The state-trait sense of self inventory: A psychometric study of self-experience and its relation to psychosis-like manifestations

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A B S T R A C T

The sense of self is a fundamental construct in the study of the mind, yet its psychological nature remains elusive. We introduce a novel 25-item inventory to investigate selfhood both as an enduring trait and a temporary state. We hypothesized two foundational aspects of the self: identity (related to self-referencing and continuity over time) and agency (the perception of controlling own's actions and thoughts). Results from two population studies highlight a singular self-trait factor combining agency and identity. In contrast, self-state measures revealed a bifactorial structure with a high-order factor and three lower-order subfactors: state-identity, state-agency, and state-technology. These factors were predictive of psychosis-like experiences, schizotypal traits, and hopelessness. Mediation analysis demonstrated that the negative association between the sense of self and hopelessness is mediated by depressive manifestations. Our research provides a tool to shed new light on the complexity of the sense of self and its mental health implications.

1. Introduction

The sense of self regards the first-person experience of conscious life. A basic form of the self concerns a pre-reflective, implicit level of self-experience that is intrinsically embedded in the world through action and perception (Zahavi, 2008; Gallagher, 1986). Such a foundational level of selfhood is also called the minimal self or ipseity (Nelson, Parnas, and Sass, 2014). The notion of intentionality (Husserl, 1982; Brentano 1874) further suggests that consciousness always has a target such as, for instance, something in the external world, bodily perceptions, emotions, mental contents, or thoughts (Searle, 1992). Intentional consciousness is a non-momentary, self-referential process within a temporal structure (Klar and Northoff, 2021). As proposed by the French philosopher Maurice Merleau-Ponty (1945), self-experience encloses relatedness among our situational presence, our past, and our future, providing coherent self-experience over time and allowing a sense of agency.

Two main components can be distinguished from this perspective on the sense of self (Vanhaudenhuyse et al., 2011). Primarily, the first-person perspective that all experience is my experience allows an elementary sense of identity depending on (i) self-referential processing and the (ii) temporal integration of self-experiences (Scalabrini et al., 2022; Van der Meer et al., 2010; Damasio, 1998). Secondly, the subjective sense that "I control my actions and thoughts" and "I am aware of their consequences", establishes a fundamental sense of agency (Haggard, 2017; Kircher and Leube, 2003; Gallagher, 2000). The distinction between these self-features

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tallies with the description of the self as composed of the "Me" as the knowing subject and the "I" as the subjective agent who interacts with the environment (James, 1890; Christoff et al., 2011). Integral to the conceptualization of the sense of self is the sense of ownership). Whereas body ownership relates to whether a body part or whole body is experienced as 'mine', experiential ownership concerns the 'mineness' of first-person, subjective experiences (Blanke and Metzinger, 2009; Tsakiris, 2010). Although agency and ownership often coincide, the relationship between these two aspects of self-consciousness is complex and has been the subject of research (Liang et al., 2021). In essence, the "sense of self" materializes as the experiential sum of these characteristics (Gillihan and Farah, 2005), and is underpinned by distinct yet interconnected neural mechanisms (Di Plinio et al., 2020).

Various psychometric instruments have been developed to specifically assess the sense of agency (Asai et al., 2008; Polito et al., 2013; Tapal et al., 2017), temporal continuity of selfhood (Sokol and Serper, 2019), or self-reflection (Rosenberg, 1965; Grant et al., 2002). Other instruments include the self-efficacy scale (Sherer et al., 1982) and the locus of control scale (Rotter, 1966) for agency-related constructs. The embodied sense of self scale addresses the sense of self more comprehensively (Asai et al., 2016), but focuses on abnormal experiences and puts a temporal extension outside the concept of the minimal self as based on narrative and memory, whereas a temporal structure is inherent to implicit consciousness (Vogeley and Kupke, 2007; Parnas et al., 2005). The inventory of psychotic-like anomalous self-experiences (Cicero et al., 2017) also assesses anomalous self-experiences as based on the examination of anomalous self experience semi-structured interview (Parnas et al., 2005), evaluating disturbances in cognition, consciousness, self-awareness, and somatization, and displayed strong psychometric qualities in various studies (Pionke-Ubych et al., 2021; Nelson et al., 2019). Critically, these questionnaires do not provide distinct measures of states and traits. Given that the sense of self can change with psychopathology (Jeannerod, 2009; Basten and Touyz, 2019), social interaction (Ohata and Tani, 2020), experimental manipulations (Haggard, 2017), automation (Di Plinio et al., 2019), and human–machine interactions (Wen and Imamizu, 2022), the assessment of both self-states and self-traits is needed to allow a more integrative evaluation, considering both latent personal attributes and situational factors (Steyer et al., 2015).

The clinical need for instruments assessing the sense of self on a spectrum is emphasized by the psychopathological nature of psychotic disorders (Nelson and Sass, 2009). Self-disturbances underly schizophrenic pathology and express through symptoms including hallucinations, delusions, catatonia, thought disorder, social cognition, and lack of insight (Sass and Parnas, 2003). Accordingly, anomalies have been described in self-referential processing (van der Meer et al., 2013; Kuhn and Gallinat, 2013), sense of agency (Cermolacce et al., 2007; Frith et al., 2000), and in the functional interaction between the two constructs (Ebisch and Aleman, 2016). Interestingly, various aspects of the self can be influenced by constant interactions with devices, social media, and virtual identities, for example reducing the individual sense of agency (Di Plinio et al., 2019). The effect of devices on the sense of self is an evolving area of study, with implications for mental health, social interaction, and identity formation in the digital age (Cramer, 2018; Hampshire et al., 2021; Pelau et al., 2021). When interacting with technological devices, cognitive properties critically hinge on factors related to our embodiment (Haugeland, 1998; Clark and Chalmers, 1998; Gallagher, 2000) since software applications can cover or mediate cognitive functions. Finally, online social interactions can influence self-identity (Gonzales and Hancock, 2011) and cause social isolation (Primack et al., 2017), raising questions about the authenticity of the self in digital spaces.

Aberrant self-processing can emerge before, and can predict, the onset of psychotic symptoms (Sass and Parnas, 2003; Nelson et al., 2012; Schultze-Lutter, 2009). Furthermore, it's worth noting that psychotic-like experiences are not confined to clinical populations but are distributed across the general population as well (Stefanis et al., 2002). Additionally, self-disturbances can be linked to other clinical conditions such as depression (Davey and Harrison, 2022) and feelings of hopelessness (Benson et al., 2013). Recent insights suggest that the self is experienced differently in depression, often structured by negative self-related thoughts, pervasive low mood, lack of volition, and a preoccupation with self-deficits (Ratcliffe, 2015). Notably, depression and hopelessness are predictors of psychotic symptoms (Kelleher et al., 2013) and suicide risk (Pompili et al., 2022). Depressive and psychotic conditions during adolescence have significant immediate and long-term adverse consequences, including increased risks of suicidal thoughts and behaviors, and difficulties in education and employment (Hards et al., 2023). Given these insights, it becomes crucial to develop a psychometric tool capable of measuring individual differences in fundamental aspects of self-experience within the general population to help understanding the involved psychological mechanisms.

The present study aimed to develop the state-trait sense of self inventory (st-SoSI), an original self-report questionnaire consisting of items assessing multiple aspects of an individual's pre-reflective sense of self from an ipseity perspective, considering the subjective agent's natural embeddedness in the environment and temporal extension (Vanhaudenhuyse et al., 2011; Ebisch and Aleman, 2016; Di Plinio et al., 2020). The questionnaire underwent a two-step psychometric calibration process, beginning with item generation and exploratory factor analysis in a random population sample, followed by validation in an independent sample. Convergent validity was assessed by administering the final st-SoSI alongside measures of psychosis-like experiences, schizotypal personality traits, sense of agency, and hopelessness. Divergent validity was evaluated using measures of empathic experience traits. On a pre-reflective level, self and empathy are strongly intertwined phenomena, but which can nevertheless be considered distinguishable to some degree (Zahavi, 2015; Kyselo, 2014). The authenticity of self-experience and the notion that intersubjectivity entails the experience of otherness has been recognized in many definitions of the empathy concept (e.g., Stein, 1989; Gallese, 2014). Moreover, empirical findings suggest that they could be independently impaired in certain disorders and be linked to partially distinct neural mechanisms (Ebisch and Aleman, 2016; Singer et al., 2004). Our hypotheses included the identification of subordinate factors reflecting agency and identity, as well as a superordinate factor representing a general sense of self emerging from the integration of multiple self-features. Furthermore, we anticipated a negative correlation between feelings of hopelessness and the sense of self in the general population, potentially mediated by psychosis-like experiences.

