others, when crossing the street at a traffic light, due to an increased cognitive load. Higher variations of gait regularity, less arm and elbow sway, and an increased lateral body sway can be interpreted in the same light. Like in RM05, increased hyperreflexivity is accompanied by a fragmentation of gait. Not only climbing stairs but also simple walking is affected. Parts of the body, such as the arms, are not involved in the execution of the gait, and body parts are used less and less coordinated. Again, the conscious experiences and subconscious movement changes contribute to an existential self-insecurity (also here AB05 mentions the category the most), a lot of anxiety, and a feeling of lost control.

SF03a was selected as the person with the highest deviation from the average person with schizophrenia in our study, hence as the person with the most atypical MM manifestation in relation to the other patients. He deviates strongly and adversely from the other patients in almost all MMs (see Figure 4).

SF03a's following MM manifestations are remarkable in relation to the control sample of our study: the head posture, the gait regularity, arm and elbow sway, arm and elbow sway velocities, the adjustment of body sides and of limb movement, the flexibility of limb movement, the goal directedness of movement during gait, and the adjustment of sway velocities. SF03a presents with a highly slumped posture, a strongly decreased gait regularity, and with reduced arm and elbow sway and slower usage of these limbs. Especially the adjustment of body sides and limb movement is dramatically impaired in SF03a. In addition, limb movement is less flexible and limb velocities are not well adjusted to each other during gait. Although deviating strongly in MM manifestation from the schizophrenia and control sample in our study, SF03a does not present with the most descriptions of pathological self- and body experiences during the interview, but he presents with the most severe descriptions of bodily experiences, such as a loss of body agency, a psychophysical misfit, and disautomation. He also mentions hyperreflexivity the most often. His strongly decreased gait regularity and the dramatically impaired adjustment of body sides and limb movement (fragmentation of usually tacit walking) can be associated with many hyperreflexivity experiences. Like RM05 and AB04, he also displays reduced arm and elbow sway and a slower and less flexible usage of these limbs during gait. Strong feelings of self-insecurity might be reflected in a highly slumped posture.

3.4.2. Interpersonal analysis of trends

We could not find an overall trend toward more descriptions of SD experiences when MM manifestation was increased. SF03a as the person with the highest manifestation of MM in relation to the control sample did not present with the highest total mentioning of SD experiences.

However, looking at certain categories of SD experiences, we can see clear trends. For instance, the more hyperreflexivity the individuals experienced, the higher the impairment in adjustment and flexibility related MM. As stated above, hyperreflexivity seems to be intertwined with a fragmentation of successive movements (such as gait). These movements lose their relatedness, smooth transition, and "grace" (31). Often less movement of limbs or a certain stiffness in them and a reduced goal directedness during gait coincides with reduced adjustment. Not the entire body is involved in the execution of a certain movement, some body parts are used less and less coordinated, and the body is not utilized as a unity. Naturally, such experiences promote existential feelings of self-insecurity, a loss of control, and even feelings of being devitalized.

This trend can be supported by our correlational analysis of the entire sample. As stated above, many relational MM displayed a correlational trend with increased experiences of hyperreflexivity.

Furthermore, the most intense bodily experiences (loss of body agency, psychophysical misfit, and somatic depersonalization) only appear in the patient with the highest MM manifestation: SF03a. Again, this is in line with our correlational analysis: As stated above, people who displayed increased MM mostly reported body-related SD experiences, such as somatic depersonalization, psychophysical misfit, bodily disintegration, cenesthetic experiences, or general motor disturbances. Looking at correlations within the entire sample, a reduced goal directedness of limb movement, for instance, is significantly related to experiences of somatic depersonalization, a reduced flexibility of limb movement, or to feelings of bodily disintegration.

Finally, although the four subgroup patients vary in their MM manifestation, they share a common basis of anomalous self- and bodily experiences. All report existential feelings of self-insecurity, loss of control, feelings of devitalization, hyperreflexivity, and instances of disautomation.

4. Discussion

4.1. Key findings

Our study revealed the following key findings. First, the correlational analysis suggests an association of the theory-independent MM with SDs, specifically in the domain of cognition, self-experience, and bodily experiences. Stronger manifestations of the MM, hence an increased motor impairment, were related to more severe SDs (H1). Second, many MMs, primarily relational and adjustment-related ones, were associated with specific anomalous experiences. A stiffened, less coordinated and goal-directed gait is intertwined with, e.g., subjective experiences of somatic depersonalization, or the perturbation of the first-person perspective (H2). Third, MM manifestations are not precisely reflected in the individuals' descriptions of anomalous self- and body experience. However, we found clear trends of more and more intense descriptions with increasing MM manifestation, when looking at specific experiences, such as hyperreflexivity (H3).

Our findings conform to the results of the few previous studies which described associations between SDs or self-experience and motor or neurological symptoms. Hasselwander (62) found associations of balance and gait parameters with perceived self-efficacy and global cognition in people with schizophrenia spectrum disorder. Likewise, many of our MM displayed correlational trends not only with body- and self-experience but also with cognition-related anomalous experiences (EASE subdomain 1). Tonna et al. (11), who performed a stabilometric analysis with force platforms and a gait analysis with wearable sensors, found preliminary associations between SDs (EASE total scores, and domains 1, 3, and 4) and both postural and dynamic motor parameters. Gait parameters, pointing to an overall loss of gait fluidity and naturalness, were related to cognitive impairment (EASE domain 1), abnormal bodily experiences (EASE domain 3), and a loss in self demarcation (EASE domain 4). While our MMs confirm a general disruption of the gait cycle with less coordination and flexibility of limb movement, we not only found correlational trends with cognitive impairment (EASE subdomain 1) and disturbed body experience (EASE subdomain 3) but also with anomalous self-experiences (EASE subdomain 2) of the patients. Unlike Tonna et al. (11), we could not find meaningful correlations of postural markers with SDs. Associations of the head posture (our only significant postural marker) with SDs contradict our hypothesis and raise the question, of whether we may have found a spurious correlation influenced by confounding variables, such as body physicality (BMI) and medication load, or by our small sample size. Content-wise, however, the correlational patterns of postural conditions with SDs in Tonna's study resemble our SD associations with relational and adjustment-related MM. Tonna et al. (11) found that a stiffened posture (decreased sway area) with increased compensatory balancing movements was intertwined with an impairment in the subjective experience of the body (EASE subdomain 3), whereas a greater postural instability (increased sway area) with reduced compensatory movement was associated with a higher permeability of self-boundaries (EASE subdomain 4). Similarly, we found that a stiffened (less limb flexibility), less coordinated and less goal-directed gait was not only related to an overall increase in anomalous bodily experiences or a reduction in self-awareness but also to specific anomalous experiences, such as somatic depersonalization and a diminished first-person perspective. Missing reports of MM associations with specific transitivistic experiences (EASE subdomain 4) in our study are due to the fact, that we, according to our hypothesis, focused on specific experiences of EASE subdomain two and three. Future analyses might shed light on the association of our MM with experiences of pathological permeability.

