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The neural bases of sport fan reactions to teams: Evidence from a neuroimaging study

Ricardo Cayolla[1] | Rui Biscaia[2] | Roy F. Baumeister[3] | Marc Fetscherin[4] | Sónia Brito-Costa[5] | Isabel C. Duarte[6] | Miguel Castelo-Branco[6]

[1]Department of Economics and Management, Portucalense University, REMIT, Porto, Portugal

[2]Department for Health, Faculty of Humanities and Social Sciences, University of Bath, Bath, UK

[3]School of Psychology, The University of Queensland, Saint Lucia, Queensland, Australia

[4]Department of Business, Rollins College, Winter Park, Florida, USA

[5]Polytechnic Institute of Coimbra, Applied Research Institute (I2A), Coimbra, Portugal

[6]Institute of Nuclear Sciences Applied to Health, Universidade de Coimbra, Coimbra, Portugal

Correspondence
Ricardo Cayolla, Department of Economics and Management, Portucalense University, REMIT, Rua Dr. António Bernardino de Almeida, no. 541/619 4200-072 Porto, Portugal.
Email: rcayolla@upt.pt, ricardo.cayolla@gmail.com

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Abstract

This study uses neuroimaging methods to identify patterns of brain activation among sport fans in reaction to team stimuli. In a whole-brain analysis without selected regions in advance, the purposes were to identify the structures involved when fans are exposed to positive, neutral, and negative events and to learn what events activate more limbic networks. A total of 53 individuals participated in and functional magnetic resonance imaging experiment involving the presentation of videos in various situations. Findings indicate the activation of the cingulate gyrus and other structures of the limbic system, as the hippocampus and parahippocampus. We also found involvement of the ventral tegmental area of the reward system. Additionally, brain activity in emotional regulation and memory areas were more influenced by positive than neutral and negative videos. It was also found the involvement of other areas not directly included in the limbic or reward systems. This study provides the neural basis of fan reactions to team-related stimuli. Sport clubs should be aware that negative content seems to be suppressed from emotional memory and positive videos trigger more emotion and memory areas than neutral and negative videos.

1 | INTRODUCTION

The advertising revenue forecast for American sport organizations is expected to reach $1.33 billion in 2022 and $1.82 billion in 2027 (Statista, 2023). The size of the sports market in the USA is estimated at $73 billion and expected to grow to 89 billion in the year 2026 (Research and Markets, 2021). In Europe, the combined revenues of the top 20 football teams in 2021/22 were worth €9.2 billion including broadcast-, commercial- and matchday-related revenues (Deloitte, 2023). Due to such a high profile industry, researchers have devoted increased attention to emotional and motivational factors linked to sport consumption (e.g., Biscaia et al., 2012) and to understand the importance of one's identity as a fan of a team (e.g., Lock & Heere, 2017).

The present research used brain imaging to illuminate fans' reactions to video excerpts of football (i.e., soccer) games, and thus provide an understanding of the neural basis of fans' emotional reactions to team-related stimuli. Among the great puzzles regarding sports fans (consumers) is what sustains their interest despite frequent and almost inevitable disappointment? A top national sports league may have 15–30 teams, but only one can be the champion, and so almost all the others end up their season with disappointment. Even the

technical equality that precisely just as many games are won as are lost (across the full league) may translate into psychological negativity, given widespread evidence that bad events have stronger psychological impact than corresponding good ones (e.g., Tierney & Baumeister, 2021). If the average fan experiences equal numbers of wins and losses, and the losses are suggested to have greater impact (Baumeister et al., 2001), why do fans keep watching? Providing millions of people with net negative psychological experience would seem to be a risky and unpromising business model, but sport team brands continue to gain prominence in contemporary societies (Deloitte Sports Business Group, 2020).

Sport brands can capitalize on the psychological connection shared with fans (Couvelaere & Richelieu, 2005), but it is important to note that certain teams (e.g. Manchester United, Juventus) have the potential to polarize fans' reactions because they simultaneously have large numbers of 'lovers' and 'haters' (e.g., Popp et al., 2016). That is, some team brands trigger emotional reactions among fans that can either have a positive or negative valence on their behaviors (e.g., Havard, 2014). These tend to be highly successful teams, such that their many victories intensify the love and appreciation of their fans, but also entail defeating many other teams, whose fans may come to resent and despise the perennially successful opponents who frequently thwart their favorites. Thus, understanding the factors driving fan reactions towards team brands is paramount to deepen the relationships fans-teams (Funk & James, 2001). In addition, it is commonly accepted that fan identification assumes a pivotal role in the creation and/or destruction of team brand value (Kim et al., 2019).

Despite the contribution of previous studies to understand the importance of fan identification to their team brands (Lock & Heere, 2017), the vast majority of extant research is based on traditional methodological approaches including questionnaires or interviews with fans (e.g. Bauer et al., 2005). These approaches are characterized by the functioning of an explicit, easily accessible memory, which often limits the understanding of the cognitive mechanisms underlying fan reactions to the teams (Hsu, 2017). As noted by Baron et al. (2017), it is vital for marketers to understand the processing of cognitive skills involved in attention, emotion, memory and decision-making, and neuroimaging methods might provide a key contribution to it. The functional magnetic resonance imaging (fMRI) technique is known as the "workhorse in consumer neuroscience" (Smidts et al., 2014, p. 259), but there is a dearth of research on how neural underpinnings are associated to fans' reactions towards team brands.

Based on previous literature and limited understanding of fans' neural responses to team brands, the current study aims to provide a neuroscientific contribution to the consumption literature by identifying patterns of brain activation through fMRI when sport fans are exposed to positive, neutral and negative stimuli related to the teams they have affective connections with. The purpose of the current study is to investigate the neural basis of fans' emotional reactions to the valence of stimuli related to their teams (positive, neutral and negative). In doing so, we hope to contribute to a deeper understanding of the mechanisms of emotional drive in the mind of consumers with a high emotional connection with brands.

