BY OLIVIA FERRARI

A Dose of Dance

WHAT HAPPENS IN OUR HEADS WHEN WE DANCE? NEUROSCIENTISTS HAVE ASKED, AND NEW APPROACHES ARE ANSWERING, REVEALING HIDDEN BRAIN BENEFITS.

The dancers sprawled on stage, backs arched, with their shoulders and feet supporting their stretched bodies. Taking deep, shuddering breaths, they trembled and swayed in time with the music — a dark, droning tone typical of butoh, an avant-garde style of dance invented in Japan in the 1950s.

Less typical of butoh were the brain scanners that sat atop the dancers' scalps, and the brain scan visualizations that swelled behind the dancers' bodies in real time.

The performance, which took place in February 2023 at the University of Houston, Texas, was a collaboration between researchers and artists to capture what happens in our brains when we dance. According to the team, the performance was the first time that researchers have synchronously recorded and visualized brain activity from five performers at once.

Constantina Theofanopoulou, a neuroscientist from the Rockefeller University in New York and a flamenco dancer, helped develop the team's approach for deciphering and displaying the dancers' brain scans, explaining that the performance is one of many recent attempts to understand dance's impacts on the brain. Research thus far has shown that dance provides plenty of different brain benefits for dancers of different styles and skill levels, from better body perception to improved memory. By strengthening the brain's connections, it combats cognitive decline. And by extending the pleasure cycle, it coordinates activity between brain regions, and possibly between

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FROM TOP: MOLESKO STUDIO/SHUTTERSTOCK; ALBERT M. SANCHEZ

VIRGINIA TECH neuroscientist Julia Basso (left) uses mobile EEG methods to monitor the brain activity of synchronized dancers.

brains, indicating its strength as a social and therapeutic tool. Whether performed by professionals or amateurs, dance is increasingly used in therapy and medicine, where even more benefits could be discovered.

RHYTHMS IN our bodies, like heartbeats and brain oscillations, are integral to our identity as humans. Our impulse to dance is no different. Dancing is so ingrained in who we are that some scholars believe that the ability could've arisen as many as 1.8 million years ago, when the anatomy of our ancient ancestors transformed to allow for better bipedal coordination, control, and balance. But despite the significance of dance, neuroscientists struggle to understand its influence on our brains.

That's because determining what happens in the brain during dance has long been logistically difficult. Until recently, research looking to link brain activity with dance has required research participants — both skilled and amateur dancers of specific styles — to slip inside cramped brain-scanning machines, where they would perform salsa hand movements or tango foot movements while the rest of their bodies remained stationary.

"Scientists were hoping to find the brain network of dance, but they realized that they have to make the technology work first," Theofanopoulou says.

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Comprising the regions of the brain that are activated and connected by dance, the brain network of dance is most active when the whole body is in motion. But movement and sweat can disrupt mobile brain-scanning methods, detaching their machinery and affecting their accuracy. This is especially true of mobile electroencephalography (EEG) methods, which use small, scalp-attached sensors to measure electrical impulses in the brain.

Setting out to solve these issues, Theofanopoulou and her team developed a mobile scanning method to track dancers' brain activity with minimal disturbances due to movement. Their EEG approach, which involved the specialized fitting and fastening of sensors, as well as the special selection of movements (nothing too sharp or too sudden), managed to record the butoh dancers' brain activity at an impressive millisecond resolution.

Publishing a paper that outlined their approach in *BioMed Central Neuroscience* in November 2024, Theofanopoulou and her team even considered what hair products the dancers used to optimize their EEG technology. The result is a more accurate method for mobile brain scanning, which could support new breakthroughs in the science of dance.

DESPITE LOGISTICAL obstacles, past research has revealed some scattered information on the impacts of dance on the brain. Since the 1990s and 2000s, studies have shown that music stimulates the cerebellum, which controls coordination and movement, as well as the brain's pleasure centers. And adding movement to music only intensifies those sensations. In 2022, a review in

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the *American Journal of Dance Therapy* found that dancing — not necessarily in a choreographed way, but just moving to music — increases serotonin in the body, potentially boosting mood and reducing stress in the moment.

Some research suggests that our powerful pleasure centers respond especially well to dance because it extends the pleasure cycle. While this cycle normally includes phases of wanting, liking, and satisfaction, it is possible that dancing prolongs the liking phase and weakens the satisfaction one, drawing out the pleasure cycle and sustaining positive emotions for longer.

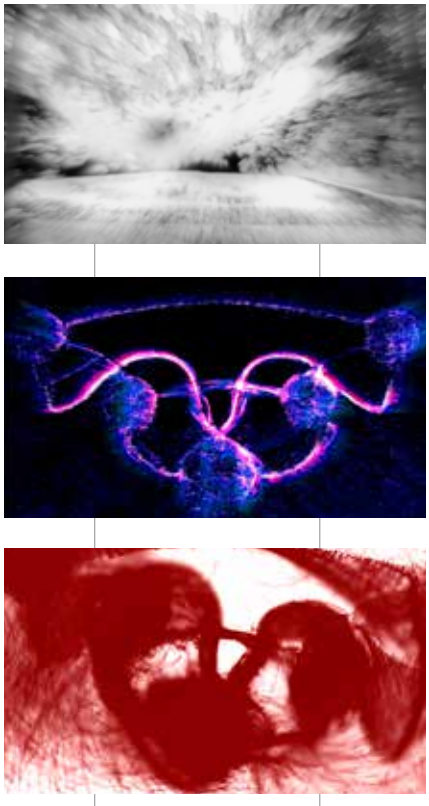
Katharina Conradi, a dance teacher and a dance therapist based in the Netherlands, helps people use different types of dance to process grief and other heavy emotions, and says that they often feel "lifted up" after dance therapy sessions. She credits this lift to the release of tension that dance provides in the brain and body at the same time. In fact, it's possible that this simultaneous release is essential to the benefits of dance therapy, which is associated with improved physical and mental health, especially for people dealing with psychological trauma.

