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How mental fatigue affects brain function and cognitive performance in healthy adults: an fMRI study

Submission date
11/08/2026

Recruitment status
No longer recruiting

Registration date
14/08/2026

Overall study status
Completed

Last Edited
12/08/2026

Condition category
Other

[_] 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
Mental fatigue is the feeling of being mentally tired after doing demanding thinking tasks for a long time. It can affect attention, decision-making and performance, but researchers do not yet fully understand what changes occur in the brain when people become mentally fatigued.
This study aimed to find out how mental fatigue affects brain activity and thinking performance in healthy adults. The researchers used functional magnetic resonance imaging (fMRI), a type of brain scan, to measure brain function and blood flow in the brain while participants completed mental tasks.

Who can participate?
Healthy adults aged 18 to 35 years could take part. Participants had to be right-handed, non-smokers and not taking medication. People with medical, mental health or psychiatric conditions, colour blindness, claustrophobia, or any implants that were not safe for MRI scanning could not take part.

What does the study involve?
Participants attended two study sessions. In one session, they completed a challenging computer task called a Stroop task for about 45 minutes while having an fMRI brain scan. This task was designed to make people mentally fatigued.
In the other session, participants watched an emotionally neutral nature documentary for about 45 minutes while having the same type of brain scan. This acted as a comparison condition.
Before and after each session, participants completed a short computer task called a Go/NoGo task, which measures attention, self-control and response inhibition. Participants also completed questionnaires about mental fatigue, mood, sleepiness, attention, boredom, motivation and workload.

What are the possible benefits and risks of participating?
Participants were unlikely to receive a direct health benefit from taking part. However, the study could improve understanding of how mental fatigue affects the brain and cognitive performance, which may help inform future research.

Possible risks included temporary mental tiredness from completing demanding cognitive tasks. Some people may also find MRI scans uncomfortable because they involve lying still in a confined space for a period of time. People with claustrophobia or MRI-incompatible implants were excluded from participation.

Where is the study run from?
The study was run from Vrije Universiteit Brussel and Universitair Ziekenhuis Brussel in Belgium.

When is the study starting and how long is it expected to run for?
August 2024 to August 2025.

Who is funding the study?
The study is funded by Universitair Ziekenhuis Brussel (UZ Brussel), Belgium.

Who is the main contact?
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Study information

Scientific Title
Brain function and cognitive performance during and after a mentally fatiguing Stroop task compared with an emotionally neutral documentary in healthy adults with different levels of mental fatigue susceptibility: a randomized crossover fMRI study

Study objectives
The aim of this study is to investigate the effects of experimentally induced mental fatigue on brain function and cognitive performance in healthy adults using fMRI.

Ethics approval required
Ethics approval required

Ethics approval(s)
Approved 28/02/2024, Commissie Medische Ethiek (CME) (Laarbeeklaan 101, Jette, 1090, Belgium; +32 2 477 55 85; ethiek@uzbrussel.be), ref: EC-2023-373

Primary study design
Interventional

Allocation
Randomized controlled trial

Masking
Blinded (masking used)

Control

Active

Assignment
Crossover

Purpose
Basic science

Study type(s)

Health condition(s) or problem(s) studied
Mental fatigue and its effects on brain activity and cognitive performance in healthy adults

Interventions
Participants completed both an experimental mental fatigue condition and a control condition in a randomized crossover order, with the two experimental sessions separated by at least several days.

The order of the two experimental conditions was randomised using the web-based randomisation tool Randomization.com. All participants completed both the mental fatigue and control conditions in a crossover design, with the order of the two conditions determined by the generated randomisation sequence.

Mental fatigue condition: Participants performed a prolonged modified Stroop task while undergoing functional magnetic resonance imaging. The task was designed to induce mental fatigue through sustained cognitive effort and lasted approximately 45 minutes. Participants responded to colour-word stimuli using MRI-compatible response buttons. BOLD signal, cerebral blood flow (CBF), and cognitive performance were recorded during the task.

