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The self in art therapy – Brain-based assessment of the drawing process

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ABSTRACT

Art therapy plays important role in classical psychological assessment as it allows expressing the subject's sense of self. However, its effectiveness and validity could be impeded by lack of relationship to the patients' neuronal changes in their brain. The aim of our theoretical-empirical paper is to propose a novel brain-based quantitative objective measurement of the self and how it shapes the drawing process. We discuss recent data that how the autocorrelation window (ACW) is related to the temporal continuity of self in current neuroscience and further develop a method to use ACW to measure the temporal continuity of the drawing process, probing it in two case studies. As expected, the schizophrenic subject shows lower ACW values compared to the healthy subject and reflects the well-known deficit in the temporal continuity of the self in schizophrenia. We concluded that ACW and eventually other measures of the brain's spatiotemporal structure might be able to serve as objective markers of the self in the drawing process. As our approach connects brain, self, and drawing process, it provides the theoretical basis for the future development of a brain-based assessment of the self in the drawing process and art therapy.

Introduction

Art therapy – Drawing process and self-continuity

Art therapy is a classic therapeutic method for expressing and evaluating the subjects' sense of self in, for instance, schizophrenia [1]. Among all the methods, drawing, which involves both the process and products of image making (from crude scribbling through to more sophisticated forms of symbolic expression), has been one of the most widely-used methods in art therapy in psychiatry and clinical psychology [1,2]. Assessment of the drawing including its relation to the self has been framed mostly in psychoanalytic terms [3,4]. Psychoanalytic approaches interpret the ready-made drawings as a projection of the subject's sense of self, that expresses the deeper unconscious layers of self, including its continuity across time, i.e., self-continuity [5,6]. Self-continuity was broadly viewed as an subjective perception of interconnections among one's past, present, and future [6,7]. The exact relationship between drawings and specifically self-continuity remains unclear, though. Specifically, despite the introduction of various methods [4–6], we are still lacking generally accepted objective markers for the drawing process itself including its relation to the self, e.g., self-continuity, that operate independent of the therapists' interpretation of the ready-made drawings.

Various psychiatric disorders can be characterized by an abnormal sense of self where especially the temporal continuity of the self, i.e., self-continuity is altered. Disturbances of the self-continuity are well known in psychiatric disorders like schizophrenia [8–10], depression [11–13], and bipolar disorder [14]. These changes in self-continuity can be manifested in the subjects' drawings themselves and, even more important, in the way and process how the subject draws, which has

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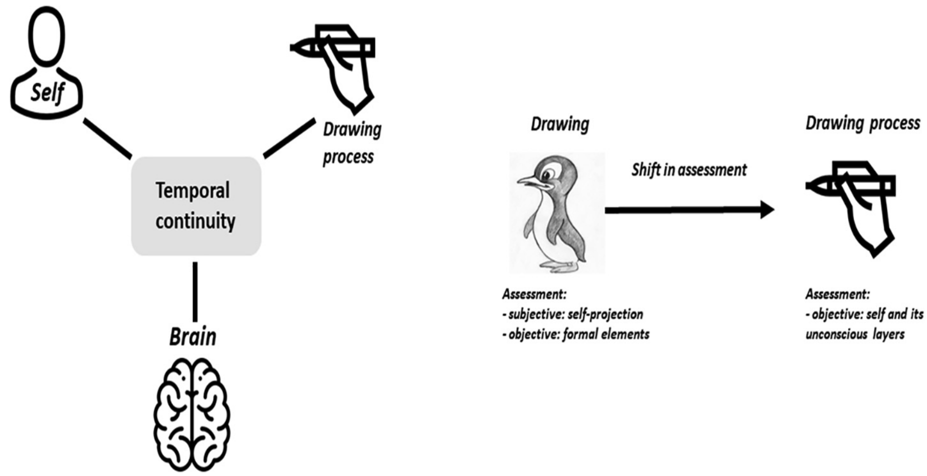


Fig. 1. Temporal continuity as "common currency" of brain, self, and drawing process (left). Shift in assessment from drawing to the drawing process (right).

been observed in specifically schizophrenia [15,16]. That raises the question whether the drawing process itself is closely related to the self, including its self-continuity. Specifically, tracking down the temporal continuity of the drawing process could provide an objective marker of the temporal continuity of the self, i.e., self-continuity, beyond the subjective interpretation of the final drawings by the therapist.

