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Evidence for Depressogenic Spontaneous Thoughts and Altered Resting-State Connectivity in Adolescents With a Maltreatment History

Ferdinand Hoffmann, PhD, Essi Viding, PhD, Vanessa B. Puetz, PhD, Mattia I. Gerin, MSc, Arjun Sethi, PhD, Georgia Rankin, BSc, Eamon J. McCrory, PhD

Objective: Childhood maltreatment has been associated with major depressive disorder (MDD). Atypical self-generated thoughts (SGT), lacking in positive and privileging negative content—a feature of ruminative thinking—might represent one vulnerability factor for developing depression. Rumination in MDD has been linked to alterations in resting-state functional connectivity (RSFC) of the subgenual anterior cingulate cortex (sgACC) to the default mode network and the fronto-parietal network (FPN). This study aimed to investigate online SGT content and its variability, as well as sgACC RSFC, as potential risk markers for depression in adolescents who experienced maltreatment.

Method: Adolescents 12 to 16 years old (29 with maltreatment history [MT] and 39 with no maltreatment history [NMT]) performed an established mind-wandering task. Participants made nondemanding number discriminations during which intermittent questions probed their SGTs that were classified as off-task, positive, negative, self-related, other-related, past-oriented, or future-oriented. Resting-state data were acquired separately for 22 of 29 MT and 27 39 NMT adolescents, and seed-based functional connectivity analyses of the sgACC were performed.

Results: MT, relative to the NMT adolescents, generated significantly fewer positively valenced thoughts, and exhibited more extreme ratings for positively valenced thoughts. MT adolescents also showed significantly reduced RSFC between the sgACC and the FPN. Group differences in depressive symptoms between the MT and NMT adolescents were partly accounted by differences in sgACC-FPN RSFC.

Conclusion: Adolescents who experienced maltreatment show a reduction in positively valenced spontaneous thoughts and reduced sgACC-FPN RSFC at the neural level. These may contribute to a ruminative thinking style, representing risk factors for developing depression later in life.

Key words: child maltreatment, depression, self-generated thoughts, rumination, resting-state functional connectivity

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Childhood maltreatment is associated with significantly increased risk of a range of psychiatric disorders.[1] A common outcome is the development of major depressive disorder (MDD).[2] Adverse early life events such as maltreatment can lead to an internalization of negative self-referential schemas that bias information processing toward negative and away from positive content, a feature of a ruminative thinking style.[3] There is some preliminary evidence that ruminative thinking partially mediates the relationship between childhood maltreatment and depressive symptoms in adults.[4,5] One way of indexing spontaneous thoughts that naturalistically captures the features of ruminative thinking is through the measurement of self-generated thoughts (SGT).[6]

SGTs arise independently of external stimulation from the environment, and comprise experiences such as mind-wandering, day-dreaming, planning, and rumination.[6] Recent evidence has shown that in line with the cognitive model of depression, there is good evidence that patients with MDD tend to engage in more ruminative SGTs.[7,8] Specifically, they appear to have less positive and more negative past and self-related thoughts than healthy controls.[7] Further studies of clinical populations are required to consolidate this evidence base. However, several studies of healthy controls complement these studies of patients who are depressed, demonstrating that past-related SGTs are associated with lower mood, depressive symptoms and an increased stress response.[9-11]

Ruminative thinking is thought to represent one vulnerability factor for developing MDD.[12] In healthy controls and patients with MDD, ruminative thinking has been strongly linked to abnormal functioning of the subgenual anterior cingulate cortex (sgACC).[13,14] The sgACC shows increased activity during sadness,[15] and has been

implicated in the behavioral withdrawal and negative self-reflective processes associated with rumination in healthy controls[14,16] and patients with MDD.[13,17] More specifically, heightened coupling between the sgACC and the default mode network has been commonly observed in MDD and associated with rumination.[17] It has been proposed that self-referential processes supported by the default mode network are integrated with affectively laden, behavioral withdrawal processes related to the sgACC.[13] Abnormal sgACC RSFC to parts of the fronto-parietal network has also been reported in adolescents with MDD.[18,19] Decreased RSFC to prefrontal brain regions was found to be associated with increased rumination.[18] This was interpreted as deficient top-down modulation of the fronto-parietal network, down-regulating negative emotional thoughts.[18] Together these findings suggest that alterations in sgACC RSFC to the default mode network and the fronto-parietal network might be critical in contributing to the emergence of depressive rumination.