Nelson et al. (41, 42) highlight hyperreflexivity as one of the cardinal facets of basic self-disturbances and propose (1) source monitoring deficits and (2) aberrant salience (including associated disturbances of memory, prediction and attention processes) as its neurological underpinnings. (1) Source monitoring deficits describe the difficulty to distinguish between endogenous (self-generated) and exogenous (externally generated) stimuli, namely efference copies or corollary discharges (CDs) (11, 41, 63, 64). An important difference between self- and externally generated stimuli is their predictability. Self-generated actions usually are highly predictable. Hence, they involve neural signals (efference copies), which are used to predict and suppress or "dampen" the sensory activity usually arising from the following proprioceptive input (65, 66). However, when self-generated stimuli are not effectively "dampened" in perception, they can be experienced as coming from

the outside. For example, if tacit thoughts or sensations come to the fore, they are not automatically identified as one's own and become the center of an objectifying awareness (hyperreflexivity) (41). (2) Similarly, the term aberrant salience describes the excessive attention to information of the environment that is normally irrelevant or highly familiar (67, 68). One neurologically-based concept often mentioned within the context of aberrant salience is "latent inhibition" (69, 70). It characterizes a gating mechanism that allows organisms with complex nervous systems to cease responding to stimuli upon repeated exposure, hence known stimuli with no apparent or emotional value. A breakdown of the gating mechanisms leads to a direction of attention to fragmentary stimuli that normally go unnoticed (aspects of the environment, but also self- or bodily experiences) at the cost of the perception of larger meaningful Gestalts. Again, hyperreflexivity and disautomated perception and action are the consequence.

Supporting Nelson's statements, we found various descriptions of intense hyperreflexivity in all our subsample individuals. Often the symptom was experienced to intrude self- and bodily perception as well as the perception of the environment. Hyperreflexivity not only consistently compromised the structure of consciousness of all our subgroup patients but also systematically intensified with greater impairment in adjustment and flexibility related MM.

This also corresponds to phenomenological concepts of schizophrenia as a disturbance of the pre-reflexive temporal constitution of self-experience, as we described in a previous article (1).

4.2. Phenomenological classification of the results

Within the current phenomenological discourse, there are different explanatory approaches to the core disturbance of schizophrenia (1, 3, 20, 23, 24, 27, 28, 71). One group of researchers locates a disturbance of the basal self-experience (SDs) at the heart of schizophrenia psychopathology (71), and another group focuses on a disruption of the implicit bodily functioning in perception and action (a disembodiment) as the core disturbance of the illness (3, 20, 24, 27–30). In our study, the participants reported a common basis of anomalous self- and bodily experiences but presented with different manifestations of motor impairment (MM). Specific anomalous self-experiences, such as hyperreflexivity, clearly intensified with greater motor aberrations but others did not. Unconscious MM manifestations were not directly reflected in descriptions of anomalous experiences. In line with Tonna et al. (11) and Knack et al. (1), instead of understanding SDs or motor impairment as endophenotypes or core disturbances of schizophrenia symptomatology, we hypothesize them to be two consequences of a disturbed pre-reflexive, embodied experience. In fact, corollary discharges (CDs) not only differentiate between self-generated and externally generated sensations but monitor and integrate sensory-motor feedback on the actual body state and hence are responsible for the fluidity and coordination of motor flow (11, 72, 73). Understanding schizophrenia as a disturbance of embodied pre-reflexive experience means to understand the illness as an impairment of processes that constitute our consciousness *before* all (deliberate) reflection (1). Only the automatic and implicit experience and usage of the lived body [the body as tacit medium of all our experiences (74)] enables a relief of the intentional and reflexive consciousness (1, 75). I can type this text and focus on the message of the sentence without thinking about the movement of my fingers or the meaning of each individual word. The embodied, pre-reflexive experience is the basis of and comprises the entire spectrum of processes in our consciousness: Feeling, thinking, perceiving, and moving. As Knack et al. (1) points out: Thinking has, against first intuitions, a large pre-reflexive part. Seldom, we consciously put together a thought but rather follow a flow of thoughts. We do not need to ask ourselves *how* we think but can focus on *what* we think [ibid.]. It is the same with perception and movement. When seeing a clock, we do not have to put together clockface, digits, and hands of the clock but we can focus on the time. Tying shoelaces, we tie the knot without thinking about how to do it (1). According to Fuchs (76), the self-evidence of automatic processes originates from their repetitive execution. It is acquired by experience—watching, training, and practice—and stored in our bodily memory ("Leibgedächtnis") (77). Actions, perceptions, and movements become embodied, insofar as the lived body is used as a tacit medium of experience, not as a "machine," which has to be directed and controlled (1). Using textual examples of our subgroup patient AB04, we can demonstrate how a disturbance of the embodied pre-reflexive experience has an impact on all levels of consciousness—feeling, thinking, perceiving including self-perception, and moving. Starting with existential experiences of hyperreflexivity as a tangible and easy to describe symptom, AB04 reveals experiences of fragmented perception in reading ("*[To understand] the whole sentence, the context, and then the next one after it, this mass, or something like that, that's too much")*, fragmented movement when walking stairs ("*The stairs seem different heights to me. As if the levels are different, as if I had to climb higher to overcome the next stair than the other.")*, an alienation of the own thoughts and actions (*"That sounds really weird. My thoughts are clearly mine because I think them. But I don't have the feeling that they are just mine.")*, a long-standing insecurity in self-perception and a feeling of worthlessness ("*For years I thought I had to die. [. . .] You just have the feeling that you are worth nothing if you are supposed to be killed.")*, and finally even a questioning of his own situatedness in the social world (*"I stand there and then I don't know how to stand. And then someone starts walking and then I start walking too and then I think: Mh, the other person is long gone while I still think about the traffic lights."*), as well as a questioning of common sense (*"Why do we have money and not* exchange [things]? *[. . .] With the carbon dioxide [in mineral water]: why does it bubble? [. . .]")*. Taking these extensive experiences, it is no surprise that all our subgroup patients present with intense feelings of loss of control over their lives, plans, and even own bodies. The fact that MMs are related to but are not exactly reflected in the self-experience of the individuals supports the pre-reflexive nature of the disturbance underlying the schizophrenic illness. Moreover, the fact that our MMs correlate with the first three EASE subscales (cognition, self-experience and bodily experiences) further supports the idea of an underlying disturbance of the pre-reflexive experience that has an effect on all levels of consciousness.