Self-continuity – From the brain's spatiotemporal features to the drawing process

Neurobiologically, the self has been associated with neuronal activity in the resting state that reflects the brain's spontaneous activity and its spatiotemporal structure [17–20]. Being based neuronally on the spontaneous activity's spatiotemporal structure, this led to the development of a spatiotemporal characterization of self [6,21]. The self is here characterized by different spatiotemporal (rather than cognitive) features which can be conceived as distinct layers operating on an unconscious level with 'self-continuity' being one such layer [6,22].

Given that the drawing process itself operates on spatiotemporal grounds, one may now suppose that such spatiotemporally conceived self strongly shapes and is expressed in the spatiotemporal features of the drawing process itself. For instance, the temporal continuity of self, i.e., self-continuity, may directly translate into and thus be reflected in the temporal continuity of the drawing process. Accordingly, we assume that spatiotemporal features provide direct connection between drawing process and self. To obtain objective markers of the drawing process, one may thus want to search for those spatial or temporal features that signify and measure the self. We here focus on one such spatiotemporal marker, the temporal continuity of self, i.e., self-continuity.

Following the literature, self-continuity can be described in different ways, perceptually, psychologically, and neuronally. Self-continuity refers to the temporal continuity of self, which can be operationally defined as how we perceive and experience our own person (including its body and mental states) as one and the same person across time [5,6,23]. Such self-continuity holds for different time scales including shorter ones like over one minute as well as longer ones including days or even years. Psychologically, it could be described as episodic simulation (ES) or mental time travel [6,24], that is, one's ability of remembering the past and imagining the future events, and could furtherly be measured by some logistic system, i.e. Future Self-Continuity Scale by Ersner-Hershfield in 2009. [5] Neuronally, such temporal continuity over different time scales can be measured by what is described as "auto-correlation window" (ACW). Put in a nutshell, the ACW measures the degree to which neuronal states at different time points correlate with each other thus being a proxy of "neuronal continuity" [25–28].

Most importantly, recent findings suggest that temporal continuity on the neuronal level (as measured by ACW or other related measures like scale-free activity) in the brain's spontaneous activity (as obtained in EEG and fMRI) are directly related to the self (as measured by self-consciousness scale) [20,27]. These findings suggest direct connection between temporal continuity on neuronal, e.g., ACW, and psychological, e.g., self, levels. Given that the drawing process is engineered by the self as based on the brain's neuronal continuity, one may want to suggest direct link between neuronal ACW, the temporal continuity of the drawing process, and self-continuity. That is the main focus in the present paper.

Hypothesis and the aim of this paper

The main and overarching aim in this paper on art therapy of drawing is to establish the connection between neuronal markers, drawing process, and self on both theoretical and empirical grounds. For that purpose, we shift the focus from the drawing itself (and its subjective interpretation by the therapist) including its colors [29] to the dynamics of the drawing process, that is, the way subjects temporally structure their painting of contents (and colors). More specifically, we investigate the temporal continuity of the drawing process as we consider temporal continuity as "common currency" (see below for details) of brain, self, and drawing process (see Fig. 1).

Specifically, we aim to demonstrate that a measure of temporal continuity on the neuronal level, that is, ACW, can be well applied to measure temporal continuity during the drawing process as manifestation of the brain-based self-continuity. This carries major implications for psychiatry. An altered sense of self with abnormal self-continuity as in schizophrenia, as possibly based on abnormal temporal continuity on the neuronal level, e.g., ACW, should then be manifested in a correspondingly altered temporal continuity in the drawing process. This is exactly what our case studies suggests.

We first briefly review the most widely used current methods of drawing assessments that quantify drawings as self-projections – this will be done in the first part of the paper. Secondly, we will review recent findings on temporal continuity of the self, i.e., self-continuity on both psychological and neuronal grounds including its measured in terms of ACW. This will be discussed in the second part. Thirdly, conducting a case study in the third part of this paper, we will then apply that very same measure, e.g., the ACW, to the drawing process of a healthy and schizophrenic subject respectively. That serves to illustrate the potential usefulness of ACW as neuronal measure of self-continuity in assessing drawings in a quantitative way in current art therapy.

It shall be noted that our paper here does not yet aim to provide fullfledged empirical data. Instead, we here only aim to introduce the concept of such novel brain-based assessment of the drawing process which will be supported by two case studies. Moreover, our study focuses on the spatiotemporal features of the drawing process itself as engineered by the subjects' self; that is to be distinguished from the perception and cognition of drawings whose neural basis is investigated in neuroaesthetics [30,31].