2 | LITERATURE REVIEW

2.1 | Team brands and fan identity

There is a large stream of research focused on the value consumers attach to the name and symbol of their favorite teams (Gladden & Milne, 1999). Building on the seminal studies of Aaker (1991) and Keller (1993) about brand equity, numerous studies have examined consumer-based perceptions of team brands and related behavioral intentions or self-reported behaviors (see Kunkel & Biscaia, 2020). Although it is commonly accepted that well-known brands such as sport teams evoke strong passionate feelings and reactions (Veloutsou et al., 2020), the affective component of fans' connection to the teams requires a deeper understanding. Sport team brands operate in an environment with strong rivalries provoking deep, passionate feelings that can be negative for certain consumers and positive for others (Havard & Dalakas, 2017). For example, anecdotal evidence suggests that Manchester United fans often exhibit a deep love by their team and hate by rival teams such as Manchester City or Liverpool FC (Smith & Sekhri, 2020). Also, recent research on the neural basis of love towards sport teams reveals that feelings of affection toward one's favorite team and intense hostility against opposing teams co-exist in fans' mind (Duarte et al., 2017), which highlights the importance of understanding the love towards brands (Ahuvia, 2005) in sport environments and how the level of identification with the team may influence fans' neural responses.

Consumers who love a brand are more likely to continue investing time and energy to support that brand over time (Batra et al., 2012), and fan identity has been shown to be an attitudinal barometer to understand how fans react to their teams and opponents (Uhrich, 2020). Fan identity refers to the meaning individuals attach to their role of being fans of their favorite team (Biscaia et al., 2018), and is different from team identity. That is, while the concept of team identity is grounded on the social identity theory (Tajfel, 1981) and represents a category-based measure of fandom to assess the importance of belongingness and social interaction with other fans of the team (Lock & Heere, 2017), fan identity is a role-based measure of fandom underpinned by identity theory (Stryker & Burke, 2000) that captures perceptions on how important the role of being a fan is to the individual.

People have role identities representing the characteristics attributed to oneself within a social role (e.g., how a person sees him/herself as a fan of a team), and the formation of these role identities is often dependent on the individual's social structures (e.g., family and peers) or demographic elements (e.g., age and social context) (Stets & Burke, 2014) that are organized in a salience hierarchy (Stryker, 2007). The higher the salience of that role identity, the greater the possibility of behavioral choices related to the expectations of such identity (Stryker & Burke, 2000).

The level of one's identification with a team has been suggested to be a central element to understand the cognitive and affective responses to team- and opponent-related stimuli (Berendt & Uhrich, 2018). For example, Uhrich (2020) noted that fan identification shapes the

acceptance of club management decisions, the engagement in extra-role behaviors and decreases estrangement from the club. Trail et al. (2005) reported that role identification positively influences the level of fan self-esteem and indirectly leads to behaviors of Basking in Reflected Glory (BIRGing) and Cutting Off Reflected Failure (CORFing). This suggests fans often associate themselves with successful teams and dissociate from negative sporting results (Jensen et al., 2016). Similarly, the reactions to opponent teams are also affected by one's identity as a fan. Berendt and Uhrich (2018) refer that the identification with a team shapes fans' aggressiveness towards rivals, while Dalakas and Melancon (2012) noted that fan identity can generate negative responses towards rival teams and associated sponsors. While previous studies have collectively set the ground to understand the importance of fan identity to sport team brands, neuroimaging approaches are warranted to understand how consumer brains react (Hsu, 2017) to their teams and opponents; thus expanding the knowledge derived from self-reported consumer measures and subsequent actions (Guerrero Medina et al., 2021; Vezich et al., 2017).

2.2 | Consumer neuroscience and sport

Consumer neuroscience is a recent marketing sub-field (Sánchez-Fernández et al., 2021) that has generated an increasing research interest (Stanton et al., 2017), and the sport literature is no exception (Bilgiç et al., 2020). As noted by Smidts et al. (2014), consumer behavior and marketing issues can be studied through neuroscience insights and techniques. Neuroscience techniques contribute to a deeper understanding of the functioning of the human brain when exposed to different stimuli (Stanton et al., 2017) and how it affects consumer decision-making process (Baron et al., 2017; Solnais et al., 2013). Decades of research in psychology indicate that negative events tend to have a stronger effect in the brain, grow more rapidly, and engage in a more complex and varied panel of options (e.g., Rozin & Royzman, 2001; Taylor, 1991). That is, with the same stimulus intensity, negative stimuli tend to have greater impact on brain activation than positive ones. The apparent absence of contrary instances suggests that the negativity effect is a deeply rooted feature of the mind, presumably for evolutionary reasons: among early humans, as among many animals, avoiding danger was more important than exploiting opportunities. A failure to appreciate a positive opportunity might be unfortunate but would not usually be fatal, whereas a single failure to appreciate danger could well mean death (Tierney & Baumeister, 2021).

The negativity effect has been found in psychophysiological and neuroscientific data. For example, Smith et al. (2003) used electrocortical tools when exposing individuals to negative and positive pictures and found evidence of larger negative stimulation concerning the positive one in the visual cortex, regardless of the valence of the background picture. Cunningham et al. (2004) identified a brain area (right inferior frontal/insular cortex) where negative stimuli were associated with larger neural activity. In turn, Petro et al. (2018) examined facial expressions and observed that "positivity is associated with an emotion regulation mechanism that allows for overcoming the initial negativity" (p. 696). These findings are important to consider when studying sport fans because they are exposed to a variety of positive and negative stimuli (e.g., goals scored or suffered by their teams), the outcome of the games is unpredictable and under the control of managers (Yoshida & James, 2011), and their identification as fans of a team often shapes their reactions (Davis et al., 2019).

In the realm of sports, researchers are progressively investing in the examination of sport fans' neural responses to teams (Hungenberg et al., 2020). Bilgiç et al. (2020) noted that the midcingulate cortex was activated during both positive and negative football game situations, leading them to conclude that fans have a different emotional processing and altered brain activity that can result in unusual behaviour (in search of rewards and motivational states). Botzung et al. (2010) examined memory accuracy (activation of dorsal frontoparietal regions) and confidence (related to recruitment of insula and medial temporal lobe) among basketball fans. Duarte et al. (2017) studied fans' tribal love and observed the recruitment of the amygdala, ventral tegmental area (VTA), and substantia nigra (SN) during the visualization of the team-related videos. Cikara et al. (2011) noted that fans increase the activity in the limbic system when exposed to the failure of opponent teams, while the anterior cingulate and the insula were activated when the negative stimulus was related with their team. In turn, Park et al. (2009) studied the neural correlates of winning and losing situations noting a higher emotional elimination for negative emotional responses than in positive ones. For these authors, when viewing winning situations, the activation of the right and left occipital lobes, the left temporal lobe, the left limbic lobe, the middle occipital gyrus, the superior temporal gyrus, and the guneus can be suggested by the subjects remembering pleasurable experiences.