"This form of therapy is very successful because it combines the thinking and the physical together," Conradi says. "It's always an … integration."

DANCE CONNECTS so many parts of the brain that some neuroscientists say it has a whole-brain effect, activating not only the cerebellum and motor areas, but also the parts of the brain that perceive sensory information, control cognition and emotion, and process rhythm, creativity, and sociality. Some scientists suspect that coordination among these parts of the brain has a kind of synergistic effect that makes us feel good.

"There [are] so many different things going on," says Julia Basso, a neuroscientist at Virginia Tech, whose work concentrates on the connection between the brain and the body. "[Dance] is so complex in what it offers that you get the social, you get the rhythmic, you get the creative, you get the cognitive, all in one setting."

Over time, engaging repeatedly in choreographed dance even changes the structure of the brain, strengthening connections between brain regions. Studies show that professional dancers have higher connectivity in areas of the brain that are associated with motor and sensorimotor activities. These improved connections can result in a better ability to coordinate one's own body, and to efficiently integrate internal and external information on the fly.



IN THE BUTOH study, abstract scenes, shapes, and brains were used to visualize dancers' brain activity, which was monitored by Theofanopoulou (below) using a unique mobile scanning method.

People who dance also have some specific mental abilities that are sharper than those of people who don't. Studies have shown that experienced ballet and contemporary dancers have a strong memory for complex motion sequences, while expert hip-hop dancers have a talent for rotating images in their minds, potentially indicating superior spatial processing. Dancers also possess a more accurate sense of proprioception, or the positioning of their body and body parts, according to a 2022 study in *Scientific Reports*.

Because of the positive effects dance has on brain connectivity and flexibility, dance therapy can be a powerful tool, especially for elderly people. Though the therapeutic potential of dance and dance therapy are still being tested, some studies suggest that learning to dance choreographed sequences improves memory and attention abilities over time, decreases the risk of dementia, and strengthens motor skills in people with Parkinson's disease. Dance-training programs involving new and increasingly difficult choreography also promote neural plasticity more than other types of physical activity, according to research published in *PLOS One*, which is important for healing and protecting the brain as it ages.

FROM TOP: BADIE KHALEGHIAN, FROM THEOFANOPOULOU ET AL. 2024. BMC NEUROSCIENCE (3); DOUGLAS ADESKO

"Dance can be a really important way to support the aging process," Basso says, "because it keeps our mind growing and fresh."

WITH ITS special sensors and scientific steps, Theofanopoulou's mobile scanning method was designed to be used to better understand dance therapy's effects on neurodegenerative diseases like Parkinson's, expanding the existing research to reveal the effects of different levels of involvement and intensity — essentially different doses of dance — on treatment outcomes. But that's not all. It was also designed to untangle dance's ability to bring people together.

In the past decade, dozens of studies have shown that our brains can align when we collaborate, and particularly when we collaborate with friends, family, or romantic partners. Now, some scientists are starting to scrutinize the brain activity of dancers, suspecting that when our bodies work as one, our brains do, too. "Dance [could enhance] what's called interbrain synchrony," Basso says, "so that when we dance with other humans … our brain rhythms [could] actually synchronize with one another."

While the recordings from Theofanopoulou's butoh performance are still being analyzed, she says that the real-time visualizations of the dancers' brain activity are expected to show signs of synchrony, something that other scientists are also working to find. Projected behind the dancers as they performed, the visualizations appeared as abstract scenes and shapes, and as 3D brains, that shifted and surged according to the degree of similarity between the dancers' brain oscillations.

Though the mechanisms of this plausible alignment of brain activity remain unsettled, it's possible it occurs as a result of the shared motions, as well as the shared concentration and commitment, that are involved in moving together to choreography. Dancing with a partner requires the coordination of the body, the breath, and the heartbeat, and involves the synchronization of the dancers' senses of sight, sound, touch, and rhythm. Brain activity is therefore only one of many bodily functions that may align as dancers match their moves.

ACCORDING TO Basso, dance may bring people together, boosting social connectivity and mood, through interbrain synchrony. But dance may also build bonds through neurochemistry. Studies suggest that synchronized activities — dance as well as making music — can create social ties by releasing endorphins. Some scientists believe this is why dance arose, spread, and persisted in humans in the first place: as a form of interpersonal coordination that promotes positive feelings and helps us stick together as a complex social species.

The social power of dance is also seen in the activity of individual brain cells: Neuroscientists believe that the mirror neurons that activate when we mimic others may also activate when we watch them dance, unconsciously preparing us to dance, too. Not only that, but matching others' moves in dance and dance therapy may explain the enhanced empathic abilities seen in expert dancers over time, since increased activity in mirror neurons is linked to the ability to perceive and anticipate others' movements as well as their emotional states.

In Conradi's dance therapy practice, group dance can be especially empowering. "The whole idea of being together … can be by itself healing," she says. "Because then you don't need to think, and you are supported by others."

OF COURSE, Theofanopoulou's butoh performance cannot solve all of the mysteries of dance's impacts on the brain. But Theofanopoulou believes that the cognitive benefits of dance are clear, and will only become clearer with future applications of the performance's methodology.

Improving our mood and keeping us sharp, the evidence suggests that dance is a mechanism for fighting cognitive decline and bringing people together. "We need to believe this convincing evidence," Theofanopoulou says, "and have dance work as medicine." D

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Olivia Ferrari *is a New York City-based journalist with a background in research and science communication.*

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