Evaluation of hypothesis/idea

First part: Current methods of drawing assessment in art therapy

Content- vs structure-based approaches in art therapy assessment

The psychodynamic methods of assessment understand drawings as projection of the self [32]**.** Specifically, the inner conflicts and objects of the self are supposed to be mirrored and reflected in the objects or contents of the drawings [32]**.** Drawings are supposed to reflect the self that paints the drawings and is manifested in the contents and colors of its own drawings. Such self-based view of drawing thus amounts to what we describe as "content-based method of assessment". This entails a qualitative method of assessment that, as it relies strongly on the interpretation by the art therapist, is subjective (rather than objective).

The psychodynamic and self-based nature of drawings is abandoned in the more quantitative and objective methods of assessment like DDS and DAPA (see Supplemental data Table 1). Instead of understanding drawings as projections of the self and its objects in terms of the contents in the drawings, the quantitative approaches focus more on the stochastic or statistical description of formal elements in the drawing's overall structure like points, curves, color of the drawings. The self- and content-based approach is here thus replaced by a "structure-based method of assessment" that, as it remains independent of the art therapist, is more objective.

Quantitative and objective methods of art therapy assessment

Some the most widely-used art assessment methods throughout the history of art therapy are included in the supplemental data (see Supplemental data Table 1).

Drawing vs drawing process – What do we need to assess

In sum, different methods for the assessment of drawings have been suggested with some being less and others being more quantitative and objective. The more subjective ones are mostly psychodynamic and focus on the interpretation of the drawing itself by the therapist – the drawing is interpreted as expression or projection of the self, e.g., self-projection. In contrast, the more objective ones focus on formal elements within the drawing [29]. While that provides a more objective assessment, it nevertheless leaves out the self that is expressed in the drawing. Ideally, one would like to combine and include markers of both subjective self and objective drawing within one and the same quantifying measure. We will demonstrate that that is indeed feasible by going back to and utilizing those measures of the brain's neuronal activity that are related to the self and its shaping of the drawing.

Despite their differences in terms of assessment, i.e., objective vs subjective, and consideration of self, i.e., inclusion vs exclusion, psychoanalytic and non-psychoanalytic approaches nevertheless share that they both conceive the drawing as the main object of analysis and assessment. The drawing is presupposed as ready-made and final. That neglects the drawing process itself, though. The drawing process is engineered by the self and should therefore express the self and its deep unconscious layers (as psychodynamic approaches aim to reveal in their subjective interpretations of the final drawings).

At the same time, the drawing process may offer the opportunity of objective quantified assessment which, as it is based on and engineered by the self, may then also provide information about the self and its subjective unconscious layers. As there are currently no measures available for the drawing process itself, we now shift our focus to the self and how it is measured in neuroscience.

Second part: Measuring self-continuity with the autocorrelation window (ACW) – Theories

Self-continuity and its neural basis – Assessment by autocorrelation window (ACW)

Central to human life is our self and its continuity of time – "self-continuity" [5,33–35] is the temporal core of our personal identity [29]. While much attention has recently been devoted to the self at one particular moment in time, i.e., "synchronic self", and its neural correlates [36,37], less is known about "self-continuity" and thus about the "diachronic self" and its identity.

Targeting the diachronic self, a recent study investigated spontaneous activity in fMRI measuring its degree of scale-free activity with the power law exponent (PLE) that describes the "dynamic structural memory" across different points in time in the brain's spontaneous activity [27,38]**.**The same subjects also underwent psychological assessment with the self-consciousness scale (SCS). The SCS includes different subscales, private, public, and social self-consciousness. Huang et al. [27] could now observe direct relationship between PLE and private SCS in specifically VMPFC: the higher the PLE in VMPFC of individual subjects, the higher their degree of private self-consciousness (as measured in private SCS) and thus the higher their self-continuity (across different scales time).

Yet another study by Wolff et al. [20] investigated directly self-continuity in EEG. In addition to PLE, they also used an even more direct measure of temporal continuity of neuronal activity, that is, the auto-correlation window (ACW). Roughly, the ACW measures the degree to which one time point in neuronal activity can predict the subsequent ones: the more later time points can be predicted, the higher the auto-correlation, and thus the longer the ACW [20,25,38] The ACW thus measures the temporal continuity of neuronal activity.