While the study of neural basis of fans' reactions to sport teams is gaining track in the literature (e.g., Davis et al., 2019; Hungenberg et al., 2020), further exploration is needed because previous attempts have used small samples, a binary paradigm (i.e., fans vs. not fans; Cikara et al., 2011), only focused in the neural mechanism of the mental processes (i.e., identification of the anatomical regions; Schaefer & Rotte, 2007a), did not assess the negativity effect bias (Baumeister et al., 2001), and the neural reactions among highly identified fans are still to be understood. In addition, fans are exposed to a variety of positive, neutral and negative stimuli that occur in a random order when exposed to their teams' core product (i.e., games). Thus, understanding what happens in fans' brains in such unpredictive environment is imperative due to the role of different brain areas on psychological states and decision-making processes (Duarte et al., 2018).

2.3 | Emotions and brain functioning

Schultz (2015) suggests that any stimulus or event one reacts to, or object one consumes, is a reward. The reward system is a group of neuronal structures involved in the reinforcement mechanisms including the ventral tegmental area (VTA), anterior cingulate cortex, hippocampus, hypothalamus and thalamus (Berridge & Kringelbach, 2015). An understanding of the reward system among sport fans is quite valuable, given that they tend to vicariously experience their teams'

successes and failures (Lock et al., 2011). In addition, as fans are emotionally connected to their teams and represent the lifeblood of the sport industry (Wann & James, 2019), knowing the structures of the limbic system involved when they are exposed to different game-related stimuli is paramount to better manage team-fan relationships over time.

The limbic system has a well-known role in emotions and memory formation, and can be divided into an 'emotion limbic system' and a 'memory limbic system' (Rolls, 2015). The most emotion-related limbic structures include the amygdala, prefrontal cortex, anterior cingulate and orbitofrontal cortex. The orbitofrontal cortex provides a link to transfer the reward information to hippocampus, and backward the recall of an emotional state associated to the recall of a memory with emotional content (Rolls, 2015). Previous studies refer that explicit memories depend on specific regions of the brain (Squire & Zola, 1996a; 1996b; 1998), including the hippocampus and in synchrony with other brain regions. In sport-related studies, Botzung et al. (2010) reinforced the importance of hippocampus in memory recovery, while Duarte et al. (2017) suggested a relationship between the activation of the hippocampus (as part of the mesolimbic pathway) and pleasure situations associated to favorite teams.

The role of the hippocampus in memory goes far beyond mere coding or retrieval (Henke, 2010), and implicit memories are separate of intentional remembering (Stallen et al., 2010). Squire (2009) refers that memories are not consolidated in one place but are stored in several places where several groups of neurons work in a network. Implicit memory is the "absence of conscious recollection", and explicit memory the "conscious recollection of previous experiences" (Graf & Schacter, 1985, p. 501). Memory is a distinct brain function, separable from other perceptual and cognitive abilities, with multiple memories (Squire, 2009).

Having in consideration the expertise of fans (i.e., they often have strong emotional states towards an object of identification—team; Klucharev et al., 2008) and the familiarity with their teams brands (Biscaia et al., 2016), one may expect the activation of structures of the limbic system when fans are exposed to team stimuli. Also, considering the highly emotional context of sport (Wise, 2004), it is expect that team-related stimuli should trigger VTA arousal and regions such as the parietal lobule (Andersen, 2011; Wagner et al., 2005). Furthermore, despite some studies noted that positive events activate large portions of consumer brains, previous literature on psychology (e.g. Baumeister et al., 2001; Tierney & Baumeister, 2021) and consumer neuroscience (e.g. Smith et al., 2003) often suggest that negative events have a stronger effect in the brain due to a survival mechanism (Tierney & Baumeister, 2021). Extending from previous literature on consumer neuroscience (e.g., Sánchez-Fernández et al., 2021) sport fans' neural reactions (e.g., Duarte et al., 2017), and psychology (e.g., Tierney & Baumeister, 2021), the current study conduct whole brain analyses to (1) better understand what structures are involved when fans highly identified with their teams are exposed to a different stimulus (positive, neutral and negative) induced by the sport environment, and (2) what stimuli activate more reward and limbic networks.

3 | METHOD

3.1 | Participants

This study was conducted with fans of Futebol Clube do Porto (FCP) and Associação Académica de Coimbra (AAC), two teams competing in the Portuguese top football league (*Liga Portugal*) at the time of data collection. In 2019, *Liga Portugal* was acknowledged as the 6th strongest football league worldwide (Statistics, 2020), and both FCP and AAC are among the teams with the largest base of followers (LPFP, 2015). A total of 61 fans of these teams were recruited using a snowball sampling (Harsh, 2011) as this technique often engenders an inherent trust among participants, which is pivotal in studies conducted in medical facilities. Of those recruited, three did not complete the functional measurements (i.e., fMRI). In addition, five participants were also excluded due to having, at least, one predictor equal to zero leading to a final sample of 53 supporters that were considered for the study. All participants were male, with ages ranging from 20 to 60 years old ($M = 34.9 \pm 10.7$ years). A total of 33 participants were paid members (i.e., paying a monthly or annual fee to the club), with 31 having six or more years of that status. In line with previous sport fan studies (e.g., Doyle et al., 2013; Trinh, 2018), all participants attended at least one live game of their teams in the prior season. With one exception, all participants were right-handed (i.e., joystick used with the right hand during the fMRI – see details below). All the subjects had normal or corrected to normal vision. An informed consent form was signed by all participants in accordance with the Declaration of Helsinki. All study tasks were conducted in a laboratory of a large Portuguese University with worldwide prestige (The Times Higher Education, 2020).

