Report

On/Off Switch for Consciousness

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Abstract

A recent article reports that the activation of glutamatergic Chx10-derived neurons in the pedunculopontine nucleus (PPN) in mice arrests all ongoing movements while simultaneously causing apnea (temporary cessation of breathing) and bradycardia (slow heart rate). This global motor arrest has a pause-and-play pattern with an instantaneous interruption of movement followed by a short-latency continuation from where it was paused. This pause-play effect is said to be different from ventrolateral periaqueductal gray-induced freezing which can be induced by stressors in the environment notwithstanding that there appears to be the same combination of motor and autonomic features. The authors explain their results primarily in terms of an arrest of motor activity while at the same time emphasizing how this phenomenon differs from all other known behaviors involving total motor arrest. They do hypothesize that the arrest evoked from the activation of Chx10-PPN neurons could be embedded within an "attention-related cognitive state" which seems to be suggesting a loss of consciousness.

Keywords: Consciousness, glutamatergic Chx10-derived neurons, pedunculopontine nucleus, motor arrest, freezing, attention-related cognitive state.

1. Introduction

A recent article[1] reports that the activation of glutamatergic Chx10-derived neurons in the pedunculopontine nucleus (PPN) in mice arrests all ongoing movements while simultaneously causing apnea (temporary cessation of breathing and bradycardia (slow heart rate). This global motor arrest has a pause-and-play pattern with an instantaneous interruption of movement followed by a short-latency continuation from where it was paused. This pause-play effect is said to be different from ventrolateral periaqueductal gray-induced freezing which can be induced by stressors in the environment notwithstanding that there appears to be the same combination of motor and autonomic features.

"We have found a group of nerve cells in the midbrain which, when stimulated, stop all movement. Not just walking; all forms of motor activity. They even make the mice stop breathing or breathe more slowly, and the heart rate slow down," explains Professor Ole Kiehn, who is co-author on the study. (Quoted in *Science News* 27 July, 2023)

"There are various ways to stop movement. What is so special about these nerve cells is that once activated they cause the movement to be paused or freeze. Just like setting a film on pause. The actors movement suddenly stop on the spot," says Ole Kiehn. (Quoted in *Science News* 27 July, 2023)

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Of course there are instances where a conscious sentient being can freeze and become totally immobile and not actually lose consciousness. For instance when a hunting dog freezes when it picks up the scent of its prey. Also rats, mice, squirrels, and other prey species can freeze, often in a crouch, utterly devoid of movement except for breathing, when threatened by predators. But this freezing is not passive, it is a coordinated, protective defense against danger. This is the ventrolateral periaqueductal gray-induced freezing induced by stressors in the environment that is not exhibited by the subjects of this study. This pause-and-play pattern with an instantaneous interruption of movement simultaneously causes temporary cessation of breathing and a slow heart rate. Just the opposite to the normal reaction to life-threatening situations.

When the researchers ended activating the nerve cells, the mice would start the movement exactly where it stopped. Just like when pressing "play" again. "This 'pause-and-play pattern' is very unique; it is unlike anything we have seen before. It does not resemble other forms of movement or motor arrest we or other researchers have studied. There, the movement does not necessarily start where it stopped, but may start over with a new pattern," says PhD Haizea Goñi-Erro, who is first author of the study. (Quoted in *Science News* 27 July, 2023)

The learned authors stop short of speculating that this pause/play effect amounts to a complete loss of consciousness, however they do say: “The attentional shift when reacting to novel environmental cues might be facilitated by the global motor arrest, but it could also be either the trigger or a consequence of it. Regardless of chronology, we hypothesize that the arrest evoked from the activation of Chx10-PPN neurons could be embedded within an attention-related cognitive state. Such a role would highlight the integrative role of the PPN as a whole in driving both motor and cognitive aspects for a coherent behavioral response.”[1] However it is difficult to see how an ‘attention-related cognitive state’ can be anything other than waking consciousness.

A supplementary discussion to the paper describes in more detail how this “pause-play” effect elicited in this study is distinctly unique and indicates behavioral and physiological characteristics not to be found in previously studied instances of “freezing” and motor arrest and which can really only be explained by the subject mice experience a total loss of consciousness or mental black-out.

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References

[1]Goñi-Erro, H., Selvan, R. 1 2, Caggiano, V., Leiras , R. & Kiehn, O. “Pedunculopontine Chx10+ neurons control global motor arrest in mice” *Nature Neuroscience* (2023) Sep;26(9):1516-1528. doi: 10.1038/s41593-023-01396-3.