Wolff et al. [19] did show that both PLE and ACW in the brain's spontaneous activity predicted the degree of private self-consciousness. Longer ACW and thus higher temporal continuity in the neuronal activity lead to higher temporal continuity with higher private self-consciousness on the mental level. Accordingly, longer temporal continuity on the neuronal level, i.e., the ACW, translates into longer temporal continuity on the mental level, i.e., self-continuity as measured by private self-consciousness.

The relationship between temporal continuity on the neuronal level and self-consciousness on the psychological level is of interest given that psychologically the self can indeed be characterized by its continuous nature, specifically self-continuity resulting in personal identity [6]. The self has been demonstrated to delay reward choice more strongly than non-self [5] the self thus appears to infuse temporal delay with temporal continuity into psychological functions such as reward. This is even more interesting given that the ACW on the cellular level has been related to the degree to which monkeys can delay reward delivery [24]. Temporal continuity, on both the neuronal and psychological levels, thus seem to provide the "glue," or "common currency," between the brain and the self. (See Fig. 2).

From brain and self to the drawing process – Temporal continuity as "common currency"

The data suggest that temporal continuity provides the "common currency" of neuronal and psychological levels of brain and self. Neuronal continuity, as measured with ACW, thus translates into corresponding temporal continuity on the psychological or mental level of the self, e.g., self-continuity. That is central for understanding and measuring the drawing process.

Since the self is based on the brain, one would assume that the brain's temporal continuity is also manifested in the temporal continuity of the drawing process including its expression of the temporal

