

Fear in action: How Pavlovian fear learning shapes goal-directed motor responses

ABSTRACT:

Background

Environmental stimuli may acquire fear-related properties through pairing with an aversive event and may profoundly influence behavior. However, the cognitive and neural mechanisms through which aversive experiences shape future behavior remain still debatable.

Aims

The project aimed to re-evaluate the role that the motor system plays in the acquisition, storage and update of Pavlovian fears.

Method

Three studies were conducted involving a total of about 150 healthy young adults. In the experiments, participants learned to anticipate the occurrence of different somatosensory aversive events following the presentation of different visual stimuli (i.e. Pavlovian fear learning). Multiple methodologies were combined, i.e. kinematic analysis, double coil single pulse TMS, EEG and skin conductance response monitoring.

Results

Results provide unifying evidence that the activity of the cortical motor system is profoundly shaped by the acquisition, storage and update of Pavlovian fears. Indeed, fear learning modulated somatomotor neural oscillations, which in turn induced inhibition of the corticospinal system, and shaped goal-directed motor responses. Thus, we show that Pavlovian fears entail the acquisition of organized sets of sensori-motor contingencies associated with the expected aversive events, which in turn shape action.

Conclusions

This project significantly advances the mechanistic understanding of the acquisition, storage and update, revealing the so far neglected - but crucial - role of the cortical motor system. The inclusion of motor system responses into models of Pavlovian fears may bring to a new understanding of, and treatments for, maladaptive forms of fear learning, such as in anxiety- or pain-related disorders.

Keywords

Fear, Pavlovian conditioning, Pain anticipation, Motor system, Transcranial magnetic stimulation (TMS), Electroencephalogram (EEG), Skin conductance, Kinematic, Reaching, Goal-directed response, Psychophysiology

Published Work:

Degni, L. a. E., Dalbagno, D., Starita, F., Benassi, M., Di Pellegrino, G., & Garofalo, S. (2022). General Pavlovian-to-instrumental transfer in humans: Evidence from Bayesian inference. *Frontiers in Behavioral Neuroscience*, *16*, 945503. doi:10.3389/fnbeh.2022.945503

Pirazzini, G., Starita, F., Ricci, G., Garofalo, S., Di Pellegrino, G., Magosso, E., & Ursino, M. (2023). Changes in brain rhythms and connectivity tracking fear acquisition and reversal. *Brain Structure & Function*, *228*(5), 1259–1281. doi:10.1007/s00429-023-02646-7

Sellitto, M., Terenzi, D., Starita, F., Di Pellegrino, G., & Battaglia, S. (2022). The cost of imagined actions in a reward-valuation task. *Brain Sciences*, *12*(5), 582. doi:10.3390/brainsci12050582

Starita, F., Garofalo, S., Dalbagno, D., Degni, L. a. E., & Di Pellegrino, G. (2022). Pavlovian threat learning shapes the kinematics of action. *Frontiers in Psychology*, *13*, 1005656. doi:10.3389/fpsyg.2022.1005656

Starita, F., Pirazzini, G., Ricci, G., Garofalo, S., Dalbagno, D., Degni, L. A. E., Di Pellegrino, G., Magosso, E., & Ursino, M. (2023). Theta and alpha power track the acquisition and reversal of threat predictions and correlate with skin conductance response. *Psychophysiology*, *60*(7), e14247. doi:10.1111/psyp.14247

Starita, F., Stussi, Y., Garofalo, S., & di Pellegrino, G. (2023). Threat learning in space: How stimulus-outcome spatial compatibility modulates conditioned skin conductance response. *International Journal of Psychophysiology*, *190*, 30–41. doi:10.1016/j.ijpsycho.2023.06.003

Starita, F., Stussi, Y., Garofalo, S., & Terenzi, D. (2024). Editorial: The neurobiological and cognitive underpinnings of appetitive and aversive motivation. *Frontiers in Behavioral Neuroscience*, *18*, 1383393. doi:10.3389/fnbeh.2024.1383393

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