Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Behavioral Sciences

Utilizing electroencephalography (EEG) to investigate positive affect☆

Philip A Gable[1], Katharina Paul[2], Gilles Pourtois[3] and Jeffrey Burgdorf[4]

Electroencephalography (EEG) is a widespread neurophysiological measure used to study cognition, emotion and their interaction. There is a strong history and a growing body of EEG research investigating positive affect (PA). In the current article, we focus on EEG components which are increasingly informing the science of PA. We review EEG frequency evidence from alpha-band (recorded over lateral prefrontal leads) and beta-band (over the motor and pre-motor cortex) as measures of approach motivation in PA. We also review evidence of the event-related potential called the Reward Positivity, and the frequency components underlying it in the context of reward processing and learning. These EEG measures have been highly informative of PA, however, they are but a few of the potential EEG measures informing the study of PA.

Addresses
[1] Department of Psychological and Brain Sciences, University of Delaware, United States
[2] Institute of Psychology, University of Hamburg, Germany
[3] Department of Experimental-Clinical and Health Psychology, Ghent University, Belgium
[4] Feinberg School of Medicine, Northwestern University, United States

Corresponding author: Gable, Philip A (pagable@gmail.com)

Current Opinion in Behavioral Sciences 2021, **39**:190–195

This review comes from a themed issue on **Positive Affect**

Edited by **Henk van Steenbergen**, **Disa Sauter**, **Blair Saunders** and **Gilles Pourtois**

For a complete overview see the Issue and the Editorial

Available online 10th May 2021

https://doi.org/10.1016/j.cobeha.2021.03.018

Electroencepalography (EEG) is a powerful neurophysiological technique to explore affect, using a millisecond time resolution. In the current article, we focus on the state-of-the-art EEG measures of positive affect (PA). Before introducing them, we feel it is important to define our terms. Affect is a broad term that encompasses emotion and mood, and it reflects the subjective feeling state (affective valence) of an emotion. Motivation, and specifically approach motivation is an important component associated with PA and is the internal state of the organism that reflects the impetus or energy it will expend to accomplish something [1].

Importantly, while intuitively PA goes along with approach motivation, motivational direction and affective valence are not always confounded (e.g. approach-motivated anger). More specifically, PA can vary in approach motivational intensity depending on the stage of goal pursuit [2]. For example, some PAs are high in approach-motivational intensity and occur during the pursuit of a goal. These states likely prepare an individual to act. Other PAs are low in approach-motivational intensity and occur after a goal has been achieved. Finally, PA is usually studied at two levels, the level of general behavioral tendencies (i.e. personality traits) and at the level of current affective states (i.e. emotion and mood). By considering both components of PA, that is, affective valence and approach-motivational intensity, as well as by parallelizing findings from trait and state levels, the current review provides a consistent description on how each of the introduced EEG measures relates to different dimensions of PA.

EEG has been frequently applied to research on PA. EEG allows researchers to extract the summation of large clusters of postsynaptic electrical potentials at the scalp level. The complex patterns of electrical brain activity are then related to psychological states, specific events (either externally driven or internally generated), or behavioral manifestations. Usually, the EEG signal is not recorded from one location only, but high-density montages are used routinely nowadays, which allows for the collection of brain activity at multiple sites simultaneously, and yields complex/multi-dimensional data sets. The EEG signal is extremely rich, but most work examines it using either time-domain or time-frequency analyses. The event-related potential (ERP) is a time domain analysis corresponding to small-amplitude phase-locked and time-locked neural events. They are characterized by electrophysiological properties (including latency, amplitude, polarity, topography and neural sources). Alternatively, time-frequency decompositions of the EEG signal

☆ Given his role as Guest Editor, Gilles Pourtois had no involvement in the peer-review of the three articles where he is co-author, and has no access to information regarding their peer-reviews. Full responsibility for the editorial process for these articles was delegated to Blair Saunders.

are performed to determine frequency spectra and to extract pre-determined frequency bands, including delta, theta, alpha or gamma.