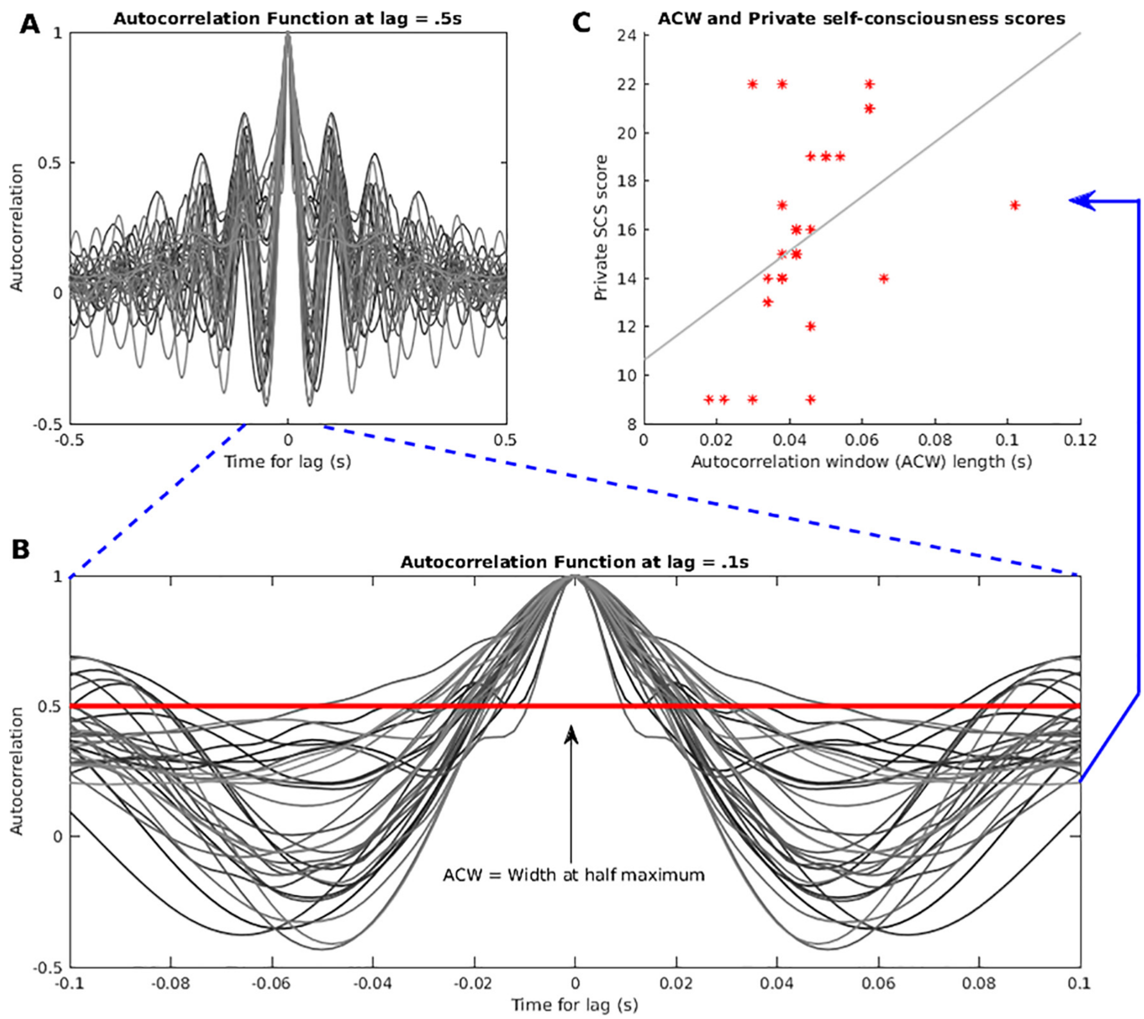


Fig. 2. Autocorrelation window calculation and implications for self-relatedness. **A)** Autocorrelation functions of electroencephalographic data of all participants. Each line constitutes the autocorrelation function of one individual participant. When any signal is correlated with itself (autocorrelation), two identical copies of the signal are gradually separated and their similarity at that point of separation (lag) is measured. In A) the x-axis is the lag of the two copies, with the point 0 being no separation (the timepoints of the two copies align) and the maximum points (here 0.5/-0.5) being the maximum separation between the two copies of the signal. When the lag is zero (timepoints align), the autocorrelation function is 1 which indicates that the two signals correlate perfectly. Once the signals are separated, however, the correlation (y-axis) between them decreases. **B)** Enlarged view of the autocorrelation function at lag = 0. The autocorrelation window (ACW) is measured as the distance between the function when the autocorrelation is 0.5, or at half maximum. Since the x-axis measures time, the ACW is a duration measured in seconds. Red line: reference line for autocorrelation at 0.5, at which point the ACW is measured. **C)** Correlation between ACW and self-consciousness scale (SCS) Private subscore. The ACW – the distance in time between the autocorrelation function at 0.5 – has been shown to correlate with measures of self-consciousness, specifically the Private subscore of the SCS [20]. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

continuity of the self, i.e., self-continuity. In other words, we assume that temporal continuity provides the "common currency" of brain, drawing process, and self (See Fig. 3).

We measured temporal continuity in the brain by the ACW and demonstrated its relation to the self, e.g., self-continuity. One would now assume that we can also measure the temporal continuity of the drawing process by itself with exactly the same measure that index the relationship of brain and self, that is, the ACW. Therefore, we, in a next step, apply the ACW to measure the temporal continuity of the drawing process itself; that will be probed in a case study with two subjects, a healthy one and a schizophrenic one.

Third part: Measuring the drawing process with the autocorrelation window (ACW) – A two-case example

Measurement of drawing process I – Methodology

Based on (i) that ACW measures temporal continuity, and that (ii) temporal continuity provides the "common currency" of brain, drawing process, and self, we now apply ACW to the drawing process itself measuring its temporal continuity. That makes necessary to develop a novel methodology that allows first to collect a time series of data during the drawing process, and secondly to convert and analyze that very same time series with ACW. Both steps shall be described briefly in the following.

Instead of analyzing the static single drawings in traditional art therapy and assessments, we here simply provided a conversion method which added the time factor (in the Y axis), with an eye to make it similar to signal processing.

An iPad (2016 version) with application *Memopad* made by Tayasui company was used for the test. The participant could only use the 19 colors and the "pen" mode to draw, which only have one equal thickness of each brush. The eraser and undo function could also be used during the drawing.

The following are the steps for drawing, which inspired by the book

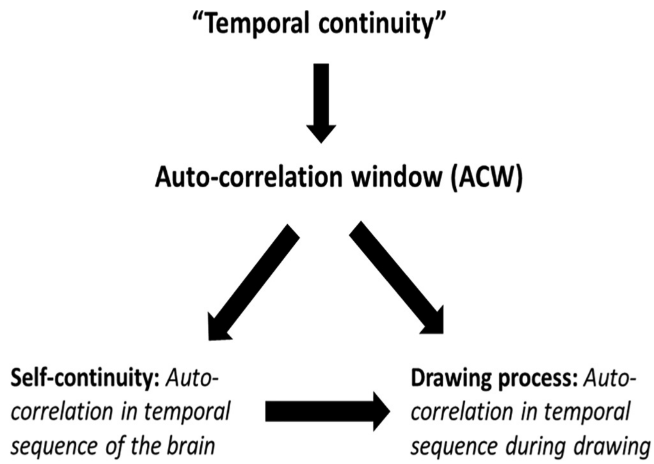


Fig. 3. Measurement of temporal continuity by autocorrelation window in self and drawing.

