On the nature and origin of self-esteem

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CHAPTER 3
The Temporal Nature of State Self-Esteem as a Real-Time Process

Abstract

Research regarding the variability of state self-esteem commonly focuses on the *magnitude* of variability. In the current article we provide the first empirical test of the *temporal structure* of state self-esteem as a real-time process during parent-adolescent interactions. We adopt a qualitative phenomenological approach, whereby moment-to-moment emotional and behavioral indicators of state self-esteem are measured as they emerged during the interactions, resulting in state self-esteem time series. We conducted Detrended Fluctuation Analyses (DFA) on the state self-esteem time series and found that they exhibited a form of structured variability, called *pink noise.* The mean DFA exponent differed significantly from that of randomized surrogate data ($p < 0.01$), which revealed uncorrelated random variability, called *white noise.* This finding shows that the temporal structure of state self-esteem variability exhibits self-similarity and is not random. Additionally, a weak positive relationship was found between the DFA and context-independent autonomy levels. [10]

[10] This chapter is based on De Ruiter, N. M. P., Den Hartigh, R. J. R., Cox, R. F. A., Van Geert, P. L. C., & Kunnen, E. S. (2014). The temporal structure of state self-esteem variability during parent–adolescent interactions: more than random fluctuations. *Self and Identity,* (December 2014), 1–20. doi:10.1080/15298868.2014.994026

Self-esteem is conceptualized as having both a trait element (characterized as relatively stable and predictable across time), as well as a state element (characterized by fluctuations from moment to moment and a high level of variability) (Donnellan et al., 2012). While the number of theoretical and empirical studies focusing on state self-esteem is increasingly growing, these studies tend to focus on the magnitude of state self-esteem variability (e.g., Leary & Downs, 1995). To date, very little theoretical or empirical research has been done concerning the nature of the moment-to-moment fluctuations that occur in state self-esteem, which we refer to as the temporal *structure* of state self-esteem variability.

The current article provides the first test of the temporal structure of state self-esteem as a moment-to-moment (i.e., real-time) process. We begin by exploring the implicit assumptions held regarding state self-esteem variability and its temporal structure, and how these assumptions may be at the root of why the temporal structure of state self-esteem variability has remained outside of the limelight. Next, we suggest that the temporal structure of state self-esteem exhibits more meaningful dynamics than is commonly attributed to it, and more specifically, that state self-esteem can be conceptualized as a process that exhibits *fractal* characteristics. We test whether this is indeed the case for adolescents during parent-adolescent interactions, and we explore how the temporal structure of state self-esteem is related to a pivotal indicator of healthy adolescent development, namely, autonomy.

3.1 Implicit Assumptions Regarding the Temporal Structure of State Self-esteem Variability

The common conceptualization of state self-esteem stems from the notion that state self-esteem is the “barometric” element of self-esteem, which is variable across time and contexts and fluctuates around the relatively stable “baseline” level of self-esteem (Rosenberg, 1986). This conceptualization is consistent with the basic axiom of standard psychometric theory, which posits that there is a true underlying level of a latent variable, and that this true level is expressed by a score (measured by an instrument) that is subject to error. Therefore, the observed score is equal to the true score plus error, where the error is by definition independent from the true score (Lord & Novick, 1968; Van Geert & Van Dijk, 2002). For self-esteem specifically, state self-esteem is commonly approached as the “error” around (and independent from) – what is thought to be – a more meaningful baseline level that is trait self-esteem, where the “error” is contextually-based error. Indeed, according to a prevailing theory in self-esteem research – the Sociometer Theory (Leary, 2005) – trait self-esteem is viewed as the resting level of self-esteem in the absence of contextual information, and state self-esteem is thought to fluctuate around this resting level of self-esteem as a function of social cues in the immediate context (Leary, 1999). Therefore, the underlying assumption is that, without the presence of contextual events, state self-esteem is expected to be equal to the baseline level of trait self-esteem.

Empirical research has primarily approached state self-esteem *variability* as a function of external factors, as a reaction to the immediate context. Studies therefore often focused on the magnitude of the reaction to external cues, either by measuring the test-retest level of state self-esteem before and after an experimental contextual cue (e.g., Heatherton & Polivy, 1991; Leary & Downs, 1995; Murray, Griffin, Rose, & Bellavia, 2003; Thomaes et al., 2010), or by measuring between-individual differences in the level of *self-esteem stability* (Kernis et al., 1993, 1989), conceptualized as a dispositional quality of how reactive an individual is to daily events (e.g., Franck & De Raedt, 2007; Jordan, Whitfield, & Zeigler-Hill, 2007; Kernis et al., 1989; Koole, Dijksterhuis, & Van Knippenberg, 2001; Oosterwegel, Field, Hart, & Anderson, 2001; Savin-Williams & Demo, 1983).

Regarding the temporal *structure* of state self-esteem variability, self-esteem researchers who build upon the above assumptions have yet to explicitly describe – theoretically or empirically – what the temporal nature of state self-esteem dynamics is. Generally speaking, however, the standard psychometric theory that underlies the baseline approach (see above) indicates that the variability around the true score is symmetrically distributed, due to the fact that the variability is assumed to be the cause of independent and randomly varying contextual factors (Van Geert & Van Dijk, 2002). Following this basic theory, state self-esteem represents a short-lived experience, which – given the absence of a new contextual cue – will return back to the baseline level (Alessandri & Caprara, 2012). Given this conceptualization, the variability of state self-esteem should resemble *white noise* (Diniz et al., 2011; Gilden, 2001; Stadnitski, 2012; Van Orden, Holden, & Turvey, 2003, 2005), which is temporally random variability that is created when there is no carry-over effect from one state to the next (see Figure 1a).