Coming back to the neurodevelopmental underpinnings of schizophrenia psychopathology, we hypothesize that the disruption of an embodied pre-reflexive experience is rooted in the early impairment of the integration of multisensory and motor signals, a process which also has been emphasized for the development of a coherent self-experience (15, 78, 79). Chen et al. (80) identified a decreased functional activity pattern between visual areas and the primary sensorimotor area in people with schizophrenia and concluded that the sense of self relies on the spatial and temporal integration of sensory-motor signals. Similarly, Ehrsson (81) induced disturbances in self-experience (out-of-body experiences) in healthy controls when creating a mismatch between visual perception and proprioceptive signals. Early neurodevelopmental impairments in sensory-motor integration might manifest as pervasive changes in the structure of consciousness, appearing as cognitive, affective, and motor symptoms as well as changes in overall perception and as self-disorders (SDs). Ultimately, we can confirm Henriksen's (8) finding: SDs are not just another symptom cluster but part of an early alteration of the pre-reflexive experience, which gives rise to common symptoms, such as delusion, hallucination, and social withdrawal.

4.3. Limitations and future directions

Due to the complexity of our data assessment (movement assessment, and long and detailed interviews), we ended up with a comparably small sample size. As described in our previous publication, the sample size was an interdisciplinary compromise taking into account effect sizes of previous studies, power calculations, and the availability of the motion laboratory (31). A priori power analyses (g*power) suggested a total sample size between 10 and 29 for the detection of medium to large effects ($d = 0.5$–0.8), when assuming an alpha-level of $p < 0.05$ and a power of 0.8 for a correlation analysis. Because the few existing previous studies (47) found large effect sizes, and because our variables were distributed normally, we chose to calculate parametric correlations despite our small sample size. However, correlational analyses are specifically affected by small sample sizes. De Winter et al. (82), therefore, suggest the usage of different correlation coefficients across distributions and samples. Hence, in addition to the reproduction of our study with a greater sample size, future studies on the association of movement and SDs might invest some time to single out the most appropriate correlation coefficient. Furthermore, to not cover up correlational trends and hints toward associations, which might be more pronounced in bigger samples, we chose not to correct for multiple testing. In future studies, which build on hypotheses formulated on the basis of the preliminary findings of this study and operate on larger sample sizes, we ought to replicate the correlational trends with rigorous correction methods (50). Moreover, multi-methodological research poses well-known challenges, particularly in the integration of qualitative and quantitative data (83–85). Because there are hardly any standardized procedures for the integration of such different data sets, we first analyzed the data separately and afterward related the respective findings to each other on a rather exploratory or descriptive level. Future studies could benefit from the ongoing development of analysis strategies for mixed data (85). Moreover, to prevent a confirmation bias, for the composition of our subsample, we developed the movement index as a selection criterion based on the individuals' MM marker manifestation. We intended to depict the entire spectrum of MM manifestation of our schizophrenia sample. However, due to the use of absolute values, information on the direction of the MM manifestation (positive or negative deviation of the average participant with schizophrenia) was lost. This might be the reason, why IH12 and AB04, although both being selected as examples of a medium deviation of the average person with schizophrenia, differ significantly in their MM manifestation. In future studies, we would suggest using an adapted selection criterion, if in need of a subsample. One option is to reverse the polarity of certain MMs, so that all MM values point toward the same direction (e.g., higher values = more impairment). Finally, due to space limitations and to not overwhelm the reader with too much information, we chose to focus on pathological descriptions of self-experiences. The one subsample individual who described many salutogenic experiences (specifically movement-related hobbies which were associated with feelings of sovereignty), however, presents with a favorable MM manifestation in relation to the schizophrenia sample. For the purpose of a holistic research approach, in future studies we would like to systematically answer the question whether and how movement-related activities improve motor symptoms and SDs. Since instruments such as the EASE interview only assess the pathological side of self-experience and come with a relatively rigid interview structure, the question remains if data gained from their implementation is suitable for an open qualitative analysis like the one we did. Overall, our study shows that the connection of self-experience, body experience, and quantitative movement data should be considered within research, clinical examinations, and treatment of schizophrenia.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the local Ethics Committee of the Medical Faculty of Heidelberg University (S-629/2018). The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

LM planned and conducted the study (recruitment of participants and assessment of data) and wrote the manuscript. DM transcribed the subgroup interviews. DM and LM analyzed the qualitative and quantitative data. TF supervised the study.

LM, DM, and TF formed a focus group, which met regularly to discuss data assessment and analysis. LM, DM, and MK interpreted and discussed the results. LM, MK, and TF integrated the results into the current phenomenological discourse. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1212508/full#supplementary-material

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FAKULTÄT FÜR
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Promotionsausschuss der Fakultät für Verhaltens- und Empirische Kulturwissenschaften der Ruprecht-Karls-Universität Heidelberg / Doctoral Committee of the Faculty of Behavioural and Cultural Studies of Heidelberg University

Erklärung gemäß § 8 (1) c) der Promotionsordnung der Universität Heidelberg für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften / Declaration in accordance to § 8 (1) c) of the doctoral degree regulation of Heidelberg University, Faculty of Behavioural and Cultural Studies

Ich erkläre, dass ich die vorgelegte Dissertation selbstständig angefertigt, nur die angegebenen Hilfsmittel benutzt und die Zitate gekennzeichnet habe. / I declare that I have made the submitted dissertation independently, using only the specified tools and have correctly marked all quotations.

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Ich erkläre, dass ich die vorgelegte Dissertation in dieser oder einer anderen Form nicht anderweitig als Prüfungsarbeit verwendet oder einer anderen Fakultät als Dissertation vorgelegt habe. / I declare that I did not use the submitted dissertation in this or any other form as an examination paper until now and that I did not submit it in another faculty.