"*Art Therapy Exercises: Inspirational and Practical Ideas to Stimulate the Imagination*." The descriptions in each step are the only instruction the testers gave to the participants during the whole course. (i) Step1: draw yourself as animal; (ii) step 2: draw the scenes of the following emotions (excitement, anger, depression); (iii) step 3: free drawing.

The whole course was recorded through screen recording function by iOS11. There were no time limits for each of the steps. After the participants finish the drawing. The whole course of drawing was recorded as drawing videos and was input into MATLAB (R2018b) for analyzing. The temporal resolution of the iPad function was 1/60 s (1frame = 1/60 s).

After analyzing by MATLAB, we obtained two plots as output from our calculation. Plot A illustrates the decreasing of the total numbers of blank (white) pixels of the whole screen over time – which indicates the rate that the subject draws a single picture. The X axis of the plot is time. The Y-axis is the number of the white pixels. Generally, the index will decrease as the participants put more and more lines and colors on the screen. However, the usage of undo and eraser can add additional variables.

Plot B is the autocorrelation function (ACF) of the first graph. The whole process of drawing was divided into frames by MATLAB as depending on the temporal resolution of the recording. Each frame shows the number of white pixels at that time point; this allows us evaluating the correlation of the white pixels between different time points reflecting the autocorrelation between white pixels at different time points. That auto-correlation function (ACF), in turn, allows to calculate the autocorrelation window (ACW). The total duration of the recording video of each step/drawing was also obtained. The ACW collected from MATLAB used 'frames' as units; the formula for transferring from 'frames' to 'seconds' was the following: ACW (secs) = (ACW (frames)/total frames in the ACF) * Duration of the video * 2 (see Fig. 4).

The autocorrelation window (ACW) was calculated in MATLAB (v2016a) using custom scripts. According to Honey et al on 2012 [23], the ACW is defined as the full-width-at-half-maximum of the autocorrelation function for the EEG time course. It estimates the width of the mean lobe of the autocorrelation.

To calculate the ACW, we examined the autocorrelation function at the following lag-times: 0.1 s, 0.5 s and 1.0 s. The number of steps for all three lag-times was 23, though the 0.1 s lag computed 101 coefficients, 0.5 s lag computed 501 coefficients, and 1.0 s lag computed 1001 coefficients. The ACW values computed for all three lag-times were identical.

All data was sampled at 500 Hz, the size of the window was 20 s, and the overlap of the window was 50%.

Measurement of drawing process II – Results and discussion

Comparing the drawings from the healthy subject (Fig. 4) and the subject with schizophrenia (Fig. 4), some observations of the numbers shall be mentioned (Fig. 4). First, the average drawing durations for each theme are much shorter in the subject with schizophrenia (14.67 s) than the drawing durations of the healthy subject (79.167 s). Secondly, the average ACW in healthy subjects (23.403 s) being much longer than the ACW in the schizophrenic subject (8.592 s). Since ACW measures temporal continuity of the self, these data suggest that the healthy subject draws in a temporally much more continuous way than the schizophrenic subject. Third, comparing the drawing contents from the schizophrenic subject and the healthy subject, more varieties of color were used in every single picture by the healthy subject. The structure of each painting were also more concrete in the healthy subject comparing to the doodling-like drawing made by the schizophrenic subject. (see Fig. 5).

Together, our data suggest decreased temporal continuity during the drawing process in the schizophrenic subject. Put conversely, decreased temporal continuity means increased temporal fragmentation in the drawing process. Such temporal fragmentation has also been observed on the psychological or better phenomenological level in that schizophrenic subjects experience their own self as more fragmented across time, e.g., temporal fragmentation of self [8,9].

Moreover, analogous temporal fragmentation can also be observed on the neuronal level as the brain's spontaneous activity shows decreased functional connectivity and lower cross-frequency coupling in schizophrenia [9,10]. Unfortunately, no neuronal data about the ACW itself are yet available in schizophrenia. Following the temporal fragmentation of both drawing process and self, one would expect abnormally short ACW in the spontaneous activity in schizophrenia as neuronal basis of the temporal fragmentation of both self-continuity and drawing process.

Measurement of drawing process III – Question and limitations

Question: ACW was used to be adopted to stationary signal analysis. Could it be applied into the analysis of plot A?