Using EEG to study PA

A large body of EEG studies suggests that specific ERP components and well-defined EEG oscillations (both during active processing and at rest) shed light on the influence of PA on information processing in the human brain. Instead of being merely redundant or mutually exclusive, the variety of ERP and frequency components inform about possible facets of PA. The scientific understanding of PA has greatly benefited from the use of multiple neurophysiological indices concurrently, as opposed to focusing on only one exclusively. No one EEG correlate of PA is sufficient to unpack the complexity of PA, but when considering multiple EEG correlates of PA, different pieces of the puzzle come together to create a meaningful picture.

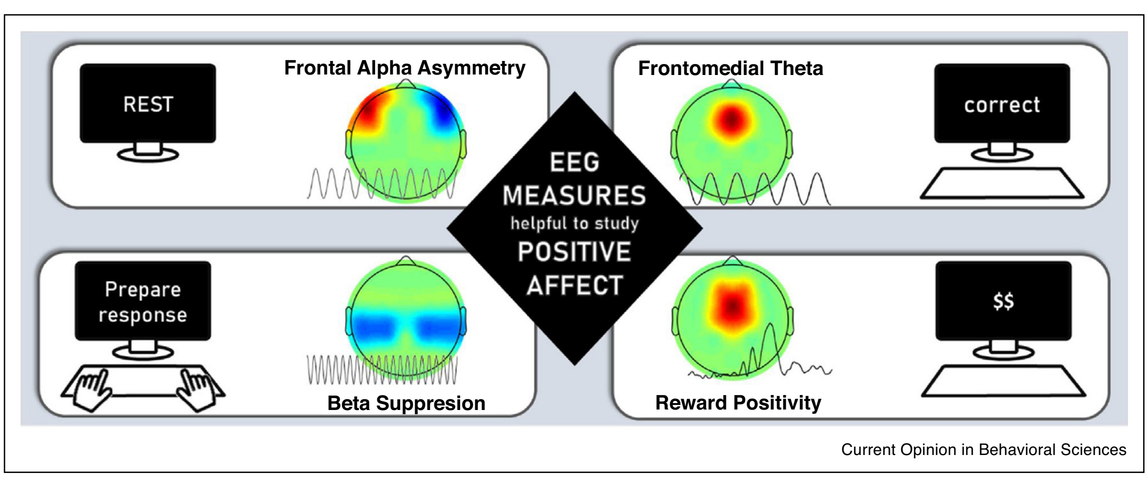
We highlight evidence of how past EEG work has informed our understanding of PA at different levels. In the following, we focus on four EEG measures that have been used to (1) test the validity of a broad underlying valence/motivational system (alpha-band recorded over lateral prefrontal leads), (2) quantify the motivation to act and approach (beta-band over the motor and premotor cortex), (3) study the influence of positive affect on information processing (frontal theta-band) as well as (4) probing the role of positive affect in reward processing and learning (Reward Positivity) (Figure 1).

Frontal alpha asymmetry: measuring positive valence and approach motivation

Much affective research has examined asymmetric frontal cortical activity. Predominantly, EEG is used to assess asymmetric frontal cortical activity comparing alpha power (8–13 Hz) activity levels between the left and right frontal sites. Alpha power is inversely related to regional brain activity as suggested by hemodynamic and behavioral measures [3]. EEG frontal asymmetry typically uses difference scores, based on the premise that one hemisphere may be inhibiting the opposite hemisphere [4]. EEG frontal asymmetry can be examined as a 'resting' baseline measure or as an active state measure. Baseline measures are typically recorded when an individual sits quietly for about 4–8 min, alternating eyes open and closed each minute. This type of frontal asymmetry is thought to reflect a trait-like individual difference measure [5]. To establish more causal evidence, other research has manipulated asymmetric frontal cortical activity through affective tasks or examined the influence of manipulations of cortical activity on affective variables [6].