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Appendices

Appendix A: search terms, sample strategy and generative questions of the systematic review

Search terms	Inclusion	Exclusion
Schizophrenia AND Embodiment Schizophrenia AND Body Schizophrenia AND Moving Body Schizophrenia AND Motor Schizophrenia AND Motor Symptom(*) Schizophrenia AND Motor Domain Schizophrenia AND Movement Schizophrenia AND Movement Characteristic(*) Schizophrenia AND Psychomotor Schizophrenia AND MOBI Schizophrenia AND somatosensory Schizophrenia AND posture Schizophrenie AND Körper Schizophrenie AND Bewegung Schizophrenie AND Bewegungsbesonderheit(*) Schizophrenie AND Bewegungssymptom(*)	- Book publications or peer-reviewed journals - Date of publication does not matter - Studies and articles on patiens with schizophrenia and movement related symptoms. Movement- and body-related symptoms have to be mentioned intentionally, not incidentally ("beiläufig") - Any intervention (psychotherapie, behavioral, creative), any kind of experiment, observation, case studies - Any control group (active, passive, healthy individuals, other diagnoses), no control group needed - Any study design and evidence level	- No Wikipedia, no posters, no unpublished articles - Search terms have to be mentioned in combination with Schizophrenia: no other diagnoses, such as Autism or Depression - No first-person relatives, no animal studies - No medication studies: example: "The effects of atypical and conventional antipsychotics on reduced processing speed and psychomotor slowing in schizophrenia: A cross-sectional exploratory study.")

Primary Research Question	Subordinate Research Questions
Bestandsaufnahme **What movement characteristics/motor symptoms/motor expressions of people with schizophrenia are described by different fields of research and pactice?** **Welche Hinweise auf Bewegungsbesonderheiten/Motorische Symptome von Menschen mit Schizophrenie kann man in der interdisziplinären Fachliteratur (forschungs- und praxisbezogen) finden?**	- How is Schizophrenia defined/Wie wird Schizophrenie definiert? (Als Basis für Ihre Symptomdefinition) - What terms are used to describe movement/motor characteristics of people with schizophrenia overall?/Welche Oberbegriffe werden verwendet, um bewegungsbezogene oder motorische Besonderheiten von Menschen mit Schizophrenie zu beschreiben? - Which movement characteristics/motor symptoms are described in detail?

	What belongs to a „motor domain“?/Welche Symptome werden im Einzelnen beschrieben? Was gehört zur „Motor Domain“?
	- What commonalities and differences can we find?/Welche Gemeinsamkeiten und Unterschiede stellen wir fest? Bzgl.
	  o Zu Grunde liegender Schizophreniebegriff
	  o Ätiologie/Entstehung von Bewegungssymptomen
	  o Komponenten/Symptome
	  o Anforderungen an die Praxis
	  o Fachbereich/Disziplin
	- Can we find central definitory aspects of a „motor domain“ and aggregate the single definitions to categories?/Können wir zentrale Definitionsmerkmale einer „Motor Domain“ extrahieren und die einzelnen Definitionen zu Kategorien zuordnen?

Perspektiven **How can we define a motor symtoms of schizophrenia in an interdisciplinary way?** **Wie können Bewegungssymptome vor dem Hintergrund des** *(für uns relevanten)* **wissenschaftlichen Diskurses <u>disziplinübergreifend</u> definiert/verstanden werden?**	- *What implications does a transdisciplinary definition of a motor domain have for (clinical) research and pactice?/Was bedeutet die disziplinübergreifende Definition/das disziplinübergreifende Verständnis für die Forschung und Praxis?* - *What challenges evolve for research and practice?/Welche Anforderungen ergeben sich an Forschung und Praxis?*

Appendix B: study protocol

	VORBEREITUNG* (vor Ankunft des/r Proband/in), * die Vorbereitungstabellen gelten für alle Experimente			
	Schritt	**Zu Tun**	**Materialien**	**Anmerkungen**
1.	Termin vereinbaren	Termin vereinbaren Informationsschrift zuschicken/aushändigen (für Patienten/für Kontrollprobanden) Ggf. Anfahrtinfos schicken/aushändigen	Informationsschrift (für Pat/Kontroll), Anfahrtinfo-dokument	
2.	Sportkleidung	besorgen, entsprechende Größe (+m/f) auswählen, reinigen, bereit legen (zB. über Stuhl hinter Umkleide-Trennwand)	Sporthose und –Oberteil in entsprechender Größe (m/f), Stirnband	
3.	Umkleidekabine	Umkleide-Trennwand aufstellen, adäquaten Platz für Umziehen schaffen, ggf. hinter der Trennwand aufräumen	Umkleidetrennwand	
4.	Laufbahn vorbereiten	1. Helles Klebeband auf den Boden: Laufbahn von Wand zu Wand Breite ca. 50-80 cm Länge: gesamte Länge des Labors Markierung des Messvolumens auf Krep-/Klebeband (zB. für Tandem-Walk, min. 10 Schritte lang/Seitenlinie der Bahn)	Klebeband/Crepe-band	
5.	Tisch und Stuhl vorbereiten	Tisch und Stuhl zum Lesen und Unterschreiben der Unterlagen (siehe Schritt 5) bereit stellen oder frei räumen, ggf. säubern, Snacks und Wasser bereit stellen	Tisch, Stuhl, Snacks (Kekse, Obst), eine Flasche Wasser, ein Glas	
6.	Unterlagen bereit legen	Unterlagen auf Tisch zur Bearbeitung durch die Probanden 1. Einwilligungserklärung (für Kontrollprobanden) 2. Fragebogen zu demographischen Daten (für Kontrollprobanden) 3. Instruktionsschrift (für Patienten/für Kontrollprobanden) **4. Formular zur Auszahlung der Aufwandsentschädigung**	Einwilligungserklärung (für Pat/für Kontroll) Fragebogen zu demographischen Daten (für Patienten/für Kontrollprobanden) Instruktionsschrift Informationsschrift Experiment (auf Lager, falls nicht gelesen), Formular zur Auszahlung der Aufwandsentschädigung	
7.	Vermessung vorbereiten	Vermessung vorbereiten: Maßband an die Wand heften, Waage bereit Stellen	Maßband, Waage	
8.	Kamera bereitstellen	GoPro auf Brett am rechten Ende der Laufbahn (von der Tür aus gesehen) bereit stellen. Probanden werden frontal gefilmt.	GoPro	
9.	Kalibrieren	Qualisys System einschalten und kalibrieren	Kalibrationsstaab	
10.	Marker raus legen	49 beklebte Marker raus legen	Marker, doppelseitiges Klebeband	
11.	Kraftmessplatten testen	Kraftmessplatten (einschalten und) testen	Kraftmessplatten	