2. Methods

2.1. Participants

Participants in this study were recruited from the adult general Italian population through vouchers and posters distributed in public places as well as with online advertisement on social media. The participation was voluntary and anonymous. The link and QR codes distributed led to an online survey built using Qualtrics XM (Provo, UT). Informed consent was obtained from all participants after a comprehensive explanation of the survey and of the study procedure in line with the Declaration of Helsinki (2013). The Local Ethics Committee approved the experimental protocol.

Two different samples were used for the construction and validation of the Sense of Self Inventory. The first sample (study 1: construction sample) included 537 participants among which 464 completed both versions of the SoSI and 537 completed the Trait version. The first sample allowed us to construct the definitive st-SoSI. The second sample (study 2: validation sample) included 342 participants which filled the definitive st-SoSI. Sociodemographic information of the two samples is reported in Table 1.

2.2. Item construction

The initial version of the questionnaire comprised 40 items on "trait" and 40 items on "state" in Italian language. These 80 items were constructed according to a multidimensional conceptualization of the sense of self, as indicated by both psychological literature and neuroscientific evidence (as described in the Introduction). Thus, two main latent dimensions of the sense of self were taken into consideration. The first dimension entailed the identity aspect of the sense of self, encompassing the subjective encoding of oneself as a distinct being with personal autobiographical background. The second dimension encompassed the subjective sense of agency, which is related to the extent to which an individual feels in control of her/his actions, feelings, and thoughts and of the consequences of such actions.

More specifically, items included how much the participants feel in control over their own actions, emotions, and thoughts, how much the participants feel that their identity is stable over time, how much the participants are able to identify themselves through their senses (e.g., voice, body image, face image, emotions), how much the participants feel in control of their body movements, how much the participants feel in control and responsible for the consequences of their actions, how much participants' interactions with electronic devices disrupt their self-awareness.. Example items are: "I *feel that I am in control of my actions*"; "*My identity is stable*"; "*I feel as if my emotions are not real*"; "*When I use electronic devices, I perform actions without wanting to*".

Before the administration to the participants, the items were presented to five Italian psychologists and psychometrists to help evaluating their lexical clarity and their conceptual validity. Appropriate corrections were made to the items to improve their accuracy.

Table 1
Sociodemographic information on the participant samples.

	Sample 1 (EFA)		Sample 2 (CFA)	
	N	%	N	%
Gender				
Female	374	80.60 %	262	76.61 %
Male	89	19.18 %	75	21.93 %
Non-Binary	1	0.22 %	5	1.46 %
Occupation				
Student	210	45.26 %	146	41.48 %
Temporary Job	76	16.38 %	43	12.22 %
Stable Job	145	31.25 %	141	40.06 %
Unemployed	33	7.11 %	22	6.25 %
Psychiatric diagn.				
Yes	–	–	47	14 %
No	–	–	295	86 %
Neurologic diagn.				
Yes	–	–	18	5 %
No	–	–	324	95 %
Drugs consumpt.				
Yes	–	–	29	8 %
No	–	–	313	92 %
Age				
Mean ± St. Dev.	29.8 ± 10.1		30.7 ± 9.1	
Range	[18, 71]		[18, 62]	

2.3. Study 1: Construction of the st-SoSI

Participants filled in the questionnaire online through the Qualtrics platform. Items were valued by each participant on a discrete scale ranging from 1 to 9. For each question, the lower score (1) was labelled "*disagree*", the intermediate score (5) was labelled "*neither agree nor disagree*", and the higher score (9) was labelled "*agree*".

Exploratory factor analyses (EFA) were separately run on trait and state questionnaires after the removal of extremely skewed items. The removal of skewed items is essential to retain only informative items, grant multivariate normality, allow better interpretation, and avoid biasing the covariance matrix (Fabrigar et al., 1999). To investigate the appropriateness of the sample size in our study, we used a Monte Carlo measurement of the Tucker's congruence coefficient in factor analysis (de Winter, Dodou, & Wiering, 2009; Korth & Tucker, 1976; Lorenzo-Seva & ten Berge, 2006; see also Di Plinio et al., 2019, 2020). We divided our original sample of 464 participants into two random subsamples and conducted independent factor analyses on each. This process was iteratively repeated 1,000 times, each time with varying sample sizes ranging from 40 to 230. In every cycle, we calculated the Tucker's congruence coefficient (K) to compare the factors derived from both subsamples. We then averaged the K values for each sample size category and used a hyperbolic function to predict the K value specific to our total sample size (N_{tot}). We proceeded with a separate EFA for State and Trait because the scales were formulated using parallel sentences, and combining identical sentences would compromise the integrity of the factorial procedure. Adequacy of the correlation matrix for factor analysis was investigated with Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) test. Adequacy of the correlation matrix is suggested by a significant Bartlett's test ($p < 0.05$) and a KMO index > 0.70.

The EFA was run using the following characteristics. Prior to the factor analysis, a parallel analysis (PA) (Horn, 1965; Ledesma and Valero-Mora, 2007) was employed to select the number of factors to use in the factor analysis. PA uses a Monte Carlo statistical procedure to generate null distributions of simulated eigenvalues starting from random datasets (10,000) with the same sample size and the same number of variables as the original dataset. Then, the eigenvalues from the original factor analysis were compared with those generated using PA. The number of factors to retain for the factor analysis was selected as the number of eigenvalues above the 95th percentile from the null distribution. An oblique *parsimax* rotation was adopted for the factorization, which was implemented in the MatLab function "*factoran*". The *parsimax* rotation ensures a high interpretability of latent factors and allows for a certain degree of correlation among factors (Sass and Schmitt, 2010), which is expected given the obvious association between the sense of agency and the sense of identity.

To ensure a consistent structure of the final st-SoSI, we retained only items in which the load on latent factors (lambda) was equal or above 0.40. Additionally, we retained only latent factors which showed an internal consistency (Cronbach's alpha) equal to or above 0.80. Notably, ensuring high weights and high reliability in this step is crucial to ensure high measurement precision, high replicability, low measurement error, and high predictive validity of the final scales of the questionnaire (Nunnally, 1978; Costello and Osborne, 2005; DeVellis, 2016).

2.4. Study 2: Validation of the st-SoSI

The final version of the st-SoSI (25 items) was administered to the second sample along with the following questionnaires. The Community Assessment of Psychic Experiences (CAPE) consists of 42 items and assesses the extent of psychosis-like experiences in healthy population (Konings et al., 2006). The CAPE includes three subscales: positive symptoms (20 items), negative symptoms (14 items), and depressive symptoms (8 items). The Sense of Agency Scale (SoAS) was included as it quantifies the self-perceived sense of agency (Tapal et al., 2017). The SoAS is made up of two subscales: negative agency (7 items) and positive agency (6 items). The Schizotypal Personality Questionnaire (SPQ) was included to measure the extent of schizotypal dimensions in healthy subjects (Fossati et al., 2003; Raine, 1991). The SPQ comprehends three subscales: cognitive-perceptual schizotypy (25 items), interpersonal schizotypy (33 items), and disorganized thoughts (16 items). The Beck Hopelessness Scale (BHS) is a 20-items inventory with true–false items measuring three key aspects of hopelessness: feelings about the future, loss of motivation, and expectations (Beck et al., 1988). The total BHS score is calculated as the sum of "true" (or 1) among all the items. The Empathic Experience Scale (EES, Innamorati et al., 2019) includes the measures of two dimensions of intersubjective understanding processes: Vicarious Experience (15 items) and Intuitive Understanding (15 items).

Confirmatory factor analyses (CFA) were run separately on the trait and state questionnaires. Various factorial structures were tested through structural equation modelling (SEM) to investigate the best factor structure for each of the two questionnaires.