Control condition: Participants watched an emotionally neutral nature documentary for approximately 45 minutes while undergoing the same magnetic resonance imaging procedures. The documentary served as a low-cognitive-demand control condition.

In both conditions, participants performed a 5-min Go/NoGo task before and immediately after the mental fatigue/control period to assess cognitive control and response inhibition. BOLD signal and CBF were assessed during the task. Subjective mental fatigue and other psychological measures were also assessed during both experimental sessions.

Intervention Type
Behavioural

Primary outcome(s)
1. BOLD brain activity and CBF measured using simultaneous BOLD/ASL fMRI at before intervention (PRE), during intervention (DURING), immedialtely after intervention (POST)

2. Cognitive performance during the Go/NoGo and Stroop tasks measured using accuracy (%) and reaction time (ms), recorded using E-Prime 3.0 at before intervention (PRE), during intervention (DURING), immedialtely after intervention (POST)

3. Subjective mental fatigue measured using Mental Fatigue Visual Analogue Scale (M-VAS) at before intervention (PRE), immedialtely after intervention (POST)

4. Mood measured using Brunel Mood Scale (BRUMS) at before intervention (PRE), immedialtely after intervention (POST)

5. Sleepiness measured using Karolinska Sleepiness Scale (KSS) at before intervention (PRE), immedialtely after intervention (POST)

6. Subjective workload measured using 4-item National Aeronautics and Space Administration Task Load Index (NASA-TLX-4) at before intervention (PRE), immedialtely after intervention (POST)

7. Situational motivation measured using Situational Motivation Scale (SIMS) at before intervention (PRE), immedialtely after intervention (POST)

8. Subjective attention measured using Visual Analogue Scale for Attention (A-VAS) at before intervention (PRE), immedialtely after intervention (POST)

9. Subjective boredom measured using Visual Analogue Scale for Boredom (B-VAS) at before intervention (PRE), immedialtely after intervention (POST)

Key secondary outcome(s)

Completion date
02/08/2025

Eligibility

Key inclusion criteria
1. Male or female
2. Aged 18–35 years
3. Healthy, with no neurological, cardiovascular or musculoskeletal disorders
4. Right-handed
5. Not using medication
6. Non-smoker

Healthy volunteers allowed
Yes

Age group
Adult

Lower age limit
18 Years

Upper age limit
35 Years

Sex
All

Total final enrolment

Key exclusion criteria
1. Presence of a chronic health condition, including neurological, cardiovascular, or musculoskeletal disorders
2. Colour blindness
3. Participation in concurrent care or other research trials
4. History of mental or psychiatric disorders:
- Increased risk of burnout, defined as a Burnout Assessment Tool score ≥ 2.59
- High general fatigue, defined as a Multidimensional Fatigue Inventory score > 57
- Symptoms of depression, defined as a Beck Depression Inventory-II score > 16
5. Use of medication
6. Non-compliance with pre-trial requirements concerning caffeine intake, strenuous exercise and standardized dietary intake
7. Claustrophobia
8. Metal dental implants, or braces
9. Any non-MRI-compatible implant

Date of first enrolment
30/08/2024

Date of final enrolment
02/08/2025

Locations

Countries of recruitment
Belgium

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Universitair Ziekenhuis Brussel
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Sponsor information

Organisation
Vrije Universiteit Brussel

ROR
https://ror.org/006e5kg04

Funder(s)

Funder type

Funder Name
Universitair Ziekenhuis Brussel

Alternative Name(s)
Universitair Hospital Brussel, UZ Brussel, UZ

Funding Body Type
Government organisation

Funding Body Subtype
Universities (academic only)

Location
Belgium

Results and Publications

Individual participant data (IPD) sharing plan
Anonymized individual participant data may be made available upon reasonable request, subject to a data use agreement and applicable ethical and data protection requirements.

IPD sharing plan summary
Available on request

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Participant information sheet	in Dutch version 1		12/08/2026	No	Yes
Protocol file	version 3	22/01/2024	12/08/2026	No	No