	VORBEREITUNG* (nach Ankunft des/r Proband/in), * die Vorbereitungstabellen gelten für alle Experimente			
	Schritt	**Zu Tun/Instruktion**	**Materialien**	**Anmerkungen**
1.	Begrüßung	- Eigene Vorstellung - Hiwis/Techniker vorstellen - Wasser? Snacks? - Haben Sie die **Allgemeine Informationsschrift** zur Studie gelesen? Info: Grundsätzlich geht es darum die Schizophrenie besser zu verstehen. Viele Wissenschaftler*innen schauen sich dafür hauptsächlich das Gehirn von Betroffenen an, wenige den Körper und noch weniger den Körper in Bewegung. Wir wollen uns heute Gang-/Koordinationsbewegungen anschauen. Wir machen das mit „Motion Capture“, moderner 3-dimensionaler Bewegungserfassung“ mit kleinen reflektierenden Markern, die wir auf ihre Haut kleben wollen. (Marker zeigen, Kameras erklären/Bildschirme erklären – Alles, was unsere/r Techniker während des Experiments sieht, können Sie auf diesem Bildschirm auch selbst sehen. Wir zeigen Ihnen das gleich, wenn wir Ihre Marker aufgeklebt haben). - Bevor wir unser Experiment durchführen, brauche ich von Ihnen noch eine **Einwilligungserklärung und ein paar Daten zu ihrer Person.** - Dafür können Sie sich setzen, die Info zum heutigen Experiment sowie die Einwilligungserklärung in Ruhe durchlesen und dann, wenn Sie keine Fragen mehr haben, unterschreiben. (Nehmen Sie sich Zeit, stellen Sie gerne Fragen!) - Fragebogen für demographische Daten - Instruktionsschrift für MoCap Experiment - **Ist es in Ordnung, dass wir Sie filmen?** - Fragen?	Einwilligungserklärung, Fragebogen demographische Daten, Instruktionsschrift, Informationsschrift (falls nicht im Vorfeld gelesen)	ACHTUNG: **Probandencode** von Fragebogen zu demographischen Daten für Speicherung der Datensätze nutzen!
2.	Umziehen	Umkleidekabine zeigen, Sportkleidung zeigen - Ihre Schuhe müssen Sie bitte ausziehen - Wir kleben Ihnen auch Marker auf die Füße - Bitte stecken Sie das T-shirt in die Hose und ziehen die Hose so weit hoch, wie möglich.	Sporthose und –Oberteil in entsprechender Größe (m/f), Umkleidetrennwand	ACHTUNG: Probanden sollten barfuß gehen

3.	Vermessen	Scheitelhöhe ausmessen Gewicht erfassen Zu den Angaben auf Fragebogen für demographische Daten hinzufügen (in Farbe)	Maßband, Waage, bunter Stabilo	ACHTUNG: Abgleich Messung und Eigenangaben
4.	Marker Kleben	- Die Marker müssen auf ganz bestimmte Punkte am Körper geklebt werden, damit das Computersystem sie erkennt. Diese Punkte richten sich nach ihren Gelenken (siehe Skelettbild an der Wand). Wir kleben zum Beispiel zwei Marker an ihr Handgelenk. Die Markerpositionen müssen bei allen Versuchspersonen gleich sein. Um die richtigen Positionen für die Marker zu finden, müssen wir Sie beim Aufkleben der Marker berühren. Ist das in Ordnung? - Sie können jederzeit Bescheid geben, wenn Ihnen etwas unangenehm ist und natürlich immer Fragen stellen.	(vorbereitete) Marker, doppelseitiges Klebeband, Marker placement anhand des im Anhang beschriebenen Markersets.	ACHTUNG: Während dem Kleben der Marker immer wieder nach Wohlbefinden der Probanden erkundigen. „Ich berühre sie jetzt an der Schulter. Ist das in Ordnung?“
5.	Kleidung fixieren und Reflektoren abkleben	Reflektoren abkleben, da sie vom System sonst als Marker erfasst werden.		

	EXPERIMENT 1: GANG					
	Schritt	**Instruktion**	**Materialien/Zu Tun**	**Zeit (HiWi)**	**Name der Datei (HiWi)**	**Anmerkungen**
1.	Einschalten der Kamera		Kamera Record drücken			
2.	Statische Pose	Damit das System die Marker, die wir ihnen angeklebt haben, finden kann, müssten Sie sich einmal hier hin stellen (auf Markierung auf Kraftmessplatten, schauen in Richtung Kamera, von Tür aus: rechte Wand). Bitte stellen Sie ihre Füße hüftbreit auf den Boden und halten die Arme rechtwinklig (zeigen).	Kalibrierung der Person in Qualisys			
3.	Mittlere Marker entfernen	**ACHTUNG: Nach der statischen Pose mittlere Marker an Fuß und Beinen entfernen**				
4.	Gehen vor der Messung	Wir schauen uns ihren natürlichen/persönlichen Gang an.	Stoppuhr/Handy	2-3 min	Keine Aufnahme	

		Laufen Sie innerhalb des markierten Pfades hin und her. Laufen Sie in einer für Sie angenehmen Geschwindigkeit. Wir wollen sicher gehen, dass Sie ganz bequem laufen, so wie Sie immer laufen, deshalb nehmen wir Sie einige Minuten beim gehen auf. Das kann einem am Anfang etwas lang vorkommen. Bitte versuchen Sie beim Gehen **nicht** zur Seite, sondern nach vorne zu blicken. Nach ein paar Minuten bitte ich Sie gleichzeitig zum Gehen von 100 rückwärts zu zählen. Sie laufen einfach weiter und fangen an zu zählen. Ich sage Bescheid, wenn Sie anhalten können.	Gehen zum Eingewöhnen	ab erstem Schritt (bis sich die Probanden an das Laufen gewöhnt haben)		
5.	Simple Walk		Aufnahme einfaches Gehen. Start der Aufnahme nach Drehung an der linken Wand, bei erstem Schritt geradeaus	Aufnahme von 4 Bahnen **1 Bahn = 1x Hin und Her**	Datum_Probandencode_Simple Walk_MoveNr Beispiel: (am 09.11.2018) 181109_LM11_Simple Walk_Move1 Überordner Walk **ACHTUNG: ggf. muss mit eine gesamte Aufnahme mit dem Batch Captcher gemacht werden, damit das System nicht abstürzt. Diese müsste dann hinterher entsprechend zugeschnitten, beschriftet und abgespeichert werden.**	**1 Bahn = 1x Hin und Her** Beenden der Aufnahme nach 4 Bahnen. ProbandIn läuft weiter
6.	Dual Task	Bitte zählen sie ab Ihrer nächsten Drehung von 100 rückwärts. Zählen Sie bitte so, dass wir es auch hören können. Es ist kein Problem, wenn Sie einen Fehler machen. Dann fangen Sie bei der Zahl, die Sie falsch gezählt haben, einfach noch einmal an.	Aufnahme Gehen mit gelichzeitigem Zählen. Start der Aufnahme, wenn ProbandIn zählt, wiederum bei	Aufnahme von 4 Bahnen **1 Bahn = 1x Hin und Her**	Datum_Probandencode_Dual Task_MoveNr Beispiel: (am 09.11.2018) 181109_LM11_Dual Task_Move1 Überordner Walk	Beenden der Aufnahme nach 4 Bahnen, ProbandIn wird gebeten, anzuhalten.