This implicit assumption is directly implied by the common methodological approaches to repeated measures of state self-esteem, which focus on central tendencies of self-esteem (i.e., measures at the aggregate level). Firstly, repeated measures are often averaged in order to gain a measure of the true level of self-esteem (i.e., of trait self-esteem) (DeHart & Pelham, 2007); a technique that depends on the assumption that there is a meaningful average level that state self-esteem fluctuates around. Secondly, repeated measures are often utilized in order to determine the standard deviation of state self-esteem (i.e., self-esteem stability, see above), which implies that the noise (i.e., variability) around the baseline level produces a temporally stable level of variability (DiDonato, England, Martin, & Amazeen, 2013; Van Orden et al., 2003). Together, these methodological approaches imply that state self-esteem is a stationary signal with a constant mean and standard deviation, i.e., central characteristics of white noise.

3.2 State Self-esteem Variability as a Fractal Process

We question the assumption that state self-esteem variability is purely a function of exogenous events, as well as the assumption that the temporal structure of the resulting variability is random (i.e., white noise). Alternatively, we posit that each state self-esteem event is in itself a process, and that this process interacts with neighboring (i.e., future) state self-esteem processes. These dynamics are defined as *interaction-dominant* dynamics, where the coordination of the process at large is a function of the internal dynamics, which occur within a context, but which are not a function of the context alone (Van Orden et al., 2003). From this conceptualization, state self-esteem exhibits both short-term and long-term carry-over effects. We suggest, therefore, that state self-esteem is a self-coordinating process, rather than a passively reactive (i.e., stimulus-response like) and random process.

Many human processes, such as word naming (Van Orden et al., 2003; Wijnants, Hasselman, Cox, Bosman, & Van Orden, 2012), finger tapping (Gilden, Thornton, Mallon, 1995), walking (Hausdorff, Peng, Ladin, Wei, & Goldberger, 1995), standing (Duarte & Zatsiorsky, 2000), rhythmical aiming (Wijnants, Cox, Hasselman, Bosman, & Van Orden, 2012), neuromagnetic activity (Linkenkaer-Hansen et al., 2005) and mental-rotation tasks (Gilden & Hancock, 2007) have recently been conceptualized as depending on interaction-dominant dynamics have been found to exhibit *pink noise* (see Figure 1b). Pink noise is structured variability characterized by correlated activity across many time scales (Van Orden et al., 2003; Wijnants, Cox, Hasselman, Bosman & Van Orden, 2012).

Pink noise is significant for a number of reasons. Firstly, it is indicative of a fractal process. Fractals are characterized by their self-similarity, which can refer to spatial or temporal self-similarity. Spatial fractals occur “when the same object replicates itself on successively smaller scales” (Segev, Soljačić, & Dudley, 2012, p. 209), which is (statistically) true for many geometrical objects in nature, such as the Romanescu broccoli. The current article concerns temporal fractals, where variability is statistically similar across multiple time scales (seconds, minutes, etc.). Any point in a fractal process, therefore, possesses the “dynamic memory” of all preceding points of the process and is therefore embedded in the historical context of the system (Delignières et al., 2004; Diniz et al., 2011). The presence of pink noise is also significant in that it indicates a balance between order and chaos (Wijnants, 2014), which characterizes healthy and well-coordinated systems (Herman, Giladi, Gurevich, & Hausdorff, 2005; Wijnants, Hasselman, Cox, Bosman, & Van Orden, 2012). Indeed, pink noise lies on a continuum between *white noise* and *Brown noise* (see Figure 1), which we will describe below.

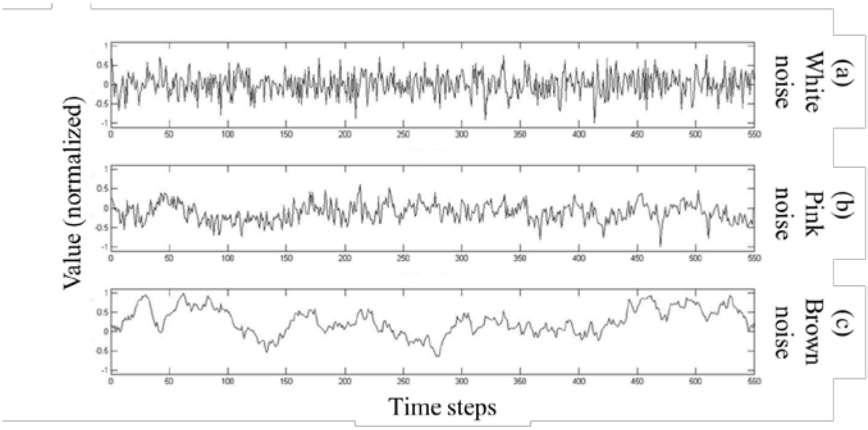

Figure 1. Three simulated types of noise patterns: White noise (a), pink noise (b), and Brown noise (c).

White noise is random and temporally uncorrelated noise distributed symmetrically around an average level (Figure 1a), referred to above regarding the traditional “barometer” view of state self-esteem. White noise is considered maladaptive because it reflects excessive flexibility to the extent that the system is unstable and does not demonstrate any memory of the previous state (Hausdorff, 2009). Processes approaching white noise have indeed been found to indicate abnormalities; for example, the temporal variability in trial-by-trial word-naming tasks in young dyslexic readers (compared to non-dyslexic readers) (Wijnants et al., 2012). At the other end of the spectrum, Brown noise is highly rigid and overly determined, such that the next state of a process is equal to the previous state plus a random influence (Figure 1c). Brown noise is considered unhealthy because it indicates that the system does not adapt effectively to the current context and is therefore “stuck” in the previous meaningful state (Gilden & Hancock, 2007). Processes approaching Brown noise have indeed been found to indicate abnormalities; for example, the temporal variability of reaction times of a mental rotation task in adults with Attention Deficit Hyperactivity Disorder (ADHD) (compared to individuals without ADHD) (Gilden & Hancock, 2007).