3.2 | Measures and tasks

Before the fMRI session, participants completed a questionnaire with demographic information and the Spectator Identification Scale (SSIS; Wann & Branscombe, 1993) that includes seven items validated by Theodorakis et al. (2010) to the Portuguese context. This scale was adopted as the items are representative of how individuals perceive themselves as fans of their favorite team (Biscaia et al., 2018), brevity and practical utility (Lock & Heere, 2017), serving as criterion to verify whether participants showed high levels of fan identification. All items were ranked on a 5-point scale, anchored by 1 (low identification) and 5 (high identification).

During the fMRI scans, participants were watching short video streams of plays that resulted in scoring a goal, and they had to classify them as positive, negative or neutral. The experiment had a block design (Figure 1). Each video block, which beginning was synchronized with the beginning of volume acquisition, could last between 6 and 12 s and it was followed by the response block of 9 s. A black screen followed each pair of video/response, defining the baseline period, which was jittered in time (9–15 s). It means each participant underwent two EPI-BOLD scans of 10 min each during the visualization of

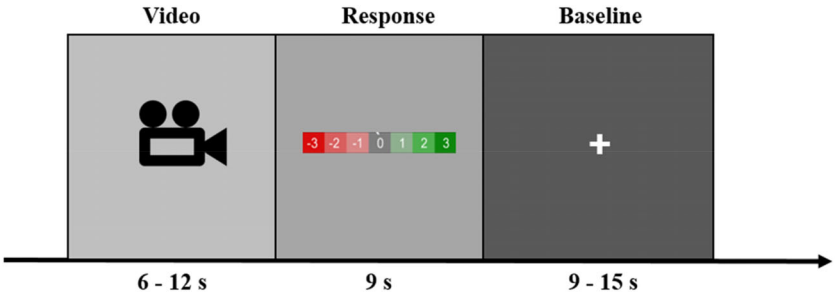

FIGURE 1 Experimental design. The videos with distinct duration were followed by a response period, in which participants classified the videos in a scale from −3 to 3 by means of a MR-compatible joystick. Following this, a period of fixation started jittered in time.

videos. A total of 35 videos were presented. The participants were asked to classify each video in a −3 to 3 scales using a joystick they had in one of their hands, right after the video presentation. This individual classification was used to define the condition (positive, negative or neutral) of the videos for each individual. Positive videos were rated with positive values, negative videos with negative values, and neutral with zero. Considering the final cohort of participants, 41.75% ± 9.52% of the videos were considered positive, 37.23 ± 10.86 were negative and 21.01% ± 11.52% were neutral.

The experiment has a block design. The video presentation was randomized in each session and for all participants. The video collection was distinct for FCP and AAC fans, because of the nature of the design which implied the following video categories: videos of favorite team's winning (average rating ± SD 2.63 ± 0.53) or losing moments (average rating ± SD −1.80 ± 1.04); videos of winning (average rating ± SD 2.60 ± 0.62) or losing (average rating ± SD 2.30 ± 0.99) moments of their favorite team against historic high rival teams; videos of historic rival team's winning (average rating ± SD −1.01 ± 1.20) or losing (average rating ± SD 0.77 ± 1.25) moments; and videos of Italian B-series teams (average rating ± SD −0.05 ± 0.79). The last ones were chosen to create options for neutral ratings, given their very high likelihood of being unknown goal situations to the Portuguese participants, as confirmed by the debriefing after the scanning session. To ensure the consistency of visual content, all videos showed only the on-field play leading to a scored goal, without any images of spectator reactions, coaches' reactions, or trophy celebrations.

3.3 | MRI acquisition parameters and data analysis

The experiment was performed in a 3 T Magnetom Trio Tim whole body scanner (Siemens, Erlangen, Germany), using a 12-channel head coil. A T1-weighted MPRAGE was measured for anatomical identification. The acquisition parameters included a repetition time (TR) of 2530 ms, echo time (TE) of 3.42 ms, total time of acquisition of 6 min, resolution 1 mm^3, flip angle of 7°, matrix size 256 × 256, field of view of 256 × 256 and a slice thickness of 1 mm. As EPI-BOLD sequences suffer distortions caused by susceptibility artefacts, we acquired gradient echo field maps (GRE) before each Echo Planar Imaging (EPI) sequence to map those distortions. GRE maps were acquired with the same orientation and the same field of view, during 54 s and prior to each EPI sequence. Functional information was obtained using EPI sequences acquired with the slices parallel to the AC-PC line, interleaved, phase encoding direction A/P, covering nearly the whole brain. The acquisition parameters included a slice thickness of 3 mm and voxel size 4 mm^2, 36 slices, TR of 3000 ms, TE of 30 ms, flip angle of 90°, matrix size 256 × 256 and FOV of 256 × 256, 190 volumes (approx. 10 min). Two sequences were acquired for the study. The visual stimulation videos were shown inside the MR scanner by means of an LCD screen (NordicNeuroLab, Norway) and the participants viewed the stimuli through a mirror mounted above the participant's eyes. The monitor had a frequency rate of 60 Hz, dimensions of 698.40 × 392.85 mm, and was placed ∼156 cm away from the participants' head. Audio from the videos was provided through headphones. The subject could select the response using an MR-compatible joystick (Hybridmojo, San Mateo CA, USA).

EPI-BOLD images were undistorted using the GRE maps in the AnatAbacus v1.1 plugin (Breman et al., 2009) for BrainVoyager QX. The whole pre-processing and analyses were performed in BrainVoyager QX 2.8.2 (Brain Innovation, The Netherlands). Data were pre-processed using slice scanning time correction; motion correction (the second run was corrected in relation to the first volume of the first run); and filtered in the time domain (two cycles). The anatomical and functional data were co-registered automatically and manually verified, and then transformed to the Talairach space. A General Linear Model (GLM) random effects (RFX) analysis was done at group level and the predictors' model was obtained by convolution of the time course belonging to each condition with a two-gamma hemodynamic response function. An F-test was conducted to study the effects of valence (positive, neutral and negative). The resulting map was corrected for multiple comparisons using false discovery rate (FDR) with a fixed q value lower than 0.01. Reported clusters included at least 25 contiguous voxels. In the clusters showing statistically significant differences, post hoc tests were performed to understand which conditions differentially activated that cluster. A Bonferroni correction was used considering the number of tests.

