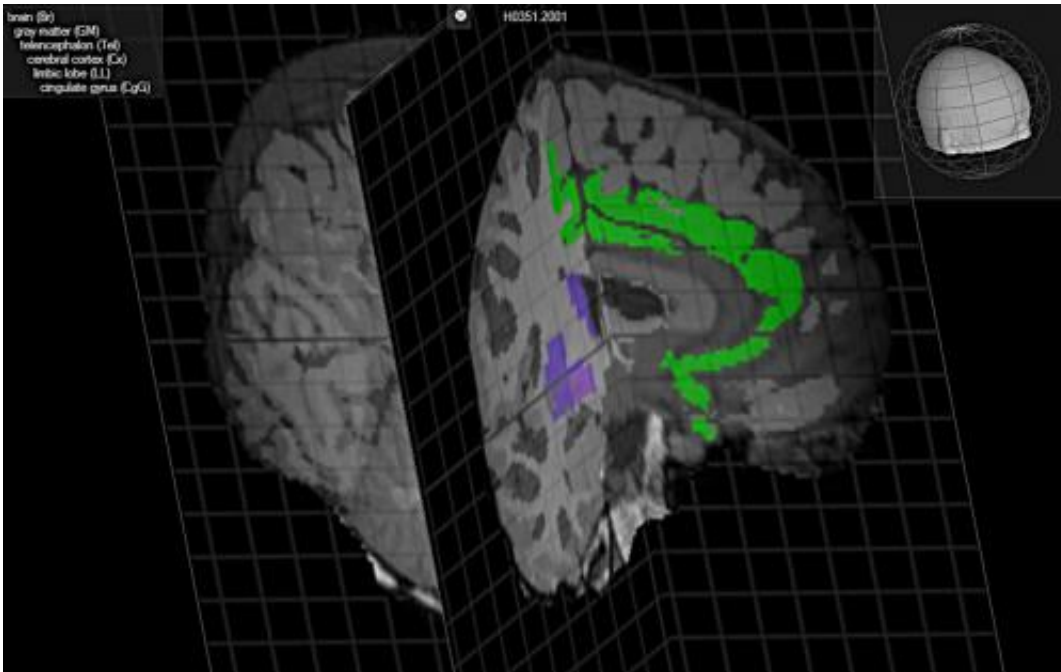


Is the key to consciousness in the claustrum?

May 26 2014, by Klaus M. Stiefel



The location of the claustrum (blue) and the cingulate cortex (green), another brain region likely to act as a global integrator. The person whose brain is shown is looking to the right (see the inset in the top right corner). Credit: Brain Explorer, Allen Institute for Brain Science

Consciousness is one of the most fascinating and elusive phenomena we humans face. Every single one of us experiences it but it remains surprisingly poorly understood.

That said, psychology, neuroscience and philosophy are currently making interesting progress in the comprehension of this phenomenon.

The main player in this story is something called the [claustrum](#). The word originally described an enclosed space in medieval European monasteries but in the mammalian brain it refers to a small sheet of neurons just below the [cortex](#), and possibly derived from it in brain development.

The [cortex](#) is the massive folded layer on top of the brain mainly responsible for many higher brain functions such as language, long-term planning and our advanced sensory functions.

Interestingly, the claustrum is strongly reciprocally connected to many [cortical areas](#). The [visual cortex](#) (the region involved in seeing) sends axons (the connecting "wires" of the nervous system) to the claustrum, and also receives axons from the claustrum.

The same is true for the [auditory cortex](#) (involved in hearing) and a number of other cortex areas. A wealth of information converges in the claustrum and leaves it to re-enter the cortex.

The connection

[Francis Crick](#) – who together with [James Watson](#) gave us the structure of DNA – was interested in a connection between the claustrum and [consciousness](#).

In a recent paper, published in [Frontiers in Integrative Neuroscience](#), we have built on the ideas he described in his [very last scientific publication](#).

