A network analysis on self-harming and problematic smartphone use – The role of self-control, internalizing and externalizing problems in a sample of self-harming adolescents

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ABSTRACT

Background: Research has shown an increased risk for Non-suicidal self-injurious (NSSI) behavior as well as Problematic Smartphone Use (PSU) and particularly in adolescence, a developmental period defined by multi-level changes and still poor self-control capacities associating with risk-taking behaviors.
Objective: The current study was aimed to assess the pattern of mutual relations characterizing NSSI considering self-control, internalizing and externalizing problems, and investigating how PSU fits within the network since NSSI and PSU are here conceptualized as attempts at emotion regulation. Age and gender differences were also assessed.
Method: Participants were Italian adolescents presenting NSSI behavior ($N = 155$; Mage = 14.68; SD = 1.647; Range = 11–18; 43.2%-females); the sample is based on community recruitment. A Network Analysis was performed to assess the organizational structure of NSSI; age and gender differences were assessed through multivariate rank tests further applying multiplicity control.
Results: The emerged Network showed the centrality of low self-control and internalizing problems for NSSI. NSSI and PSU were associated through low self-control, and so were PSU and externalizing problems. Significant age differences were observed showing a decrease in NSSI as age increases ($stat = -2.86$; $adj.p = .029$). No gender differences have emerged.
Conclusions: The current findings provide support for the consideration and investigation of PSU as regards NSSI behavior in adolescence. Moreover, these findings point to the relevance of prevention practices during this peculiar developmental period, particularly sustaining self-control capacities and the use of more adaptive emotion regulation strategies, thereby limiting the accrue of at-risk behaviors.

1. Introduction

Adolescence represents the transition from childhood to adulthood and is characterized by a sequence of changes referred to cognitive, emotional, physical and psychosocial development, although psychosocial maturity follows the biological one [1–3]. From a neuro-developmental perspective, the increasing structural complexity and the unbalanced structural and functional transformations between the prefrontal cortical areas responsible for the top-down regulation of emotions and impulses, and subcortical areas instead involved in the generation of the experience of emotion and pleasure as well as reward-seeking, predispose adolescents toward poor decision making, difficulties in emotion regulation and low self-control capacities [1]. As such, this developmental period is crucial to set the basis for emotion regulation [1] as necessary to manage emotions and social relationships [4], to avoid excessive risk-taking behaviors [5] as well as dealing with stress [6], all critical aspects considering the low self-control reported in adolescence [7–9]. Notably, self-control regards impulse-control referred to the ability to inhibit one's reaction in favor of greater priorities [10,11] as well as the capacity to initiate favorable and goal-

directed behaviors [12–14]. Adolescents' low self-control has been associated with the emergence of emotional problems such as internalizing symptoms referred to anxiety and depression symptoms [8,15] and with the emerging of risk and addictive behaviors [8]. Furthermore, it should be highlighted that today's adolescents are digital natives and that this media generation [16,17] faces peculiar, and somewhat still unknown, challenges as they seem more present online than in real life, to the point of translating developmental stages related to social behavior in the on-line world [18,19].

1.1. Non-suicidal self-injurious

Within the last couple of decades Non-suicidal self-injurious (NSSI) has seen a significant increase, which spreading has been shown in association with the increased use of messages and SNSs [20–23]. These tools and platforms all simultaneously accessible through the smartphone which allows the continuous access to the Internet. Accordingly, research has also shown that adolescents showing NSSI behavior do use the internet as a way to interact with others, as an attempt to feel less isolated [24] and to seek social support [21]. Prevalence-wise, literature findings showed that the lifetime prevalence, among the general population, has gone from 2,4% (95% CI: 2,0–2,8) in 2000 to 6,4% (95% CI: 5,8–7,2) in 2014, and particularly among young females [25]. Referring specifically to the adolescence period, rates are instead higher and comparable among males and females, with the prevalence of NSSI ranging between 7.5% and 46.5% [26]. Notwithstanding, although evidence regarding age differences in NSSI are contradicting [27,28], prevalence rates seem to peak around middle adolescence (around 15 years of age) while decreasing when going into early adulthood [29].

NSSI is currently included in the Diagnostic and Statistical Manual of Mental Disorders - 5th Edition (DSM-5), within the disorders in need of future research [30], where is defined as the "intentional self-inflicted damage to the surface of his or her body… with the expectation that the injury will lead to only minor or moderate physical harm (i.e., there is no suicidal intent)" [30] (pp. 803). NSSI onset is usually underhanded and occurs during pre-adolescence, between 12 and 14 years of age [31,32]. It is associated with long-term mental illnesses and increased use of medical services and prescription of psychotropic medications [31,33]. It is also significantly associated with internalizing symptoms [29,34–37], and depressive symptoms, in particular, seem one of its main predictors [29,37]. Internalizing symptoms subsume symptoms experienced as inner distress given and given by heightened negative affectivity and unpleasant emotions, which are then usually expressed in the form of anxiety and/or depression symptoms and/or withdrawal [38]. On the other hand, overtly expressed distress is regarded in terms of externalizing symptoms and associated with impulsivity, hyperactivity, anger, and aggression manifested through disruptive behaviors directed toward the surrounding environment [38]. In this regard, a specific distinction between NSSI and externalizing symptoms should be made as NSSI represents an external manifestation of internal suffering (as referred to internalizing symptoms) that, differently from classical externalizing symptoms, is though directed toward the self and not the environment. Nonetheless, NSSI has been reported in association with externalizing symptoms and disorders (e.g. Conduct disorder, ADHD symptoms) [39], and both are associated with low self-control capacities and impulsivity [40–43]. Still, as previously reported, NSSI has been shown to greatly associate with internalizing symptoms, whereby NSSI behaviors might function as a regulatory strategy towards the negative affectivity and painful emotions experienced [36,44–47]. NSSI is indeed considered as a form, although maladaptive, of emotion regulation [46,48], with individuals showing this behavior reporting a higher physiological reactivity and a reduced tolerance toward distress [49,50].