While the fractal properties of state self-esteem across real time have not been examined to date, there is an abundance of evidence that real-time cognitive and motor processes reveal pink noise (for a review, see Wijnants, 2014). Moreover, there is rising evidence that pink noise is also displayed in socio-emotional processes, such as trial-by-trial reaction times in racial-bias tasks (Correll, 2008), short conversational storytelling sessions (Butner, Pasupathi, & Vallejos, 2008), and mood across the long term (from 1 to 2.5 years) (Gottschalk, Bauer, & Peter, 1995). Closely related to self-esteem, Vallacher and colleagues have shown that verbal self-reflection (regarding trait-like properties) expresses interaction-dominant dynamics, where self-reflection converges onto relatively coherent regions of positivity or negativity (Vallacher et al., 2002) and exhibits pinks noise (Wong, Vallacher, & Nowak, 2014). Finally, Ninot and colleagues (Fortes et al., 2004; Ninot et al., 2005) measured state self-esteem as a long-term process (i.e., approximately a year and a half), where the smallest time interval between successive state self-esteem measurements was approximately 12 hours. While Ninot and colleagues did not examine *real-time* variability of state self-esteem, they showed that the dynamics of state self-esteem are a function of intrinsic dynamics (described by a moving-average model), and that state self-esteem exhibits pink noise (Delignières et al., 2004).

The above findings regarding self-evaluation processes as characterized as interaction dominant, and as exhibiting pinks noise, supports our hypothesis that the real-time process of state self-esteem will demonstrate pink noise. Given that state self-esteem fluctuations are conceptualized as occurring in the here-and-now (e.g., Kernis et al., 1993, 1989; Leary & Downs, 1995; Rosenberg, 1986b), it is important that the temporal structure of state self-esteem is also investigated across real time, as is done in the current study.

3.3 A Qualitative Phenomenological Account of State Self-Esteem.

To date, researchers interested in variability of state self-esteem have used the *experience sampling method* (e.g., Delignières et al., 2004; Oosterwegel, Field, Hart, &

Anderson, 2001). While this method is highly suitable for capturing daily fluctuations of state self-esteem, it is not ideal for capturing state self-esteem as a real-time process (with fluctuations occuring from moment-to-moment). This is because the very act of reporting on the momentary self-experience of one's self would disrupt the organic process of state self-esteem and would not capture the *continuous* state self-esteem process. To remedy this, we suggest that it is helpful to collect qualitative data that is phenomenological by nature, based on naturally emerging positive and negative self-experiences.

Cognitions of self-evaluation are traditionally measured as characteristics of (both state and trait) self-esteem. However, when investigating the phenomenological experience of self-esteem, it is important that researchers move toward a more holistic approach, where emotions and behavior are considered (Ryan & Brown, 2003; Scheff & Fearon, 2004). For state self-esteem specifically, it is even more imperative that cognitions are not relied upon as the sole source of information, as it is likely that self-evaluation will first occur without conscious monitoring, and therefore, not as cognitions (Cunningham & Zelazo, 2007; Ryan & Brown, 2003).

In the current chapter, we focus on the positivity and negativity of *behavioral* and *affective* experiences of the self. These self-experiences can be conceptualized as lower-order components of state self-esteem that, by means of intrinsic dynamics, emerge into a higher-order experience of the self, i.e., state self-esteem (see Chapter 2), where all lower-order components are conceptualized as having equal weight in the process of emergence. State self-esteem is therefore the general level of positivity or negativity regarding the self at that moment, and the separate emotional and behavioral experiences of the self are indicators of that general level.

[11]The reason for including behavioral indicators of state self-esteem is that behavior reflects how an individual sees or feels about him or herself (Atkinson, 1964; Leary, 2004). For self-esteem, the positivity or negativity of the behavioral experience of the self is reflected in autonomy (Deci & Ryan, 1995), where real-time expressions of autonomy are thus relevant for real-time self-esteem (i.e., state self-esteem). According to the Self-Determination Theory (SDT), autonomous actions are manifestations of a secure sense of self and a high level of true self-esteem, and self-worth is reflected in agency and proactivity (Deci & Ryan, 1995). In our study, autonomous actions need not indicate separation and individuation from the parent (Kroger, 1998), as is often adopted when considering autonomy. Instead, in accordance with the SDT, autonomous actions are those that express agency, proactivity, free-will, and ownership of behavior.

We included emotions as an indicator of state self-esteem as emotions reflect an individual's personal reality regarding their self-worth (Cognitive-Experiential Self Theory; Epstein, 1993). Specifically, 'self-conscious' emotions are of relevance to state self-esteem,

[11] The following information regarding the behavioral and emotional indicators of state self-esteem is identical to the information given in Section 1.4. It is included here for the sake of completeness in the current chapter.

which are socially-situated emotions pertaining to the self, such as pride and shame (Tangney & Fischer, 1995). These are in contrast with emotions that are not self-conscious, such as affection or anger (which reflect appraisals of the context and concerns in an immediate relationship, Frijda, 2001).

When considering the phenomenological experience of state self-esteem, it is necessary to distinguish between those expressions of positive state self-esteem that are genuine, and those that are not. This perspective stems from the SDT (Deci & Ryan, 1995), where 'genuine' high self-esteem is the result of *self-determined* actions, i.e., acting in accordance with one's own interests and values, rather than trying to gain self- or other-regard (Ryan & Brown, 2003).Researchers have suggested that positive self-esteem expressions are not genuine when an individual misrepresents his or her self-feeling (i.e., a discrepancy between privately experienced self-feelings and expressed self-feelings), and that positive self-esteem expressions are genuine when an individual represents his or her self-feelings in a honest way (i.e., no discrepancy between privately experienced self-feelings and expressed self-feelings) (Kernis & Paradise, 2002).

In the current study, we incorporate this distinction (and its identification according to Kernis and Paradise, 2002) into our measurement of state self-esteem. This is done by conceptualizing *positive* state self-esteem as expressions of positive self-experience that do *not* entail or coincide with a discrepancy of valence between simultaneously expressed emotions or autonomous behavior. Discrepancies of valence occur when one experience is positive by nature and the other (simultaneously expressed experience) is negative by nature (e.g., verbally expressing pride while non-verbally expressing embarrassment). Moreover, discrepancies include both experiences of the *self* as well as experiences of the *significant other* with which the individual is interacting. It is important that discrepancies regarding experiences of the significant other are also included, as one can only experience genuine self-esteem if one is not simultaneously being 'fake' in immediate relationships with significant others (Kernis, 2003).