With respect to the trait-sense of self questionnaire, the following four models were tested: model 1, a mono-factorial model with a single trait-sense of self factor; model 2, a two-factor model with distinct identity and agency factors (identity and agency items were selected according to the initial item conceptualization); model 3, a hierarchical two-factor model with distinct identity and agency factors and a second-order trait factor; model 4, a bifactor model with two factors as in model 2 and with an additional factor encompassing all trait-items.

With respect to the state-sense of self questionnaire, the following five models were tested: model 1, a bifactor model with three factors as in model 3 and with an additional factor encompassing all state-items; model 2, a three-factors model including an identity factor, an agency factor, and a device-related factor (as indicated in the results from the EFA on the first data sample); model 3, a hierarchical model with three factors as above and with an additional, higher-order global factor; model 4, a one-factor state model with a single factor encompassing all the items; model 5, a two-factors model with a factor encompassing items related to identity and agency and a second factor encompassing items related with devices.

The validity of the multidimensional sense of self construct was investigated by calculating correlation coefficients between the st-

SoSI scores and the outcomes of the other questionnaires (CAPE, SoAS, SPQ, BHS, EES). We additionally tested the association of st-SoSI scores with demographic and clinical variables including age, education (levels: middle school, high school, bachelor degree, master degree, PhD), gender (levels: female, male, non-binary), occupation (levels: student, temporary job, stable job, unemployed), legal status (single, engaged, cohabitant, married), presence/absence of psychiatric diagnoses, presence/absence of neurological diagnoses, presence/absence of psychoactive drug consumption. The association with age was tested using linear Pearson correlation. The association with the remaining (categorical) demographic variables was tested using multiple one-way analyses of variance.

2.5. Mediation analysis

To further explore the influence of the sense of self on health, a mediation analysis was performed based on the lavaan software in R (Rosseel, 2012) through JASP. Since the negative effect of depression and psychosis on health including hopelessness and suicide is widely recognized, we wanted to test if hopelessness can be traced to a diminished sense of self. We used the sense of self (self-trait) as predictor in the mediation analysis. The depressive, positive and negative CAPE subscales, the Interpersonal, Disorganized, and Cognitive SPQ subscales), and confounders (gender, age) were added as mediators to estimate direct and indirect effects of the sense of self on hopelessness. The analysis was run using full information maximum likelihood. Standardized estimates were used to obtain scale-independent effect sizes. The confidence intervals for significance were then computed using the bias-corrected percentile method after bootstrapping with replacement, as suggested by Biesanz, Falk, and Savalei (2010).
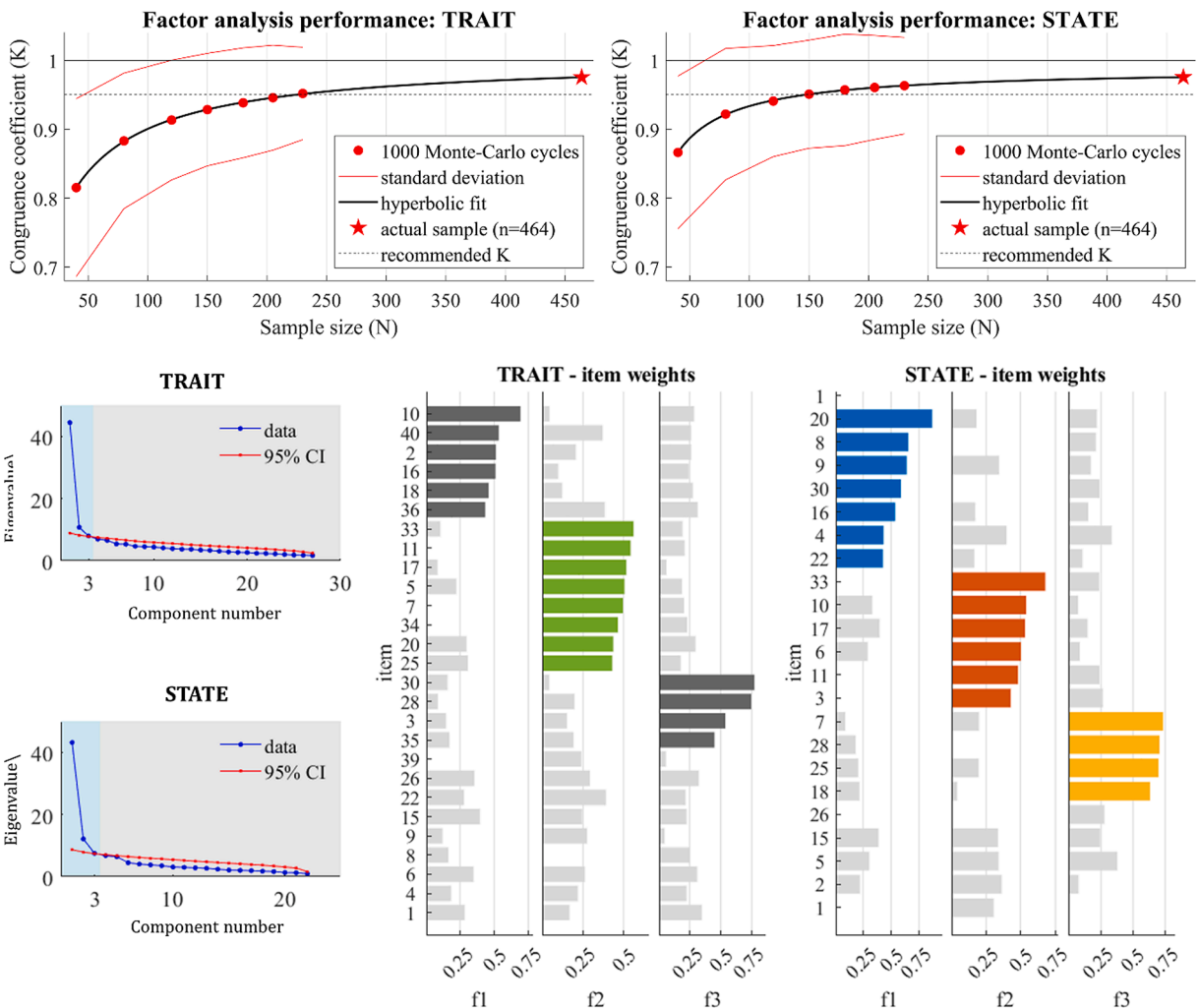

Fig. 1. Results from the Parallel Analyses and Exploratory Factor Analyses of st-SoSI item scores. Top: Results from Monte Carlo analysis of Tucker's congruence coefficient suggested a high consistency of the factor analyses. Bottom left: Results from the parallel analyses indicated three underlying factors to be retained for both trait and state data. Bottom center and right: Factor loadings of each item on the three factors for the trait and state dimensions. Items with lambda $>= 0.40$ are colored while items with lambda < 0.40 are shaded in grey.

3. Results

3.1. Study 1: Construction of the st-SoSI

With respect to the analysis of the response shape (item skewness): 13 items were removed for the trait questionnaire (items 12, 13, 14, 19, 21, 23, 24, 27, 29, 31, 32, 37, and 38); 17 items were removed for the state questionnaire (items 2, 4, 14, 17, 18, 19, 21, 22, 25, 26, 31, 33, 34, 35, 36, 39, and 40). The robustness of our sample size and the results of the factor analysis were confirmed by Monte Carlo measurements of Tucker's congruence coefficient, indicating a high level of consistency with a value higher than 0.95 (K > 0.95). This suggests that our analysis is both reliable and valid. By retaining eigenvalues above the 5 % interval, the parallel analyses suggested the existence of three factors for both the trait and state questionnaires. The correlation matrices for both trait and state dimensions were well suited for factor analysis as indicated by Bartlett's test of sphericity (trait: chi-square statistic = 7580.4; degrees of freedom, DF = 780; p < 0.001; state: chi-square statistic = 9173.0; degrees of freedom, DF = 780; p < 0.001) and by the KMO test (trait: KMO = 0.928; state: KMO = 0.943). For the trait questionnaire, we found: a 6-item factor "Trait1", an 8-item factor "Trait2", and a 4-item factor "Trait3". The 9 remaining items were not included in any of these factors (lambda < 0.40). For the state questionnaire, we found: a 7-item factor "State1", a 6-item factor "State2", and a 4-item factor "State3", while the 5 remaining items were not included in any of these factors (lambda < 0.40). These results are shown in Fig. 1.