In light of the relevance of both internalizing and externalizing symptoms, it is also worth noting that they both associate with a reduced propensity for prosociality (i.e., behaviors and actions characterized by altruism, thus aimed at benefiting others) [51], Which instead has a

protective role, as supporting adolescents' well-being [52] and is associated with reduced NSSI [53], while further favoring socialization. Indeed, prosocial behaviors take place in the social environment, rendering them a critical matter during adolescence since social relationships, with peers in particular, are fundamental for adolescents' psychosocial development and well-being [2].

1.2. Problematic smartphone use

Smartphones are becoming essential tools in everyone's lives [54], used for instant messaging, shopping, news, music, SNSs use and so on [17,55], with SNSs, in particular, being highly associated with increased and more problematic smartphone use [23,43,55,56]. Smartphones are thus both extrinsically and intrinsically rewarding, but the problems referred to smartphone use are not intrinsic to the tool itself but to the dysfunctional approach people develop towards it [55]. Todays' adolescents, show high rates of internet and smartphone use, so much that the incidence of technology-based behavioral addictions is significantly increasing [57]. However, the DSM-5 [30] only recognizes Internet Gaming Disorder (IGD; included in the third section of the DSM-5 dedicated to conditions in need for future research), and the International Classification of Diseases 11th (ICD-11; [58]) only Gaming Disorder (both online and offline) as clinically relevant technology-related behavioral addictions, whereas not Smartphone Addiction or Problematic Smartphone Use (PSU). Nonetheless, such maladaptive/problematic use of the smartphone regards impulse-control difficulties and has started to be regarded by some as an addiction-like behavior since the device might be used compulsively to the point of it interfering with social life, as its use is associated with rewarding feeling that might foster craving as well as withdrawal symptoms when prevented from using it [59,60]. In this regard, it seems relevant to mention the ICD-11 proposed approach for the classification of behavioral addictions. Notably, the ICD-11 workforce has suggested that behavioral addictions should be considered as impulse-control disorders subsuming difficulties in controlling the impulse to put in action the behavior of interest as it is felt rewarding to the point of disregarding potential long-term negative consequences [61]. Nonetheless, there still is not enough research on PSU for it to be recognized as either behavioral addiction or as an impulse-control disorder. Accordingly, the term Smartphone Addiction is still debated as there is an open discussion referred to it presenting the characteristics, and the long-term consequences, to be recognized as a clinically significant diagnostic label [60,62,63]; as such, from hereon, the present paper will solely use the term PSU.

In line with the above, and mindful of the novelty of the current digital generation, not much information is available as to how PSU progresses throughout adolescence as well as later on during adulthood. Still, research findings have shown that among adolescents aged 15–16 years PSU seems greater than among young adults aged 19 years and older [64]. However, in a recent study [65] which considered a sample age ranging between 3 to over 50 years, it was reported an age-dependent PSU, in which the group of adolescents (between 12 and 19 years of age) reported the lowest scores of PSU, while the highest scores emerged concerning the group of young adults (between 20 and 34 years of age). These findings are indeed unexpected, albeit it might be that this generation is so accustomed to going through life with such tool, that its salience might be thus minimized. However, adolescents are still deemed at risk for PSU, as adolescence is characterized by high emotional reactivity and still poor regulation capacities [1] and PSU has emerged as highly associated with individuals' self-control capacities [66]. Specifically, low self-control has emerged as a significant predictor of PSU [67,68], also mediating the relationship between PSU and difficulties related to stress [69] or interpersonal adaptation [66]. As such, with self-control being linked to both emotional and behavioral regulation [1,70], high self-control would instead allow a more conscious and rational use of the smartphone, thereby assuming a protective role toward PSU [66].

On the other hand, anxiety and depression symptoms, as well as internet use and female [67,71–73], all appeared as further risk factors, although motivation emerged as the aspect most influential in determining people's PSU levels [74]. Overall, increased media use seems associated with both internalizing and externalizing problems [75] and the levels of depression and anxiety symptoms [76,77], stress, and anger specifically, were shown to significantly contribute to PSU severity [78]. Moreover, anger particularly distinguished those showing a more severe PSU [78], which is coherent with PSU being a predictor of reduced altruism, instead important for the promotion of prosocial behaviors favoring adolescents' well-being [52].

1.3. The current study

The current study relies on a network perspective of psychopathology [79], whereby signs and symptoms of a disorder or phenomenon are considered as constituent of it and not only its manifestation. As such, disorders and psychopathological phenomena should be conceptualized as more complex and dynamic systems constituted by mutually influencing factors that operate as a network [79–81]. It is on this theoretical ground that the present study aims to exploratorily investigate, through a Network Analysis, the pattern of mutual relations characterizing NSSI in a sample of adolescents performing NSSI. In particular, the organizational structure resulting from the associative pattern comprising self-control, internalizing and externalizing problems as well as prosociality (considered as positive prognostic factors), viewed as constitutive and not causal of the considered phenomenon, will be assessed while also investigating how PSU contributes to and fits within this network. The present study further aims to investigate age and gender differences as regards all considered variables.