3.4 The Current Study

Our study provides the first account of a qualitative phenomenological approach to state self-esteem across real time, where positive and negative emotional and behavioral self-experiences that are expressed during interaction with a significant other are observed. We aim to investigate the temporal structure of state self-esteem variability as a real-time process. The current study focuses specifically on adolescents, as adolescence is a significant period for self-esteem development (Harter & Whitesell, 2003; Robins, Trzesniewski, Tracy, Gosling, & Potter, 2002). We hypothesize that the temporal structure of state self-esteem variability will be structured, rather than random, thereby resulting in long-range correlations as indicated by the presence of pink noise (*Hypothesis 1*).

Moreover, we examine the relationship between the temporal structure of adolescents' state self-esteem variability and the static (i.e., non-temporal) and self-reported levels of adolescent trait and state self-esteem. This is useful in order to ascertain how the temporal measure of structure relates to the more traditional measures of self-esteem levels. We hypothesize that the temporal *structure* of state self-esteem is a distinct concept from the *level* of self-esteem. We therefore expect there to be no significant correlations between the temporal structure of state self-esteem and the static measures of self-esteem levels (*hypothesis 2*).

Finally, we examine the relationship between the temporal structure of adolescents' state self-esteem variability and a theoretically relevant psychological variable during adolescence, so that the meaning of the temporal structure can be grounded in psychological theory related to adolescence. We examine the association with adolescents' levels of self-reported context-independent autonomy, as this is an indicator of positive psychosocial adjustment during adolescence (Noom, Dekovic, & Meeus, 1999)[12]. Considering that – firstly – higher autonomy levels indicate healthy adjustment in adolescents (Noom et al., 1999), and that – secondly – fractal characteristics indicate healthy human processes (Herman et al., 2005), we hypothesize that fractal characteristics in adolescent state self-esteem and autonomy levels of adolescents will be positively related (*hypothesis 3*).

3.5 Method

3.5.1 Participants

Participants were thirteen adolescents (3 boys, 10 girls) and their parents (1 male, 12 females). The mean adolescent age was 13.30 years (*SD* = 0.90). The parent-adolescent dyads that took part in this research responded to recruitment flyers that were handed out in various local community centers and schools. The participants had no indication of clinical diagnoses and were of average socioeconomic status. The majority of the dyads were Dutch, with one American-Dutch dyad and one British dyad. Participation was voluntary, and children were rewarded after the video-recordings took place with a five Euro gift-voucher.

3.5.2 Procedure

Before the video-recordings took place, adolescents filled out a questionnaire regarding their trait self-esteem and their autonomy. Later, each dyad was video-recorded in their home environment during a semi-naturalistic interaction by the first author. The dyads were given three consecutive topics to discuss. The nature of each topic was such that the parent and child would try to come to a mutual agreement. The first discussion topic was neutral (for example: If you could have one super power, which would you have?). The second was a conflict topic relevant to each dyad at that moment (for example: cleaning up your room). The last discussion topic was a new neutral topic comparable to the first (i.e., A-B-A design, Granic et al., 2003). In assigning both neutral and conflict topics, a range of emotions and behavior were potentially elicited (Granic et al., 2003; Hollenstein & Lewis, 2006). Dyads were told that they could move on to the next topic when they felt they were finished with the previous one, keeping in mind that they should take about five minutes for each topic. Dyads were also assured that there are no 'right' or 'wrong' things to say or do, and that we (the researchers) are simply interested in their natural responses to each other.

[12] Note that this refers to general autonomy levels as measured with questionnaires, and not to autonomous behavior expressed during the parent-adolescent interactions.

The dyads were given no further instructions and were left alone in a room of their choice for the duration of the video-recorded interaction. After the filming was finished, the participants were asked to immediately fill in a self-report measure of state self-esteem. The observational videos were subsequently coded.

3.5.3 Coding Procedure

Based on the video-recorded interactions, theoretically important emotional (Epstein & Morling, 1995; Scheff & Fearon, 2004; Stipek et al., 1992) and behavioral (Allen et al., 1994; Deci & Ryan, 1991; Noom et al., 2001) measures were collected that, together, indicate the participants' phenomenological state self-esteem (see Measures, below).

Coding of emotions was largely based on the SPAFF coding system (Coan & Gottman, 2007). Adaptions were made in order to distinguish between self-directed affect and other-directed affect, and were data-driven (in accordance with the Grounded Theory; Glaser & Strauss, 1967). Coding of behavior was largely based on Noom et al. (2001)'s framework of emotional, functional, and cognitive autonomy during adolescence, in combination with Savin-Williams and Jaquish's behavior checklist for self-esteem (Savin-Williams & Jaquish, 1981).

Coding was done in the program The Observer XT 10.5. Each utterance and action observed in the video-recorded interaction was coded, based on a combination of the adolescents' facial expressions, body posture, intonation, and verbalizations.

Coders were extensively trained until 75% agreement between the trainee and the trainer was reached based on the unaggregated time series for each measure. Average between-observer reliability based on explained variance between the two time series was $R^2 = .79$ for behavior and $R^2 = .81$ for affect.

3.5.4 Measures

Phenomenological state self-esteem indicators.

