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Sex differences in interoception and mental health: an investigation across the menstrual cycle

Submission date
05/11/2024

Recruitment status
Recruiting

Registration date
19/12/2024

Overall study status
Ongoing

Last Edited
10/08/2026

Condition category
Mental and Behavioural Disorders

[X] Prospectively registered
[X] Protocol
[_] Statistical analysis plan
[_] Results
[_] Individual participant data
[X] Record updated in last year

Plain English summary of protocol

Background and study aims
Many common mental health conditions (e.g. anxiety and depression) are more common in women than men and the presentation and persistence of these conditions often differs between men and women. However, what underlies sex differences in mental illness is unclear. Recent research suggests that the ability to perceive the internal state of your body (e.g. feeling your heartbeat; 'interoception') might be important for mental health and well-being, underlying key cognitive abilities such as emotion regulation. Importantly, sex differences in interoception are well documented. Research suggests that compared to men, women tend to be less accurate at perceiving interoceptive signals and yet report more attention to interoceptive signals.

Given known links between interoception and mental health, questions remain regarding the extent to which sex differences in interoception relate to sex differences in mental health and why men and women differ with respect to interoception. In women, periods of physical and hormonal change (e.g. the menstrual cycle, pregnancy, menopause) are often associated with changes in mood and mental health. However, whether physical and hormonal change (e.g. during the menstrual cycle) impacts interoception is not yet known.

This project will examine the contribution of interoception to mental health and mood in both sexes across the menstrual cycle, examine the utility of digital technology (i.e. smartphone application) for the assessment of interoception over time, and test the feasibility of implementing interoceptive training intervention.

Who can participate?
Cisgender females and males aged 18 to 40 years old with normal or corrected-to-normal vision and hearing, and no known neurological or cardiac condition/s will be invited to take part. Prospective participants must have an iPhone 7 or above, with iOS 13 or above (compatibility of the smartphone application at present) and report fluency in English. The study is restricted to those living within the UK and EU countries. See Participant Exclusion Criteria below for the full list of exclusion criteria.

What does the study involve?
For ~7 months, both female and male participants will use a specially designed smartphone app to track their daily and weekly mood, mental health, and physical symptoms, including menstrual cycle information (naturally cycling females only). Daily and weekly measures of interoception (beliefs, attention and cardiac interoceptive accuracy) will be included. After three months, a smaller sample of participants will take part in lab sessions to measure interoceptive accuracy across bodily systems e.g. breathing. In the last 2 months, participants will be randomly assigned into groups to receive either cardiac interoceptive accuracy or non-cardiac interoceptive accuracy training, with some also completing CBT materials, to examine the influence of training on aforementioned variables (mood, mental health and interoception).

What are the possible benefits and risks of participating?
Possible benefits:
Participants will have the opportunity to receive personalised insights (e.g., health indices, alcohol use) and receive ongoing updates and resources regarding the study and its progress. More broadly, by taking part in this study participants will be contributing to research that will advance our understanding of mental health.

Possible risks:
Some topics may be sensitive to participants, e.g., mental health. Participants will not be forced to answer questions, will be reminded that they can skip questions or stop at any time and will be paid for their participation up until the point they stop.
To measure respiratory interoception, participants will experience different levels of resistance to their breathing but will always be in control of their breathing. Participants with asthma are advised not to participate but this does not affect their participation in the other tasks.
Participants who report moderate anxiety sensitivity, measured on the Physical Concerns subscale of the ASI-3, will not be invited to participate in the task.
To measure arousal, participants will see a database containing highly arousing images. Participants who self-report the presence of a phobia can opt out of the task/will not be invited to participate in the task, and participants who do participate will first undergo thresholding (i.e. practice) trials of increasing intensity to consent that they are happy to see images of similar level of intensity in the experimental trials. If not, they will not continue in the task but can participate in the others.

Where is the study run from?
The study is run from University of Surrey (Guildford, UK) in collaboration with Royal Holloway University of London and University College London (London, UK).

When is the study starting and how long is it expected to run for?
April 2024 to April 2027.

Who is funding the study?
Medical Research Council (MRC) (UK).

Who is the main contact?
The Principal Investigator of this study is Dr Jennifer Murphy (Jennifer.murphy@surrey.ac.uk) and the Research Fellow is Dr Rosie Donaghy (r.donaghy@surrey.ac.uk).

Contact information

Type(s)

Scientific, Principal investigator

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Additional identifiers

Protocol serial number
MRC Reference: MR/X010295/1

Study information

Scientific Title
Sex differences in interoception and mental health: an investigation across the menstrual cycle

Study objectives

In this study, we aim to investigate sex differences in interoception and mental health (anxiety, depression, somatic symptoms), and understand the potential underlying mechanism contributing to these differences.

