

## Mental fatigue and padel

Diaz-Garcia, Jesus; Ring, Chris; Manzano-Rodríguez, David; Garcia-Calvo, Tomas

DOI:

[10.17398/2952-2218.2.107](https://doi.org/10.17398/2952-2218.2.107)

License:

Creative Commons: Attribution (CC BY)

*Document Version*

Publisher's PDF, also known as Version of record

*Citation for published version (Harvard):*

Diaz-Garcia, J, Ring, C, Manzano-Rodríguez, D & Garcia-Calvo, T 2024, 'Mental fatigue and padel: state-of-the-art and beyond', *Padel Scientific Journal*, vol. 2, no. 1, pp. 107-117. <https://doi.org/10.17398/2952-2218.2.107>

[Link to publication on Research at Birmingham portal](#)

### General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

### Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact [UBIRA@lists.bham.ac.uk](mailto:UBIRA@lists.bham.ac.uk) providing details and we will remove access to the work immediately and investigate.



## **MENTAL FATIGUE AND PADEL: STATE-OF-THE-ART AND BEYOND**

### **FATIGA MENTAL Y PÁDEL: ESTADO DE LA CUESTIÓN**

JESÚS DÍAZ-GARCÍA  
Faculty of Sport Sciences,  
University of Extremadura.  
Orcid: 0000-0002-9430-750X

CHRISTOPHER RING  
School of Sport,  
Exercise and Rehabilitation Sciences,  
University of Birmingham.  
Orcid: 0000-0001-9921-0435

DAVID MANZANO-RODRÍGUEZ  
Faculty of Sport Sciences,  
University of Extremadura.  
Orcid: 0000-0001-8524-4570

TOMÁS GARCÍA-CALVO  
Faculty of Sport Sciences,  
University of Extremadura.  
Orcid: 0000-0002-2550-418X

**Autor de correspondencia:** Jesús Díaz García. Faculty of Sport Sciences, Avda de la Universidad, s/n, 10003, Cáceres, Spain. [jdiaz@unex.es](mailto:jdiaz@unex.es)

Recibido: 02/11/2023

Aceptado: 27/12/2023

## ABSTRACT

Padel is attracting increased research interest. Although the focus has been on the physical and technical-tactical demands of the game, recently more attention is being paid to its mental demands and, more specifically, the importance of mental fatigue. This literature review provides an overview of mental fatigue in padel. First, we consider the mentally fatiguing nature of padel. Padel players must make complex decisions under high-time pressure, maintain self-confidence, and communicate with their partners in an emotionally charged context. With these cognitive demands, it is not surprising that padel matches and tournaments are mentally fatiguing. Second, we review evidence confirming that mental fatigue is detrimental for padel players' performance, in agreement with findings observed in other sports. Third, we evaluate strategies to tackle mental fatigue and its effects on padel performance. Until now, the only proven long-term countermeasure is Brain Endurance Training. Finally, we make a series of recommendations for coaches and players to deal with mental fatigue, that focus on the quantification and modulation of mental fatigue among padel players. We strongly recommend i. to include subjective ratings of mental fatigue (i.e., VAS scale) before and after training and competitive matches, ii. to reduce the cognitive load of training before competitions by, for example, use positive feedback or habitual training exercises, and iii. to use Brain Endurance Training during non-competitive moments of the season.