The following measures were obtained by means of coding:

Self-affect is self-directed affect. Both positive self-affect and negative self-affect were scored. Positive self-affect was scored on a scale of 0 to 3, which includes 0 = neutral, 1 = self-interest (e.g. adolescent speaks enthusiastically about an idea she/he has), 2 = humor (e.g. adolescent laughs in self-assured manner while speaking/behaving), 3 = pride (e.g. adolescent compliments him-/herself). Negative self-affect was scored on a scale of 0 to -3, which includes 0 = neutral, -1 = embarrassment (e.g. adolescent speaks with eyes cast down), -2 = anxiety (e.g. adolescent fidgets and avoids eye contact while opposing parent), -3 = shame (e.g. adolescent speaks in sad and serious tone during self-invalidation). Conflicting self-affect could be coded (i.e., simultaneous positive and negative scores) when verbal and nonverbal expressions of self-affect conflicted, for example, if an individual verbally expressed positive self-affect by complimenting himself (e.g. "I'm always right") while nonverbally expressing embarrassment (i.e., looking downwards and speaking in a soft voice). Positive or negative *self*-affect could be distinguished from positive or negative emotional experiences of the parent or the general interaction based on the timing of the action or utterance. For example, if a child said something and then smiled directly afterwards, this was coded as self-affect because it is clear that the smile is directly related to something that the *child* said/did. If, on the other hand, the child smiled after the *parent* said something, this was not coded as positive self-affect.

Autonomy was scored on an ordinal scale of -2 to 3[13], where -2 = submission (e.g. adolescent changes opinion in accordance with what parent thinks without being offered counter arguments), -1 = attitudinal heteronomy (e.g. adolescent expresses not knowing the answer to a question that does not require specific knowledge), 0 = neutral, 1 = attitudinal autonomy (e.g. adolescent contributes an idea), 2 = agency (e.g. adolescent initiates a change in discussion topic), 3 = self-assertion/confrontation (e.g. adolescent rejects accusation made by the parent).

Self-Experiential Incoherence was scored after coding took place for each moment during the interaction that was coded. Self-Experiential Incoherence is taken into consideration in the calculation of state self-esteem, alongside Self-affect and Autonomy (see State self-esteem calculation, below) in order to ensure that expressions of positive state self-esteem are genuine (Kernis, 2003; Ryan & Brown, 2003) (see Introduction). Self-Experiential Incoherence was scored on a scale of 0 to 3, and is equal to the sum of instances at t_x in which self-experiences contradict themselves (based on the coded measures above), and in which other-directed affect contradicts itself. In order to determine whether other-directed affect contradicts itself, positive and negative measures of *Connectedness* were included as a third observational measure (see below). In Table 1 the three possible instances of Self-Experiential Incoherence at t_x are outlined, based on the rationale outlined by Kernis (2003).

Connectedness is other-directed affect, which was scored for the adolescent during or directly following the *parent's* utterance or action. Both positive and negative connectedness were scored. Positive connectedness was scored on a scale of 0 to 3, which includes 0 = neutral, 1 = other-interest (e.g. adolescent smiles while parent speaks), 2 = other-joy (e.g. adolescent laughs while/after parent speaks/acts), 3 = affection (e.g. adolescent hugs parent). Negative connectedness was scored on a scale of 0 to -3, where 0 = neutral, -1 = other-disinterest (e.g. adolescent looks away and turns body away while parent speaks), -2 = other-frustration (e.g. adolescent responds to parent with whining tone), -3 = contempt (e.g. adolescent expresses hurtful comment in sarcastic tone). Positive and negative connectedness could be simultaneously scored if verbal and nonverbal expressions conflicted. An example of this is if an adolescent verbally expresses connectedness by laughing when the parent tells a joke, while expressing a hurtful comment in a sarcastic tone.

Table 1
Possible instances of Self-Experiential Incoherence

[13] The autonomy scale is not symmetrical as there were more categories for autonomous behavior compared to heteronomous behavior.

Mismatch of simultaneous codes	**Theoretical rationale**
Positive self-affect and negative self-affect	Lack of trust in internal processes
Positive connectedness and negative connectedness	Not being genuine in relationships
Negative autonomy and positive self-affect	Dissonance between behavioral expression and internal processes

Note: The Self-Experiential Incoherence score is a sum of the number of instances of Self-Experiential Incoherence simultaneously present at t_x

Self-report self-esteem measures.

Self-report state self-esteem was collected as a static score of the individuals' state self-esteem directly after the video-recorded interaction took place. After reading the question "How do you feel at this moment", adolescents were asked to answer by responding to the statement "In general I like myself". The degree to which the adolescent agreed with this statement was indicated by marking an X on a horizontal line where 0.0 = "I disagree" and 8.5 = "I agree" (see Ninot, Fortes, & Delignières, 2001).

Self-report trait self-esteem was measured (before the video-recorded interaction took place) using the Rosenberg (1979) self-esteem scale, including 10 questions regarding individuals' feelings toward themselves in general (e.g., "I take a positive attitude toward myself"). Trait self-esteem was measured on a Likert scale from 1 to 5 (1 = very true, 5 = not at all true).

Self-report autonomy was measured (before the video-recorded interaction took place) using a questionnaire that measured three categories of subjective and context-independent autonomy: Attitudinal autonomy (one's ability to make decisions, and define opinions and goals), emotional autonomy (a feeling of confidence in one's own choices and goals), and functional autonomy (the ability to develop a strategy to achieve one's goals; Noom et al., 2001). The three categories of autonomy were measured on a Likert scale from 1 to 5 (1 = never true, 5 = almost always true). The general level of autonomy is equal to the average of the three categories.

3.5.5 Analysis Plan

State self-esteem calculation.

State self-esteem (SSE_t) was calculated as the sum of the behavioral and affective expressions of self-experience at t_x (i.e., Autonomy and Self-affect) on an ordinal scale of -5 to 6. SSE was calculated for every second of the interaction. When no scores were given for either Self-affect or Autonomy, SSE_t= 0 (i.e., neutral). This was the case for moments in which the adolescents did not say or do anything. A positive SSE_t score was only given if the simultaneous score for Self-Experiential Incoherence = 0. This is in accordance with our focus on *genuine* expressions of positive state self-esteem (see Introduction). The calculation for SSE_t was conducted in Microsoft Excel (Version 2010), and is described by the following formula (1):

$$SSE_t = \begin{matrix} (SA_t + AU_t)\ ;\ if\ (SA_t + AU_t > 0)\ and\ (SEI_t = 0); otherwise, \\ 0 \end{matrix} \quad (1)$$

Where SA_t is Self-affect, AU_t is Autonomy, and SEI_t is Self-Experiential Incoherence at t_x.