To do so we will:
1. Investigate whether sex differences in interoception are related to sex differences in mental health i.e. common mental health conditions (anxiety, depression), mood, and the presence of somatic symptoms
2. Investigate whether periods of physical and hormonal change underlying the menstrual cycle in females contribute to sex differences in interoception and mental health
3. Investigate whether interoceptive training can improve interoception and mental health

Ethics approval required
Ethics approval required

Ethics approval(s)
Approved 19/07/2024, University of Surrey Ethics Committee (Assurance Team (formerly Research Integrity and Governance Office), Assurance Team Research, Innovation and Impact, Senate House, Guildford, Surrey, GU2 7XH, United Kingdom; +44 (0)1483 683490; ethics@surrey.ac.uk), ref: FHMS 23-24 001 EGA

Primary study design
Observational

Study design
Multicentre longitudinal study with a randomised parallel trial intervention

Study type(s)
Efficacy

Health condition(s) or problem(s) studied
Identifying sex differences in interoception (i.e. the perception of the internal state of the body), common mental health disorders (i.e. anxiety, depression) and mood, and somatic complaints (i.e. physical symptoms), and identifying whether the menstrual cycle may contribute to these differences.

Interventions
For ~7 months, both female and male participants will use a specially designed smartphone app to track their daily and weekly mood, mental health, and physical symptoms, including menstrual cycle information (naturally cycling females only). Daily and weekly measures of interoception (beliefs, attention and cardiac interoceptive accuracy) will be included. After three months, a smaller sample of participants will take part in lab sessions to measure interoceptive accuracy across bodily systems e.g. breathing.

In the last 2 months, participants will be randomly assigned into groups to receive either cardiac interoceptive accuracy or non-cardiac interoceptive accuracy training, with some also completing CBT materials, to examine the influence of training on aforementioned variables (mood, mental health and interoception).

Intervention Type
Behavioural

Primary outcome(s)
Interoceptive accuracy will be measured using:
1. Scores from the Interoceptive Accuracy Scale, measured at baseline, weekly intervals and items reported daily (experienced sampling method).
2. Scores from a Phase Adjustment Task (PAT) at baseline and at weekly intervals.
3. Scores on weekly lab-based tasks assessed at weekly intervals
3.1. Cardiac interoceptive accuracy (Phase Adjustment Task)
3.2. Respiratory interoceptive accuracy (a Respiratory Resistance Detection task)
3.3. The degree of convergence between observed autonomic response (cardiovascular activity, skin conductance) and perceived arousal during exposure to affective images.

Interoceptive attention will be measured using:
1. Scores from items on the Interoceptive Attention Scale, at baseline and daily/weekly intervals.

Mental health (anxiety, depression, stress) will be measured using:
1. Scores on momentary mood items reported daily (experience sampling method).
2. Scores on validated questionnaires taken at baseline and weekly intervals.
Regarding questionnaires, anxiety and depression will be measured using the Hospital and Depression Scale, and the Anxiety Sensitivity Index (ASI-3). Stress will be measured using the Perceived Stress scale (PSST-8). Physical symptoms will be measured using items from the Somatic Symptoms Scale and Premenstrual Symptoms Screening Scale.

Key secondary outcome(s)
1. Emotion regulation will be measured using:
1.1. Scores on the Difficulties in Emotion Regulation Scale assessed at weekly intervals
1.2. Scores on items taken from Emotion Regulation Questionnaire reported daily (experience sampling method)
1.3. Modulation of physiological arousal in lab-based task assessed at weekly intervals (in a subsample after 12 weeks of study start)
2. Obsessive Compulsive tendencies will be measured using scores on items from the OCI-4 reported at daily/weekly intervals
3. Sexual health (sexual activity and sexual desire) will be measured using scores from self-developed items reported daily (experience sampling method)
4. Alexithymia will be measured using scores on the Toronto Alexithymia Scale (TAS-20) at baseline and at the end
5. Intolerance of Uncertainty will be measured using scores on the Intolerance of Uncertainty scale (IUS-12) at baseline and at the end
6. Self-efficacy will be measured using scores on the Rosenberg Self-efficacy Scale (Rosenberg, 1965) at baseline and at the end
7. Paranoia will be measured using scores on the Revised Green et al. Paranoid Thoughts Scale (R-GPTS) at baseline and at the end as well as via daily reports (experience sampling method)

Completion date
26/04/2027

Eligibility

Key inclusion criteria
1. Sex assigned female or male at birth
2. 18-40 years old

3. Have an iPhone 7 or above with iOS 13 or above (for compatibility with the smartphone app)
4. Have sufficient fluency in English (for comprehension of task instructions)
5. Based in the UK or an EU country
6. Provide informed consent
For full list of exclusion criteria, see Participant Exclusion Criteria below.