			Drehung an der linken Wand.			ACHTUNG: Es kann sein, dass die ProbandIn in der Mitte der Bahn anfängt zu zählen. Dann starten wir die Aufnahme, bei der nächsten Drehung an der linken Wand.

	EXPERIMENT 2: BALANCE & KOORDINATION					
	Schritt	**Instruktion**	**Materialien/Zu Tun**	**Zeit (HiWi)**	**Name der Datei (HiWi)**	**Anmerkungen**
1.	Einschalten der Kamera		Kamera Record drücken			
2.	Statische Pose	Damit das System die Marker, die wir ihnen angeklebt haben, finden kann, müssten Sie sich einmal hier hin stellen (auf Markierung auf Kraftmessplatten, schauen in Richtung Kamera, von Tür aus: rechte Wand). Bitte stellen Sie ihre Füße hüftbreit auf den Boden und halten die Arme rechtwinklig (zeigen).	Kalibrierung der Person in Qualisys			
3.	Mittlere Marker entfernen	**ACHTUNG: Nach der statischen Pose mittlere Marker an Fuß und Beinen entfernen**				
4.	Statische Balance: Static Balance Test	Heute wollen wir Ihre Bewegung bei Balance und Koordinationsaufgaben untersuchen/erfassen. Ich werde Sie zuerst bitten auf verschiedene Arten im Stehen zu balancieren und dann zu gehen. Es ist überhaupt nicht schlimm, wenn Ihnen das Balancieren schwer fällt.	Kraftmessplatten mit Markierung, entlang der X-Achse des Labors Stoppuhr für die Zeit	Jeweils 60 Sekunden auf der Kraftmessplatte werden gemessen. 30 Sek mit geöffneten und 30 Sek mit geschlossenen Augen. **Messung:**	Datum_Probandencode_Balance_TestNr Beispiel: (am 09.11.2018) 181109_LM11_Balance_Test1 181109_LM11_Balance_Test2 **ACHTUNG: bei der Bezeichnung der Tests mit Nummern darauf achten, welches Bein vorne ist bzw. auf**	ACHTUNG: Besser zuviel, als zu wenig Vorlauf. ACHTUNG: Die Tests sollten jeweils nur

		Bitte machen Sie unbedingt einen Schritt, wenn Sie das Gefühl haben umzufallen/zu kippen. Wir wollen nicht, dass Sie sich verletzen. (Jede der 5 Balance-Szenarien vormachen) Auf meine Anweisung, stellen sie sich auf die Markierung, (Ausrichtung zur rechten Wand) und legen sie Ihre Hände auf die Hüften wenn sie sicher stehen: 1) **Stand Beidbeinig:** Als erstes schauen wir uns den Stand auf beiden Beinen an (Beine geschlossen, kleine Markierung): Wenn ich Bescheid sage, stellen Sie sich auf die Markierung, beide beine geschlossen, blicken nach vorn und legen die Arme auf die Hüften, wenn Sie sicher stehen. Wir erfassen das Stehen für 30 Sekunden. Dann bitte ich Sie die Augen zu schließen und wir erfassen noch einmal 30 Sekunden. Ich sage dann „Danke“ und Sie können wieder von der Markierung herunter treten. 2) **Einbeiniger Stand Rechts/Stehen auf rechtem Bein:** Danach wollen wir uns den Stand auf einem Bein ansehen. Gleiches Spiel (vormachen): Sie gehen Sie auf die Markierung, heben ein Bein, blicken nach vorn und legen die Hände an die Hüften sobald Sie stabil stehen. Versuchen sie die Balance so lange wie möglich zu halten, wir erfassen wieder 30 Sekunden und dann bitte ich Sie die Augen zu schließen, wir erfassen noch einmal 30 Sekunden, Ich sage		- Reset der Kraftmessplatten (KMP) jeweils vor Versuch 1-5. - Start: bevor der Proband auf die Platten tritt - Ende: wenn der Proband die Platte verlassen hat - Markierung in der Aufnahme setzen, wenn Proband nach 30 Sek (auf Anweisung hin) die Augen schließt. - **ACHTUNG: Wenn Proband einen Schritt macht, ist der Teil des Versuchs beendet und es geht weiter im Protokoll. Es muss dann entweder direkt eine Markierung gesetzt werden oder die KMP ge-resettet werden.**	**welchem Bein gestanden wird. Siehe Reihenfolge in 2. Spalte. Ggf. Bezeichnung „links, rechts“ ergänzen.**	einmal gemacht werden. Schafft ein Proband es nicht 30 Sekunden die Balance zu halten gibt es KEINE Wiederholung, dies ist Teil des Tests und gewollt.