4 | RESULTS

Descriptive statistics for the SSIS indicate participants exhibit high levels of fan identity. With exception to one individual who did not answer all items, the analysis of participants' answers to all seven

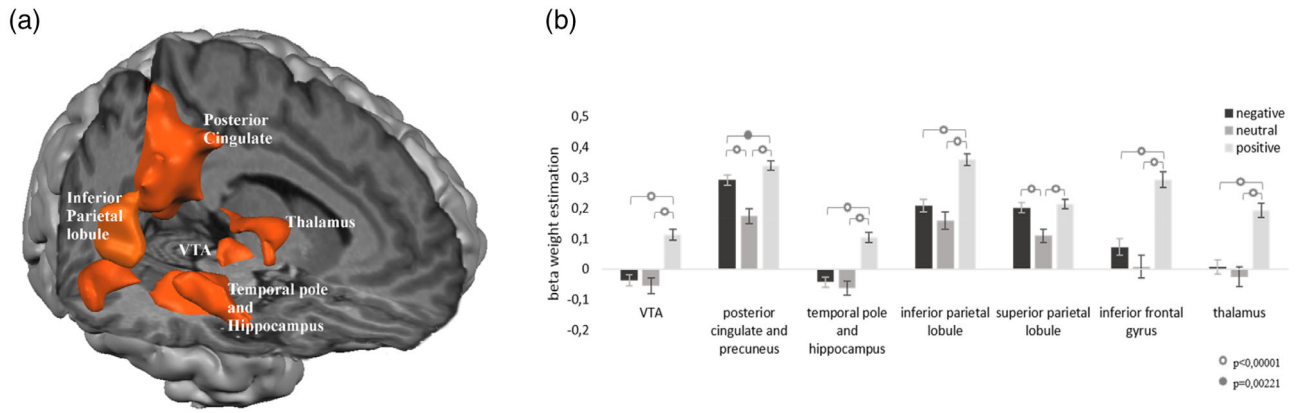

FIGURE 2 Video appraisal activates limbic and brainstem regions involved in memory, emotional and reward processing. (a) The *F*-map revealing the significant main effect of video visualization ($F(2,104) > 8.33$, $p(FDR) < 0.01$ corrected). The functional results obtained at the group-level were projected in the brain of a single subject in Talairach space. (b) Beta weight estimations (after removing serial correlations) for each predictor (negative, neutral and positive) across a set of regions activated by video appraisal. Significant comparisons are marked with hollow circles (Bonferroni corrected, $p < .01$) and filled circle for $p < .05$ (Bonferroni corrected).

TABLE 1 Regions revealing significant main effect of video visualization in ANOVA analysis.

	Talairach coordinates						
	Hemisphere	*X*	*Y*	*Z*	*t* value	Sig.	Number of voxels (mm^3)
VTA	Right, Left	−6	−25	−8	10.977	0.000047	2754
Posterior cingulate and precuneus	Right, Left	−6	−58	22	22.541	<0.000001	20,802
Temporal pole, parahippocampus and hippocampus	Right	42	11	−23	16.309	0.000001	12,220
Inferior parietal lobule	Right	63	−28	25	17.708	<0.000001	3730
Superior parietal lobule	Left	−36	−70	28	14.707	0.000002	817
Inferior frontal gyrus cortex	Right	61	2	13	14.429	0.000003	1799
Thalamus	Right, Left	0	−7	10	12.949	0.00001	1795
MT+	Right	45	−49	−2	14.683	0.000002	3155

Note: The peak voxel of each region is described using Talairach coordinates. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

items indicated they scored levels of fan identity between 2.14 and 5.00 ($M = 4.09$, $SD = 0.76$, $n = 52$). The fMRI results allowed to determine the main effects of the valence of video appraisal (positive, neutral and negative) on brain activity. Figure 2 shows the significant main effect of video appraisal ($F(2,104) > 8.33$, $p(FDR) < 0.01$) in different regions involving the posterior cingulate and precuneus, a cluster overlapping the temporal pole, uncus, parahippocampus, hippocampus, right inferior parietal lobule, thalamus, ventral tegmental area, inferior frontal gyrus, superior parietal lobule and MT+/V5. The main activated areas related to memory, emotions and reward processing in the evaluation of videos, with emphasis on the emotional effect apparent in VTA, as well as a link to the emotional and mnemonic processes with the activation of the inferior parietal lobule.

Table 1 details the peak voxel of those areas and the cluster size. Considering the emotional character and the attention required in the viewing of the videos by fans, a high number of voxels of the posterior cingulate and precuneus were observed. It is also important to note the activation of the VTA to positive predictions.

The beta weight estimation for each predictor (negative, neutral and positive) across the areas that showed a main effect for the valence are presented in Figure 2. Reward related (VTA and striatum), memory (hippocampus) and frontoparietal regions (inferior frontal gyrus and inferior parietal lobule) are mainly recruited by positive content. In addition, no region shows a higher activation for negative video content.

From the whole brain analysis, the activations of limbic system structures emerge when fans are exposed to positive, neutral, and negative events; the cingulate gyrus and other structures of the limbic system, as the hippocampus and parahippocampus were also activated. These findings allow addressing the first study objective. Accordingly, the analysis identified regions involving the posterior cingulate and precuneus, thalamus, a cluster overlapping the right temporal pole, parahippocampus, and hippocampus. It was also found a significant involvement of the ventral tegmental area (VTA) of the reward system.

Regarding the comparison of negative, neutral and positive events, positive video content contributed greatly to the signal

changes as per the second study objective. This was revealed by the beta weight estimation in the majority of identified regions within the reward and limbic networks and indicates fans' positive emotions related to their teams were specially weighted. We also found the involvement of other areas not directly included in the limbic or reward systems, with a role in multimodal sensory information integration and consequently a link to the emotional and mnemonic processes(e.g., the mirror neuron system; Gallagher & Frith, 2003; Iacoboni & Dapretto, 2006). The areas were the right inferior parietal lobule, the left superior parietal lobule and the right inferior frontal gyrus.

5 | DISCUSSION

Through a whole brain scan, the current study examined the structures of the limbic system involved when sport fans were exposed to positive, neutral and negative videos linked to their teams, and whether negative events activate more reward and limbic networks than neutral and positive videos. Given that previous studies about sport fans are mainly derived from self-reported consumer measures, and considering the hedonic nature of sport consumption experiences and its unpredictability (Funk & James, 2001), the current study used neuroimaging methods to examine the mechanisms of emotional drive in the mind of individuals with strong role identities as fans of their teams. This study extends previous literature through the provision of empirical evidence of a positive bias among sport fans when subject to different team-related stimuli.