According to the theory of latent vulnerability, maltreatment results in measurable alterations in a number of neurocognitive systems that reflect calibration to neglectful and/or abusive early environments.[20,21] These changes may represent (at least in part) an adaptation in response to an adverse caregiving environment during childhood. However, such alterations are also thought to incur a longer-term cost, as they may mean that an individual is poorly optimized to negotiate the demands of other, more normative environments, and as such become more vulnerable to future stressors.[20,21] For example, in a recent study we found that childhood maltreatment was associated with altered neural responses to autobiographical memories, including increased activation of the amygdala and connectivity with the salience network during negative memory recall.[22] This raises the question as to whether the valence of spontaneous thought content of adolescents who have experienced maltreatment is altered. In the current study, we aimed to investigate whether adolescents who experienced maltreatment but were without a diagnosis of MDD show depressogenic SGT patterns and altered sgACC RSFC. In light of prior clinical research, both indices potentially represent associated vulnerability markers at different levels of analysis (behavioral versus neural) for developing depression in the future.

The majority of research on rumination and thought content in the context of childhood maltreatment has relied on questionnaire methods,[4,5] which, despite certain strengths (eg, cost-efficiency, replicability), exhibit poor ecological validity in capturing online thoughts and their content.[23] A growing body of work on SGTs in healthy individuals and psychiatric populations suggests that to gain insight with regard to SGTs and their content, both in health and in illness, it is necessary to use online experience sampling measures.[7,10]

The first aim of the current study was to investigate online SGT contents and their variability in adolescents 12 to 16 years old who had experienced documented maltreatment, compared to a carefully matched control group. We therefore used an established nondemanding choice reaction time task (CRT) that allowed spontaneous SGTs in participants. During this task, participants were probed at random time points, first, about how much they were on task, and, second, about the specific content of their thoughts,[10,24] such as if their thoughts were focused on certain temporal epochs (future or past), involved different referents (self or other), or varied in valence (negative or positive). This task is particularly useful as an objective online measure of the amount and specific content of SGTs, but also of their variability over time, as participants are asked about the SGTs repeatedly throughout the task.

Our second aim was to investigate whether adolescents who experienced maltreatment compared with their peers would show alterations in sgACC RFSC, which have been strongly implicated in rumination in healthy controls and patients with MDD.[13,14] We therefore acquired resting-state data on a subset of the adolescents who had undergone behavioral testing, and seed-based functional connectivity analyses of the sgACC were performed.

Based on previous findings of altered SGTs in adults with MDD[7] and studies reporting a ruminative thinking style in adults with a history of maltreatment,[4,5] we hypothesized that adolescents who experienced maltreatment would engage in more depressogenic SGTs. We expected adolescents who had experienced maltreatment to exhibit less positive and more negative, self-related and past-oriented thoughts. At the neural level, we hypothesized that adolescents who experienced maltreatment would exhibit increased sgACC RSFC to regions within the default mode network and reduced sgACC RSFC to prefrontal brain regions, in line with studies of rumination in MDD.[13,18] Finally, we hypothesized that potential differences in SGTs and sgACC RSFC would in part explain differences in depressive symptoms between maltreated and nonmaltreated adolescents.

METHOD

Participants

A total of 29 adolescents (12−16 years old) who had experienced maltreatment (MT group) were recruited from a London Social Services (SS) Department and adoption agencies. A matched sample of 39 adolescents (12−16 years