RSNA Press Release

Brain Activity Goes to Extremes in Soccer Fans

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Francisco Zamorano, Ph.D.

OAK BROOK, Ill. – Studying brain patterns in soccer fans, researchers found that certain circuit regions of the brain were activated while viewing soccer matches involving their favorite team, triggering positive and negative emotions and behaviors, according to a new study published today in *Radiology*, a journal of the Radiological Society of North America (RSNA). The researchers say these patterns could apply to other types of fanaticism as well, and that the circuits are forged early in life.

Soccer is a global phenomenon, and its followers exhibit a broad spectrum of behaviors, from spectatorship to intense emotional engagement, providing a useful model for studying social identity and emotional processing in competitive situations.

Rivalries run deep in the history of sports, and fans can be very protective of their "home" team and favorite players. These same fans run the gamut of emotions watching their team succeed or fail over the course of a game or match, cheering when they score or raging at a bad call. Soccer fans are known for their team loyalty and enthusiasm, particularly in Europe and South America.

"Soccer fandom provides a high-ecological-validity model of fanaticism with quantifiable life consequences for health and collective behavior," said lead author Francisco Zamorano, biologist, Ph.D. in medical sciences at Clínica Alemana de Santiago and associate professor at Facultad de Ciencias para el Cuidado de la Salud, Universidad San Sebastián, Santiago, Chile. "While social affiliation has been widely studied, the neurobiological mechanisms of social identity in competitive settings are unclear, so we set out to investigate the brain mechanisms associated with emotional responses in soccer fans to their teams' victories and losses."

For the study, researchers used functional MRI (fMRI)—a technique that measures brain activity by detecting changes in blood flow—to examine 60 healthy male soccer fans (20–45 years) of two historic rivals. Fanaticism was quantified with the Football Supporters Fanaticism Scale, a 13-item scale that measures the fanaticism of football fans, assessing two sub-dimensions: "Inclination to Violence" and "Sense of Belongingness."

Brain imaging data were acquired while participants watched 63 goal sequences from matches involving their favorite team, a rival or a neutral team. A whole-brain analysis was conducted to compare neural responses when

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participants viewed their favorite team scoring against an archrival (significant victory) versus when the archrival scored against their team (significant defeat), with control conditions for non-rival goals.

The fMRI results showed that brain activity changed when the fan's team succeeded or failed.

"Rivalry rapidly reconfigures the brain's valuation–control balance within seconds," Dr. Zamorano said. "With significant victory, the reward circuitry in the brain is amplified relative to non-rival wins, whereas in significant defeat the dorsal anterior cingulate cortex (dACC)—which plays an important role in cognitive control—shows paradoxical suppression of control signals."

Paradoxical suppression refers to the attempt to suppress a thought, feeling or behavior and it results in the opposite outcome.

Higher activation in the reward system regions occurred when participants' teams scored against rivals versus non-rivals, suggesting in-group bonding and social identity reinforcement. Dr. Zamorano notes that the effect is strongest in highly fanatic participants, predicting momentary self-regulatory failure precisely when identity is threatened and accounting for the puzzling ability of otherwise rational individuals to suddenly "flip" at matches.

"Clinically, the pattern implies a state-dependent vulnerability whereby a brief cooling-off or removal from triggers might permit the dACC/salience control system to recover," he said. "The same neural signature—reward up, control down under rivalry—likely generalizes beyond sport to political and sectarian conflicts."

The neural results identify mechanisms which may inform communication, crowd management, and prevention strategies around high-stakes events in the reward amplification and control down-regulation under rivalry, Dr. Zamorano noted.

"Studying fanaticism matters because it reveals generalizable neural mechanisms that can scale from stadium passion to polarization, violence and population-level public-health harm," he said. "Most importantly, these very circuits are forged in early life: caregiving quality, stress exposure, and social learning sculpt the valuation–control balance that later makes individuals vulnerable to fanatic appeals. Therefore, protecting childhood is the most powerful prevention strategy. Societies that neglect early development do not avoid fanaticism; they inherit its harms."

Soccer fandom offers an ethical, high-validity proxy to time-lock these processes in the brain and to test interventions (framing, fairness cues, event design, crowd management, etc.) that translate to politics, sectarianism and digital tribalism, he noted.

Dr. Zamorano adds that urgency is evident with today's global conflicts and political narratives. For example, he said the January 6, 2021, U.S. Capitol assault, demonstrated how political fanaticism can override democratic norms when identity fusion reaches critical mass.