Upon analyzing factor reliability using Cronbach's alpha, we identified high reliability in one TRAIT factor (factor 2) with an alpha > 0.80. To maintain high accuracy and consistency, we excluded the non-reliable factors (factors f1 and f3) from the TRAIT questionnaire. Conversely, all STATE factors exhibited high reliability (alpha > 0.80). To further check the reliability of these factors, we employed a Monte Carlo procedure, gauging the interdependence between the number of subjects and sample size (Fig. 2). Even with smaller subsamples, our results consistently indicated high reliability for the four final factors (trait-f2, state-f1, state-f2, and state-f3). Upon this procedure, two factors (f1 and f3) within the trait questionnaire failed to exhibit requisite levels of reliability. As a result, to ensure the robustness and accuracy of the instrument, these two factors were judiciously excluded from the final questionnaire.

In summary, our first study produced two questionnaires for the Sense of Self Inventory: one for 'trait' and another for 'state'. The
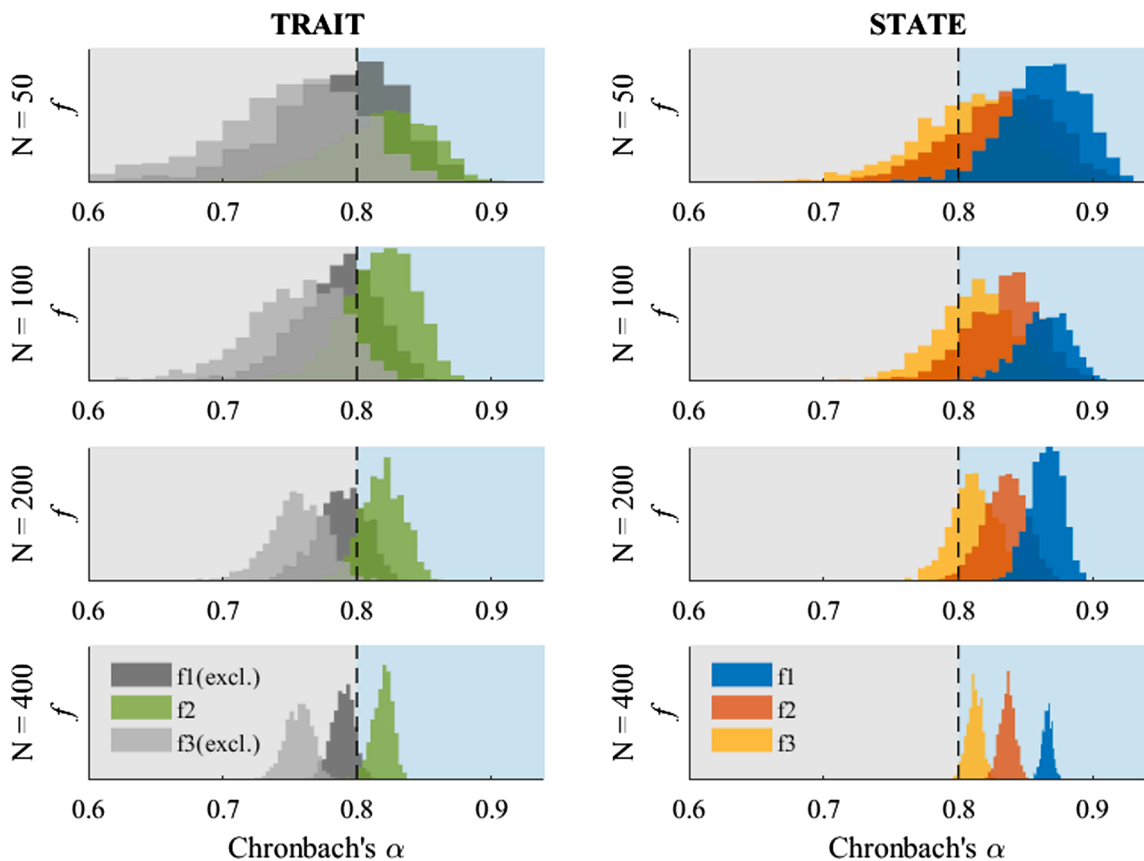

Fig. 2. Reliability of trait and state factors derived from Exploratory Factor Analysis. The figure illustrates results from the Monte Carlo procedure to assess the stability of the factor reliability (left panels: traits; right panels: state). Reliability remained high also considering sub-samples with restricted sample sizes. As expected, the reliability tended to converge on the estimated reliability scores as the sub-sample increases. Two out of three factors in the trait questionnaire (f1 and f3) did not show high reliability and were not included in the questionnaire.

trait questionnaire featured a single factor that encompassed eight items related to agency and identity. The state questionnaire, however, was more complex, comprising three factors: *Identity* (seven items), *Agency* (six items), and *Technology* (four items). Notably, the emergence of a *Technology* factor was unexpected, as we initially anticipated those items to fall under the Agency category. Average scores and item distributions for each factor in the State-Trait Sense of Self Inventory (st-SoSI) are detailed in Fig. 3. The specific items, along with their English translations provided by a native speaker, can be found in Table 2. A complete list including items removed during the construction of the st-SoSI can be found in the Supplementary Materials.

3.2. Study 2: Validation of the st-SoSI

Results with respect to the sense of self trait indicate model 1, the monofactorial model, to have high fit indices and a high factor reliability (α = 0.82, 95 % CI [0.79 0.85]). Based on these results, we selected model 1 as the best model with respect to the trait dimension of the questionnaire. The standard equation modeling results are shown in Table 3. We also examined if dropping single items would improve reliability, but the results showed that dropping any item would lead to lower reliability of the trait-SoSI.

The results with respect to the sense of self states indicate Model 3 to be the best model: a bifactorial model with three factors (7 items State-Identity, 6 items State-Agency, and 4 items State-Technology) and a general factor (17 items State-SoSI). (Table 4). Reliability was high for the general state-SoSI factor (0.91, 95 % CI [0.89 0.92]), the State-Identity factor (0.85, 95 % CI [0.82 0.87]), and the State-Agency factor (0.83 95 % CI [0.80 0.85]), while it was moderate/high for the State-Technology factor (0.75, 95 % CI [0.71 0.79]). Also in this case, the results showed that dropping any single item would not improve the reliability of any factor or subfactor.