Based on this EEG work, a large number of studies have found that greater relative left frontal activity is associated with the experience of PA, whereas greater relative right frontal activity is associated with the experience of negative affect (NA). This line of research suggests that the experience of PA or NA (affective valence) is the influencing factor of asymmetric frontal cortical activity. This model is typically called the valence model of frontal asymmetry and fits affective evidence when PAs are associated with approach motivation and NAs are associated with withdrawal motivation. However, other studies comparing low versus high approach-motivated PA have revealed that high approach-motivated PA is associated with greater relative left frontal activity than low approach-motivated PA (see Ref. [7••] for review). This growing evidence supports a model that motivational direction,

Figure 1



Schematic of the EEG measures that can be used to study positive affect. Overview of the four main EEG measures discussed in this review.

rather than affective valence is driving frontal asymmetry. Specifically, that greater relative left frontal activity is associated with approach motivated states and traits. Greater relative right frontal activity is associated with withdrawal motivated states and with motivational conflict [8]. A motivational distinction of greater relative left frontal asymmetry is important for PA in emotional situations when there is not a one-to-one relationship between approach motivation and PA (e.g. two positive affect states that are high versus low in approach motivation, but are equivalent in positive valence). Other situations occur when relative left frontal activity is increased by manipulations that do not increase PA, such as transcranial direct current stimulation [9]. In sum, both models have relevance to research on PA, but research examining diverse PAs varying in motivational intensity are more consistent with predictions derived from the motivational direction model than the affective valence model.

Beta activity over the motor cortex: measuring approach-motivated motor-preparation

During movement, preparation for movement, and observation of movement, the motor cortex and pre-motor areas of cortex become more active [10]. This increase in activity reduces EEG beta power (13–30 Hz) over the motor and pre-motor cortex. Suppressed beta activity over the motor cortex appears to be a neural correlate of motor-action preparation. For example, increasing beta suppression over the motor cortex is related to faster motor movement [11]. Past work has found that approach motivation enhances motor preparation as measured by reduced beta activity. Both state [12] and trait [13] approach motivation enhance beta suppression.

Beta suppression over the motor cortex appears to be a measure of motor readiness occurring during different motivational states [14•]. Anticipatory and consummatory PAs vary in approach motivational intensity [2]. Positive Affects that occur during pursuit of a goal, tend to be high in approach-motivational intensity. As such, these states likely prepare an individual to act. Positive Affects that occur after a goal has been achieved, tend to be low in approach-motivational intensity. In a recent study, researchers [15,16] directly tested whether high (pregoal) versus low (postgoal) approach-motivated PA states would differ in beta suppression and relate to cognitive processes that facilitate goal pursuit. Results revealed that beta suppression was highest in pregoal positive states, relative to postgoal positive and neutral states. Additionally, greater motor-action preparation in high approach-motivated positive states predicted cognitive narrowing in this and other studies [17,18]. Approach motivated pregoal states enhance neural preparation for motor-action, as well as cognitive processes to facilitate goal pursuit.

Beta suppression may also reflect emotional-based decision making for motivated action processes [19••]. Collectively, these results demonstrate a unique contribution of the motor system in goal pursuit. Beta suppression may be an important indicator of motivated action, and play an important role in decision making for emotion-based decisions, as well as actions.

Reward Positivity, Delta, and Theta: reward processing and learning

Another important line of research in the context of PA focuses on reward processing. While everyone would agree, that encountering something positive feels good, this truism has been only recently formally modeled [20]. Using a computational model approach, it has been shown that participants report to feel better after receiving positive performance feedback or a monetary reward [21•], in particular when this reward was unpredicted [22,23]. The motivation to collect positive experiences is a crucial mechanism for reinforcement learning and adaptive behavior. Because of its excellent temporal precision, EEG has been used extensively to study this rapid (emotional) process. One of the most studied EEG components in reinforcement learning is the Reward Positivity (RewP) [24–26], a positive going fronto-central component, peaking around 250 ms after evaluative feedback. The RewP has been shown to be larger for positive compared to negative performance feedback (e.g. wins versus losses). Moreover, the amplitude of the RewP component has been linked to positive prediction errors, that is, when outcomes are better than expected. EEG/ERP source localization and combined EEG/fMRI analysis have identified the anterior cingulate cortex and the medial prefrontal cortex as likely sources of the RewP [25,26]. Given its close links to reward processing and positive prediction errors [27], one could consider the RewP as a measure of processes that lead to or are integrated in PA.