**Keywords:** Cognitive fatigue, Brain Endurance Training, performance, racket sports.

## RESUMEN

El pádel suscita cada vez más interés en la investigación. Aunque la atención se ha centrado en las exigencias físicas y técnico-tácticas del juego, recientemente se está prestando más atención a sus exigencias mentales y, más concretamente, a la importancia de la fatiga mental. Esta revisión bibliográfica ofrece una visión general de la fatiga mental en el pádel. En primer lugar, consideramos la naturaleza de fatiga mental del pádel. Los jugadores de pádel deben tomar decisiones complejas bajo una gran presión de tiempo, mantener la confianza en sí mismos y comunicarse con sus compañeros en un contexto cargado de emociones. Con estas demandas cognitivas, no es sorprendente que los partidos y torneos de pádel sean mentalmente fatigantes. En segundo lugar, revisamos las pruebas que confirman que la fatiga mental es perjudicial para el rendimiento de los jugadores de pádel, de acuerdo con los hallazgos observados en otros deportes. En tercer lugar, evaluamos las estrategias para hacer frente a la fatiga mental y sus efectos sobre el rendimiento en el pádel. Hasta ahora, la única contramedida probada a largo plazo es el entrenamiento de la resistencia

cerebral. Por último, hacemos una serie de recomendaciones para entrenadores y jugadores para hacer frente a la fatiga mental, que se centran en la cuantificación y modulación de la fatiga mental entre los jugadores de pádel. Recomendamos especialmente i. incluir medidas subjetivas de fatiga mental (i.e., VAS scale) antes y después de los partidos y partidos de competición, ii. Reducir la carga cognitiva de los entrenamientos cercanos a la competición mediante, por ejemplo, el uso de feedback positivo o ejercicios de entrenamiento habituales, y iii. Utilizar Brain Endurance Training durante fases de la temporada en las que no haya torneos.

*Palabras clave:* Fatiga cognitiva, entrenamiento de la resistencia cerebral, rendimiento, deportes de raqueta.

## Introduction

Padel, a racket sport played in doubles in a 20 x 10 m. court enclosed by glass and fences, has attracted the interest of researchers (Denche-Zamorano et al., 2023). Most of these publications have focused on the physiological (Cádiz-Gallardo et al., 2023) and technical-tactical (Martin-Miguel et al., 2023) demands of the game. More recently, it was reported that padel is both mentally and physically effortful; padel induces a state of mental fatigue among players (Díaz-García, González-Ponce, López-Gajardo, et al., 2021) that can impair performance (Díaz-García et al., 2023). The main purpose of this article is to summarize and bring out the existing findings about mental fatigue in padel. Specifically, this review considers i. the mentally fatiguing nature of padel, ii. the detrimental effects of mental fatigue on padel performance, iii. the possible countermeasures for players to tackle these detrimental effects, and, iv. a series of practical recommendations about measures of mental fatigue and its modulation.

## The mentally fatiguing nature of padel

Mental fatigue, a psychobiological state evoked by prolonged and demanding cognitive activities, is characterized by subjective (e.g., Borg ratings, enhanced feelings of exertion), behavioral (e.g., impaired reaction time), or/and physiological (e.g., changes in heart rate variability or electroencephalographic activity) symptoms in athletes (Van Cutsem et al., 2017). During a professional tournament, Díaz-García, González-Ponce, López-Gajardo et al.

(2021) collected subjective ratings of mental fatigue and measured cognitive performance during a 45 s incongruent Stroop task and reaction time during a Psychomotor Vigilance Task, before and after padel matches. Three main conclusions were drawn. First, padel matches increased subjective feelings of mental fatigue and impaired performance on the Stroop task and Psychomotor Vigilance Task. These findings reveal that padel games evoke a state of mental fatigue with subjective (i.e., feelings of tiredness) and behavioral symptoms (i.e., impaired response inhibition and attention). Similarly, authors have reported the mentally fatiguing nature of soccer (Thompson et al., 2019) and netball (Russell et al., 2022) games. Second, when players played more than one game per day, a very common situation in the early rounds of professional tournaments, the mental fatigue at the start of the second game of the day was higher than at the start of the first game of the day. This finding shows incomplete recovery in mental fatigue between games when players play more than one game per day. Third, the finding that mental fatigue was highest after the last game of a tournament day and lowest before the first game of the next tournament day showed that a good night's sleep enables players to recover to their baseline state of mental fatigue.

