Altered resting-state networks in adolescent non-suicidal self-injury – a graph theory approach

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Background

Non-suicidal self-injury (NSSI) is a highly prevalent transdiagnostic symptom. In adolescents, the prevalence for single events of NSSI in population-based samples is 17.2% (1), while NSSI disorder (a person engages in self-injury without suicidal intent five or more days within the past year) affects 4% in non-clinical and around 50% in adolescent in-patient samples.

Previous NSSI history has shown to predict future NSSI, suicide attempts (2), the risk for suicide (3) and Borderline Personality Disorder (BPD) (4). NSSI is to be seen as a transdiagnostic risk marker or precursor of psychopathology in general (5).

Up to date, little is known about the neurobiological basis of NSSI. Therefore, research on the neurobiological mechanisms underlying NSSI is needed to clarify the neural correlates associated with the behavior (6).

Methods

We examined resting-state-functional-connectivity (RSFC) in female adolescents aged 12-17 years engaging in NSSI, and age-matched healthy controls using graph theory (R packages igraph and brainGraph (7, 8)). Analyses:

1) Group differences on global and regional network measures and
2) Associations between network measures and clinical characteristics in patients.

Mixed linear models were evaluated using the Bayes Factor. BF 3 – 20: “positive evidence”, BF > 20: “strong evidence” (9).

Results

Patient characteristics are presented in **Table 1**.

Adolescents engaging in NSSI demonstrated longer average characteristic path lengths and a smaller number of weighted hubs globally.

Regional measures indicated lower efficiency and worse integration in orbitofrontal and paracentral regions and higher weighted coreness in the pericalcarine gyrus (**Figure 1**).

In patients, lower pericalcarine nodal efficiency was associated with suicidal thoughts in the past year while higher orbitofrontal weighted local efficiency was associated with NSSI during the past month. Higher right but lower left pericalcarine weighted hubness was associated with more suicide attempts during the past year (**Figure 2**).

Table 1. Patient and participant characteristics

	NSSI n (%) / mean (SD)	**Control** n (%) / mean (SD)
N	33	29
Age	15.84 (1.33)	16.02 (1.12)
Right handedness	30 (91)	27 (93)
Body mass index	21.89 (3.48)	20.73 (2.46)
Regular use of medication	4 (12)	1 (4)
Substance use[a]	5 (15)	1 (4)
Acts of NSSI last year	66.39 (76.80)	0
Acts of NSSI last month	3.39 (5.45)	0
Suicidal thoughts last year	5.50 (6.46)	0
Suicidal thoughts last month	1.13 (0.99)	0
Suicide attempts lifetime	1.83 (1.38)	0
Suicide attempts last year	1.00 (0.77)	0
Number of BPD diagnostic criteria	4.24 (2.33)	0.07 (0.26)
BPD diagnosis	14 (42)	0 (0)
Depressive symptoms	29.67 (15.15)	4.07 (3.59)
Depression diagnosis	25 (76)	0 (0)

Note. NSSI = non-suicidal self-injury; BPD = Borderline Personality Disorder. SD = standard deviation. [a]On three or more days in the last three months.

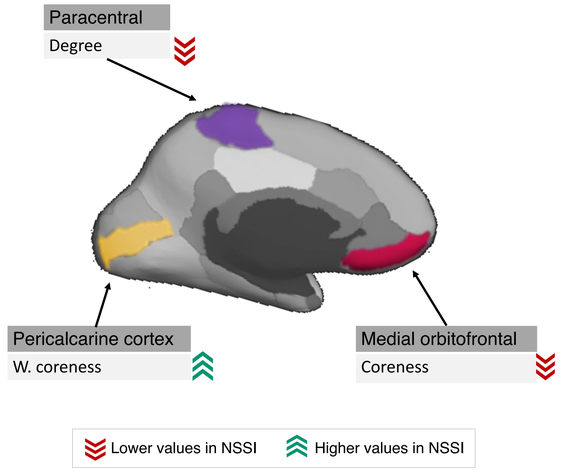

Figure 1. Regional group differences in network measures between adolescents engaging in NSSI vs. healthy controls

Note. *Coreness* = k-core, largest subnetwork comprising nodes of degree at least k. *W. (= weighted) coreness* = s-core, largest subnetwork comprising nodes of strength at least s. Regions of interest illustrated on left hemisphere, but models calculated for left and right hemispheres (with hemisphere as a covariate).

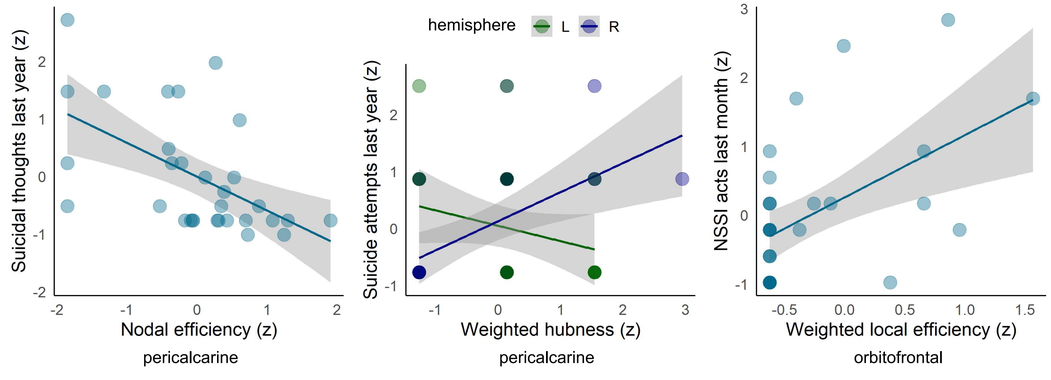

Figure 2. Associations between graph-based measures of regional connectivity and clinical characteristics in patients engaging in NSSI

Associations of graph-based measures with suicidal thoughts, suicide attempts and acts of NSSI. Results from models with BF (= Bayes Factor) > 20 are shown. Each individual measurement is represented by a circle; lines represent linear regression coefficient and grey shaded area represents the standard error. Circles appear darker when multiple measurements are overlaid.

Conclusion

Globally, results indicate less efficient information transfer and fewer areas of highly interconnected nodes, which are central for information integration, in adolescents with NSSI than in controls.

Findings of lower regional orbitofrontal coreness are in line with findings from task-based fMRI (10, 11, 12) and might suggest a deficit of the orbitofrontal regulation of emotional responses and impulsivity normally executed by the OFC on the amygdala.

The role of paracentral degree and pericalcarine coreness needs to be clarified in future studies.

Using a graph-based technique to identify functional connectivity networks, this study adds to the growing understanding of the neurobiology of NSSI.

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References: (1) Swannell et al., 2014, *Suicide & Life Threat Behav* (2) Arsanaow et al., 2011, *J Am Acad Child Adolesc Psychiatry* (3) Hawton et al., 2015, *J Affect Disord* (4) Ghinea et al., 2019, *Psychiatry Research* (5) Ghinea et al., 2020, *J Affect Disord* (6) Westlund Schreiner et al., 2017, *J Affect Disord* (7) Csardi et al., 2006, *InterJournal, Complex Systems* (8) Watson et al., 2018, *Brain Behav* (9) Raftery, 1995, *Sociological Methodology* (10) Sauder et al., 2016, *Development and Psychopathology* (11) Vega et al., 2018, *Brain Imaging and Behavior* (12) Osuch et al., 2014, *Psychiatry Res.*