The attention posed on PSU is given by the increased smartphone use reported worldwide [54], which with all its possibilities of use (referred to accessing multiple platforms at ones, including sending messages and using SNSs) and with internet access always available, seems to have favored the spreading of NSSI [23,82]. Furthermore, both NSSI [36,48] and PSU [83] can be conceptualized as forms of emotion regulation to which self-control capacities are strongly associated [70]. In this respect, although the self-control and regulation capacities of adolescents at large are still developing, the capacities of those presenting NSSI behavior are already poor, which is coherent with the positive association shown between NSSI and emotion dysregulation [48,84,85] as well as impulsivity [42]. Emotion dysregulation and impulsivity are also significantly associated with PSU [86–89]; as such, the investigation of PSU position and connections within the NSSI network has the intent to provide evidence relevant to the broader field of emotion regulation in adolescence, since their joint presence and the adding up of their psychosocial consequences might further challenge and/or prevent these digital native adolescents from developing more adaptive regulation capacities useful to support their mental health later in adulthood [1]. Indeed, regulation capacities rapresent transdiagnostic mechanisms relevant to clinical practice [90], which, considering the differential developmental trajectories that mental health issues present during the developmental period might take when transitioning into adulthood [91], should be particularly taken into account.

Accordingly, by conceptualizing NSSI [36,48] and PSU [83] as expressions of psychological suffering, understanding the interplay among some of their shared variables might allow intervening upon the factors leading to such behaviors while also avoiding them from reciprocally influencing and aggravating each other. For example, PSU was reported to specifically associate with maladaptive cognitive emotion regulation (i.e., the conscious strategies used to cope with an event) [92] whereby the "stress posting" performed via the SNSs platforms available on the smartphone would allow the externalization of feelings and emotions in a cathartic manner while further allowing social support seeking [20]. Accordingly, when such "stress posting" is performed by an adolescent that performs NSSI behaviors, the smartphone might be used as a further

mean for emotion regulation potentially leading to an increased frequency of NSSI behavior by normalizing and reinforcing the NSSI behavior, for the person as well as for others [21,93]. As such, a further issue regards the sharing of self-injurious based content on the internet which might lead to clustering NSSI adolescents, thus risking the normalization of the behavior [21] and increasing the probabilities of its maintenance, while also increasing the chances of initiating such behavior on the part of those already vulnerable [20,21,82]. Although the specific and direct association between NSSI and PSU still needs to be investigated, it is though worth highlighting that nocturnal smartphone use was specifically shown to associate with increased NSSI [94] as well as heightened internalizing and externalizing symptoms [23]. This is particularly relevant since nocturnal smartphone use and increased time using the smartphone, in general, were reported to associate with both sleep problems and depression symptoms [76,77,95], which is critical since depression symptoms significantly contribute to both PSU [73,76–78] and NSSI [34,37,96].

Given the reviewed body of literature, it is hypothesized that:

H1. Self-control will show a high centrality within the Network;

H2. Self-control will show a negative association with NSSI [97,98] as well as PSU [57,66–68,99];

H3. Internalizing problems will show greater closeness to NSSI [34–37] while externalizing problems will greatly associate with PSU in line with its association with anger as well as impulsivity [73,78,86,100].

2. Method

2.1. Procedure and participants

The considered data refer to multiple pre-test phases of the broader LOOK@ME research-intervention project [101]. The project aims to provide tailored psychosocial and psycho-educative interventions and focus groups to community Italian adolescents, with the intent of improving their self- and emotional regulation to support their mental health. Approvals were obtained before questionnaires' administration through an informative consent divulged by the schools' principals and signed by both parents of minors or by the participants themselves if already 18 years of age. Participants also provided oral consent before participation. The study was approved by the Ethical Committee of Psychology at the University of Padova (number 2322, June the 6th, 2017) and was conducted in compliance with the Declaration of Helsinki (Italian law 196/2003, EU-GDPR 679/2016).

Data were obtained through an online survey using validated questionnaires, administered between 2017 and 2019 to middle schools and high schools located in Padua. The adolescents considered in the present paper complied with the following inclusion criteria: (i) having completed both modules of the self-harming questionnaire irrespective of their final score; (ii) being aged between 11 and 18 years. The final sample is a community sample composed of $N = 155$ adolescents performing NSSI ($M_{age} = 14,68$; SD = 1.647; Range = 11–18; $N = 67$–43,2% - females).

2.2. Measures

2.2.1. Brief Self-Control Questionnaire

The Brief Self-Control Questionnaire (BSCS) is a brief self-report [102] composed of 13 items measured on a 5-point Likert scale (from 1 "*not at all like me*" to 5 "*very much like me*"); the Italian validation of the tool has been performed by Chiesi and colleagues [103] and was employed in the current study. It assesses self-control as referred to the capacity of controlling distracting thoughts or to avoid the pursuit of distracting activities, and the capacity to control and regulate one's impulses (e.g. food and drink intake). It also refers to the capacity of

controlling one's behavior in favor of more harmonious interactions and to feelings of guilt and shame, albeit considered as adaptive toward failure and misconduct. Higher scores index higher self-control capacities. In the present study, the internal consistency is α = 0.73.