"The participants showed classic signs of compromised cognitive control, exactly what our study found in the reduced dACC activation," Dr. Zamorano said. "In short, investigating fanaticism is not merely descriptive—it is developmentally informed prevention that protects public health and strengthens democratic cohesion. When we discuss fanaticism, the facts speak for themselves."

"Brain Mechanisms across the Spectrum of Engagement in Football Fans: A Functional Neuroimaging Study." Collaborating with Dr. Zamorano were José María Hurtado, Ph.D., Patricio Carvajal-Paredes, Ph.D., César Salinas, M.T., Ximena Stecher, M.D., Patricia Soto-Icaza, Ph.D., Rommy Von Bernhardi, M.D., Ph.D., Waldemar Méndez, Pablo Billeke, M.D., Ph.D., Vladimir López, M.D., Ph.D., and Claudio Silva, M.D., Ph.D.

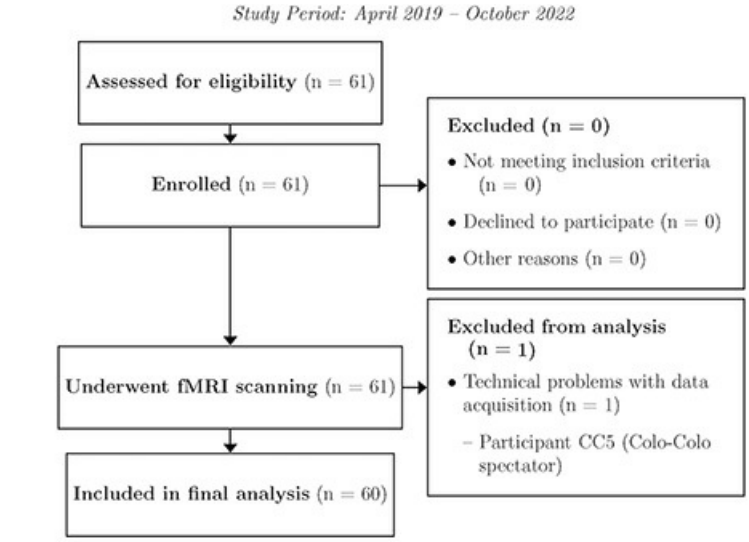
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For patient-friendly information on brain MRI, visit *RadiologyInfo.org*.

Images (JPG, TIF):

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Team Affiliation	Total	Spectators	Fans	Fanatics
Colo-Colo	29	19	9	2
Universidad de Chile	31	19	10	2
Total	**60**	**38**	**19**	**4**

Note: Participants were healthy male volunteers recruited through social media and direct outreach to organized supporter groups. Classification into spectators, fans, and fanatics was based on the Football Supporters Fanaticism Scale (FSFS) scores: Spectators: 31–52; Fans: 22–30; Fanatics: 13–21).

Figure 1. Flow diagram of the current study. fMRI = functional MRI.

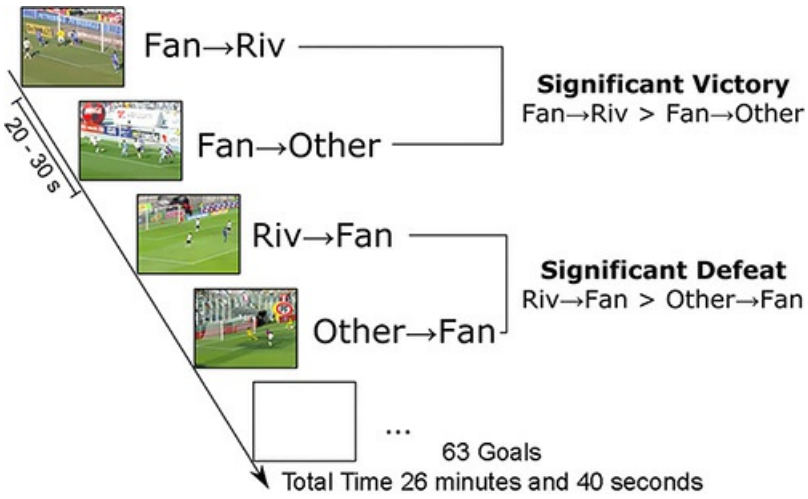


Figure 2. Schematic representation of the functional MRI procedure and generation of variables of interest. "Other" represents a nonrelevant team, also termed nonrival. Riv = rival.