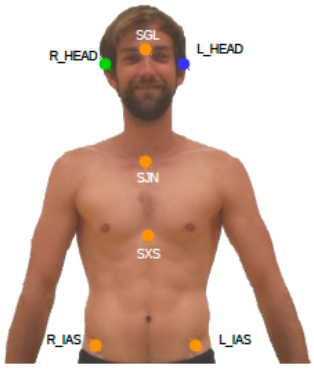
		„danke“ und Sie können von der Markierung herunter gehen. 3) **Einbeiniger Stand Links/Stehen auf linkem Bein:** Wir machen das gleiche noch einmal mit dem anderen Bein. 4) **Tandem Stand, rechtes Bein vorne**: Jetzt schauen wir uns an, wie es mit der Balance aussieht, wenn die Füße voreinander stehen. Dafür stellen Sie sich bitte auf die große Markierung. (Vormachen) Stellen ein Bein auf die Markierung und das andere direkt dahinter, sodass sich die Füße berühren. Wenn Sie auf der Markierung stehen, nehmen Sie die Hände an die Hüften sobald Sie stabil stehen und schauen nach oben. Ich stoppe die Zeit und bitte Sie nach 30 Sekunden die Augen zu schließen, dann erfassen wir noch einmal 30 Sekunden. Wenn ich „danke“ sage, können Sie die Augen öffnen und von der Markierung herunter gehen. Sollten Sie auch nur das leichteste Gefühl haben umzukippen, dann machen Sie unbedingt einen Schritt. **5) Tandem Stand linkes Bein vorne:** Anweisung wie oben.				
4.	Dynamische Balance: Tandem Walk	Jetzt machen wir noch zwei Koordinationsaufgaben und dann sind wir schon fertig. Wir fangen mit dem „Tandem Walk“/“Seiltänzergang“ an. Dafür laufen Sie bitte auf dieser Linie und setzen einen Fuß direkt vor den anderen, sodass die Zehen des einen Fußes, die Verse des anderen Fußes	Aufnahme des Tandem Walks. Start der Aufnahme bei erstem Schritt des/der Proband*in	Aufnahme von 2 Bahnen, eine Bahn ca. 2 m (hin geöffnete Augen, zurück geschlossene Augen)	Datum_Probandencode_Tandem Walk Beispiel: (am 09.11.2018) 181109_LM11_Tandem Walk	

		berühren. (So wie gerade beim Balancieren, Vormachen) Bitte laufen Sie in die eine Richtung mit offenen, in die andere mit geschlossenen Augen. Sie können bei dieser Markierung beginnen und bei dieser umdrehen und mit geschlossenen Augen zurück gehen. (Markierungen auf Laufbahn zeigen).				
5.	Dynamische Balance: Star Jump	Als letztes würde ich Sie gerne dazu auffordern, den „Spreizsprung“, umgangssprachlich auch „Hampelmann“ genannt, zu machen. Beim Spreizsprung öffnen sich die Beine, während die Arme nach oben gehen. (einmal zeigen, Sie können gerne einmal mitmachen, gemeinsame Übungsphase von 5 Sprüngen). Jetzt würde ich sie bitten, den Spreizsprung einmal alleine zu machen. (Blick in Richtung Kamera).	Aufnahme des Spreizsprungs in Richtung der Kamera. Start der Aufnahme nach gemeinsamer Übungsphase/nach Aufforderung allein zu springen	Aufnahme von mind. 6 Sprüngen	Datum_Probandencode_Star Jump Beispiel: (am 09.11.2018) 181109_LM11_Star Jump	

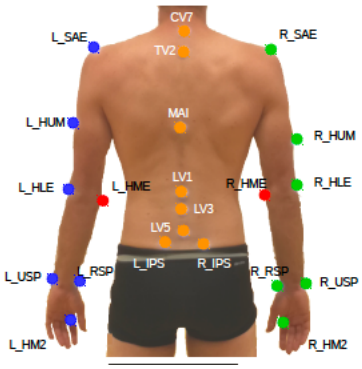
	ABSCHLUSS			
	Schritt	**Zu Tun**	**Materialien**	**Anmerkungen**
1.	Marker entfernen	Marker vorsichtig entfernen, ggf. Creme für Hautreizungen anbieten, idealerweise Marker direkt neu bekleben (für den nächsten Versuch vorbereiten) Wie geht es Ihnen? Trinken Sie doch noch einen Schluck Wasser/nehmen sich ein paar Snacks.	Creme gegen Hautreizungen, doppelseitiges Klebeband, Wasser/Snacks, Glas	
2.	Umziehen	Kleidung einsammeln, idealerweise direkt mitnehmen und waschen	Sporthose und –Oberteil in entsprechender Größe (m/f)	
3.	Verabschiedung	Vielen Dank, dass Sie mitgemacht haben. Haben Sie noch Fragen? Falls Ihnen später noch Fragen einfallen oder Sie weitere Informationen haben möchten, können Sie sich gerne bei mir melden. (Ggf. Flyer mitgeben/Informationsschrift mitgeben).	Flyer, Informationsschrift	

4.	Lab Aufräumen, ggf. Vorbereitung für nächste VP	Auffüllen von Snacks und Wasser, Bekleben der gebrauchten Marker	Doppelseitiges Klebeband	
5.	Datenbearbeitung	- GoPro Video auf PC, SD Karte wieder in die Kamera - Labeln der Marker - Zuschneiden der einzelnen Laufsequenzen (=Moves) - Bezeichnung der einzelnen Sequenzen: siehe Versuchsprotokoll - ACHTUNG: Originaldaten (unbeschnitten) in eigenem Ordner beibehalten - Ordnerstruktur anlegen (siehe Bild) - Link zum Teilen der Daten an Lily (ZIP File) - Daten in qtm. Und mat. Format teilen **ACHTUNG: Falls vergessen wurde, die mittleren Marker nach der Statischen Pose abzunehmen, diese in den Daten bitte löschen.**		

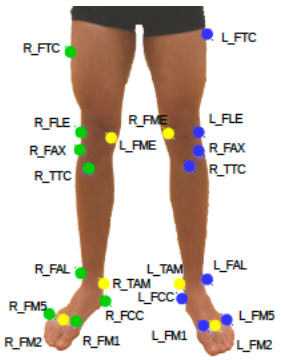
Markerset



Marker Name	Bone Landmark
L/R Head	Above the Ear
SGL	Skull Glabella
SJN	Sternum Jugular Notch
SXS	Sternum Xiphisternal Joint
IAS	Ilium Anterior Superior Iliac Spine



Marker Name	Bone Landmark
CV7	7^{th} Cervical Vertebra
TV2	2^{nd} Thoracic Vertebra
MAI	8^{th} Thoracic Vertebra
LV1/3/5	1^{st}, 3^{rd}, 5^{th} LumbarVertebra
IPS	Ilium Posterior Superior Iliac Spine
SAE	Scapula Acromial Edge
HUM	Humerus - Tracking Marker
HLE	Humerus Lateral Epicondyle
HME	Humerus Medial Epicondyle
USP	Ulna Styloid Process
RSP	Radius Styloid Process
HM2	Hand 2^{nd} Metacarpus Medial



Marker Name	Bone Landmark
FTC	Femur Greater Trochanter
FLE	Femur Lateral Epicondyle
FME	Femur Medial Epicondyle
FAX	Fibula Apex of Styloid Process
TTC	Tibia Tibial Tuberosity
FAL	Fibula Apex of the Lateral Malleolus
TAM	Tibia Apex of the Medial Malleolus
FCC	Foot Calcaneus
FM1	Foot Head of 1^{st} Metatarsal Bone
FM2	Foot Head of 2^{nd} Metatarsal Bone
FM5	Foot Head of 5^{th} Metatarsal Bone

Marker placement. The figure was first published in [216]. Names and descriptions of bone landmarks are taken from the Color Atlas of Skeletal Landmark Definitions by Serge van Sint Jan [261] and follow the Gaint IOR markerset [262]. They are explained in detail by Kevin Stein [216].