Correlational profiles of the st-SoSI are shown in Table 5. Convergent validity was confirmed between the SoSI scales and questionnaires measuring the stability of thought patterns. More specifically, all the state-trait dimensions of the SoSI were inversely associated with psychosis-like experiences (CAPE: positive, negative, and depressive subscales), with schizotypal personality features (SPQ: cognitive, interpersonal, disorganized subscales), and with hopelessness (BHS). Additionally, the SoSI was associated with the sense of agency (SoAS: positive correlation with the positive agency subscale, inverse correlation with the negative agency subscale).
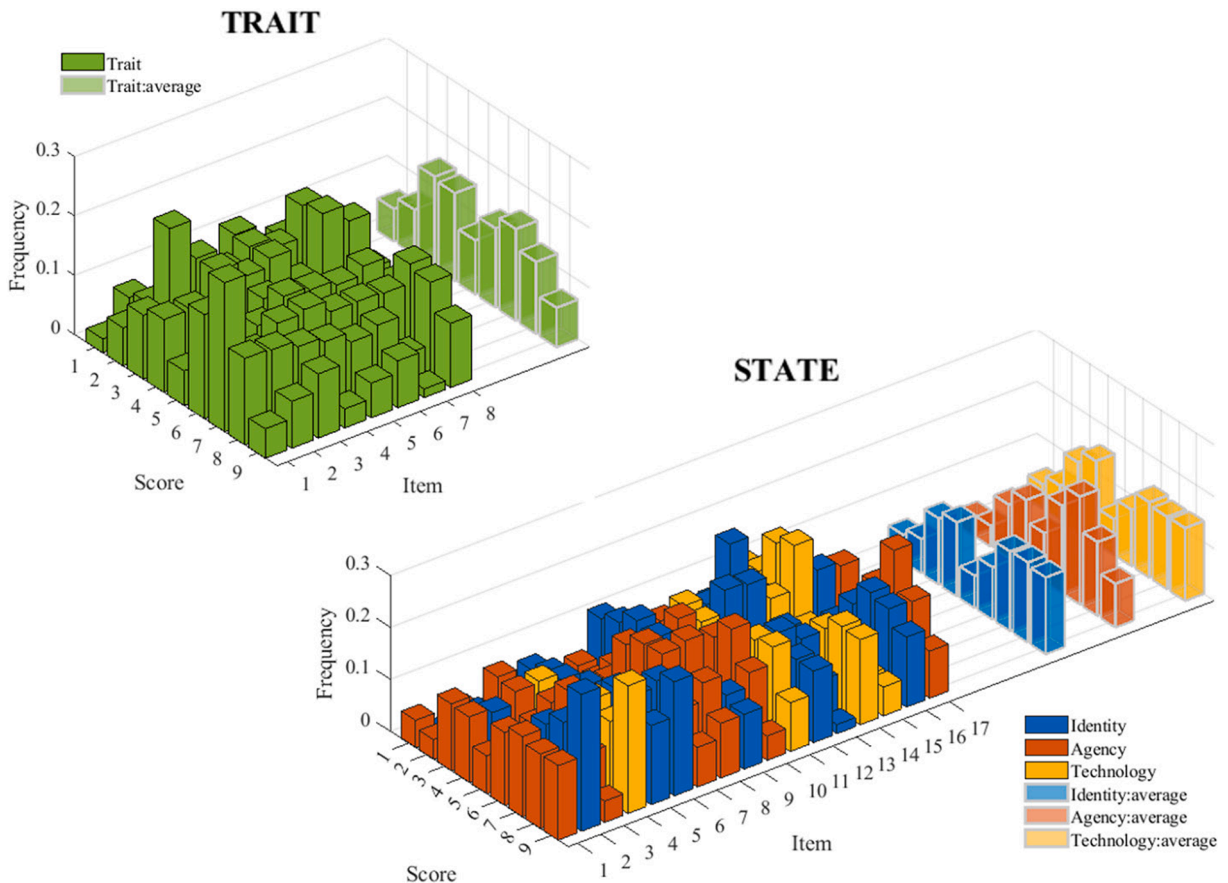

Fig. 3. Average Values of Items in the State-Trait Sense of Self Inventory. The figure illustrates the frequency distributions of each score for each item in the st-SoSI (study 2, validation). Averages across items of each factor are shown in light colors. Here, the number of items refers to the final item number in the final questionnaire, after the exclusion of non-relevant items and non-reliable factors.

Table 2

English and Italian translations of st-SoSI final items.

#	Scale	IT	EN
		Descriva in maniera adeguata come si sente o agisce di solito. La scala di valutazione va da 1 (in disaccordo) a 9 (d'accordo). Non si soffermi sulle singole domande e cerchi di rispondere il più sinceramente possibile.	Please describe how you typically feel or act. The rating scale ranges from 1 (disagree) to 9 (agree). Do not dwell on individual questions and try to answer as honestly as possible.
1	Trait	Ho il controllo sul modo in cui esprimo le mie emozioni	I have control over the way I express my emotions
2	Trait	Sono in conflitto con l'idea che ho di me	I am in conflict with how I see myself
3	Trait	Mi sento sempre me stess*	I always feel like myself
4	Trait	Ho la sensazione di poter dirigere i pensieri nella mia testa	I feel that I am able to control the thoughts in my head
5	Trait	So sempre con precisione qual è il posto in cui voglio andare	I always know exactly where I want to go
6	Trait	Non so immaginare me stesso nel futuro	I can't imagine myself in the future
7	Trait	Ho un'idea precisa di come io appaia agli altri	I have a clear idea of how I appear to others
8	Trait	Le mie azioni sono in contrasto con ciò che voglio veramente	My actions conflict with what I really want
		Descriva in maniera adeguata come si sente o agisce in questo momento. La scala di valutazione va da 1 (in disaccordo) a 9 (d'accordo). Non si soffermi sulle singole domande e cerchi di rispondere il più sinceramente possibile.	Please describe how you feel or act in this moment. The rating scale ranges from 1 (disagree) to 9 (agree). Do not dwell on individual questions and try to answer as honestly as possible.
1	State Identity	Le mie azioni sono in contrasto con ciò che voglio veramente	My actions are in contrast with what I really want
2	State Agency	Le mie azioni mi fanno sentire in relazione con l'ambiente	My actions make me feel connected to the environment
3	State Tech.	Continuerò ad usare il mio smartphone senza che io lo voglia veramente	I will continue to use my smartphone even if I do not want to
4	State Tech.	Perdo la cognizione del tempo quando uso dispositivi elettronici	I lose the track of time when I use electronic devices
5	State Identity	Mi sento me stess*	I feel like myself
6	State Identity	La mia identità è instabile	My identity is unstable
7	State Identity	Faccio difficoltà ad immaginare come sarò in futuro	I struggle to imagine what I will be like in the future
8	State Identity	Sono in conflitto con l'idea che ho di me	I am in conflict with the idea I have of myself
9	State Agency	Sono consapevole di dove intendo andare	I know where I want to go
10	State Agency	Riesco a dirigere i pensieri nella mia testa	I am able to control the thoughts in my head
11	State Tech.	Interagendo con la tecnologia mi sentirei distaccat* dalla realtà	When I interact with technology, I feel detached from reality
12	State Agency	Sento di essere padrone delle mie azioni	I feel that I am in control of my actions
13	State Identity	Ho un'idea precisa di come io appaia agli altri	I have a clear idea of how I appear to others
14	State Agency	Sento di avere il controllo sul modo in cui esprimo le mie emozioni	I feel that I am in control over how I express my emotions
15	State Identity	Ho la sensazione che le emozioni che potrei provare non siano reali	I feel as if my emotions are not real
16	State Agency	Non sto controllando i miei pensieri	I am not in control of my thoughts
17	State Tech.	Quando uso dispositivi elettronici, compio azioni senza controllo o volontà	When I use electronic devices, I perform actions without wanting to

Table 3

Results of the Structural Equation Models for the Trait-SoSI Scale.

	Fit Indices					Baseline test		
	CFI	TLI	RMSEA	AIC	BIC	χ^2	df	p
Model 1	0.95	0.93	0.075	10,128	10,208	40.9	14	< 0.001
Model 2	0.92	0.88	0.098	11,505	11,601	81.2	19	< 0.001
Model 3	0.92	0.87	0.101	11,507	11,607	81.2	18	< 0.001
Model 4	0.98	0.94	0.064	11,466	11,596	24.2	10	0.007

Although model 4 (bifactor) had the highest chi-squared statistic, the model 1 (monofactorial) was selected as the best model since it had a highly reliable factor. Notably, the model 1 also had good fit indices (CFI = 0.95, RMSEA < 0.10, low AIC and BIC values).

Table 4
Results of the Structural Equation Models for the State-SoSI Scale.

	Fit Indices					Baseline test		
	CFI	TLI	RMSEA	AIC	BIC	χ^2	df	p
Model 1	0.95	0.93	0.060	23,513	23,797	216	96	< 0.001
Model 2	0.89	0.88	0.081	23,632	23,839	374	116	< 0.001
Model 3	0.89	0.88	0.081	23,632	23,839	374	116	< 0.001
Model 4	0.83	0.81	0.103	23,805	24,001	553	119	< 0.001
Model 5	0.84	0.81	0.102	23,789	23,989	535	118	< 0.001

Model 1 (bifactor) was selected as the best model as it was associated with highly reliable factors and the best fit indices.

Table 5
Correlations between SoSI Factors and other Continuous Variables.