Answer: With an eye to revealing the methodology of our experiment concretely and clearly, we only took a shorter and simple drawing series of topic from both a healthy subject and a schizophrenic subject as example. One may notice that there are some abrupt fluctuations (sharp polylines) in the graph of the changing of the area (plot A). These result from the usage of the "eraser" and "undo" function of the software, which would make sudden change to the whole area size. However, when extended to a more time-consuming topic of drawing, these sharp polylines could be neglected and plot A will thus get closer to a stationary signal which goes up and down depending on the changing of the speed of drawing by the subjects. (see Fig. 6).

The initial idea of the usage of "eraser" and "undo" function was to offer the subjects a better drawing experience with the opportunity to revise their unsatisfied strokes during the making of the drawings. Since it would cause abrupt fluctuations (sharp polylines) in the plot A of the short-time drawings, we are considering prohibiting these functions in the future experiments.

Conclusion

Art therapy of drawing is a classic method for assessments in psychiatry and clinical psychology. However, its effectiveness on evaluating one's mental structure is impeded by lack of objective quantitative measurement. Instead of focusing on the interpretation of the drawing (or painting) itself, we here analyze the drawing process itself. For that, we use a measure that is based on the brain's temporal structure and expressed in the temporal features of self.

Specifically, we here suggest analyzing the drawing process with

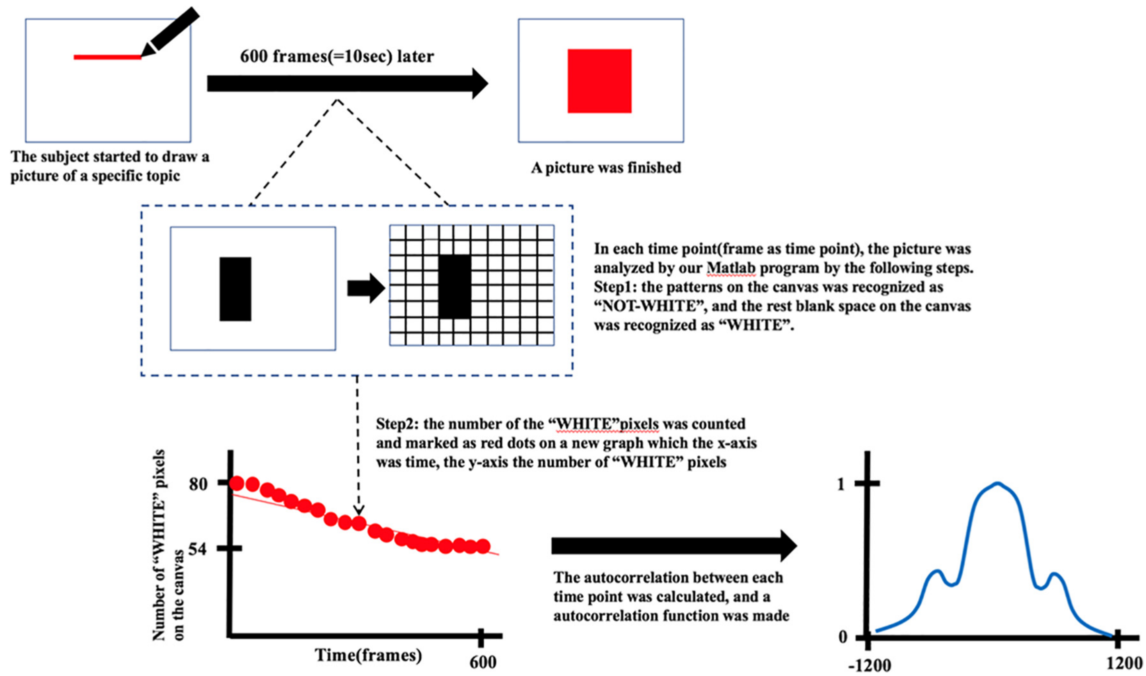
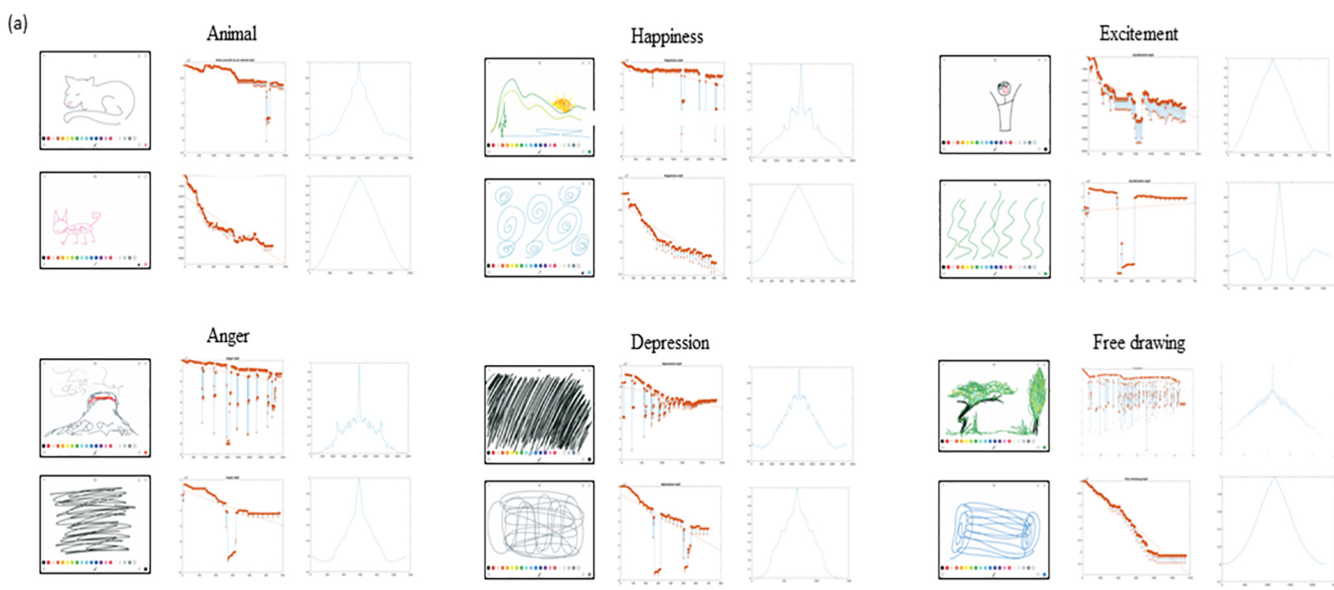