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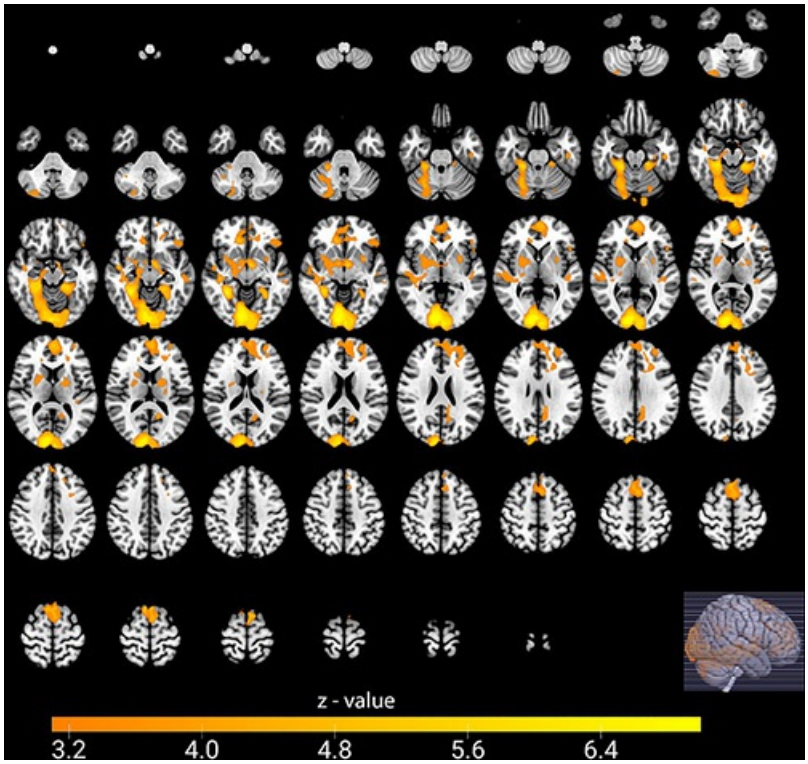


Figure 3. Functional MRI (blood oxygenation level–dependent) maps show brain activity of football fans resulting from significant victory, representing the subtraction of brain activation of fans when their team scores against the rival minus when they score goals against any other team (fan-rival > fan-other). "Other" represents a nonrelevant team, also termed nonrival.

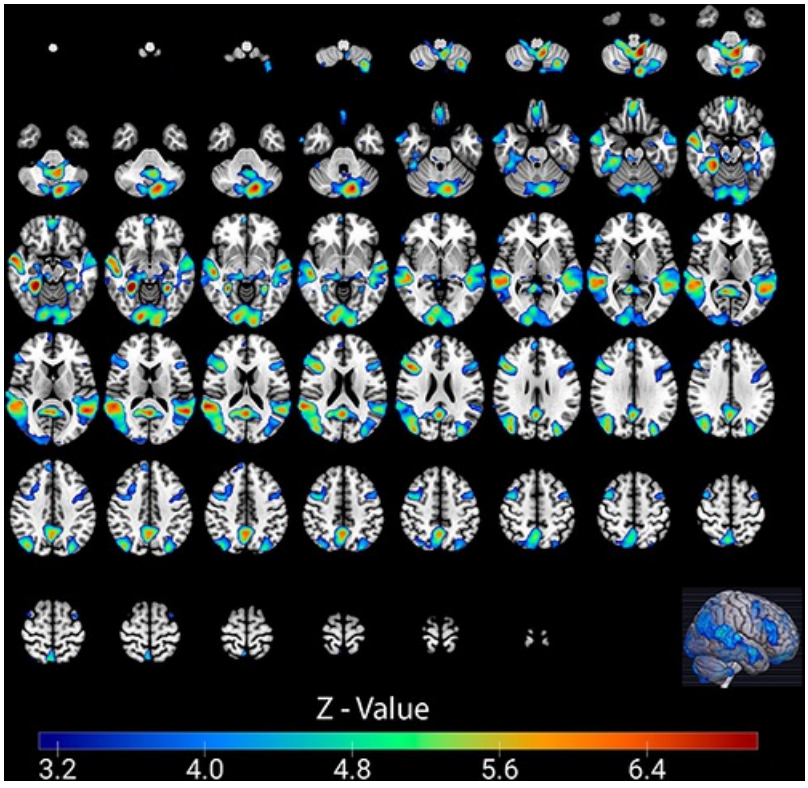


Figure 4. Functional MRI (blood oxygenation level–dependent) maps show brain activity of football fans resulting from significant defeat, representing the subtraction of brain activation of fans when their team is defeated by the rival minus when their team is defeated by other teams (rival-fan > other-fan). "Other" represents a nonrelevant

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team, also termed nonrival.

