Rhythm of Breathing Affects Memory and Fear

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Summary: A new study reports the rhythm of your breathing can influence neural activity that enhances memory recall and emotional judgement.

Source: Northwestern University.

Breathing is not just for oxygen; it's now linked to brain function and behavior.

Northwestern Medicine scientists have discovered for the first time that the rhythm of breathing creates electrical activity in the human brain that enhances emotional judgments and memory recall.

These effects on behavior depend critically on whether you inhale or exhale and whether you breathe through the nose or mouth.

In the study, individuals were able to identify a fearful face more quickly if they encountered the face when breathing in compared to breathing out. Individuals also were more likely to remember an object if they encountered it on the inhaled breath than the exhaled one. The effect disappeared if breathing was through the mouth.

"One of the major findings in this study is that there is a dramatic difference in brain activity in the amygdala and hippocampus during inhalation compared with exhalation," said lead author Christina Zelano, assistant professor of neurology at Northwestern University Feinberg School of Medicine. "When you breathe in, we discovered you are stimulating neurons in the olfactory cortex, amygdala and hippocampus, all across the limbic system."

The study was published Dec. 6 in the *Journal of Neuroscience*.

The senior author is Jay Gottfried, professor of neurology at Feinberg.

Northwestern scientists first discovered these differences in brain activity while studying seven patients with epilepsy who were scheduled for brain surgery. A week prior to surgery, a surgeon implanted electrodes into the patients' brains in order to identify the origin of their seizures. This allowed scientists to acquire electro-physiological data directly from their brains. The recorded electrical signals showed brain activity fluctuated with breathing. The activity occurs in brain areas where emotions, memory and smells are processed.

This discovery led scientists to ask whether cognitive functions typically associated with these brain areas — in particular fear processing and memory — could also be affected by breathing.

(https://i1.wp.com/neurosciencenews.com/files/2016/12/amygdala-fear-breathing-public-neurosciencenews.jpg)
The amygdala is strongly linked to emotional processing, in particular fear-related emotions. So scientists asked about 60 subjects to make rapid decisions on emotional expressions in the lab environment while recording their breathing. Presented with pictures of faces showing expressions of either fear or surprise, the subjects had to indicate, as quickly as they could, which emotion each face was expressing. NeuroscienceNews.com image is for illustrtive purposes only.

The amygdala is strongly linked to emotional processing, in particular fear-related emotions. So scientists asked about 60 subjects to make rapid decisions on emotional expressions in the lab environment while recording their breathing. Presented with pictures of faces showing expressions of either fear or surprise, the subjects had to indicate, as quickly as they could, which emotion each face was expressing.

When faces were encountered during inhalation, subjects recognized them as fearful more quickly than when faces were encountered during exhalation. This was not true for faces expressing surprise. These effects diminished when subjects performed the same task while breathing through their mouths. Thus the effect was specific to fearful stimuli during nasal breathing only.

In an experiment aimed at assessing memory function (https://neurosciencenews.com/memory-fear-breathing-5699/) — tied to the hippocampus — the same subjects were shown pictures of objects on a computer screen and told to remember them. Later, they were asked to recall those objects. Researchers found that recall was better if the images were encountered during inhalation.

The findings imply that rapid breathing may confer an advantage when someone is in a dangerous situation, Zelano said.

“If you are in a panic state, your breathing rhythm becomes faster,” Zelano said. “As a result you’ll spend proportionally more time inhaling than when in a calm state. Thus, our body’s innate response to fear with faster breathing could have a positive impact on brain function and result in faster response times to dangerous stimuli in the environment.”

Another potential insight of the research is on the basic mechanisms of meditation or focused breathing. “When you inhale, you are in a sense synchronizing brain oscillations across the limbic network,” Zelano noted.

ABOUT THIS MEMORY RESEARCH ARTICLE

Other Northwestern authors include Heidi Jiang, Guangyu Zhou, Nikita Arora, Dr. Stephan Schuele and Dr. Joshua Rosenow.

Funding: The study was supported by grants R00DC012803, R21DC012014 and R01DC013243 from the National Institute on Deafness and Communication Disorders of the National Institutes of Health.

Source: Marla Paul – Northwestern University (https://news.northwestern.edu)

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Original Research: Abstract (http://www.jneurosci.org/content/36/49/12448) for “Nasal Respiration Entrains Human Limbic Oscillations and Modulates Cognitive Function” by Christina Zelano, Heidi Jiang, Guangyu Zhou, Nikita Arora, Stephan Schuele, Joshua Rosenow and Jay A. Gottfried in *Journal of Neuroscience*. Published online December 7 2016 doi:10.1523/JNEUROSCI.2586-16.2016

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Abstract

Nasal Respiration Entrains Human Limbic Oscillations and Modulates Cognitive Function