The additive model reflects the dynamic nature of self-experience (see Introduction), as well as our conceptualization that autonomous and emotional self-experiences carry equal weight in the emergence of state self-esteem.

Hypothesis 1: analysis of temporal structure of state self-esteem.

Detrended fluctuation analysis (DFA; Peng, Havlin, Stanley, & Goldberger, 1995) was applied to each state self-esteem time series. This technique is especially useful for testing the temporal structure of variability when time series are non-stationary and/or relatively short (< 1024 data points). In our sample, the length of the time series ranged from 487 data points to 1708 data points.

The DFA reveals a relation between different window sizes of data and the average fluctuation of the windowed data. More specifically, state self-esteem time series were divided into non-overlapping windows of equal length. The best fitting trend line was then determined, and the root mean square residual (average fluctuation) was calculated. This was repeatedly done for windows of different sizes (from 4 data points to ¼ of the length of the entire time series). This means that for each time scale (i.e., window size), the average fluctuation was determined. By examining the relationship between window sizes and their respective level of fluctuations, the temporal structure of the fluctuations can be determined. This relationship (the average fluctuation against increasing window-sizes) can be plotted on a log-log plot, whereby the slope indicates a DFA exponent. A DFA of 0.5 reflects Gaussian white noise (i.e., a highly random structure), a DFA of 1.5 reflects Brown noise (i.e., a highly rigid structure), and a DFA of 1.0 reflects pink noise (i.e., long-range correlations and fractal scaling; Hasselman, 2013; Wijnants et al., 2012).

To statistically test whether the empirical state self-esteem time series are characterized by a fractal structure rather than by a random structure, we tested whether the DFA dimensions obtained from the original state self-esteem time series were significantly different from the DFA dimensions obtained from surrogate time series that function as a control group (Hausdorff et al., 1995), using a paired-sample t-test. The surrogate time series were created by shuffling the order of data points within each observed state self-esteem time series (i.e., within individuals) with a random permutation. A new time series is thus created that contains the same data points, but in a random order. The shuffled time series therefore have the same mean and SD as the observed time series, but there is no carry-over effect from one moment to the next, simulating state self-esteem variability that is likely to exhibit white noise.

Hypothesis 2: association between temporal structure of state self-esteem and self-reported self-esteem measures.

To explore the relationship between the temporal structure of state self-esteem variability and the traditional measures of state self-esteem level, we calculated the Pearson correlation between DFA and self-reported state self-esteem and trait self-esteem.

Hypothesis 3: association between temporal structure of state self-esteem and context-independent autonomy.

To explore the relationship between the temporal structure of state self-esteem variability and the adolescents' context-independent autonomy levels, we calculated the Pearson correlation between DFA and autonomy (on average as well as for the three categories of autonomy separately).

3.6 Results

3.6.1 Analysis of Temporal Structure of State Self-esteem

The average SSE level across all individuals was *M* = .49 (*SD* = 0.98), based on all seconds in the time series. The length of the time series was *M* = 911.46 seconds (*SD* = 322.67). Figure 2 below shows a representative example of a SSE time series.

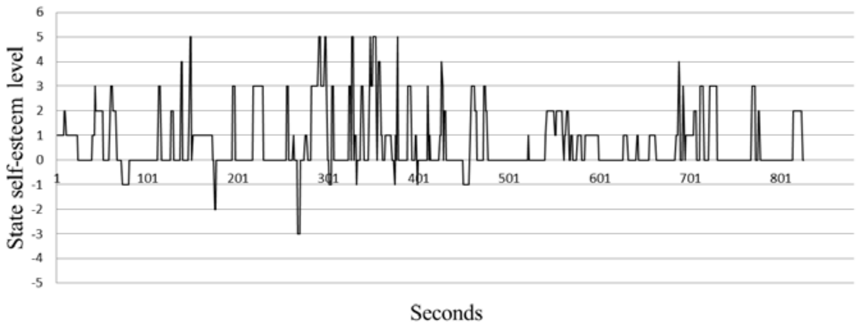

Figure 2: Example of a SSE time series based on the empirical data.

Figure 3 shows a log-log plot of the relationship between the log of the average fluctuation (Q) and the log of the window size (points in subset). The straight line indicates that there is a linear relationship, such that fluctuations in smaller windows are related to fluctuations in larger windows in a power-law fashion. The slope of the line indicates the scaling exponent, i.e., DFA = 0.89.

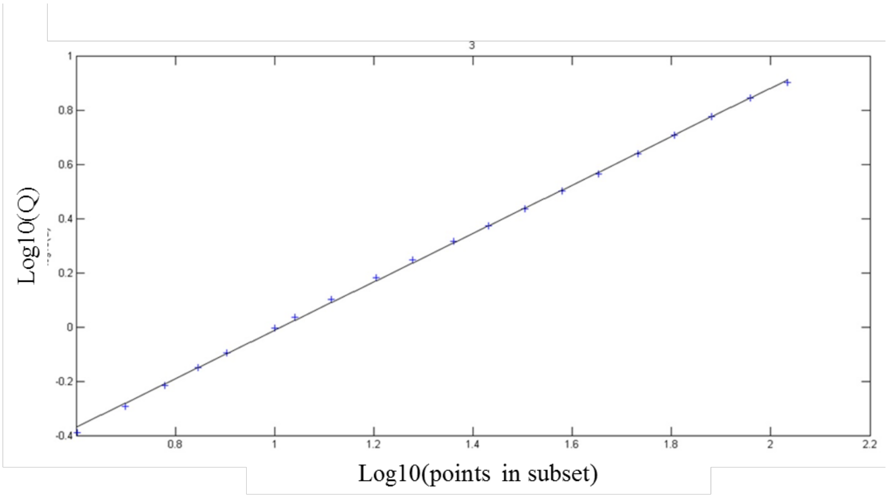

Figure 3: Example of a log-log plot of average fluctuation (Q) versus window size (points in subset) based on the empirical data. Slope (DFA exponent) = 0.89.