2.2.2. Strength and Difficulties Questionnaire

The Strength and Difficulties Questionnaire (SDQ) is a self-report ([38]; www.sdqinfo.org) composed of 25 items measured on a 3-point Likert scale (1 = "*Not True*"; 2 = "*Somewhat true*"; 3 = "*Certainly true*"). The Italian validation of the tool used in the current study can be found at www.sdqinfo.org. The SDQ is aimed at identifying individuals at-risk to develop psychosocial and adjustment problems by collecting information related to their emotional, interpersonal and behavioral profiles. Two final scores are provided: *Prosocial behavior (PROS;* i.e. the strength score*)* and a *Total difficulty* score. The Total difficulty score results from the sum of two latent variables, *Internalizing problems (INT),* measured through the *emotional symptoms* and *peer problems* sub-scales, and *Externalizing problems (EXT)*, measured through the *conduct problems* and *hyperactivity/inattention* sub-scales. INT and EXT's clinical cut-off is a scoring of 10 or above, while PROS scores should be above 6 (https://www.sdqinfo.org/). In the current study INT, EXT and PROS were considered and their internal consistency is α = 0.69, α = 0.67 and α = 0.63, respectively.

2.2.3. Smartphone Addiction Inventory-Italian Version

The Smartphone Addiction Inventory-Italian Version (SPAI; [104]), translated and validated in Italy by Pavia and colleagues [60], is aimed at measuring smartphone addiction as referred to as impulse control problems and behavioral addiction-related factors (e.g. withdrawal, compulsivity, tolerance, interpersonal problems). It is composed of 24 items measured on a 4-point Likert scale (1 = "*strongly disagree*"; 4 = "*strongly agree*") and provides a final total score which higher scores index greater smartphone addiction. The SPAI mean score level, assessed on a sample of Italian adolescents (i.e., normative data), is 38.29 (SD = 10.75) [105]. The internal consistency in the present paper is α = 0.91.

2.2.4. Self-Injurious Thought and behavior Questionnaire-Nonsuicidal

The Self-Injurious Thought and behavior Questionnaire-Nonsuicidal (SITBQ-NS; [106]) was originally an Interview assessing self-injurious thoughts and behavior without suicidal intent. The self-report version of the tool was then developed by D'Agostino and colleagues [107], which corresponds to the Italian validation of the SITBQ-NS employed in the current study. It is composed of 28 items measured either on a 3- or 5-point Likert scale; 14 items provide information regarding self-injurious thoughts and 14 regarding self-injurious behavior. To be completed, respondents need to answer *yes* to a question provided at the beginning of both modules and asking if they have ever thought about and if they have ever performed NSSI behavior. Both sets of questions relate to the NSSI thoughts and behavior's frequency at present time and over the lifetime, their intensity, concomitant drugs' use, the duration, the influence of friends, the probability of turning thoughts into actions and, in case the person performs the behavior, it also investigates if the individual has received medical treatments for the self-inflicted wounds. The tool provides three final scores referring to *Self- Injurious Thoughts, Self-Injurious behavior* and the total score, namely *Self- Injurious Spectrum,* which is considered in the present study. The total score should be 0, thus the clinical cut-off is a scoring of 1 or above (range 1–328). Higher scores index more frequent and pervasive self-harming thoughts and behavior. The internal consistency in the present paper is α = 0.93.

2.3. Statistical analysis

The analyses were performed through SPSS and R. Descriptive information was assessed and bi-variate Pearson r correlations were performed to identify the associative patterns among the considered variables. Age and gender differences were assessed for all the variables; Age was here operationalized as a 3-levels categorical variable (1 = 11–13; 2 = 14–15; 3 = 16–18), thereby specifically comparing participants distinguishable as pre- middle- and older-adolescents, respectively, as regards all included variables. Such subdivision is in line with the Italian school system and cycles (https://eacea.ec.europa.eu/national-policies/eurydice/content/italy_en) whereby middle school occurs between 11 and 13 years, the initial high-school biennium between 14 and 15 years (education is still compulsory) and the final, yet no longer compulsory, high-school triennium instead occurs between 16 and 18/19 years. Moreover, comparable age divisions can be found in other literature studies [9,108]. Bartlett's test was performed to assess homoscedasticity among the age groups and the Shapiro-Wilk test to assess variables' normal distribution. None of the variables showed a normal distribution, so age and gender differences were assessed using multivariate permutations through the R package *flip* [109]; specifically, multivariate rank tests were performed. Multiplicity control was also applied. Lastly, posthoc comparisons for the variables presenting significant age and/or gender differences were assessed using the Wilcoxon non-parametric test. All statistics were considered significant at *p* < .05.

2.3.1. Network analysis

Network Analysis is a statistical procedure, which allows the definition of the pattern of complex mutual relations (i.e., regularized partial correlations) among the variables relevant for a specific phenomenon while reporting its core features as compared to the variables showing a less influential role [110]. The network of relations emerges as the visual pattern representing the phenomenon investigated to observe how the variables mutually influence each other - thus not informing on the directionality of the associations - and providing information about possible mediation pathways [110,111]. Within the network, variables are represented as *nodes*, while the *edges* are regularized partial correlations connecting the nodes. Regularized partial correlations show the pattern of self-reinforcing variables, thus representing how nodes associate after controlling for the influence of all the other variables [112]. The Network was assessed through the R's package *qgraph* [113] and included all considered variables (i.e., INT, EXT, PROS, SPAI, SITBQ-NS, Age) with Age included as continuous variables, thereby providing information complementary to those that can be obtained by the specific comparison of the different adolescence periods reported above. The Network was assessed based on the questionnaires' total scores, instead of being at the item-level of all tools (which would have resulted in the inclusion of 118 items/nodes), to prevent on the one hand the clustering of highly correlated items (as it was the case also for subscales; e.g., SPAI sub-scales), while on the other hand avoiding overloading the network with varied information that would have limited interpretability, as well as the explorative investigation of NSSI organizational structure, referred to the mutual association among the variables of interest for the current study.