		TRAIT	STATE	STATE IDENTITY	STATE AGENCY	STATE TECH.
TRAIT	(0.82)	–	0.86	0.86***	0.82***	0.43***
STATE	(0.91)	0.86***	–	0.93***	0.89***	0.69***
STATE IDENTITY	(0.85)	0.86***	0.93***	–	0.79***	0.49***
STATE AGENCY	(0.83)	0.82***	0.90***	0.79***	–	0.45***
STATE TECH.	(0.75)	0.43***	0.70***	0.49***	0.45***	–
CAPE Positive	(0.87)	−0.32***	−0.43***	−0.41***	−0.31***	−0.40***
CAPE Depressive	(0.85)	−0.67***	−0.70***	−0.73***	−0.59***	−0.40***
CAPE Negative	(0.88)	−0.61***	−0.68***	−0.68***	−0.57***	−0.45***
SoAS Positive	(0.86)	0.51***	0.55***	0.51***	0.52***	0.36***
SoAS Negative	(0.83)	−0.49***	−0.62***	−0.59***	−0.53***	−0.44***
SPQ Cognitive	(0.75)	−0.33***	−0.42***	−0.42***	−0.31***	−0.33***
SPQ Interpersonal	(0.74)	−0.47***	−0.52***	−0.51***	−0.42***	−0.37***
SPQ Disorganized	(0.70)	−0.39***	−0.47***	−0.46***	−0.38***	−0.34***
BHS	(0.85)	−0.32***	−0.37***	−0.39***	−0.32***	−0.20**
EES Vicarious Exp.	(0.91)	−0.10	−0.10	−0.16	−0.02	−0.07
EES Intuitive Und.	(0.94)	0.11	0.04	0.01	0.12	−0.05
Age	–	0.10	0.13	0.10	0.11	0.14

Pearson's correlations show convergent and divergent validity of the state-trait sense of self inventory. Significance is indicated by asterisks (*: p <.05; **: p <.01; ***: p <.001). The reliability of each scale is indicated in parenthesis.

No correlations were detected between the state and trait dimensions of the SoSI and empathy (EES: vicarious experience subscale, intuitive understanding subscale), demonstrating good divergent validity. Additionally, state and trait dimensions of the SoSI did not correlate with participants' age. Results were still significant after correction for multiple comparisons using the false discovery rate.

Finally, we found several associations between st-SoSI scales and demographic variables, which are summarized in Table 6. In detail, we found an effect of gender (F(2,339) = 4.8, p =.008) and of occupation (F(3,338) = 3.9, p =.009) on the factor state-identity. We also found education to be associated with trait-self (F(4,337) = 4.7, p =.001), state-self (F(4, 337) = 5.2, p =.0004), state-identity (F(4, 337) = 4.6, p =.001), and state-agency (F(4, 337) = 4.4, p =.002). Multiple comparisons showing details about these results are depicted in Fig. 4. Results were still significant after correction for multiple comparisons using the false discovery rate.

3.3. Mediation analysis

Results of the mediation analysis are shown in Table 7. Although there was a significant correlation between trait-SoSI and BHS (r = -0.32, see Table 5), the model did not show direct effect of trait-SoSI on hopelessness (standardized β = -0.058, p =.26, bootstrapped 95 % CI = [-0.157 0.042]). The Depression subscale of the CAPE was a significant mediator in the model (standardized β = -0.111 (±0.040), p =.005, bootstrapped 95 % CI = [-0.189 -0.033]). The total effect of trait-SoSI and its mediators was significant

Table 6
Associations between SoSI Factors and Demographic Variables.

F-values (ω^2)	TRAIT	STATE	STATE IDENTITY	STATE AGENCY	STATE TECH.
Gender	3.5 (0.015)	2.1 (0.006)	4.8* (0.022)	0.6 (-0.003)	0.5 (-0.003)
Occupation	3.7 (0.023)	3.6 (0.023)	3.9* (0.025)	3.4 (0.020)	2.6 (0.014)
Legal status	1.0 (-0.003)	1.5 (0.006)	1.3 (0.003)	1.5 (0.006)	0.8 (0.002)
Education	4.7* (0.042)	5.2** (0.047)	4.6* (0.040)	4.4* (0.038)	2.8 (0.021)

The values of the table show the F-statistics relative to the effects of demographic variables on the dimensions of the state-trait sense of self inventory. The effect size as indicated by the omega squared (ω^2) is reported within brackets. Significance is indicated by asterisks (*: p <.05; **: p <.01; ***: p <.001).
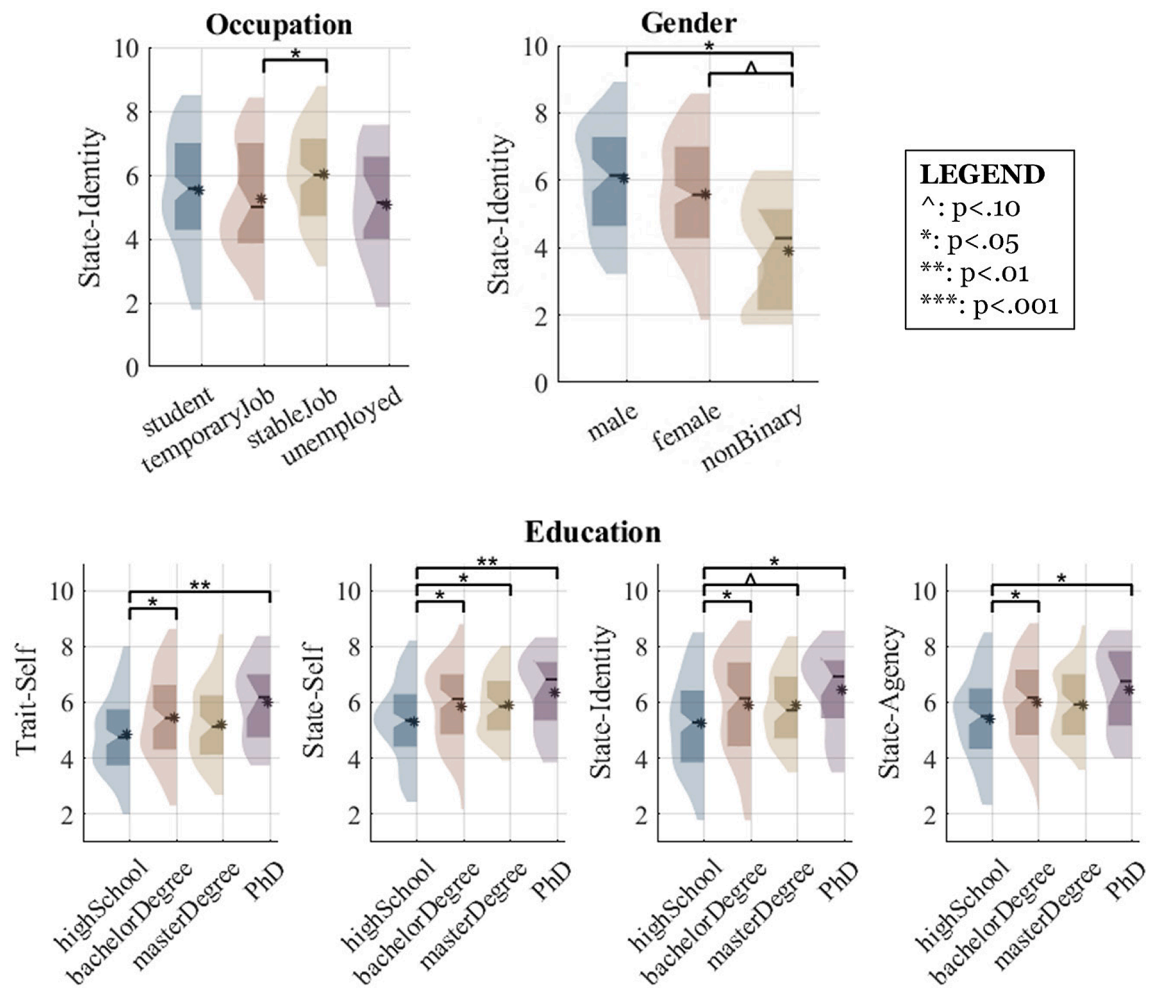
Fig. 4. St-SoSI measures as function of Demographic Variables. For each subgroup of each panel, box-plots indicating median, first, and third quartiles are shown together with the kernel-estimated distribution (smooth line) and the average (asterisk). Significance levels and trends are indicated by asterisks.