The results indicate several critical neuro-behavioral correlations that shed light on how different brain systems are involved when sport fans appraise significant team moments. The structures of the limbic system that were activated when fans who are highly identified with their teams were exposed to team-related events include the cingulate gyrus, hippocampus and parahippocampus, and we also found a strong involvement of the VTA of the reward system in the appraisal of videos, which suggests sport fans may be emotional "experts". These findings are aligned with Klucharev et al. (2008) and indicate the activation of the hippocampus and parahippocampus in sport fans. Similarly, these findings provide additional support to the idea that high involvement is one important factor (Casado Aranda et al., 2021) and there are neural differences between fans and their level of identification. Our results are also in line with Schaefer and Rotte (2007b) that family brands elicit high cognitive functions like imagination of motor tasks, autobiographic memories, or working memory. On the other hand, these results extend previous traditional research on sport fans (i.e., questionnaires) by providing neural evidence that the role of being a fan of a team (i.e., fan identity), even if only in imagination, can make a difference in the way he/she thinks and behaves.

As for the comparison of positive, neutral and negative videos, the ones with a positive valence contributed greatly to the signal changes, as revealed by the beta weight estimation in the majority of identified regions within the reward and limbic networks. Through the fMRI, we verified that though watching any of the videos activated several regions in the brain, all regions were more activated when individuals were exposed to positive videos compared to the neutral or negative videos. This was more evident in the inferior frontal gyrus, the thalamus, temporal pole and hippocampus, and VTA (i.e., areas often linked to the reward system as the VTA activation shows), suggesting that positive videos trigger a sense of well-being (Wise, 1996) and supporting the transformative role of sport teams in fans' life (Inoue et al., 2020).

The greater and more extensive response to good than bad stimuli is, in itself, an important finding from the present research, given the near universality of the opposite findings. In preparing their book, Tierney and Baumeister (2021) reported they read mainly studies that cited the original negativity effect and found almost no exceptions to it. This suggests that positive emotions and thoughts related to their teams are more relevant and evocative than negative ones for sport fans. That is, brain regions such as inferior frontal gyrus, the thalamus, temporal, hippocampus, and VTA are more activated when fans are exposed to positive events, which can help consolidate short-term into long-term memories (e.g., a team's recent positive event is retained, but a negative event seems to be suppressed). Although hippocampus activation is expected due to autobiographical factors (Sheldon et al., 2019), such recovery can be important for fans to be able to 'experience' the event again and again. Also, and the activation of VTA could reinforce this link due to the dopaminergic character (i.e., activated with reward-related memories). Fans are characterized by having higher self-esteem, lower loneliness, and being more satisfied with life (Stieg, 2020). Contrary to psychology and neural studies suggesting a negativity effect (i.e., negative stimuli have a stronger effect then positive ones; Baumeister et al., 2001), our results indicate that positive events can be more meaningful for sport fans (at least in the sense of eliciting more brain activity) and offer neural support to existent literature on fandom suggesting fans tend to cut off reflected failure (CORFing) when facing adverse teams situations, and bask in reflected glory (BIRGing) to make others think they are successful as members of a team (Jensen et al., 2016).

Although negative stimuli tend to be more intense, dense, and complex than positive ones (Baumeister et al., 2001), these stimuli may be less common in the sport context. That is, fans are likely to work cognitively so that it is lessened and forgotten in the short-time (Taylor, 1991) to avoid threats to their identity over time (Mansfield et al., 2020). On the other hand, positive stimuli are frequent in sport settings with many opportunities to connect fans with teams and other fans. In addition, fans often use social creativity strategies to maintain their ties with the teams even in situations that may seem negative to others as this reflects positively on the way they view themselves as fans (Delia, 2019). Being a fan of a team often plays an important role for an individual's life (Biscaia et al., 2018). Those who are highly identified as fans of a team tend to pay monthly or annual membership fees (McDonald, 2010), wear the club's paraphernalia, socialize with other fans, follow the team daily through different media platforms, and all these interactions generate more positive than negative stimuli throughout time. Thus, one may argue that such frequent exposure to positive stimuli improves the activation of fans'

neural reactions, likely contributing to maintaining a sense of mental balance (Heider, 1958) towards their teams and associated entities that have been suggested in previous studies about fandom (Weimar et al., 2022). For example, seeing one's favorite team score an impressive goal might stimulate the person to think "I must remember to tell my friends about that one!" and possibly rehearse it in memory so as to enable an accurate re-telling. In contrast, seeing one's favorite team be scored upon by an opponent would be less appealing to memorize for subsequent re-telling. Another possible explanation is that these results may align with the neural consequences of the 'Pollyanna Hypothesis' (i.e. human tendency to use positive words more often than negative words when communicating with others; Boucher & Osgood, 1969) suggesting a tendency of sport fans to value more the positive aspects related to their teams.

Regarding the brain areas activated while exposed to different videos, important aspects should be discussed. Inserted in the reward processing, the posterior cingulate is part of a wide system of brain areas (Boksem & Smidts, 2015), and has been suggested to help the relationship between memory, self-experience and fan actions (Botzung et al., 2010). The current results add to existent literature by providing evidence of the importance of posterior cingulate to link imagination and action. This may be related to the fact sport fans are exposed to their teams through a variety of platforms (e.g., live games, TV, internet), which likely helps recreating and accessing memories from personal experiences (Trinh, 2018). In addition, the results indicating the precuneus activation extend Botzung et al.'s (2010) study suggesting it may be a consequence of fans' attention when viewing their teams' actions in a perspective of autobiographical memory. For example, watching a positive video (e.g., goal scored by the favorite team) can be linked to one's memory of a favorable episode in the past while playing football with friends, which highlights one's effort to remember what makes him/her feel well (i.e., compensatory processes; Rozin & Royzman, 2001).