This consideration is supported by findings linking amplitude of the RewP to motivational and affective changes at both state and trait levels. On a trait level, the RewP is positively related with reward responsiveness [28], positive emotionality [29] and behavioral activation or approach motivation [30]. To study affective and motivational states, different experimental manipulations were used. For example, the amplitude of the RewP is larger in trials where participants can win money or revenge, compared to trials where they can avoid losses or neither [31–33]. Moreover, the RewP seems to scale with the motivational value of the offered reward, increasing with the likeability [34,35] or the amount of money won [36,37]. Additionally, the RewP has been reported to increase with task-irrelevant positive affect induced with positive pictures [38] or an imagery technique [39], however these last results need to be replicated further, as null-results have been reported too [40,41•]. In sum, the

RewP appears to relate to both state and trait measures associated with PA.

More recently, time-frequency analysis of the EEG data instead of classical ERPs gained attention in the context of reward processing. One reason for this is that this approach helps to disentangle different influences of overlapping ERPs (RewP, P3, N2) by parsing the EEG signal into theta (4−8 Hz) and delta (<4 Hz) activity. It has been suggested that activity in the delta band is closely related to the RewP and similarly sensitive to rewards and positive reward prediction errors [42,43]. In comparison, theta was reported to be more sensitive to negative outcomes and unsigned prediction errors [44•,45]. This led to the idea that theta activity could be a signal for the need of augmented control over information processing [46]. While much more work is needed to understand specifics of these EEG components, such as underlying phase locked activity, we would like to point out some studies, which reported affective or motivational modulations of these components. For example, increased delta activity was found when perceived control over the task and outcome was high, a concept somewhat related to approach motivation and PA [47]. By comparison, participants in PA states (induced via guided imagery [39,41•] or reward magnitude [37]) showed reduced theta responses to unexpected monetary reward feedback. This reduced theta activity was interpreted to be the result of changed expectations accompanying affective state: participants in positive mood were not surprised when gaining a reward, reflecting an optimistic bias in positive mood.

Delta and theta oscillations may reflect the synaptic plasticity mechanisms that regulate the daily rhythm of arousal and mood. The daily rhythm of arousal/tiredness and positive/negative emotion are closely related to that of theta/ delta cortical EEG power [48,49]. At a mechanic level, theta increases, and delta decreases synaptic connectivity and thus the theta/delta rhythm contributes to homeostatic plasticity with net synaptic strength remaining constant across days [48,50]. Taken together, RewP, delta and theta activity seem to relate to separate processes during reward processing. Given that PA is not only an effect of exogenous states, but can also influence the perception of exogenous states [21•,23], these markers present themselves as a promising tool to study how changes in PA unfold over time.

Conclusions

EEG has much to offer to the study of PA. EEG measures can (1) inform us about an existing valence or motivational system (such as frontal alpha asymmetry), (2) help to measure the impetus to act (beta suppression), (3) shed light on how PA colors information processing (such as frontal theta) or (3) reflect reward monitoring relevant for PA (such as the RewP). The EEG measure reviewed above are but a small portion of the signal recorded using EEG, and moreover, they are often used in isolation. Accordingly, attempts made to explore and model effects of PA on cognition and emotion when multiple EEG correlates are considered concurrently could represent a critical step in better understanding the nature and function of affective states. Simultaneously, the presented markers are not necessarily specific to positive affect, as frontal alpha asymmetry can occur in a negative affective state high in approach motivation (such as anger). Consequently, none of the EEG measures presented here can currently be understood as a direct marker or a manifestation of an underlying valence system. Nevertheless, considering a complex pattern across different EEG measures could help to inform about different components of PA when individuals are unable, or unwilling to accurately report of these motivational processes. The benefits of using EEG to study PA extend beyond those offered by other neural and physiological measures in their affordability, rapid time resolution, and minimal invasion. The current article reviewed robust signals associated with or sensitive to PA. In this context, we believe that much more exciting EEG research is yet to come on the study of PA, not only in humans, but non-human animals as well.