*Why is padel mentally fatiguing?* Van Cutsem et al. (2017) proposed that mental fatigue in sport may be caused by prolonged sport-specific cognitive or emotional demands. Díaz-García, González-Ponce, López-Gajardo et al. (2021) reasoned that padel is a cognitive demanding activity because players make decisions in a complex environment under time pressure. During a match padel players must repeatedly choose the correct response option while remembering the tips of their coach, self-analyzing their own and their partner's situation (e.g., the result), while considering the match characteristics (e.g., opponent's ranking) and their opponents' tendencies. Players need to perform these information processing cognitive demands at the same time as they prepare and execute complex technical actions, all in a very short timeframe. Moreover, playing padel elicits emotions (e.g., anxiety, anger) and creates pressure to perform. It is in this context that padel players need to maintain self-confidence and good communication with their partner. Finally, padel tournaments impose additional demands, such as interviews, travel, and sleep deprivation, that can evoke mental fatigue in professional athletes (Thompson et al., 2020).

Taken together, the abovementioned evidence shows that padel matches and tournaments are associated with a series of padel-specific cognitive and emotional experiences that create a state of mental fatigue among padel players with subjective and behavioral consequences. Clearly, the study findings

(Díaz-García, González-Ponce, López-Gajardo, et al., 2021) should be replicated and extended by studies that include physiological measures to corroborate the degree of mental fatigue. In sum, this information about the demands of padel is of importance for players and coaches because mental fatigue can impair padel performance.

### **The detrimental effects of mental fatigue on padel performance**

A systematic review of past studies has summarized their findings and concluded that mental fatigue is detrimental for psychomotor performance in a range of different sports (Habay et al., 2021), including table tennis (Le Manssec et al., 2018) and tennis (Filipas et al., 2018). A recent study has confirmed that a state of mental fatigue, induced by a 30-min Stroop task and confirmed by increased subjective feelings and cognitive task performance, impaired the subsequent psychomotor performance of padel players (Díaz-García et al., 2023). More specifically, padel shot speed and accuracy was worse after the Stroop task (when feeling fatigued) compared to before the Stroop task (when feeling fresh). A limitation of this study was the lack of psychobiological measures to corroborate the state of mental fatigue and identify plausible underlying mechanisms for the detrimental effects on performance. It is worth noting that this limitation is common with most studies in this field of research (Habay et al., 2021). Psychobiological measures can be used to evaluate theoretical accounts of the fatigue-performance relationship.

Several theories purport to explain this phenomenon. These include a mental fatigue associated-cognitive performance impairment that impairs subsequent motor commands (Ishii et al., 2014), a response of inhibition in the central nervous system (Van Cutsem et al., 2022), and increased perceived effort (Smith et al., 2015). The latter theory, which is the most popular explanation to date, was developed to explain endurance exercise termination, arguing that mental fatigue increases the cost of continuing to perform a task so that the subjective limit of endurance is reached sooner. The theory has been extended to other tasks, with mental fatigue increasing effort and impairing decision-making and technical performance (Van Cutsem et al., 2017). Mechanistic studies are needed to deepen our understanding of the reasons that mental fatigue impairs performance in padel.

In sum, it has been demonstrated that mental fatigue is detrimental for padel performance. Both accuracy and speed of padel shots, namely drive, drive volley, bandeja and drive-attack after glass, were impaired by mental fatigue induced by a prior cognitive task. Future studies should consider

including psychobiological measures, such as electroencephalographic and neuroimaging responses, to further understand the role played by psychological processes, such as mental fatigue, effort, and motivation, in determining padel performance. This rich information may help identify effective ways to deal with the detrimental effects of mental fatigue on the performance of padel players. It is evident that such countermeasures would help padel players perform optimally during individual matches and tournaments.