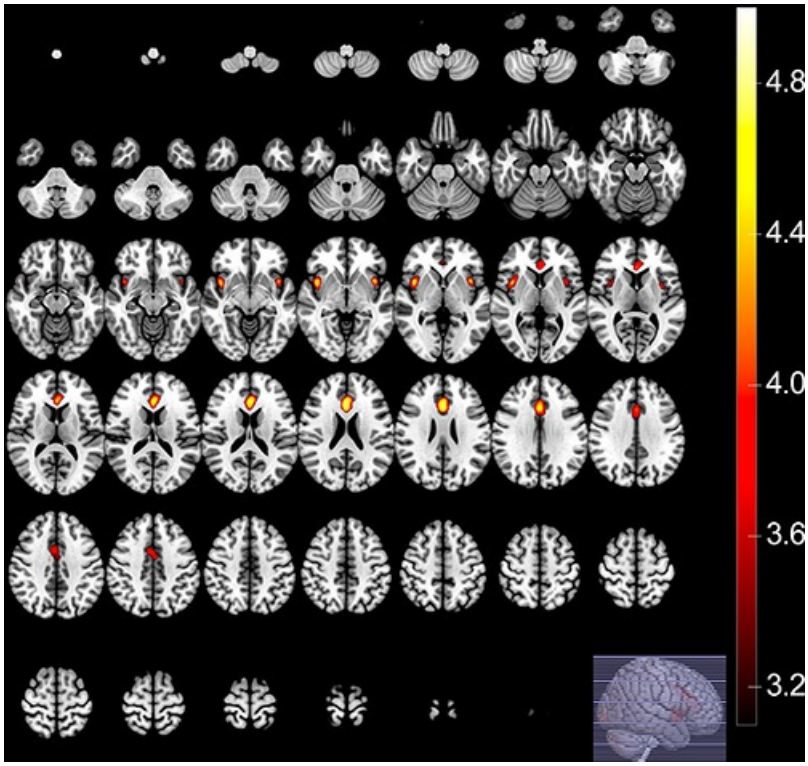
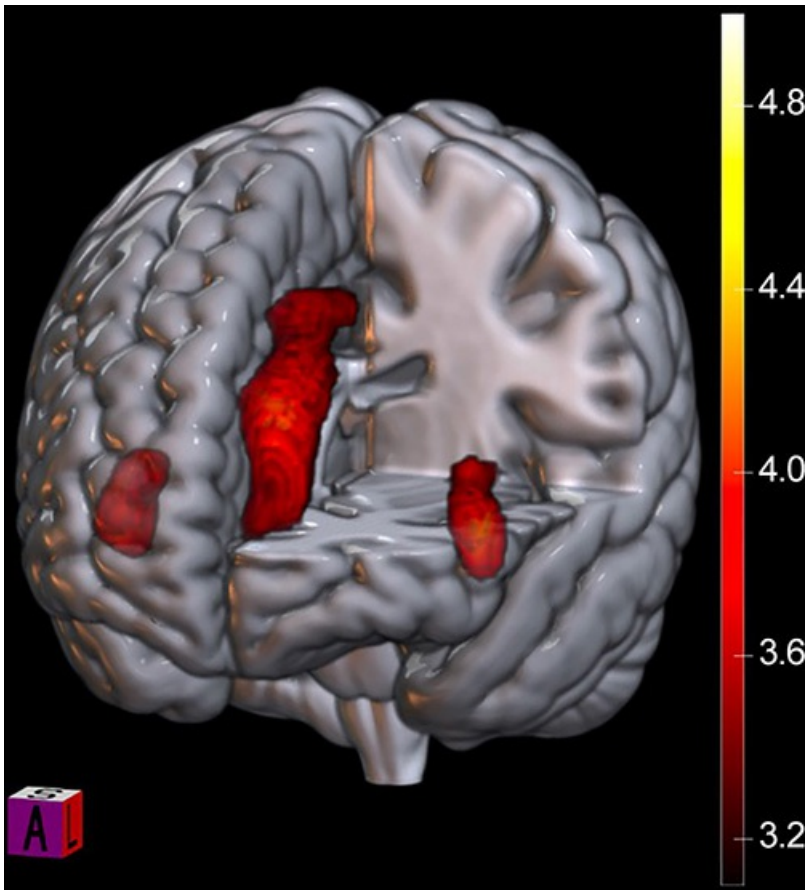


Figure 5. Functional MRI (blood oxygenation level–dependent) maps show the negative effect of significant defeat as depicted by areas that are deactivated during a defeat. Color bar represents Z values.



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Figure 6. Rendering of the negative effect of significant defeat. The salience network is deactivated during a significant defeat. Color bar represents Z values (warmer colors indicate higher positive Z value, cooler colors indicate negative/relative deactivation). A = anterior, L = left, S = superior.

Resources:

Abstract
Editorial

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