Our results also show the activation of the thalamus (i.e. which includes subregions where positive and negative effects are reported above average; Bartra et al., 2013) in sport-related events. Because the brain activation pattern of fan identity is similar to that of maternal and romantic love (Duarte et al., 2017), and taking into account the high levels fan identity of the participants, one may argue the thalamic subregions, often associated with an executive logic (Van Der Werf et al., 2003), are also linked to a sensory logic ("experiencing" at the motor level the actions being performed). This means that a positive event related to the team (e.g., a powerful shot or goalkeeper's defense) may lead fans to revisit past life events and vicariously experience sport achievements (Mahony et al., 2002). In turn, the activation of the right temporal pole in the current study highlights the importance of the visualized video content and associated context. This extends to the sport context previous studies' results describing the right temporal pole as a "storehouse" of episodic and semantic memories (Olson et al., 2007) where the importance of emotional content, new memories, and meaning is present (Mesly, 2008).

The significant involvement of the VTA is also an important finding to be highlighted. These dopaminergic pathways are thought to play an important role in motivational functions and in the processing of the stimuli reward value (Wise, 2004). The involvement of this region was likely due to the positive emotionally intense moments experienced by the fans when viewing the videos. It is also likely that there are internal memory processes, either in context ("where was I when this goal was scored?"), or in personal terms ("what did I feel when this goal was scored?"), or from a social perspective ("who was I with?), because participants in our study frequently attend live games of their team. That is, these memory judgments may be made through a first-hand, frequent, daily, lived, meaningful experience (Batra, 2019), which suggests the importance of the live experiences for sport fans (Biscaia et al., 2012), not just through the exposure to the videos. The VTA sends information to various regions of the brain (Fisher et al., 2005), and our results highlight the idea of rewards as far as fans' memories are concerned.

We further found the involvement of other areas not directly included in the limbic or reward systems, with a role in multimodal sensory information integration and consequently a link to the emotional and mnemonic processes (Table 1). The regions are the right inferior parietal lobule, the left superior parietal lobule, and the right inferior frontal gyrus. The right inferior frontal gyrus differential involvement have been identified previously in relation to positive stimulus processes (McLean et al., 2009) and manifestations of tribal love (Duarte et al., 2017), which are important in the sport context due fans' tendency to bask in reflected glory (Jensen et al., 2016). In turn, the activation of the left superior parietal lobule is common in familiar events (Wagner et al., 2005), while the right inferior parietal lobule has been suggested to play a role in emotional and memory processing (Andersen, 2011), as well as decision-making processes (Kable & Glimcher, 2009). The current results add to existent literature (Bishop et al., 2013; Duarte et al., 2017) by providing evidence of a greater activation of the parietal lobe in positive and familiar situations experienced by consumers in highly hedonic environments.

5.1 | Managerial implications

Considering the unpredictability of the sport environment, the present results highlight that fans seem to retain more positive than negative events of their teams, which is of paramount importance for managers involved with sport teams. First, as the game outcome is not under the control of sport business managers, it is important to invest in the functional and aesthetic elements of game-day experiences (Biscaia et al., 2021) to provide supporters with experiences that trigger positive memories (i.e. activation of VTA and striatum, hippocampus, and inferior frontal gyrus and inferior parietal lobule). This may include for example an investment in training stadium staff and having quality and diversified concession areas available. In addition, the creation of opportunities for social interaction between fans, the development of a vibrant stadium atmosphere (e.g., sound and visuals) and an investment in activities to celebrate team traditions could prove to be pivotal to stimulate positive brain reactions on fans, and thus strengthen their ties with the team. For example, the Haka's ritual

performed by the New Zealander National teams is often considered a highlight of every game (Trapp, 2017). Second, the marketing communications could be focused on fans' common mental associations towards their teams such as nostalgia, socialization opportunities, stadium features, organizational values or community prestige (Biscaia et al., 2016) because the current results suggest that minimizing the negative and fostering the positive is essential for fans' neural reactions to teams. Similarly, given that results showed that the type of content presented to fans influence their neural reactions, the online strategy should be carefully managed in order to highlight the positive actions in the field without relying excessively on the game outcomes (Weimar et al., 2022). This could include posts related to coaches' reactions, goal celebrations, players and supporters smiling or fan celebration and social events. Also, considering the activation of areas such as VTA, it is vital from managers to track the most recent rewarding fan memories (e.g., an athlete's field action, a social interaction in the stadium or special family day linked to a team game) in order to customize their experiences and convert short-term reward into a long-term memory that benefits both the fan and the team.

In addition, it is important to note that a fan's identity is a dynamic process. Clubs should find ways to create a positive journey to their fans and this could be achieved by increasing the points of interaction. That is, fans should be able to interact with the club often and not only on game-related experiences. The provision of additional points of interaction such as virtual tours to the stadium, physical access to the facilities during the week for physical activity purposes, kindergartens and/or regular events for children and families, and additional team brand extensions that allow fans to have more contact with the team's brand (Walsh & Lee, 2012) may prove to be important to trigger positive memories in the brain and nurture the relationship with fans throughout time. Extending from Park et al. (2009), our results indicate that positive events are more valued by fans, while negative events are suppressed. Fragmenting club communication to share more positive moments may be important to strengthen the team's brand among fans. This is of particular importance because the type of message conveyed by an organization tends to affect consumer emotions and elicit changes in behavior (Martinez-Fiestas et al., 2015). For example, many positive aspects can be added or removed from a match (e.g., game outcome, coach reactions, goal celebrations, players smiling, team plays, effort in the field, backstage scenes, stadium atmosphere, fans).

6 | LIMITATIONS AND FUTURE RESEARCH

As with any study, there are limitations that should be acknowledged and considered for future studies. First, the current investigation is limited in terms of the ecological validity challenges faced in a laboratory experimental setting. For example, the videos may have elicited different responses compared to live or broadcasted sport events. Second, not all stimuli experienced by fans in a live or broadcasted event were covered. Thus, the inclusion of a co-active condition to stress the importance of drama associated to sport games (Trail & James, 2001) could contribute to improve the understanding of fans' neural reactions to team brands. Third, future studies could be enriched by with the addition of real-time measurement of fan reactions that may be relevant in the sport context, such as cardiac response or eye-tracking (actual attention to game situations). Fourth, mapping the brain activation not only on the valence of the stimuli, but also on consequential perceptional measures (e.g., liking of the video) or choice (e.g., ranking of the videos) represents an interesting research avenue. Despite current findings highlight a stronger effect of positive stimuli on fans' neural reactions, additional studies are required to further deepen the relationship team-fans. Also, arousal and familiarity are control factors to be considered in future research, not only in presenting positive and negative videos but also due to the possible activation of specific areas (e.g., hippocampus) (Merkow et al., 2015). It is also worth noting that despite the large sample size in the current study, a more balanced sample in terms of age, gender and commitment levels towards the team brands under examination could represent an important step towards a better understanding of sport consumers' brain reactions and potential generalizations to other in highly hedonic consumption environments. Finally, the prevalent reliance on reverse inference is a limitation (Poldrack, 2006, 2011) and more studies with designs that fulfill the prerequisite of the causality are required for a more conclusive understanding questions under examination (Siddiqi et al., 2022).