Crick and co-author [Christoph Koch](#) argued that the claustrum could be a [coordinator of cortical function](#) and hence a "conductor of consciousness".

Such percepts as colour, form, sound, body position and social relations

are all represented in different parts of the cortex. How are they bound to a unified experience of consciousness? Wouldn't a region exerting a (even limited) central control over all these cortical areas be highly useful?

This is what Crick and Koch suggested when they hypothesised the claustrum to be a "conductor of consciousness". But how could this hypothesis about the claustrum's role be tested?

Plant power alters the mind



Salvia divinorum (Herba de Maria). Credit: Wikipedia, CC BY

Enter the plant [Salvia divinorum](#), a type of mint native to Mexico. The Mazatecs civilisation's priests would chew its leaves to get in touch with the gods.

It's a powerful psychedelic, but not of the usual type. Substances such as [LSD](#) and [psilocibin](#) (the active compound in "magic" mushrooms) mainly act by binding to the serotonin neuromodulator receptor proteins.

It is not completely understood how these receptors bring about altered states of consciousness, but a reduction of the inhibitory (negative feedback) communication between neurons in the cortex likely plays a role.

In contrast, *Salvia divinorum* acts on the [kappa-opiate receptors](#). These are structurally related, but their activation has quite different effects than the [mu-opiate receptors](#) which bind substances such as morphine or heroin.

In contrast to the mu-opiate receptors, which are involved in the processing of pain, the role of the kappa-opiate receptors is somewhat poorly understood.

Where are these kappa-opiate receptors located in the brain? You might have guessed it, they are most densely concentrated in the claustrum (and present at lower densities in a number of other brain regions such as the frontal cortex and the amygdala).

So, the activity of *Salvia* likely inhibits the claustrum via its activation of the kappa-opiate receptors. Consuming *Salvia* might just cause the inactivation of the claustrum necessary to test Crick and Koch's hypothesis.

Any volunteers?

Did we administer this psychedelic to a group of volunteers to then record their hallucinations and altered perceptions? Well, no. To get ethics approval for such an experiment with a substance outlawed in Australia would be near impossible.

While *Salvia* is not known to be toxic or addictive, the current societal climate is not very sympathetic towards psychoactive substances other than alcohol.

But fortunately we had an alternative. The website Erowid.org hosts a database of many thousand trip reports, submitted by psychedelic enthusiasts, describing often in considerable detail what went on in their minds when consuming a wide selection of substances.

We analysed trip reports from this website written by folks who had consumed *Salvia divinorum* and, for comparison, LSD.

We found that subjects consuming *Salvia* were more likely to experience a few select psychological effects:

- they were more likely to believe they were in an environment completely different from the physical space they were actually in
- they often believed to be interacting with "beings" such as hallucinated dead people, aliens, fairies or mythical creatures
- they often reported "ego dissolution", a variety of experiences in which the self ceased to exist in the user's subjective experience.

... and this means?

Altered surroundings, other beings and ego dissolution – this surely hints at a disturbance of the "conductor of consciousness", as expected if the conductor claustrum is perturbed by *Salvia divinorum*.

If a region central to the integration of consciously represented information is disturbed in its function, we would expect fundamental disturbances in the conscious experience. The core of a person's consciousness seems to be altered by *Salvia divinorum*, rather than merely some distortions of vision or audition.

We believe that the psychological effects of *Salvia divinorum*, together with the massive concentration of the kappa-opiate receptors (the target molecules of *Salvia divinorum*) in the claustrum support its role as a central coordinator of consciousness.

It's worth noting that our results were not black-and-white. The users of LSD also experienced (albeit to a lesser degree) translation into altered environments, fairies and ego dissolution.

This, together with a review of the literature convinced us that the claustrum is one of the conductors of consciousness, with brain areas cingulate cortex and pulvinar likely being the other ones.

Still, the claustrum appears to be special in the brain's connectivity and we think that *Salvia* can inactivate it. We hope that the experimental neuroscience community will take advantage of the window into the mind which this unique substance provides.

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