The need to breathe links the mammalian olfactory system inextricably to the respiratory rhythms that draw air through the nose. In rodents and other small animals, slow oscillations of local field potential activity are driven at the rate of breathing (~2–12 Hz) in olfactory bulb and cortex, and faster oscillatory bursts are coupled to specific phases of the respiratory cycle. These dynamic rhythms are thought to regulate cortical excitability and coordinate network interactions, helping to shape olfactory coding, memory, and behavior. However, while respiratory oscillations are a ubiquitous hallmark of olfactory system function in animals, direct evidence for such patterns is lacking in humans. In this study, we acquired intracranial EEG data from rare patients (Ps) with medically refractory epilepsy, enabling us to test the hypothesis that cortical oscillatory activity would be entrained to the human respiratory cycle, albeit at the much slower rhythm of ~0.16–0.33 Hz. Our results reveal that natural breathing synchronizes electrical activity in human piriform (olfactory) cortex, as well as in limbic-related brain areas, including amygdala and hippocampus. Notably, oscillatory power peaked during inspiration and dissipated when breathing was diverted from nose to mouth. Parallel behavioral experiments showed that breathing phase enhances fear discrimination and memory retrieval. Our findings provide a unique framework for understanding the pivotal role of nasal breathing in coordinating neuronal oscillations to support stimulus processing and behavior.

SIGNIFICANCE STATEMENT Animal studies have long shown that olfactory oscillatory activity emerges in line with the natural rhythm of breathing, even in the absence of an odor stimulus. Whether the breathing cycle induces cortical oscillations in the human brain is poorly understood. In this study, we collected intracranial EEG data from rare patients with medically intractable epilepsy, and found evidence for respiratory entrainment of local field potential activity in human piriform cortex, amygdala, and hippocampus. These effects diminished when breathing was

diverted to the mouth, highlighting the importance of nasal airflow for generating respiratory oscillations. Finally, behavioral data in healthy subjects suggest that breathing phase systematically influences cognitive tasks related to amygdala and hippocampal functions.

"Nasal Respiration Entrains Human Limbic Oscillations and Modulates Cognitive Function" by Christina Zelano, Heidi Jiang, Guangyu Zhou, Nikita Arora, Stephan Schuele, Joshua Rosenow and Jay A. Gottfried in *Journal of Neuroscience*. Published online December 7 2016 doi:10.1523/JNEUROSCI.2586-16.2016

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17 RESPONSES

January 2, 2017 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-20559)

D Gaia Castillo

(https://www.facebook.com/app_scoped_user_id/1174844779196866/)

I've been in and out of hospitals since the age of 5yo because of my chronic asthma where I've been intubated 5 times due to respiratory failure, and once a pneumothorax or chest tube because my lung collapsed from the breathing machine called "The Bird" in 1983.

So not only have I spent numerous days in and out of ERs and hospitals rooms since the age of 5yo, 5 of them were in ICU for a week, then basic room for another week due to chronically suffocating to the point of deffocating in public before the EMTs rescued me.

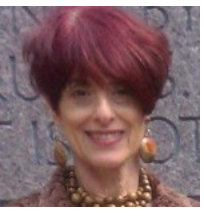
Once the tube has been removed from being intubated, which consisted of having a tube shove down my nostrils while I'm awake, and later while under, down my throat for the life support machine and then having my lungs scraped sometimes while I'm awake, I've become clairvoyant. Each time I suddenly view our world entirely in different light than most humans. You see, some of those details I wish I could forget, but I can't. There have been many times I have no recollection of events right before I've been intubated.

Today, at 57yo, my recall is pretty good where I can recall events from when I was 2yo. Because of my chronic suffocating I became an Autodidact, a self learner in order to survive in this violent world where I became a Children's Librarian Aide for 8 years. I'm able to recall where 10s of 1000s of materials are listed at better than the Librarians with Library Science Degrees that have to use their computers to locate the same materials I can simply recall. But maybe it has to do with me also being the person who has placed those books, cds, dvds, etc... in their sections down to the decimal points and or names. The thing is they are the people who've logged and labeled those materials before they're put into their sections.

Maybe my memory is healthy today due to eating clean as a vegan for many years, and because I spend a lot of time in Negative Ionospheres where I've become Lean & Keen? lol! But I do forget some things now mainly in the mornings.

Nevertheless, I can see where breathing matters when it comes to our ability to remember, but this fact only adds more to me wondering how well I could have done in life if not for my chronic asthma!

Now why did I log on to Facebook for again??



December 21, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19294)

kateposey (https://gravatar.com/kateposey)

I thought inhales activate the fight/flight (sympathetic) nervous system and exhales activate the rest-restore (parasympathetic) nervous system. Inhales, therefore, would naturally increase recall of fearful images. The problem is that most people are in fight-flight when they don't need to be and longer exhales do activate the parasympathetic. People also need to know about respiratory sinus arrhythmia which means that in healthy people a longer exhale will be followed by a shorter one.

December 19, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19267)

Maury Brooks (https://www.facebook.com/app_scoped_user_id/1222430078/)

I have worked with many people with nasal congestion in my Medical Qigong energy healing practice and have found a deep healing potential corresponds with relaxing deep into the nasal cavity region. It seems to open up memory. This article sheds a valuable light on the physical dynamics of the in breath. Thank you.