To estimate the Network, the Extended Bayesian Information Criterion (EBIC; [114]) was applied with the parameter determining the degree of regularization set at BIC = 0.5, thus indexing a more conservative approach by avoiding the consideration of spurious correlations; the Network was estimated through the Graphical Least Absolute Shrinkage and Selection Operator (GLASSO) algorithm. In the visual representation of the Network, the green edges represent positive partial correlations while the red edges show negative partial correlations [112]. The edges are weighted [110], so their thickness represents the strength of the correlation between the nodes [112]. Furthermore, the layout of the Network is so that nodes with fewer and weaker edges are placed on the outer frame, while those more relevant and connected are placed more centrally [110]. Centrality is indeed an index of the importance of a node as compared to the others [110] in which specific indices, expressed as z points, are considered, as they permit to infer which are the most influential variables within the network. Specifically, *degree* indicates the number of connections a node has, *strength*

informs of the importance of a node independently from the number of connections, *closeness* allows to quantify the total number of connections (i.e. both direct and indirect connections) thus signaling how quickly a node will be affected by changes in one of its connected nodes, while *betweenness* informs of the relevance of a node within the average pathways among two other nodes [110]. The Network stability [112] was assessed through a case-dropping subset non-parametric bootstrapping (*N* boots = 2500) applied to the weighted-edges (i.e. the true regularized partial correlations). The resulting central stability coefficient (CS) represents the maximum drop acceptable to retain a correlation strength of at least 0.70 when comparing the re-calculated indices with the original ones. CS should be above 0.25, while it is considered good if above 0.50 and ideal if over 0.70.

3. Results

The mean and standard deviation of the considered variables are shown in Table 1. Bi-variate Pearson r correlations are shown in Table 2.

Multivariate permutation rank tests were performed to assess age and gender differences. Age distribution within age groups is as follows: 11–13 year *N* = 35 (22.6%), 14–15 years *N* = 83 (53.5%) and 16–18 years *N* = 37 (23.9%). Significant age differences emerged for BSCS (*stat* = 2.29; *p* = .026) and SITBQ-NS (*stat* = −2.86; *p* = .001); yet, when applying multiplicity control, the significant age differences only referred to SITBQ-NS (*stat* = −2.86; *adj.p* = .029). Post-hoc comparison tests also showed significant differences among all age groups; specifically, participants aged between 11 and 13 years showed significantly higher scores on SITBQ-NS (SITBQ-NS Mean score = 104.77; SD = 36.31) as compared to those aged between 14 and 15 years (*p* = .028; SITBQ-NS Mean score = 87.75; SD = 29.48) and those age between 16 and 18 years (*p* = .002; SITBQ-NS Mean score = 74.68; SD = 27.69). Adolescents aged 14 to 15 years also scored significantly higher on SITBQ-NS compared to the 16–18 years group (*p* = .037). No significant gender differences were found.

3.1. Network analysis

The Network structure is depicted in Fig. 1. The strength, closeness and betweenness indices are reported in Table 3 and plotted in Fig. 2. Of the most central nodes, BSCS showed the greatest *strength* followed by INT and SITBQ-NS. Differently, the *closeness* index showed that INT has the greatest number of direct and indirect connections, followed by SITBQ-NS and BSCS.

BSCS negatively associated with EXT (−0.44), SPAI (−0.14) and SITBQ-NS (−0.13), while INT positively associated with SITBQ-NS (0.32), PROS (0.21) and EXT (0.16). SITBQ-NS is also negatively associated with Age (−0.21). Differently, SPAI maintained a more marginal position, showing the lowest strength (M = -1.243), although it was indirectly associated with SITBQ-NS and EXT through BSCS. Thus, INT, BSCS and SITBQ-NS represent the most relevant and influential nodes

Table 1
Sample descriptive information.

	M	SD
Age	14.69	1.63
BSCS	2.87	0.58
INT	9.39	3.81
EXT	8.58	3.44
PROS	9.46	2.15
SPAI	48.35	13.59
SITBQ-NS	88.47	32.24

Note. N = 155 adolescents performing NSSI; Variables mean and standard deviation; BSCS: Brief Self-Control Questionnaire; INT: Internalizing problems; ECT: Externalizing problems; PROS: Prosocial behaviour; SITBQ-NS: Self-Injurious Thought and Behaviour Questionnaire-Nonsuicidal (Total score); SPAI: Smartphone Addition Inventory-Italian Version.

within the network, although not forming a cluster, as INT and BSCS did not directly associate, which indicates that by removing one or the other node, the remaining one can still relevantly influence on the network.

The Network stability for the nodes' strength, measured through the central stability coefficient (CS; the maximum drop proportion to retain correlation at 0.7 within 95% of the sample), was 0.361.