Conflict of interest statement

Nothing declared.

Acknowledgements

The authors want to thank the organisers of the workshop on positive affect held at the Lorentz Center (Leiden, The Netherlands) in March 2020, which gave rise to this article.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1. Gable PA, Dreisbach G: **Approach motivation and positive affect**. *Curr Opin Behav Sci* 2021, **39**:203-208.
2. Gable PA, Harmon-Jones E: **Attentional consequences of pregoal and postgoal positive affects**. *Emotion* 2011, **11**:1358-1367.
3. Cook IA, O'Hara R, Uijtdehaage SHJ, Mandelkern M, Leuchter AF: **Assessing the accuracy of topographic EEG mapping for determining local brain function**. *Electroencephalogr Clin Neurophysiol* 1998, **107**:408-414.
4. Schutter DJLG, Harmon-Jones E: **The corpus callosum: a commissural road to anger and aggression**. *Neurosci Biobehav Rev* 2013, **37**:2481-2488.
5. Gheza D, Bakic J, Baeken C, De Raedt R, Pourtois G: **Abnormal approach-related motivation but spared reinforcement learning in MDD: evidence from fronto-midline Theta oscillations and frontal Alpha asymmetry**. *Cogn Affect Behav Neurosci* 2019, **19**:759-777.
6. Kelley NJ, Hortensius R, Schutter DJ, Harmon-Jones E: **The relationship of approach/avoidance motivation and asymmetric frontal cortical activity: a review of studies**

manipulating frontal asymmetry. *Int J Psychophysiol* 2017, **119**:19-30.

7. •• Harmon-Jones E, Gable PA: **On the role of asymmetric frontal cortical activity in approach and withdrawal motivation: an updated review of the evidence**. *Psychophysiology* 2018, **55**: e12879
Exhaustive review on how asymmetric frontal alpha activity is associated with the experience of positive affect, while highlighting the role of motivational direction.

8. Gable PA, Neal LB, Threadgill AH: **Regulatory behavior and frontal activity: considering the role of revised-BIS in relative right frontal asymmetry**. *Psychophysiology* 2018, **55**:1-18.

9. Ohmann HA, Kuper N, Wacker J: **Left frontal anodal tDCS increases approach motivation depending on reward attributes**. *Neuropsychologia* 2018, **119**:417-423.

10. Gable PA, Poole BD, Cook MS: **Asymmetrical hemisphere activation enhances global-local processing**. *Brain Cogn* 2013, **83**:337-341.

11. Babiloni C, Del Percio C, Vecchio F, Sebastiano F, Di Gennaro G, Quarato PP, Morace R, Pavone L, Soricelli A, Noce G *et al.*: **Alpha, beta and gamma electrocorticographic rhythms in somatosensory, motor, premotor and prefrontal cortical areas differ in movement execution and observation in humans**. *Clin Neurophysiol* 2016, **127**:641-654.

12. Meadows CC, Gable PA, Lohse KR, Miller MW: **Motivation and motor cortical activity can independently affect motor performance**. *Neuroscience* 2016, **339**:174-179.

13. Meyniel F, Pessiglione M: **Better get back to work: a role for motor beta desynchronization in incentive motivation**. *J Neurosci* 2014, **34**:1-9.

14. • Threadgill AH, Gable PA: **Resting beta activation and trait motivation: neurophysiological markers of motivated motor-action preparation**. *Int J Psychophysiol* 2018, **127**:46-51
EEG study linking trait measures of approach motivation and impulsivity with resting beta activity, suggesting that motor-action preparation indicates tendencies for planful motivated behavior.

