EXPLORING BRAIN ACTIVITY RELATED TO MISSING PENALTY KICKS: A fNIRS STUDY

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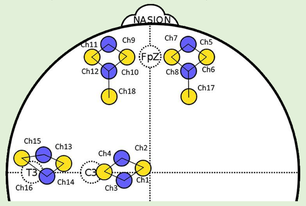
INTRODUCTION

At vital moments in professional football matches, penalty kicks were often missed. In fact, one in five penalty kicks is missed. Psychological factors, such as anxiety and pressure, are among the critical causes of the mistakes, commonly known as *choking under pressure*. Nevertheless, the factors causing this have not been fully explored in the football domain. This study focuses on the influence of the brain on this process by measuring the brain during an *in the field* experiment. Furthermore, the difference between novice and experienced football players is examined.

METHOD

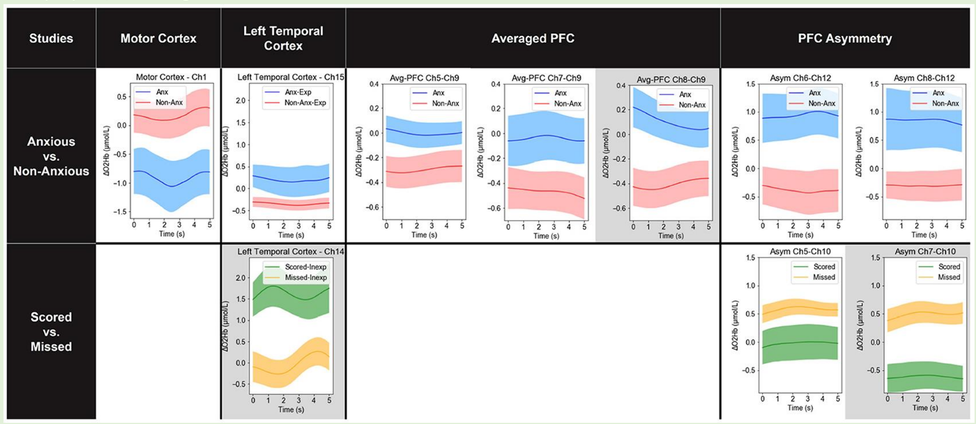
In this study we used functional near-infrared spectroscopy (fNIRS) to investigate the influence of the brain on this process. An *in-situ* study was set-up (N = 22), in which each participant took 15 penalties under three different pressure conditions: without a goalkeeper, with an amiable goalkeeper and with a competitive goalkeeper. During the last condition, pressure was also induced by the player approaching the goal from the halfway line (like in professional football penalty-shootouts), thrash-talk from the goalkeeper and researcher, delaying tactics of the goalkeeper and the possibility to win a price. Also, the first name of the participant was frequently mentioned. Both experienced and inexperienced football players were recruited, and the brain activation was compared across groups. Besides, fNIRS activation was compared that participants felt anxious against sessions that they did not. Also, fNIRS activation was between sessions. compared between penalty-scoring and penalty-missing sessions. According to existing studies, the brain regions of interest are the prefrontal cortex, motor cortex and left temporal cortex. The fNIRS receivers and optodes were positioned in such a way that four channels measured the motor cortex (Ch1 – Ch4), another four channels measured the left temporal cortex (Ch13 – Ch16) and the remaining ten channels measured the prefrontal cortex (PFC).



RESULTS

Our methods used to induce pressure were successful. This was shown by an increase in missed penalties in the last round and participants indicated that they more worried during the later rounds. Regarding the brain activation data, only the O2Hb (oxygenated) signal was analyzed, as this signal is directly related to the brain activation. The figure below shows all tests where the brain activation values for the two conditions differ at a significance level of $p < 0.05$. Test results that were still significant with $p < 0.05$ after FDR correction were labeled with a gray background. The darker line shows the mean activation and the thickness of the line shows the standard deviation for that channel(-pair). For the left temporal cortex, the results of experienced and inexperienced players were analyzed separately, as it was expected that for this brain region the results of experienced and inexperienced players would differ. For all other brain regions, the results of both groups combined were used.

For one channel, the motor cortex was activated less when players were anxious/stressed. Regarding the left-temporal cortex, experienced players showed an increased activation when being anxious, whereas inexperienced players scored more goals when activating this area of the brain more. The overall PFC (prefrontal cortex) activation was higher when players were more anxious and the PFC asymmetry (difference between left and right PFC activation) was larger when players were anxious and missed more penalties. These larger positive PFC asymmetry values indicate a higher right compared to left PFC activation. Regarding the difference between experienced and inexperienced players, so no significant results were found.



CONCLUSION

Our results provide supportive evidence for the neural efficiency theory where the correct regions of the brain should be activated to successfully perform motor tasks under mental pressure. When being anxious, the motor cortex (task-relevant area) was activated significantly less in one channel. The activation of task-irrelevant areas of the brain was more common when being anxious. This was most prominently observable in the PFC (prefrontal cortex), both in average PFC activation and the difference between left and right PFC activation. The long-term thinking ability of the PFC is an explanation for this, as players might think about the consequences of scoring/missing. For experienced players, increased activation of the left temporal cortex (related to self-instruction) was linked with being anxious. By activating the left temporal cortex more, experienced players neglect their automated skills and start to overthink the situation. We demonstrated that brain activity associated with choking under pressure in a penalty kick situation can be reflected by *in the field* fNIRS measurements. However, after FDR-correction, only 3 significant results remain. Therefore, no direct conclusion can be drawn from the results of this study alone. However, as the results are in-line with previous findings in literature, the results of this study can still be seen as a support to these theories.

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