7 | CONCLUSIONS

In this study we were able to identify neural correlates of individuals with a high identification as fans of a team by considering the type of situation they are exposed to (positive, neutral or negative videos). Positive videos trigger more emotion and memory areas than neutral and negative videos. Negative video content seems to be suppressed from emotional memory. This indicates that cognitive control circuits are under-recruited by individuals with a high level of fan identity, and that they are potentially more vulnerable to marketing messages (i.e. their cognitive control is down regulated concomitantly with the high reactivity to positive stimuli). As brand memories encompass not only the explicit memories but also the implicit memories, structured in the depths of the basic structures of the brain (Plassmann et al., 2012), the interest of these results is twofold. First, at the marketing level, it allows a better knowledge on how individuals react to brands with which they have stronger connections. Second, it contributes to a deeper knowledge about memory mechanisms of sport fans when exposed to team-related stimuli.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest. The authors of this manuscript certify that they have no affiliations with or involvement in any

organization or entity with financial or non-financial interest in this the subject matter or materials discussed in this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Ricardo Cayolla https://orcid.org/0000-0003-4015-7363
Rui Biscaia https://orcid.org/0000-0003-2752-4317
Roy F. Baumeister https://orcid.org/0000-0003-1413-3296
Marc Fetscherin https://orcid.org/0000-0002-1547-0473
Sónia Brito-Costa https://orcid.org/0000-0002-7074-887X
Isabel C. Duarte https://orcid.org/0000-0002-5620-2424
Miguel Castelo-Branco https://orcid.org/0000-0003-4364-6373

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AUTHOR BIOGRAPHIES

Ricardo Cayolla is an Associate Professor at Portucalense University, Portugal, and Scientific Coordinator of the Consumer Neuroscience Research Lab. His research focus on consumer-neuroscience, consumer-brand relationship, and sport marketing. Ricardo is also the owner of a tennis academy. Author of seven books, his work has appeared in journals such as *Frontiers in Neuroscience*, *Journal of Product & Brand Management*, *Scientific Reports*, *Social Cognitive and Affective Neuroscience*, among others.

Rui Biscaia is an Associate Professor at the Department for Health, University of Bath, UK. He is also an invited lecturer at Universidade Europeia, Portugal. His research focus on the impact organisations have on contemporary society and the promotion of long-term sustainable relationships between consumers, organisations and associated sponsors. He is co-principal investigator of a Marie Curie Research and Innovation Staff Exchange about mega-sport events and human rights. His work has appeared in journals such as the *Journal of Business Research*, *International Journal of Clinical and Health Psychology*, *European Sport Management Quarterly*, *Journal of Sport Management*, *Sport Management Review*, *Leisure Studies*, among others.

Roy F. Baumeister is a Professor at the School of Psychology of the University of Queensland, Australia. His research focuses on self-control, decision-making, the need to belong and interpersonal rejection, human sexuality, irrational and self-destructive behavior, meaning, and other topics. He has nearly 700 scientific publications, including 41 books. Google Scholar lists his citation count over 200,000, putting him among the world's most influential scientists. In 2013, he received the highest award given by the Association for Psychological Science, the William James Fellow award, in recognition of his lifetime achievements.

Marc Fetscherin is Professor of Marketing and Gelbman Family Chair of International Business at Rollins University in the Department of Business (AACSB Accredited), Florida, USA. Marc expertise is in marketing, branding and market research. He has published a number of books, book chapters and journal articles. His articles have appeared in *Harvard Business Review*, *Journal of Business Research*, *International Journal of Market Research*, *Journal of Advertising Research*, *International Marketing Review*, *European Journal of Marketing*, among others.

Sónia Brito-Costa is researcher and coordinator of the Human Potential Development Center of the of the Polytechnic Institute of Coimbra Portugal, and Chair of the Ethics Committee. She is also expert evaluator at the Research Executive Agency—European Commission, and coordinator of Research Group in Social and Human Sciences (NICSH). Her work focuses on Neurosciences, Behavioral Sciences, Forensic Psychology, and has appeared in journals such as *Frontiers in Neuroscience*, *Scientific Reports*, among others.

Isabel Catarina Duarte is a Biomedical Engineer at the Institute of Nuclear Sciences Applied to Health, University of Coimbra, Portugal. She works on Neurosciences and is an advanced user of fMRI, EEG and ECoG, EEG/fMRI, TMS and TDCS, fNIRS as tools for neuroimaging data in the context of health and disease. Her work includes experimental design, acquisition and analysis of neuroimaging data, stimuli programming (including virtual reality paradigms). Her interests are healthy cognition, epilepsy and neurodegenerative disorders. Her master's degree was done at Siemens SA Healthcare Sector, focusing on Monte Carlo Simulations and 3D reconstruction of Digital Breast Tomosynthesis.

Miguel Castelo-Branco is the Director of CIBIT, the Coimbra Institute for Biomedical Imaging and Translational. He is the Scientific Coordinator of the National Functional Brain Imaging Scientific initiative. He was also the Director of ICNAS, the Imaging Infrastructure at the University of Coimbra. Under his leadership CIBIT was classified as an Excellent Research Unit by international evaluation panels. He obtained his PhD at the Max-Planck Institute for Brain research, Frankfurt, Germany and is now Full Professor at the University of Coimbra. His achievements are well reflected in publications in top General Journals, such as *Nature*, *PNAS*, and Neuroscience (*Neuron*, *The Journal of Neuroscience*, *The Journal of Neurophysiology*, *Human Brain Mapping*, *Neuroimage*, *Cerebral Cortex*, and others).

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