Neural Correlates of the LSD Experience Revealed by Multi-Modal Neuroimaging

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Beckley / Imperial Research Programme

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What is this study about?

This is the first-ever study to examine the effects of LSD on the human brain. Using multiple brain imaging techniques, it gives us the first glimpses into what happens to the brain to produce LSD's psychedelic (and possibly therapeutic) effects.

Why did we do this study?

- Hundreds of scientific studies examined the effects of LSD in the 1950s and '60s (when it was still legal), but no study has ever before examined what it does to the brain.
- **We wanted to know: How does LSD so profoundly change consciousness? What changes underlie these effects? How psychedelics could be therapeutically beneficial?**

What did we do?

- We gave 20 people either **LSD** (75µg intravenous) or **placebo** (saline) on 2 separate days.
- On each day, they completed **brain imaging** and **self-report questionnaires.**
- Brain imaging consisted of:
  - **ASL** = arterial spin labelling = an MRI method to measure **blood flow** within the brain.
  - **Resting-state MRI** = MRI while the subject lies still with eyes closed = a method to assess **functional connections** *within* and *between* brain networks.
  - **MEG** = magnetoencephalography = a method to detect '**brain waves**.'

What did we find?

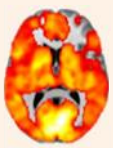
1. ALTERED CONSCIOUSNESS

All participants reported **visual hallucinations** and profound **changes in consciousness** on LSD (vs. placebo).

2. 'SEEING WITH EYES SHUT' = Brain activity normally associated with visual input.

- Connectivity of brain regions involved in vision ('visual cortex') **increased** on LSD, so that visual cortex 'talked to' much more of the rest of the brain than after placebo.

Visual cortex connectivity: **Placebo**



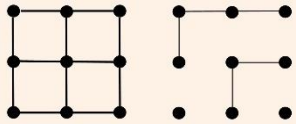
Visual cortex connectivity: **LSD**

- This increase correlated with self-reported **hallucinations**.
- Changes in **brain waves** in visual regions also correlated with hallucinations, suggesting these findings are related.
- **Blood flow** to visual regions also increased.
- **Note:** These are all properties normally associated with visual stimulation, but participants had their eyes closed!

3. 'DISINTEGRATION' = Loss of integrity/ stability *within* brain networks.

- Brain regions that together make up brain networks lost connectivity with one another, so that 'integrity' within those networks decreased.

High Integrity



Low Integrity

- Decreased integrity within a specific network – the **Default Mode Network (DMN)** – correlated with self-reported '**ego-dissolution**' and '**altered meaning**.' This suggests that the DMN underlies a stable sense of self and other aspects of normal consciousness.

ALSO:

- **Brain wave synchronisation** decreased – that is, neurons that normally fire together to produce brain waves lost their synchronisation.
- This decrease **correlated** with both DMN disintegration and ego-dissolution, suggesting the findings are inter-related.

4. 'DESEGREGATION' = Increased connectivity *between* brain networks.

- Distinct brain networks became **more connected** to one another – that is, they lost their 'separateness,' allowing for wider and more integrated communication between networks.
- An example of this is the vision finding above, but it occurs across all the brain networks.

Why is this important?

Understanding how LSD works in the brain can:

- Help unlock its **therapeutic potential**.
- Provide valuable information on the **mechanisms** underlying consciousness and its changing states.
- The 'brain wave' findings also give clues as to the **neuron-level mechanics** underlying the network-level changes. Also we found new information about changes in blood supply within the brain.

About the research team

Amanda Feilding is the founder and director of the Beckley Foundation. She and David Nutt are Co-Directors of the Beckley/Imperial Research Programme. Robin Carhart-Harris is the Programme's lead investigator.