### **How to tackle the detrimental effects of mental fatigue on padel performance?**

A systematic review summarized the strategies that athletes can use to mitigate the detrimental effects of mental fatigue on performance (Proost et al., 2022). The review identified a number of promising short-term countermeasures, including smelling odors, consuming caffeine, and adopting behavioral strategies (e.g., listening to music, motivational self-talk). Although these options are helpful for athletes and coaches, they are only likely to be effective in the short-term, and, may already be used by athletes. The only evidence-based long-term effective countermeasure against mental fatigue and its deleterious effects on performance is Brain Endurance Training. This novel training method, that adds demanding cognitive activities to standard physical training activities, has been proven effective for endurance exercise, such as running, cycling and handgrip (e.g., Dallaway et al., 2021, 2023; Staiano et al., 2022, 2023). The most popular explanation why mental fatigue is detrimental for sport performance is that, in presence of high levels of mental fatigue, athletes feel that they need to exert more effort than normal for the same actual physical demands (Van Cutsem et al., 2017). Consequently, mentally fatigued athletes report higher Ratings of Perceived Exertion. Brain Endurance Training repeatedly exposes athletes to such induced mental fatigue-associated increase in perceived effort. Consequently, after completing a multi-week Brain Endurance Training program athletes have recalibrated the relation between perceived effort and actual effort exerted during exercise (Staiano et al., 2023). They feel less mental fatigue during cognitive and physical tasks. In sum, BET allows athletes to perform at a higher level for the same Rating of Perceived Exertion or perform at the same level for lower Rating of Perceived Exertion when compared with athletes who only complete the standard physical training.

The benefits of Brain Endurance Training for grassroots padel players has been demonstrated recently (Díaz-García et al., 2023). Players were randomly

allocated to Brain Endurance Training or control groups and completed a Padel Performance Test pre-, mid- and post-training. Speed and accuracy of volley, drive volley, bandeja, and after-glass attack shots were better when fatigued for the Brain Endurance Training group compared with standard padel training. The players were less mental fatigued by a demanding cognitive task following BET than control. Although this evidence highlights the effectiveness of BET as a countermeasure to mitigate the deleterious effects of mental fatigue on the performance of core racquet skills, future studies are needed to replicate and extend the findings in professional padel players. Such studies could also include psychobiological measures to provide further insights and help us to better understand the mechanism(s) underlying the benefits caused by Brain Endurance Training.

### **Practical recommendations for padel players and coaches: measurement and management of mental fatigue**

Based on the mentally fatiguing nature of padel and the detrimental effects that mental fatigue may have on padel performance, we encourage coaches and padel players (i) to quantify the levels of mental fatigue and, (ii) to modulate the levels of mental fatigue

Our first recommendation is to quantify the levels of mental fatigue. The inclusion of subjective ratings and technology, such as Global Position Systems or video-cameras, are now commonplace in most sports, including padel. In contrast, mental fatigue is rarely measured in athletes. In large part, this is because coaches have yet to see the importance of this construct or they lack knowledge about it and its potential to undermine players' performance. A systematic review by Díaz-García, González-Ponce, Ponce-Bordón, et al. (2021) recommended to include at least one subjective rating, one behavioral measure of performance, and one physiological measure. Our recommendation is to include a rating of mental fatigue, such as the Visual Analogue Scale, a one-item scale with high effectiveness to detect small changes in the state of mental fatigue (Smith et al., 2019). This could be supplemented by measures of speed, accuracy and consistency on short simple tasks, such as the 3-min Brief Psychomotor Vigilance Task and 1-min Psychomotor Fatigue Threshold Task (Díaz-García et al., 2023). The inclusion of psychobiological measures is more complicated, but we strongly recommend, when possible, the use of heart rate variability, eye-tracker, pupillometry, or electroencephalography (Habay et al., 2022).