Fig. 4. The methodology of the measurement of the drawing process in our case studies.



(b)

Subject/drawing themes		Animal	Happiness	Excitement	Anger	Depression	free drawing	AVERAGE
Healthy	Duration	57	66	52	74	39	187	**79.167**
	ACW	20.208	7.81	47.078	3.385	12.568	49.366	**23.403**
Schizophrenic	Duration	21	15	11	10	12	19	**14.67**
	ACW	18.02	12.257	1.414	3.385	8.48	13.138	**8.592**

Fig. 5. The drawing and further calculations of the healthy subject and the schizophrenic subject. (a) The drawings and the further calculations (plot A and plot B) were divided into six blocks according to their drawing themes. In each block, the drawings and the two plots from the healthy subject (upper row in the block) and the schizophrenic subject (lower low in the block) were presented in a row from left to right. (b) The comparison of duration and ACW in different drawing themes between the healthy subject and the schizophrenic subject. The time unit for each data is "second".

exactly those measures, e.g., auto-correlation window (ACW) (and others in the future) that characterize the same temporal feature, e.g., temporal continuity in our case, on both neuronal and psychological levels of brain and self. Such spatiotemporal characterization of the drawing process opens novel doors not only for objective quantitative brain-based assessment but, even more important, for the future development of individually- or self-tailored neuronal and psychological therapeutic intervention during art therapy.

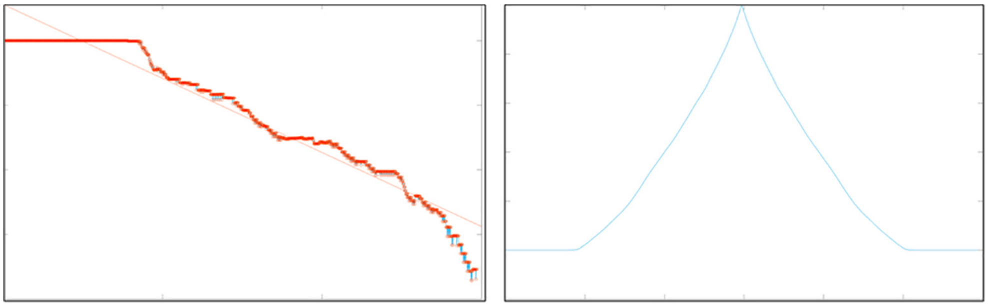


Fig. 6. An example of a more time-consuming (> 2 min) topic of drawing, which presented a more stationary plot A.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mehy.2020.109596.

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