Participant type(s)
Healthy volunteer, Resident, Other

Healthy volunteers allowed
No

Age group
Adult

Lower age limit
18 Years

Upper age limit
40 Years

Sex
All

Total final enrolment
0

Key exclusion criteria
Both sexes:
1. Impaired vision or hearing
2. Neurological or cardiac abnormalities
3. Taking psychiatric medication/s for less than 6 months
4. Above threshold for severe anxiety sensitivity as measured by the Physical Concerns subscale of the Anxiety Sensitivity Index
5. Undergoing or awaiting to undergo sex-reassignment hormone therapy or surgery (in the next 6 months)

Females only:
1. Not currently pregnant or breastfeeding (or pregnant in the last 12 months)
2. Not undergoing (or planning in the next 6 months) changes to their reproductive function that include: hysterectomy, ovarian surgery, IVF treatment, gender transitioning hormone treatment /s (i.e. testosterone)
3. No current (or a history of) hypothyroidism or hyperthyroidism
4. No current (or a history of) pelvic complaints that include: fibroids on the uterus, ovarian cysts, endometriosis, pelvic inflammatory disease, intermittent or constant pain in the lower abdomen in the last 6> months
5. No primary amenorrhoea (i.e. never experienced a menstrual cycle)
6. Provide informed consent to record menstrual cycle information

To compare menstrual cycle effects, females will be grouped by hormonal contraception status with the following inclusion criteria.

Eligible naturally cycling females are those:
1. Not taking any hormonal contraception for at least 6 months
2. No history of secondary amenorrhoea (3 months or more without a period) within the last 12 months
3. Whose cycle length is considered regular on the basis of their tracking

Eligible females taking hormonal contraception are those:
1. Taking hormonal contraception for at least 6 months or more

Date of first enrolment
06/05/2025

Date of final enrolment
15/12/2026

Locations

Countries of recruitment
United Kingdom

England

Austria

Belgium

Bulgaria

Croatia

Cyprus

Czech Republic

Denmark

Estonia

Finland

France

Germany

Greece

Hungary

Ireland

Italy

Latvia

Lithuania

Luxembourg

Malta

Netherlands

Poland

Portugal

Romania

Slovakia

Slovenia

Spain

Sweden

Study participating centre
University of Surrey
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Study participating centre
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Study participating centre
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Sponsor information

Organisation
University of Surrey

ROR
https://ror.org/00ks66431

Funder(s)

Funder type
Research council

Funder Name
Medical Research Council

Alternative Name(s)
Medical Research Council (United Kingdom), UK Medical Research Council, Medical Research Committee and Advisory Council, MRC

Funding Body Type
Government organisation

Funding Body Subtype
National government

Location
United Kingdom

Results and Publications

Individual participant data (IPD) sharing plan
The datasets generated during and/or analysed during the current study will be available on request from Dr Jennifer Murphy (jennifer.murphy@surrey.ac.uk). Further details of this are summarised below:

Participants will have been asked to give consent to data sharing prior to their enrolment in the study. At the end of the study, research data will be collated into a single spreadsheet, with a data key indicating the content of each variable, and how it was scored. Users of the data will be required to sign a data sharing agreement and expected to cite the data, to raise awareness of their existence. When researchers have signed this agreement, they will be issued with a confidential private link for accessing the data. The PI (Dr Jennifer Murphy) will determine whether a use should be granted access to the data and will do so once the potential user has

completed the appropriate licensing agreement. The researchers will publish a summary about data requests made, including the number of requests made and reasons for refusal on the PI's website.

It is not expected that the research team should have any exclusive period of use. When data are ready for sharing following completion of final analyses (or within 24 months of study completion), they will be made available. The research data will be fully anonymised prior to sharing in the repository and will be made available for a minimum of 10 years, to maximise the long-term value of the dataset. Results will be made available along with data within 24 months of the end of the study at the anticipated publication stage, in Surrey Open Research repository.

Before recruitment begins, details of data analysis and statistical methods will be outlined in OSF and accessible at the following link: https://osf.io/fsvyu/?view_only=785bf6d9bfe7440091e391fe492d98c2

IPD sharing plan summary

Available on request

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Protocol (other)		30/10/2024	26/01/2026	No	No
Study website		11/11/2025	11/11/2025	No	Yes