15. Wilhelm R, Gable PA: **Primed for movement: beta activation over the motor cortex resulting from extrinsic and intrinsic motivators**. *ADD J* 2021. (in prep).

16. Gable PA, Threadgill AH, Adams DL: **Neural activity underlying motor-action preparation and cognitive narrowing in approach-motivated goal states**. *Cogn Affect Behav Neurosci* 2016, **16**:145-152.

17. Threadgill AH, Gable PA: **Intertrial variability in emotive reactions to approach-motivated positive pictures predicts attentional narrowing: the role of individual differences**. *Biol Psychol* 2019, **142**:19-28.

18. Paul K, Pourtois G, van Steenbergen H, Gable P, Dreisbach G: **Finding a balance: modulatory effects of positive affect on attentional and cognitive control**. *Curr Opin Behav Sci* 2021, **39**:136-141.

19. •• Chen XJ, McCarthy M, Kwak Y: **Contribution of sensorimotor beta oscillations during value-based action selection**. *Behav Brain Res* 2019, **368**:111907
EEG study characterizing the time course of the processing of decision variables in value-based decision making for actions. Results demonstrate a unique contribution of the motor system in value-based decision making for actions.

20. Moors A, Van de Cruys S, Pourtois G: **Comparison of the determinants for positive and negative affect proposed by appraisal theories, goal-directed theories, and predictive processing theories**. *Curr Opin Behav Sci* 2021, **39**:147-152.

21. • Vinckier F, Rigoux L, Oudiette D, Pessiglione M: **Neuro-computational account of how mood fluctuations arise and affect decision making**. *Nat Commun* 2018, **9**
Computational model using neuroimaging data to reveal how reward attainment increases positive affect, which in turn dynamically guides decision making.

22. Rutledge RB, Skandali N, Dayan P, Dolan RJ: **A computational and neural model of momentary subjective well-being**. *Proc Natl Acad Sci U S A* 2014, **111**:12252-12257.

23. Eldar E, Rutledge RB, Dolan RJ, Niv Y: **Mood as representation of momentum**. *Trends Cogn Sci* 2016, **20**:15-24.

24. Sambrook TD, Goslin J: **A neural reward prediction error revealed by a meta-analysis of ERPs using great grand averages**. *Psychol Bull* 2015, **141**:213-235.

25. Proudfit GH: **The reward positivity: from basic research on reward to a biomarker for depression**. *Psychophysiology* 2015, **52**:449-459.

26. Becker MPI, Nitsch AM, Miltner WHR, Straube T: **A single-trial estimation of the feedback-related negativity and its relation to BOLD responses in a time-estimation task**. *J Neurosci* 2014, **34**:3005-3012.

27. Schultz W: **Dopamine reward prediction error coding**. *Dialogues Clin Neurosci* 2016, **18**:23-32.

28. Umemoto A, Holroyd CB: **Neural mechanisms of reward processing associated with depression-related personality traits**. *Clin Neurophysiol* 2017, **128**:1184-1196.

29. Speed BC, Nelson BD, Levinson AR, Perlman G, Klein DN, Kotov R, Hajcak G: **Extraversion, neuroticism, and the electrocortical response to monetary rewards in adolescent girls**. *Biol Psychol* 2018, **136**:111-118.

30. Lange S, Leue A, Beauducel A: **Behavioral approach and reward processing: results on feedback-related negativity and P3 component**. *Biol Psychol* 2012, **89**:416-425.

31. Weinberg A, Riesel A, Proudfit GH: **Show me the money: the impact of actual rewards and losses on the feedback negativity**. *Brain Cogn* 2014, **87**:134-139.

32. Threadgill AH, Gable PA: **The sweetness of successful goal pursuit: approach-motivated pregoal states enhance the reward positivity during goal pursuit**. *Int J Psychophysiol* 2018, **132**:277-286.