On average, the DFA exponent of the empirical state self-esteem time series was *M* = 0.81 (*SD* = 0.05). The lowest DFA score was 0.74, while the highest was 0.90. The temporal structure of state self-esteem variability is therefore close to pink noise, i.e., DFA ~ 1.0. The DFA values were weakly correlated with the standard deviations of the SSE time series (*r* = .14), indicating that the nature of the temporal variability of state self-esteem (i.e., DFA) is distinct from the magnitude of variability of state self-esteem (i.e., SD).

The average DFA exponent for the participants' shuffled SSE time series was *M* = 0.49 (*SD* = 0.03), indicating uncorrelated randomness very close to white noise, i.e., DFA ~ 0.5 (see Figure 4 for an example of a shuffled SSE time series).

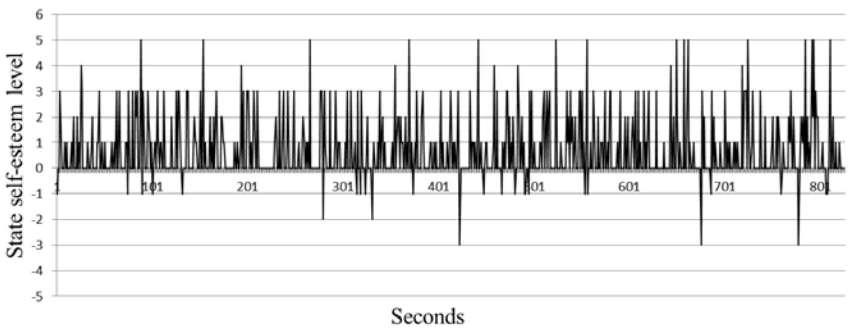

Figure 4: Example of a SSE time series based on the shuffled data.

The mean DFA scores of state self-esteem for the empirical (non-shuffled) time series and the surrogate (shuffled) time series are shown in Figure 5. The 95% confidence intervals (CI) shown in Figure 5 indicate that the DFA level indicating white noise (i.e., DFA ~ 0.5) falls within the CIs of the shuffled time series, but that this is not the case for the CIs of the empirical time series.

The difference between the mean DFA score for the shuffled and empirical time series was M = 0.32, which was significant ($t(12) = 17.29$, $p < 0.001$). We can therefore conclude that the observed SSE time series are closer to pink noise than would be expected if the time series were random, which supports *hypothesis 1*.

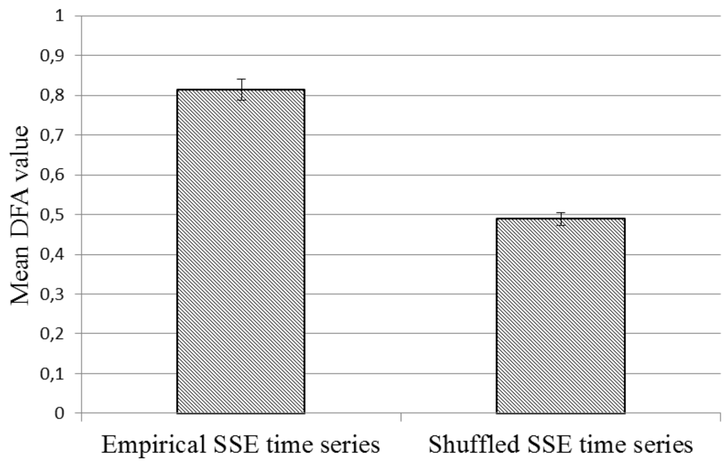

Figure 5: Mean DFA scores and 95% confidence intervals for state self-esteem (SSE) for empirical time series and for random (shuffled) time series. DFA ~ 0.5 = white noise and DFA ~ 1.0 = pink noise

3.6.2 Association between Temporal Structure of State Self-esteem (DFA) and Context-Independent Self-reported Autonomy Measures

Self-esteem.

The average self-report state self-esteem score was M = 5.94 (SD = 1.65), and the average self-report trait self-esteem score was M = 4.03 (SD = 0.57). The two measures of self-esteem were moderately correlated (r = 0.36). Neither of the static measures of self-esteem correlated significantly with the DFA values. For trait self-esteem, the correlation with DFA was r = -.52 (p = 0.07), and for state self-esteem the correlation with DFA was r = -.06 (p = 0.86). The lack of significant correlations between DFA and static self-esteem measures indicates that the temporal structure of state self-esteem variability is a distinct concept from the static levels of self-esteem, which is in support of *hypothesis 2*.

Autonomy levels.

Table 2 presents the means and standard deviations of the self-reported autonomy levels of adolescents, as well as their correlation with the DFA scores.

Table 2
Means and Standard Deviations (SD) for self-report autonomy levels, and their correlation with the DFA values for the SSE time series

Autonomy variable	Mean	SD	Correlation with DFA
Child autonomy (average)	3.43	0.57	0.25
Child attitudinal autonomy	3.43	0.74	0.16
Child emotional autonomy	3.45	0.71	0.30
Child functional autonomy	3.41	0.57	0.16

The relationship between DFA scores and autonomy measures was positive, indicating that the higher the DFA values (i.e., the closer to pink noise), the higher the levels of autonomy. Correlations were small to moderate, however, and were not significant ($p > .05$), which is partly in support of *hypothesis 3.*

3.7 Discussion

In the current article, we argued that the common assumption regarding state self-esteem (as contextually-based error around a baseline level of trait self-esteem) does not fully reflect the temporal nature of state self-esteem variability. We suggest that the coordination of state self-esteem is predominantly determined by its own interaction dynamics, thereby producing structured and meaningful temporal variability across real time. Our argument is based on the fact that other human processes that are determined by such dynamics are ubiquitously found to exhibit structured noise, i.e., pink noise (Stanley et al., 1993).