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02.11.2018
ts-mt/bw

Berufsrechtliche Beratung

Unser Zeichen: **S-629/2018** (Bitte stets angeben)

Titel: **SCHIZOPHRENIA AND THE MOVING BODY**
An Experiment on Disembodiment and Embodied Interaction

Eingereichte Unterlagen:

Ersteinreichung vom 18.09.2018:
Anschreiben vom 18.09.2018
Zusammenfassung
Checkliste Sonstige Studien
Antragsformular
Informationsschrift, Version 2 vom 18.09.2018
Informationsschrift , Experiment 1, Version 2 vom 18.09.2018
Informationsschrift Experiment 2. Version 2 vom 18.09.2018
Einwilligungserklärung, Version 2 vom 18.09.2018
Studienprotokoll, Version 02 vom 18.09.2018
CV Prof. Dr. med. Dr. phil. Thomas Fuchs vom 18.09.2018

Inhaltliche Nachreichung vom 25.10.2018:
Anschreiben vom 25.10.2018
Informationsschrift für Patienten Version 3a vom 18.10.2018 (ohne Markierung der Änderungen)
Informationsschrift für Kontrollprobanden Version 3b vom 18.10.2018
Einwilligungserklärung für Patienten Version 3 vom 18.10.2018 (ohne Markierung der Änderungen)
Einwilligungserklärung für Kontrollprobanden Version 3 vom 18.10.2018
Studienprotokoll Version 03 vom 18.10.2018 (ohne Markierung der Änderungen)
Instruktionsschrift für Experiment 1 Version 3 vom 18.10.2018 (ohne Markierung der Änderungen)
Instruktionsschrift für Experiment 2 Version 3 vom 18.10.2018 (ohne Markierung der Änderungen)

Formelle Nachreichung vom 31.10.2018:
Anschreiben vom 25.10.2018
Informationsschrift für Patienten Version 3a vom 18.10.2018 (mit Markierung der Änderungen)
Informationsschrift für Kontrollprobanden Version 3b vom 18.10.2018
Einwilligungserklärung für Patienten Version 3 vom 18.10.2018 (mit Markierung der Änderungen)
Einwilligungserklärung für Kontrollprobanden Version 3 vom 18.10.2018
Studienprotokoll Version 03 vom 18.10.2018 (mit Markierung der Änderungen)
Instruktionsschrift für Experiment 1 Version 3 vom 18.10.2018 (mit

Qualitätsmanagement DQS ISO 9001:2015 399893 QM 15

BIC SOLADEST600
IBAN DE64 6005 0101 7421 5004 29

MF HD

Markierung der Änderungen)
Instruktionsschrift für Experiment 2 Version 3 vom 18.10.2018 (mit Markierung der Änderungen)

Sehr geehrter Herr Professor Fuchs,

die Ethikkommission hat Ihr Forschungsvorhaben in der Sitzung am 08.10.2018 beraten und hat **keine Bedenken gegen die Durchführung der Studie**.

Sie gibt jedoch folgende Empfehlungen bzw. Hinweise:

Informationsschrift für Patienten und Kontrollprobanden:

- S. 6, Abschnitt: Freiwilligkeit und Rücktritt von der Studie
  Der letzte Satz ist wie folgt anzupassen: „… nicht mehr auf Ihren Wunsch gelöscht werden können."

Wir wünschen Ihnen bei der Durchführung der Studie viel Erfolg.

Bitte leiten Sie das Ergebnis der berufsrechtlichen Beratung und die studienrelevante Korrespondenz allen teilnehmenden Ärzten in unserem Zuständigkeitsbereich weiter.

Mit freundlichen Grüßen

i.V.

Prof. Dr. med. Dr. h.c. Thomas Strowitzki
Vorsitzender

Allgemeine Hinweise:

- Änderungen in Organisation und Ablauf der Studie sind der Kommission, zusammen mit einer Bewertung der Nutzen-Risiko-Relation, umgehend mitzuteilen. Sowohl die **Antragsnummer** als auch die **geänderten Passagen** sollten in den betreffenden Unterlagen **deutlich gekennzeichnet** sein, da anderenfalls keine zügige Bearbeitung möglich ist.
- Innerhalb von einem Jahr nach Studienende sollte die Studienleitung der Kommission einen Abschlussbericht vorlegen, der eine Zusammenfassung der Ergebnisse und Schlussfolgerungen der Studie enthält, unabhängig davon, ob diese vollständig abgeschlossen oder vorzeitig beendet wurde. Dafür ist die auf der Homepage der Kommission abrufbare Mustervorlage „Abschlussbericht" zu verwenden (Pfad: -> Sonstige Studien -> Vorlagen).
- Jedes Forschungsvorhaben, an dem Versuchspersonen beteiligt sind, ist vor der Rekrutierung der ersten Versuchsperson in einer öffentlich zugänglichen Datenbank zu registrieren.
- Die Ethikkommission der Medizinischen Fakultät Heidelberg arbeitet gemäß den nationalen gesetzlichen Bestimmungen und den ICH-GCP-Richtlinien. Ihren Beratungen liegt die Deklaration des Weltärztebundes von Helsinki in der jeweils aktuellen Fassung zugrunde.
- Unabhängig vom Beratungsergebnis macht die Ethikkommission Sie darauf aufmerksam, dass die ethische und rechtliche Verantwortung für die Durchführung einer Studie beim Leiter der Studie und bei allen teilnehmenden Ärzten liegt.
- Datenschutzrechtliche Aspekte von Forschungsvorhaben werden durch die Ethikkommission grundsätzlich nur kursorisch geprüft. Dieses Votum / diese Bewertung ersetzt mithin nicht die Konsultation des zuständigen Datenschutzbeauftragten. Die Einhaltung der einschlägigen Datenschutzgesetze sowie die Umsetzung des Datenschutzkonzeptes liegen in der Verantwortung des Studienleiters/Prüfers bzw. Sponsors.

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