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Neural correlates of experiences of loneliness and ostracism in children and adolescents: a systematic review

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ADMINISTRATIVE INFORMATION

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Review Stage at time of this submission - Preliminary searches.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 12 March 2025 and was last updated on 12 March 2025.

INTRODUCTION

Review question / Objective Primary question: What are the neural correlates of different types of loneliness and social ostracism in children and adolescents (age range from birth up to 18 years). This review covers the most common imaging methods used for research purposes, including magnetic resonance imaging (MRI), electroencephalography (EEG), and near-infrared spectroscopy (NIRS).

Secondary question: What are the key limitations in current research related to variability and/or coverage of (measuring) different types of loneliness?

Rationale Loneliness and ostracization in children and adolescents can have detrimental effects on social development as well as both physical and psychological well-being (Bowirrat et al., 2023;

Hawkley & Cacioppo, 2010; Williams, 2007). The children and adolescents of today are in a uniquely challenging situation as a result of growing up during the COVID-19 pandemic and the associated lockdowns, which led to an atypical social environment and an increase in mental health issues (Kauhanen et al., 2023). To the best of our knowledge, there are no previous reviews on the neural correlates of loneliness and ostracism that focus specifically on children and adolescents. While many of the earlier reviews do not specifically exclude minors from the search (Lam et al., 2021; Luo & Shao, 2023; Zovetti et al., 2021), they set other limitations on their searches which lead to imperfect coverage of loneliness and ostracization of this special age group. For example, Luo and Shao (2023) limited the results to studies using one specific questionnaire.

Existing neuroimaging research suggests that loneliness may upregulate cognitive control

networks to process socio-emotional information (Wong et al., 2022). Additionally, social isolation has been associated with both structural and functional alterations in brain networks involved in mentalizing and social processes (Zovetti et al., 2021). However, the neural correlates underlying loneliness-related changes in these neural networks are not yet well defined. A better understanding of these correlates could lead to significant advancements in the prevention and treatment of loneliness, thereby improving mental and physical health outcomes and contributing to a more comprehensive understanding of human social behavior. This review will examine the neural basis of loneliness and ostracization in minors and possibly reveal gaps in the current literature related to the approach to loneliness and ostracization research.

Condition being studied Loneliness refers to subjective feelings of dissatisfaction related to one's social relationships. Loneliness can be divided into two main subtypes: Emotional loneliness, related to a lack of close attachment with another person, and social loneliness, related to a lack of social network and sense of belonging (Hoza et al., 2000). These two concepts are connected, as more socially accepted children have a higher likelihood of also having a best friend (Parker & Asher, 1993), possibly as a result of having more opportunities to find close friends. Ostracism refers to the intentional exclusion and rejection of someone from a social network, and terms such as social isolation and social rejection are often used interchangeably with ostracism (Williams, 2007). Peer rejection tends to remain stable in adolescence (Hardy et al., 2002; Kiuru et al., 2024), which means that it can form a persistent risk factor for loneliness.

Loneliness as a subjective feeling is measured using questionnaires (Maes et al., 2022), whereas experiences of ostracism can be both measured using questionnaires (Walsh et al., 2022) or induced using experimental paradigms (Williams, 2007), some of which are compatible with MR imaging setting (Bolling et al., 2011; Williams et al., 2000).

METHODS

Search strategy The screening and assessment for eligibility for this systematic review is conducted by authors EPP, SL, HKA, and MJP. Each article is screened by one person. In unclear cases, the screeners discuss the inclusion/exclusion of the article together. Assessment for eligibility using full text is done independently by two authors for each article. Disagreements are

discussed by the two authors and in conflict situations a third author is consulted.

The goal of this literature search is to cover all MRI, EEG, and NIRS studies related to any types of loneliness or social exclusion in children and adolescents (ages 0–18 years).

An information specialist was consulted while creating the search phrase. The search phrase for PubMed is:

(brain* OR "brain"[MeSH] OR neur*) AND (infan* OR "Infant"[Mesh] OR toddler* OR child* OR "Child"[Mesh] OR adolesc* OR "Adolescent"[Mesh] OR young* OR youth* OR school*) AND (lonel* OR "Loneliness"[Mesh] OR (social AND (isolation OR exclusion) OR "Social Isolation"[Mesh]) OR ostraci* OR "Ostracism"[Mesh]) AND ("Magnetic Resonance Imaging"[Mesh] OR MRI or "magnetic resonance imaging" OR fMRI OR DTI OR dMRI OR DWI OR diffus* OR anisotrop* OR EEG OR electroencephalograph* OR NIRS OR fNIRS OR "near-infrared spectroscop*")

The formatting of the search phrase is slightly modified depending on the database (databases included: MEDLINE (PubMed), Web of Science, and Embase). The only filter used in the search is to only include publications written in English. Literature search will be reported according to Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021).

Participant or population All studies in living humans from birth to 18 years of age regardless of diagnoses are included.

Intervention Not applicable.

Comparator Not applicable.

Study designs to be included We include cross sectional and longitudinal studies that pass the inclusion criteria. We include both correlational and group comparison studies, including those with interventions.

Eligibility criteria

Screening

Screening is done based on title and abstract only. If the article meets one or more of the exclusion criteria, it is excluded. The exclusion criteria are:

1. The article is not in English.
2. The article is not an original research article (for example, reviews, case-reports, editorials, dissertations, and conference abstracts are excluded).
3. The sample includes any non-human animals.

4. There is no indication that subjects under the age of 18 years were included.
5. There is no indication that any type of loneliness or ostracization measurement was used (including questionnaires and neuroimaging tasks).
6. There is no indication that neuroimaging using either MRI, EEG, or NIRS was done.

Seeking reports for retrieval and assessment for eligibility

We will search for full-text articles of the abstracts that passed screening.

Assessment for eligibility is done using the following exclusion criteria. If one or more of the criteria are met, the article is excluded.

1. All the same criteria as in the screening phase.
2. The mean or median age of participants is 18 years or higher.

Information sources The covered databases include MEDLINE (PubMed), Web of Science, and Embase.

Main outcome(s) A qualitative synthesis of the current state of knowledge regarding the structural and functional neural correlates of loneliness and ostracization in children and adolescents.

Additional outcome(s) Identification of the research gaps and limitations in the current literature.

Data management Not applicable (no quantitative analysis is performed).

Quality assessment / Risk of bias analysis Quality assessment will be performed utilizing Joanna Briggs Institute (JBI) Critical Appraisal Tools (Moola et al., 2024). Furthermore, the limitations related to heterogeneity in measurement methods will be discussed.

Strategy of data synthesis We expect to find significant variability in the used measurements in the included studies, and therefore will not attempt a quantitative analysis of the data. This systematic review will qualitatively synthesise the earlier literature.

Subgroup analysis Not applicable.

Sensitivity analysis Not applicable.

Language restriction Only studies published in English will be considered for inclusion.

Country(ies) involved Finland.

Other relevant information Second co-authors: Silja Luotonen and Hilyatushalihah K. Audah, these authors contributed equally to this work.

Keywords Loneliness; ostracism; MRI; EEG; NIRS.

Dissemination plans We intend to publish a preprint once the manuscript is finished and then submit the article to a scientific journal. Publication has not been discussed with any specific journal at this stage. Following publication, we will employ standard measures of communication including through press releases, publication on websites and blog posts.

Contributions of each author

Author 1 - Elmo Pulli - conceiving and designing the review, planning the protocol, coordinating the review, screening and assessing the eligibility of studies, interpretation of data, writing - preregistration and original draft.

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