Table 7
Results for the Mediation Analysis.

Effect on Hopelessness (BHS)	ESTIMATE (SE)	P VALUE	LOWER CI	UPPER CI
Trait-SoSI (Direct Effect)	-0.058 (0.051)	0.26	-0.157	0.042
Trait-SoSI → CAPE-Depressive	-0.111 (0.040)	0.005**	-0.189	-0.033
Trait-SoSI → CAPE-Positive	-0.012 (0.19)	0.53	-0.049	0.025
Trait-SoSI → CAPE-Negative	0.030 (0.036)	0.40	-0.039	0.100
Trait-SoSI → SPQ-Cognitive	0.003 (0.020)	0.90	-0.036	0.041
Trait-SoSI → SPQ-Interpersonal	-0.030 (0.023)	0.20	-0.076	0.016
Trait-SoSI → SPQ-Disorganized	-0.028 (0.020)	0.17	-0.067	0.012
Trait-SoSI (Total Effects)	-0.205 (0.037)	< 0.001***	-0.279	-0.132

The table reports the results of the mediation analysis using hopelessness (BHS) as outcome. The table reports standardized estimates and 95 % confidence intervals (CI) after applying bias-corrected bootstrapping. Bold fonts indicate significant results (*: p <.05; **: p <.01; ***: p <.001).

(standardized β = -0.205, p <.001, bootstrapped 95 % CI = [-0.279 -0.132]). Despite the trait sense of self influenced all the mediators in the model (CAPE and SPQ subscales), only the effect of the mediator CAPE-Depression on BHS was significant (standardized β = 0.251, p =.005, bootstrapped 95 % CI = [0.078 0.425]), as shown in Fig. 5. Overall, these results suggest that the loss of the trait sense of self, as indexed by the SoSI, has a repercussion on individual's feelings of hopelessness which is specifically mediated by depressive experiences. We performed additional analyses to address if distress and frequency scores of the CAPE depressive subscale differentially mediated such effects. Our findings show a strong correlation between depression frequency and distress (r = 0.83, p <.001),
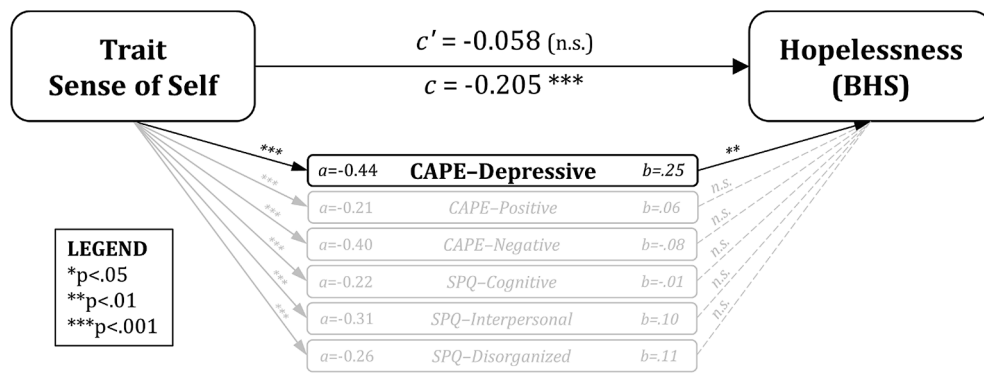
Fig. 5. Mediation model showing direct and indirect effects of Trait-Self on Hopelessness. Mediator model showing direct and indirect effects of the trait-sense of self on hopelessness. As shown in the model, depressive symptoms (CAPE-Depressive) are an important mediator between a loss of the sense of self and an increase in hopelessness. See also Table 7 for further information.

suggesting that a higher frequency of depressive symptoms is closely associated with increased distress caused by depressive symptoms. Moreover, when we conducted a mediation analysis including both frequency and distress scales, only frequency emerged as a significant mediator. This highlights the prominent role of the frequency of depressive symptoms (and not of the self-reported perceived distress) as a relevant mediating factor. The results remained significant when adding gender and age as background confounding factors.

4. Discussion

4.1. The state-trait sense of self inventory (st-SoSI)

Ontological and experimental explorations of ipseity attempted to structure our self-experience and uncover the foundational aspects of consciousness, highlighting a complex structure of the self. We conducted a thorough investigation through the psychometric development of the state-trait sense of self inventory (st-SoSI). Our exploration recognizes the foundational sense of self as an intricate construct, characterized by interweaving dimensions of identity and agency that dynamically influence one another (Gallagher, 2000; Gillihan and Farah, 2005; Ebisch and Aleman, 2016; Di Plinio et al., 2020). We focused on converging concepts such as the stability of self-identity (Nelson, Parnas, and Sass, 2014; Van der Meer et al., 2010), the ability to identify the self through emotions
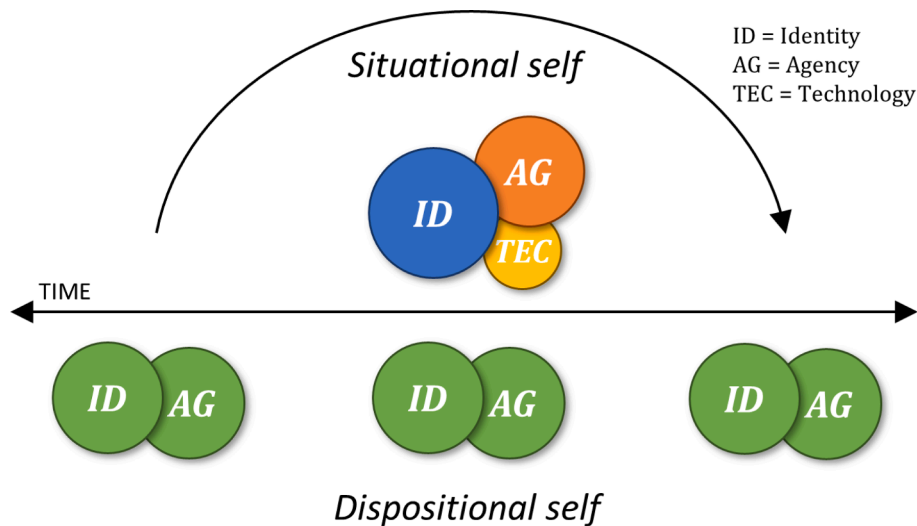
Fig. 6. Illustrative Representation of the Self Model Captured by the st-SoSI The figure illustrates the sense of self as captured by the st-SoSI, distinguishing between the scales of dispositional traits and situational states. At the heart of this model lies a pre-reflective, implicit level of self-experience – akin to the minimal self or ipseity – intertwined with individuals' actions and perceptions. This foundational layer is the genesis of personal identity and agency, evolving through the lens of intentionality. Our inventory's single-dimensional self-trait scales encapsulates both agency and identity items, reflecting the stable core of the self. In contrast, self-state resulted as a three-dimensional construct, distinguishing between the separate scales of identity, agency, and technological interaction, thereby capturing the dynamic interplay of situational influences on the self.

and the senses (James, 1984), the conscious control of bodily actions (Haggard et al., 2017), sensation (Seth, Suzuki and Critchley, 2012) and thoughts (Balconi, 2010), and self-awareness during interactions with humans and devices (Bandura, 1982; Wen and Imamizu, 2022).

Our empirical findings delineate a robust trait-self factor which merges elements of agency and identity, offering a comprehensive insight into how individuals perceive their stable sense of self. Moreover, we discerned a bifactorial state-self structure marked by a high-level factor and three distinct subfactors: state-identity, state-agency and, notably, state-technology. The state-technology factor aligns with the 'extended' aspect of the 5E cognition framework (Biological Sciences Curriculum Study, 2006; Varela et al., 1991; Pérez and Gomila, 2022), which posits that the self is always embodied, embedded, enacted, emotional, and extended (Clark, 2012; Ward & Stapleton, 2012), but also with recent perspectives viewing technology and automatisms as critical components in the evolving concept of self (Prunkl, 2022; Di Plinio et al., 2019). In this sense, this factor represents an extension of agency, ownership, and identity as redefined by technological interactions, underscoring the profound influence of digital advancements on modern human experiences (Yee and Bailenson, 2007). The role of technology assumes an intermediary position, functioning as an extension of agency, ownership, and identity (Tsakiris et al., 2007), due to personal susceptibility to be influenced by the temporary attributes of devices involved at a specific moment or period (Cornelio et al., 2022). In essence, while the trait and state measures collectively emphasize a holistic self-experience derived from an interplay of elements such as identity and agency, the bifactor structure of the state SoSI accentuates the dynamic and context-driven facets of our self-perception. Fig. 6 presents a comprehensive illustration of the st-SoSI.