4. Discussion

The primary aim of the present exploratory study was to assess the structural organization, through a Network Analysis, of the factors contributing to the NSSI phenomenon as described by the pattern of mutual relations among self-control capacities, internalizing and externalizing symptoms, prosociality as well as adolescents' age. Furthermore, the position acquired by PSU within the network has also been investigated, with the intent of observing how the two behaviors (i.e. NSSI and PSU), and related variables, associate within an already vulnerable sample comprising adolescents performing NSSI. As such, the assessment of their level of PSU is here considered as a comparative mean through which trying and define if these adolescents' state of suffering broadens to other dysfunctional behaviors as a function of their psychological state and (im)maturity. The rationale behind this resides in the conceptualization of the two as regulatory strategies [36,45–47,115–117] thus as means through which a negative and unpleasant emotional state is expressed and modulated. In this respect, it should be noted that PSU had a marginal position within the network, showing the lowest centrality indices, which suggests that PSU severity does not significantly contribute to the NSSI phenomenon overall. Nonetheless, NSSI and PSU are associated, within the network, by means of low self-control, which seems to acquire a mediating role between the two in line with the above-mentioned conceptualization of the behaviors, and coherent with expectations; specifically, low self-control hinders people capacity to control themselves from putting in action dysfunctional behaviors when in a state of sufferance and increased arousal [66]. This supports the conceptualization of NSSI and PSU as means for emotion regulation, with the potential to mutually influence each other, and thus their severity, through poor regulation capacities. Two specific types of self-control failures can be taken into account in this regard [118], namely, *under-regulation,* referred to as the weak control posed over one's impulses, and *misregulation*, instead referred to impulse-control exerted through maladaptive strategies [119]. As such, both NSSI and PSU might be conceived as resulting from the interaction of aspects related to *under-regulation* and *misregulation* and favored by the portability and possibility of use given by the smartphone, which is coherent with past studies showing that the threat and uncontrollability of stressors associates with maladaptive cognitions of problematic internet use [120]. Therefore, feelings of uncontrollability internal and/or consequential to NSSI behaviors, favored by adolescents' poor emotion regulation and self-control capacities [1] as well as by the heightened reactivity and low distress tolerance of those performing NSSI [49,50], might then lead to greater and more severe PSU. In this regard, it is noteworthy that smartphones allow attentional deployment with minimal cognitive effort; its portability and the broad possibility of use and communication, with applications such as SNSs and both offline and online platforms (e.g., games) being easy to access, makes it an always available and effortless means through which containing the arousal resulting from the perceived emotional activation derived by NSSI behavior or from the impossibility of performing the behavior through attention deployment. This proposition might also be supported by considering the mediating role of self-control in the association between PSU and difficulties in dealing with stress [99,121].

The present findings indeed further suggest that low self-control acquires a mediating role also between PSU and externalizing problems. Although within the network PSU did not directly associate with externalizing problems and has on the whole an external position, the path between the two is though shorter than that between PSU and

Table 2
Bivariate Pearson's r correlation.

	Age	BSCS	PROS	INT	EXT	SITBQ-NS	SPAI
BSCS	0.09	–					
PROS	−0.01	0.12	–				
INT	−0.02	−0.20*	0.33**	–			
EXT	−0.08	−0.60**	−0.06	0.35**	–		
SITBQ-NS	−0.27**	−0.35**	0.10	0.45**	0.36**	–	
SPAI	−0.06	−0.37**	−0.03	0.16*	0.30**	0.26**	–

Note. N = 155; *p. < 0.5; **$p < .01$; BSCS: Brief Self-Control Questionnaire; INT: Internalizing problems; ECT: Externalizing problems; PROS: Prosocial behaviour; SITBQ-NS: Self-Injurious Thought and Behaviour Questionnaire-Nonsuididal (Total score); SPAI: Smartphone Addition Inventory-Italian Version.
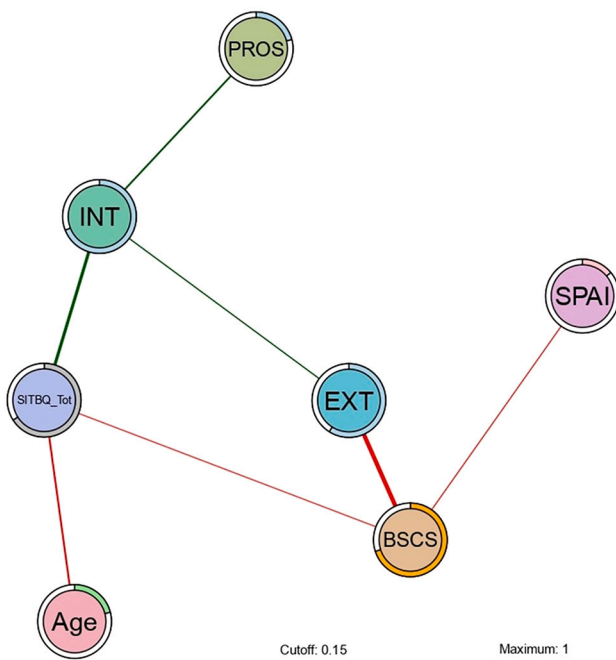

Fig. 1. Network structure.
Note. N = 155 adolescents performing NSSI; Regularized partial correlation's cutoff =0.15; BSCS: Brief Self-Control Questionnaire; INT: Internalizing problems; EXT: Externalizing problems; PROS: Prosocial behaviour; SITBQ_Tot: Self-Injurious Thought and Behaviour Questionnaire-Nonsuididal (Total score); SPAI: Smartphone Addition Inventory-Italian Version.

Table 3
Centrality indices of the Network's variables.