33. Gheza D, De Raedt R, Baeken C, Pourtois G: **Integration of reward with cost anticipation during performance monitoring revealed by ERPs and EEG spectral perturbations**. *Neuroimage* 2018, **173**:153-164.

34. Threadgill AH, Gable PA: **Revenge is sweet: investigation of the effects of approach-motivated anger on the RewP in the motivated anger delay (MAD) paradigm**. *Hum Brain Mapp* 2020, **41**:5032-5056.

35. Angus DJ, Kemkes K, Schutter DJLG, Harmon-Jones E: **Anger is associated with reward-related electrocortical activity: evidence from the reward positivity**. *Psychophysiology* 2015, **52**:1271-1280.

36. Meadows CC, Gable PA, Lohse KR, Miller MW: **The effects of reward magnitude on reward processing: an averaged and single trial event-related potential study**. *Biol Psychol* 2016, **118**:154-160.

37. Paul K, Vassena E, Severo MC, Pourtois G, Paul K, Severo MC, Vassena E, Pourtois G: **Dissociable effects of reward magnitude on fronto-medial theta and FRN during performance monitoring**. *Psychophysiology* 2019, **57**:e13481.

38. Yang Q, Zhao D, Wu Y, Tang P, Gu R, Luo Y: **Differentiating the influence of incidental anger and fear on risk decision-making**. *Physiol Behav* 2018, **184**:179-188.

39. Paul K, Pourtois G: **Mood congruent tuning of reward expectation in positive mood: evidence from FRN and theta modulations**. *Soc Cogn Affect Neurosci* 2017, **12**:765-774.

40. Bakic J, Jepma M, De Raedt R, Pourtois G: **Effects of positive mood on probabilistic learning: behavioral and electrophysiological correlates**. *Biol Psychol* 2014, **103**:223-232.

41. • Paul K, Pourtois G, Harmon-Jones E: **Modulatory effects of positive mood and approach motivation on reward processing: two sides of the same coin?** *Cogn Affect Behav Neurosci* 2020, **20**:236-249
Recent EEG study investigating the effects of a state manipulation of positive affect and motivation on reward expectations.

42. Bernat EM, Nelson LD, Baskin-Sommers AR: **Time-frequency theta and delta measures index separable components of feedback processing in a gambling task**. *Psychophysiology* 2015, **52**:626-637.

43. Watts ATM, Bachman MD, Bernat EM: **Expectancy effects in feedback processing are explained primarily by time-frequency delta not theta**. *Biol Psychol* 2017, **129**:242-252.

44. • Brown DR, Cavanagh JF: **Novel rewards occlude the reward positivity, and what to do about it**. *Biol Psychol* 2020, **151**:107841
Set of EEG studies to disentangle the overlapping influence of feedback valence and expectedness on the Reward Positivity by systematically varying experimental manipulations as well as through spectral decomposition.

45. Sambrook TD, Goslin J: **Principal components analysis of reward prediction errors in a reinforcement learning task**. *Neuroimage* 2016, **124**:276-286.

46. Cavanagh JF, Frank MJ: **Frontal theta as a mechanism for cognitive control**. *Trends Cogn Sci* 2014, **18**:414-421.

47. Zheng Y, Wang M, Zhou S, Xu J: **Functional heterogeneity of perceived control in feedback processing**. *Soc Cogn Affect Neurosci* 2020, **15**:329-336.

48. Burgdorf J, Brudzynski S, Moskal J: **Using rat ultrasonic vocalization to study the neurobiology of emotion: from basic science to the development of novel therapeutics for affective disorders**. *Curr Opin Neurobiol* 2020, **60**:192-200.

49. Kahneman D, Krueger AB, Schkade DA, Schwarz N, Stone AA: **A survey method for characterizing daily life experience: the day reconstruction method**. *Science (80)* 2004, **306**:1776-1780.

50. Malenka RC, Bear MF: **LTP and LTD. An embarrassment of riches**. *Neuron* 2004, **44**:5-21.