4.2. Integrative Analysis: Relation to psychometric constructs and demographic variables

Our analyses show a substantial convergence of the SoSI scales with psychosis-like experiences (CAPE), schizotypal personality (SPQ), hopelessness (BHS), and sense of agency (SoAS). Moreover, SoSI scores were unrelated to empathic traits (EES), showing divergent validity. A stronger relationship between SoSI and CAPE than between SoSI and SPQ may be attributed to the fact that the CAPE does not measure aspects related to diagnostic criteria, in contrast to the SPQ, which is based on DSM criteria for schizotypal personality disorder (Konings et al., 2006). A diminished sense of identity and agency at both dispositional and situational levels possibly reflects some of the psychological mechanisms involved in the relationship of depression with psychotic and phobic conditions (Gallagher and Trigg, 2016).

Our mediation model showed that the trait-self is statistically associated with individuals' hopelessness through the frequency of depressive experiences (CAPE, Depressive subscale), but not with other CAPE or SPQ subscales. Thus, individuals with low trait-self may be more prone to depressive experiences, leading to increased feelings of hopelessness. This interpretation aligns with the cross-sectional nature of our data. These findings also support that SoSI scales capture meaningful variance beyond psychosis-related experiences. Through this statistical relationship, we provide insights into the complexity of psychological factors related to the experience of hopelessness (Davey and Harrison, 2022; Benson et al., 2013) and spontaneous mind-wandering (Scalabrini et al., 2022). Our study integrates these findings by identifying a mediating role of depressive experiences between self-concept and hopelessness, thus offering a distinct perspective on self-consciousness and mental health outcomes. Care should be taken in interpreting these relationships, as correlations do not necessarily imply causal links. Understanding these associations can have implications for developing targeted interventions to address hopelessness and suicidal risk (Pompili et al., 2011), with the caveat that further research is needed to establish causality and inform intervention strategies.

Divergent validity was determined by measures of empathic experiences showing low covariance between the SOSI and EES scales. Although considered intertwined phenomena, the results show that pre-reflective aspects of self-experience and empathy could be psychometrically distinguishable. For instance, in the context of intersubjectivity, the "minimal" experience of ipseity or selfhood is relevant for self-other distinction in empathic experiences, that is, to allow the differentiation between one's own and others' experiences as a process complementary to empathy (Zahavi 2014; Gallese, 2014; Stein, 1989). However, inherent to the self is its intentional relation to the world, which is essentially a social world from the first moments of development (Di Plinio et al., 2022; Trevarthen and Aitken, 2001). The intricate relationship between subjectivity and intersubjectivity indeed represents a conceptually relevant topic of debate (Kyselo, 2016). The diverging relationship between pre-reflective measures of the self and empathy in our study could contribute to untangle this issue, as well as stimulate further discussions and future studies.

We observed significant associations between the SoSI and various demographic variables. Occupational stability was linked to a more robust state-identity, aligning with prior research highlighting the adverse effects of job instability on psychological and physical well-being (Virtanen et al., 2011; Thomson and Hunefeld, 2021). Gender had a notable effect on state-identity, possibly reflecting the challenges faced by non-binary individuals seeking social acceptance (Expòsito-Campos et al., 2023), although further investigation with balanced samples is warranted. Our findings also support the influence of education and culture on well-being (Kondirolli and Sunder, 2022; Di Novi et al., 2021), revealing a positive relationship between higher education levels and aspects of the sense of self.

Such findings offer insights into how demographic factors can impact an individual's sense of self, providing a foundation for targeted interventions and policies that aim to bolster psychological well-being. The connections between clinical indicators and SoSI offer a pathway for more personalized mental health care, emphasizing the importance of considering demographic context in the assessment and treatment of mental health conditions.

4.3. Understanding the self

Our psychometric measures contribute to the development of identity-related theories. During the lifespan, perceptual abnormalities, magical thinking, and altered cognitive processes potentially affect subjective experiences of self (van der Meer et al., 2013;

Kuhn and Gallinat, 2013; McAdams et al., 2013; Husserl, 1982). Perceptual distortions or difficulties in distinguishing between self-generated actions and external stimuli can affect the sense of control and agency (Kircher and Leube, 2003; Cermolacce et al., 2007; Haggard, 2017; Frith et al., 2000; Synofzik et al., 2008) by attributing outcomes to external or magical factors rather than personal choices (Synofzik et al., 2013). Similarly, disturbances in cognitive processes, such as thought control or thought insertion, can influence the sense of self by generating intrusive experiences (Sass and Parnas, 2003; Nelson and Sass, 2009; Gallagher, 2015). These experiences are often associated with psychosis proneness or depression and can also be present in non-clinical populations (Verdoux and van Os, 2002; Davey and Harrison, 2022; Stefanis et al., 2002). Hopelessness and anxiety often coexist in this context and can contribute to a sense of despair and a belief that there is no way to improve one's circumstances (Parnas et al., 2005; Benson et al., 2013). This can lead to feeling trapped and uncertain about the future, creating a sense of impending doom, and making it difficult to envision positive outcomes or actions.

The sense of self can evolve and change over time or modulate across situations as many psychological constructs (Steyer et al., 2015). Life experiences, personal growth, and new insights can contribute to the development and transformation of one's sense of self. The trait-self SoSI factor entails enduring and stable characteristics or dispositions that individuals believe describe their typical patterns of thoughts, emotions, and behaviors. State-self SoSI dimensions, on the other hand, reflect the immediate subjective experience in the present moment.

5. Limitations

Some issues need to be mentioned. Firstly, the sample presents an imbalance of gender since females are more abundant than males, and non-binary individuals are only a few. We hope that our preliminary findings will encourage more studies to investigate the relationship between gender identity and the sense of self. Secondly, a test–retest assessment of the SoSI is needed to allow a more comprehensive interpretation of the inventory and our findings. Third, the cross-sectional nature of our data does not allow us to infer causality about the relationships between sense of self and health outcomes as mediated by depression. Finally, convergent validity assessment implemented in our study didn't include relevant instruments such as the embodied sense of self scale (ESSS, Asai et al., 2016) and inventory of psychotic-like anomalous self-experiences (IPASE, Cicero et al., 2017), whereas we selected the empathic experience scale (EES, Innamorati et al., 2019) as a contrasting construct. Constraints during our research prevented other comparative analyses. Future research should focus on incorporating these comparative evaluations to provide a more comprehensive description of the constructs.

6. Conclusion

The st-SoSI provides a psychometrically sound and clinically relevant instrument to explore the sense of self on a healthy-to-dysfunctional continuum, whereas its factorial structure also offers theoretical insights into self-concepts. The differentiation between trait-self and state-self measures allows us to statistically explore how transient experiences and enduring dispositions are associated with self-related behaviors and outcomes in various health conditions. Individuals with a resilient sense of self, as assessed by the SoSI, may exhibit improved stress management, reduced depression, purposeful action, and a propensity to seek support when facing challenges. Therapeutic interventions, including cognitive-behavioral techniques, could be explored for targeting negative thinking patterns, enhance self-awareness, and foster adaptive strategies for enhanced control. Additionally, quality education, supportive educators, and positive learning environments may contribute to bolstering self-confidence and resilience. Cultivating a coherent sense of self and emphasizing personal strengths can potentially play a pivotal role in navigating challenges related to psychosis proneness, hopelessness, social rejection, and depression.

Author's contribution

SDP and SJHE conceived and designed the study. SDP and SA collected the data. SDP and SA developed the data processing and performed analyses. SDP prepared the manuscript with contributions from SA and SJHE. SJHE supervised the research.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2024.103634.

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