Nodes	Strength	Closeness	Betweenness
BSCS	0.951	0.559	0.689
SDQ INT	0.897	1.12	1.359
SITBQ-NS	0.806	0.976	0.679
SDQ EXT	0.519	0.35	0.34
SDQ PROS	−0.96	−0.75	−1.02
Age	−0.95	−0.79	−1.02
SPAI	−1.24	−1.47	−1.02

Note. BSCS: Brief Self-Control Questionnaire; INT: Internalizing problems; ECT: Externalizing problems; PROS: Prosocial behaviour; SITBQ-NS: Self-Injurious Thought and Behaviour Questionnaire-Nonsuididal (Total score); SPAI: Smartphone Addition Inventory-Italian Version.

internalizing problems. The latter instead directly and strongly associate with NSSI, indeed showing a great relevance within the network, which again supports the notion of NSSI behaviors as attempts at self-regulation [36,45,47]. However, specifically referring to internalizing and externalizing symptoms, it should be also noted that while the externalizing ones did not associate with adolescents' prosociality, internalizing symptoms did, albeit showing a positive association thus

mining the protective role played by prosociality and altruism. Indeed, this finding is counterintuitive and in contrast with evidence from a recent meta-analysis [51] which had observed a negative association between community adolescents' internalizing and externalizing symptoms and prosociality, with prosociality greatly associated with the latter as compared to the former. Within the emerged Network, on the other hand, prosociality and externalizing symptoms were placed further apart, thus not directly connected. This suggests that among adolescents performing NSSI, externalizing symptoms are not influenced by adolescents' altruism and prosociality, but much more by their poor self-control capacities as previously mentioned. Furthermore, as shown by the centrality indices, prosociality seems to minimally contribute to the overall network structure of NSSI, while internalizing symptoms and self-control, together with externalizing symptoms, have emerged as the variables that more strongly contribute to the NSSI phenomenon and NSSI severity, indeed creating a cluster. These findings suggest that, from a network perspective, viewing the NSSI phenomenon as a system resulting from the interaction of its constituent, prosociality has a marginal and minimally influencing role upon it, while unexpectedly contributing to it instead of being protective towards it and its constituents [51,53]. However, this finding needs replication.

As regards age differences among the considered age groups, although past findings are contradicting [27,28], the results emerged both from the network as well as by comparing pre- middle and older adolescents showed that NSSI decreases as age increases [35]. Still, all the other variables did not present such a pattern of improvement nor were they associated with age within the network, meaning that although NSSI might decrease or cease, the underlying sufferance remains. Indeed, studies showed that adolescents reporting internalizing and/or externalizing problems present a dysregulated connectivity between specific cortical (i.e. Prefrontal cortex) and subcortical structures (i.e. limbic structures), thus contributing to the symptomatology itself and to the poor capacity to modulate emotions [1]. As such, among adolescents showing psychological symptoms, the frontal areas, although more mature during late adolescence, are still unable to properly modulate and regulate the sub-cortical areas, since, beyond the structures' maturity *per se*, the issue seems to reside in how they specifically connect.

4.1. Limitations and suggestions for future research

Findings should be considered in light of some limitations. In particular, although the present sample presents a modest size, future studies performing a Network Analysis should consider broader and multicentric samples, as relevant for the Network stability; yet, because Network Analysis are, to an extent, a novelty in psychology, there is still too little research to perform an *a priori* power analysis [110]. A further limitation refers to the cross-sectional design of the study, with consequences for the investigation of age differences, for which a limitation is an uneven size among the considered age groups. Nonetheless, age included as a continuous variable within the network serves to complement the evidence obtained by comparing the different age groups (i. e., pre-adolescents, middle-adolescent and older adolescents). Future research should anyways integrate the present findings with
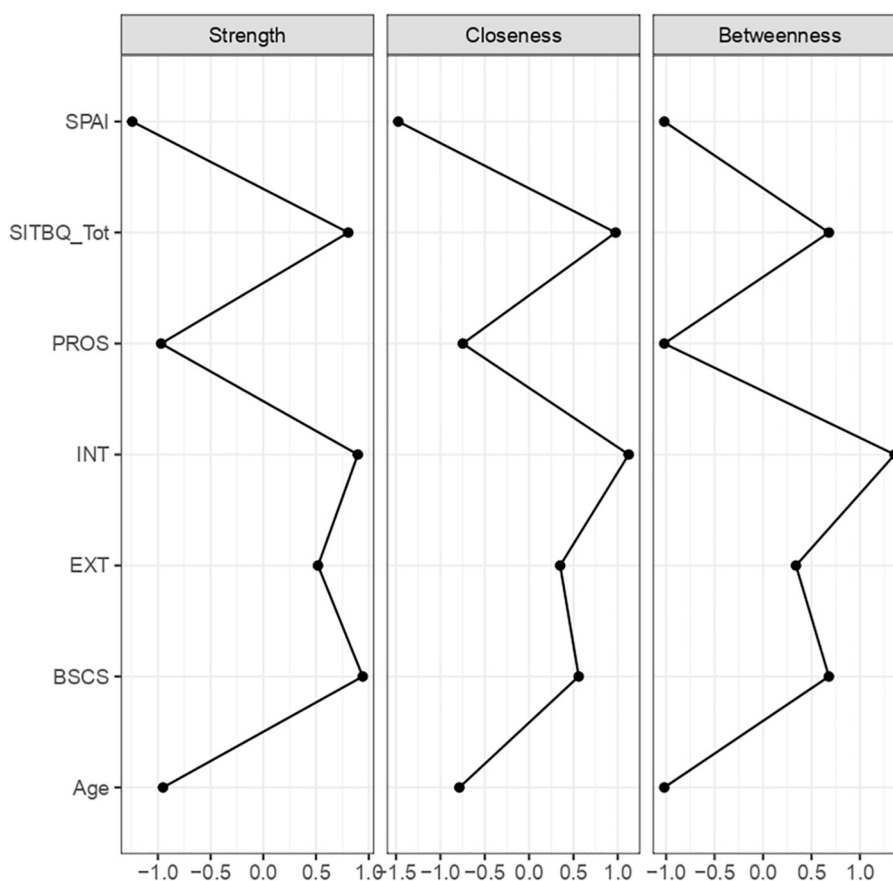
Fig. 2. Centrality indices plot.