We found that the variability of state self-esteem across real time must indeed be characterized as (approaching) pink noise. Moreover, we show that this structure of variability is significantly different from the structure of variability that would be exhibited if state self-esteem was characterized by random fluctuations with no carry-over effect from one moment to the next, i.e., white noise. This was in support of our main hypothesis (*hypothesis 1*). In addition, we found that the temporal structure of state self-esteem is a distinct concept from the valence level of (state and trait) self-esteem, which was in support of *hypothesis 2*.

For hypothesis 1, we explicitly tested the specific assumption that there is no carry-over effect from one moment to the next, which – if true – should result in random variability of state self-esteem (i.e., white noise). Although it seems clear that the commonly adopted ‘barometer’ approach to state self-esteem corresponds with a white noise hypothesis, one may argue that this interpretation of the underlying assumption is too strict. Specifically, it may be argued that the ‘barometer’ approach allows for the assumption that there is short-term carry-over effect across state self-esteem, due to – for example – continuity in the immediate context. In this case, the time series would exhibit only short-term correlations that rapidly decay across time; or in other words, Brown noise (see Figure 1c). Although we did not explicitly test this alternative hypothesis, our finding was that state self-esteem variability was close to pink noise, where the small deviations from pink noise were in the direction of white noise, and *not* in the direction of Brown noise (recall that Brown noise is at the opposite end of the noise spectrum from white noise, where pink noise lies between the two). It is therefore highly unlikely that there are only short-term carry-over effects across our state self-esteem time-series.

The above results have significant theoretical and methodological implications. We show that the nature of state self-esteem variability is less straightforward than was perhaps formerly assumed. Specifically, the presence of pink noise is indicative of a fractal process, which has underlying interaction-dominant dynamics. An important implication of this is that state self-esteem is active, rather than passive, in that it self-coordinates by balancing between self-maintained stability and flexible adaptations to external influences.

Furthermore, the presence of pink noise in state self-esteem fundamentally questions the appropriateness of single-scale measures of state self-esteem. Such measures are static by nature, as they are limited to the measurement of state self-esteem *levels* (Scheff & Fearon, 2004). However, if high-level psychometric concepts that are central to psychological theory – such as self-esteem – have a *dynamic* nature, this suggests that “behavior cannot be adequately measured with statistics based simply on mean and variance” (Lipsitz, 1992, p. 1807), and that measures are needed that also capture the level of ‘complexity’ of these concepts, that is, the extent to which they reveal coupling of multiple components or of time scales. This is not to say that measures of mean and standard deviation are not of value. Instead, our results call for a broader methodological approach to state self-esteem, where both the magnitude *and* structure of state self-esteem variability are meaningful, but distinct, characteristics to be studied.

In our study, all individuals’ state self-esteem time series approached pink noise. Moreover, the participants in our study were all psychologically healthy and well-adapted adolescents. This corresponds with the notion that pink noise is a signature of healthy, efficient, and well-coordinated behavior. Furthermore, our results showed that the level of pink noise was associated (albeit weakly) with adolescents’ context-independent autonomy levels (a pivotal indicator of positive psychosocial adjustment during adolescence; Noom et al., 1999). Specifically, higher DFA scores (i.e., closer to pure pink noise) were associated with higher emotional, attitudinal, and functional autonomy scores, although the correlation was not significant. This was partially in support of *hypothesis* 3. Future research is needed to explore which psychological concepts are highly associated with the temporal structure of variability in order to provide more clarification regarding its psychological meaning.

A few important limitations of the current study warrant noting. First, as there were no large deviations from pink noise in our sample, it is only possible for us to speculate about what deviations from pink noise might mean for state self-esteem. Previous research shows that deviations toward white or Brown noise indicate unhealthy systems (e.g., Gilden & Hancock, 2007). Therefore, it is likely that deviations in the context of state self-esteem would be indicative of maladaptive self-esteem; where deviations toward white noise indicate overly flexible state self-esteem and deviations toward brown noise indicate overly rigid state self-esteem. While past research has focused on maladaptive self-esteem as being low (e.g., Robson, 1988), unstable (based on the magnitude of the standard deviations; e.g., Kernis, 2005), and fragile (e.g., Zeigler-Hill, 2006), it is plausible that the temporal structure of state self-esteem may also be an important tool for identifying individuals with maladaptive state self-esteem. To explore this possibility, future research is needed regarding the temporal structure of state self-esteem in more heterogeneous samples, or in clinical samples.

A second limitation of the current study is that our sample does not include age groups other than adolescents, which means that it may not be possible to generalize our findings to other age groups. The adolescent period can been characterized as ‘unstable’ regarding self-esteem, where adolescents demonstrate a dip in the average valence of self-esteem (Robins et al., 2002) as well as relatively low test-retest correlations of self-esteem (Trzesniewski et al., 2003). Future research is therefore necessary in order to investigate whether state self-esteem variability is more structured (i.e., with smaller deviations from pink noise) in adults compared to adolescents, and more generally, whether the temporal structure of state self-esteem differs on average across the life span.

Third, it was beyond the scope of the current article to explore the temporal dynamics that occur in the interaction between the parent and the child, and how these dynamics relate to the temporal dynamics of state self-esteem. Future research is needed in order to investigate how the two are related.

In summary, while the general level of state self-esteem variability is regarded as meaningful (Kernis et al., 1993), our findings show that the temporal *structure* of state self-esteem variability has been unnecessarily disregarded (as ‘random’) in empirical studies of state self-esteem. Our results bring the passive and random nature of state self-esteem into question, and provide evidence that state self-esteem, as a real-time process, might be better conceptualized as an intrinsically dynamic and active process. This is an important shift in the theoretical conceptualization of the nature of state self-esteem. Based on our findings, we call for a broader methodological approach to state self-esteem, where measures of complexity are combined with measures of central tendencies (standard deviations and means). We hope that these theoretical and empirical implications will be further explored in future research.

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