December 18, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19252)

Hanna

It might be interesting to explore how these findings connect to asthma and trauma

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December 18, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19249)

Julie Nelson

I find it interesting that it found that in those who have epileptic seizures there were chances in the area of the brain such as the emotion of fear, and other emotions spoke of. Yet one such as myself who began having non-epileptic seizures that began after a head injury and are rather rare, I am given an answer with someone of a sigma of they due emotions. They have never occurred when I,ve been upset under pressure. They can be triggered by bright flashing light, lound continues noises, or when I have a really bad migraine that I can't get under control. I would say yes there is a change in my breathing.
I did find this to be extremely interesting article.

December 18, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19245)

Rosa Trillo

I am a Yoga practitioner and I love your article .Pranayama (the art of breathing) is a healing practice and sophisticated proccess.

December 16, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19220)

Shalina (http://n)

This is not new. Yogis knew this thousands of years ago. It is why yoga focuses so much on breath awareness and control. The road to the mind is through the breath. Just because the Eestern world is waking up to this now does not mean they have discovered it for the first time.

December 16, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19211)

David

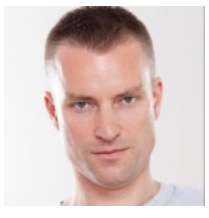
I was reading this with interest right up to Zelano's unfounded claim that with rapid breathing "you'll spend proportionally more time inhaling than when in a calm state". This is ludicrous conclusion. Given that inhaling is always followed by exhaling, unless special attention were paid to one or the other, there would be no proportional change from an average 50/50.

Then he piles on with "Thus, our body's innate response to fear with faster breathing could have a positive impact ..", to which I say no, wouldn't a controlled, lengthened inhalation followed rapid exhalation produce the actual advantage? Try that when the zombie apocalypse gets going...

December 19, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19265)

Maury Brooks (https://www.facebook.com/app_scoped_user_id/1222430078/)

A person can exhale and inhale at different speeds to change the ratio from 50/50 to something else. From my own observations as an energy healer who guides clients to live with a breath consciousness, a lot of people have a hard time inhaling a deep breath yet find it much easier to take a deep exhale. The difficulty with taking a deep breath may account for more time spent inhaling when the demand for oxygen is greater than usual.



December 30, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-20528)

Tomek (http://360chmura.pl)

David – writing 'avg 50/50' you probably mean amount of air – correct. Zelano means ('amount of') time. You can try for yourself changing the proportion, e.g. 3sec in – 6sec out and then the other way. You will probably feel the difference. The latter not only builds excitement but also supports it.
I understand that Zelano is trying to guess why it would be evolutionary beneficial.
Btw. if you associate inhale with assimilation and exhale with elimination – the above also makes sense, doesn't it?

December 16, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19208)

Karen Ramirez

This explains so many things for me…on Oct 12 2016, I suffered a Severe Asthmatic Attack, causing me to go into Cardiac arrest and Respiratory arrest….I was nonresponsive for over 5 minutes….I now can't get my thoughts together, and remembered when I first got home from the hospital 3 days later, I was scared to death, but didn't know what I was afraid of. ….2 months later my thought process is improving or at least I feel like it is….and the fear is still real but not quite as bad….it's been one heck of a road to recovery….plus I'm 55 years old, so the odds aren't exactly in my favor..

December 25, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19314)

Lucinda

I had something similar happen to me. I couldn't calm my breath at all and felt terrible. I went to see a Somatic Experencing therapist. He taught me to breath out slowly for count of 6 and to then hold my breath for count of 6 (or more if you can) then breath in normally. Repeat these breathing out and holding breaths for 3 – 5 mins. This calms down the whole breathing process and the flight or fight mode or freeze mode which you maybe in after having a shock like you have had. Give it a try and you will feel loads better!

December 14, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19189)

Joe Pepitone

It's a great article. Would like to read more on this topic.

December 14, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19182)

Nisha (http://www.HealingHome.co.uk)

This is how the ancient technology of Yoga postures (with specific sequences and movements on inhales and exhales), works so well to bring balance to the system, neurological, biological, etherical and astral. The charges around fear memories (that are hurtful), are transmuted efficiently, enabling health and wellbeing and reverential Awareness and Willpower to return.

December 9, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19151)

Lory Rolle

Loved it,

December 9, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19150)

Lory Rolle

I'm very interested in how to emotional stress can effect epileptic seizures. This is a great study. Thanks. If you can direct me to a site for this. I'd greatly appreciate it

December 19, 2016 (https://neurosciencenews.com/memory-fear-breathing-5699/#comment-19266)

Maury Brooks (https://www.facebook.com/app_scoped_user_id/1222430078/)

Hi Lory, While I am not a "specialist" in epileptic seizures, what I have found in working with clients who have them is that by careful observation of their breathing they can get to the point where they can often detect a seizure coming on 2 minutes before it happens. This is important because it then gives them a warning to get into a prevention / minimization mode.

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