Note. BSCS: Brief Self-Control Questionnaire; INT: Internalizing problems; ECT: Externalizing problems; PROS: Prosocial behaviour; SITBQ-Tot: Self-Injurious Thought and Behaviour Questionnaire-Nonsuididal (Total score); SPAI: Smartphone Addiction Inventory-Italian Version.

longitudinal information. An additional limit is also the sole consideration of self-report measures and the non-consideration of the sample and their families' socio-economic situation, which might instead underline the presence of risk or protective environmental factors. A similar limitation refers to the sample ethnicity as well as the study monocentric nature, thus limiting generalizability as a function of contextual variables.

As regards suggestions for future research, they should be considered in compliance with findings implications. Accordingly, starting from the current exploratory study and evidence, future research might then benefit from a narrower and more specific investigation of NSSI constituent variables by performing an item-level Network Analysis. Moreover, the association between NSSI and PSU through low self-control that has emerged grants warning for the already observed increase of risk behaviors in adolescence [5], so that, particularly referring to PSU in adolescents presenting NSSI behavior, future research should evaluate the specific use modalities and the content shared through apps. This is also in line with the ICD-11 proposed approach for behavioral addiction, which has been proposed in light of its foresaw clinical utility, thus encouraging clinicians to investigate the presence of other similar impulse-control disorders beyond the one initially reported [61]. Although PSU is not recognized as a behavioral addiction and diagnostic label, it does associate with impulse-control difficulties, and so does NSSI as being highly associated with impulsivity [42]. Accordingly, and coherently with the present findings, the reasoning underlining the ICD-11 proposed approach could support the furthering of research investigating also the association between NSSI and PSU.

Notwithstanding, future research should further evaluate also which are the apps most used and associated with a maladaptive smartphone use, as well as understanding the intrinsic qualities that render smartphones so appealing as potential mood enhancers for NSSI adolescents. Implications for the understanding of the aspects rendering smartphone use problematic, or not, might lead the way for means of psychological support internal to smartphones and specific for adolescents showing NSSI as well as other vulnerable populations through apps providing tailored information, support, and feedbacks [122]. This could be particularly relevant if the above-provided explanation for the NSSI-PSU association (i.e. PSU as a coping/regulatory strategy toward NSSI) is supported.

Moreover, considering the here observed reduction in NSSI behavior in adolescence, yet not of the underlying psychological suffering, future research should comparatively evaluate differences and similarities related to neurological and cognitive aspects relevant for such symptomatology also comparing how they are subjectively perceived, thus giving insights on how to provide support and develop interventions which could impact on the broader phenomenon and so improving the well-being and quality of life of adolescents performing NSSI. It is also relevant to understand how the expected adolescents' identity and social development and related stages translate within the digital means provided by smartphones more specifically. This might yield information as to how to better act preventively through more appealing and modern adolescents-oriented psycho-educative interventions programs (such as the LOOK@ME research intervention project; [101]) particularly by improving their self-awareness, referred to both emotional awareness and the improvement of their meta-cognitive reasoning, indeed supporting emotion regulation and the necessary flexibility of regulatory strategies. As such, this could improve the connectivity among neural structures in compliance with the normally maturing areas, thus

balancing their activation and modulation while strengthening emotion-regulation relevant pathways.

4.2. Conclusions

The current study has exploratorily assessed the network structure of NSSI by investigating how the variables considered as constituent of it organize in shaping the phenomenon under consideration. Moreover, the current study has further assessed how PSU fits within NSSI organizational structure, thereby investigating if the state of sufferance of adolescents performing NSSI might broadens to other dysfunctional behaviors. This exploratory purpose has allowed the settling of some initial basis on the association between NSSI and PSU. Findings pointed also to the importance of considering PSU across multiple problem-demeanors even beyond NSSI, as the consistent and continuous use of the smartphone is now so present and normalized that a problematic use of this tool might then add up to other maladaptive behaviors, particularly considering its portability and its multiple possibilities of use. A subsequent issue would then relate to the risk internal to adolescence itself and related to peer identification so that risk behaviors might more likely spread because of the fast and incredibly broad shearing of information rendered possible by smartphones as a function of all their intrinsic possibilities of use. Findings thus provide room and basis to develop preventive interventions, acting particularly on adolescents' self-control capacities and on their evaluation of regulatory strategies. Moreover, in light of the emerged age differences within NSSI, psychosocial interventions supporting pre-adolescents with clinically relevant NSSI signs and symptoms should be promulged to support psychological adjustment throughout adolescence.

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Declaration of Competing Interest

None.

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