Our second recommendation is to try to correctly manage the levels of



mental load and fatigue evoked by training. More specifically, we recommend coaches avoid creating high-levels of mental load in the training sessions leading up to competitions. Although there is not a lot of information about the extent of mental fatigue evoked by padel training activities, our practical coaching and playing experience strongly suggests that players should avoid novel, complex and time pressured scenarios just before competitions. In contrast, short and usual training activities, low-physically demanding training, or short-bouts of cognitive training presented in an engaging way may be of interest to prepare players for competitions. With regard the trainings performed in non-competitive periods, we encourage coaches to create training activities that overload the mental demands of competitions in order to prepare players for those crucial must-win scenarios. There is not a lot of information about the mentally fatiguing nature of padel training. Otherwise, there is a strong body of evidence about this topic in soccer. The authors have suggested that the mental fatigue of training tasks may be increased by: i) increase the time pressure (I.e., the time that players have to achieve the tasks' purposes) of the task (Ponce-Bordón et al., 2022); ii. increase the participation and use of coaches verbal behavior during trainings (Díaz-García, Pulido, et al., 2021), or iii. the use of short-modifications of normal training tasks (García-Calvo et al., 2021). Based on this information, it seems that increase the entropy and the emotional demands of training may increase the mental fatigue of the players subsequently. Then, to increase the mental fatigue of padel trainings, coaches should use non-regular training tasks, increase the verbal instructions to players, or increase the complexity of the task's rules. For example, include certain rules such as "service and first shots must be to the same player" or "lob must bounce after the service line", or increase the negative feedback may be effective strategies to increase the mental fatigue of the during trainings players.

## Acknowledgement

The present study has received the award "II Premios DUEX – INVESTIGA" of the "Fundación Jóvenes y Deportes de la Junta de Extremadura".

## References

- Dallaway, N., Lucas, S., Marks, J., & Ring, C. (2023). Prior brain endurance training improves endurance exercise performance. *European Journal of Sport Science*, 23(7), 1269–1278.

- <https://doi.org/10.1080/17461391.2022.2153231>
- Dallaway, N., Lucas, S. J. E., & Ring, C. (2021). Concurrent brain endurance training improves endurance exercise performance. *Journal of Science and Medicine in Sport*, 24(4), 405–411.  
<https://doi.org/10.1016/j.jsams.2020.10.008>
- Denche-Zamorano, A., Escudero-Tena, A., Pereira-Payo, D., Adsuar, J. C., & Muñoz, D. (2023). Scientific mapping of the state-of-the-art in padel. A bibliometric analysis. *International Journal of Sports Science & Coaching*, 0(0). <https://doi.org/10.1177/17479541231161993>
- Díaz-García, J., González-Ponce, I., López-Gajardo, M. Á., Van Cutsem, J., Roelands, B., & García-Calvo, T. (2021). How mentally fatiguing are consecutive World Padel Tour matches?. *International Journal of Environmental Research and Public Health*, 18(17), 9059. <https://doi.org/10.3390/ijerph18179059>
- Díaz-García, J., González-Ponce, I., Ponce-Bordón, J. C., López-Gajardo, M. Á., Ramírez-Bravo, I., Rubio-Morales, A., & García-Calvo, T. (2021). Mental load and fatigue assessment instruments: A systematic review. *International Journal of Environmental Research and Public Health*, 19(1), 419. <https://doi.org/10.3390/ijerph19010419>
- Díaz-García, J., Habay, J., Rubio-Morales, A., de Wachter, J., García-Calvo, T., Roelands, B., & Van Cutsem, J. (2023). Mental fatigue impairs padel-specific psychomotor performance in youth-elite male players. *European Journal of Sport Sciences*, In press.
- Díaz-García, J., García-Calvo, T., Manzano-Rodríguez, D., López-Gajardo, M. Á., Parraca, J. A., & Ring, C. (2023). Brain endurance training improves shot speed and accuracy in grassroots padel players. *Journal of Science and Medicine in Sport*, 26(7), 386–393.  
<https://doi.org/10.1016/j.jsams.2023.06.002>
- Díaz-García, J., Pulido, J. J., Ponce-Bordón, J. C., Cano-Prado, C., López-Gajardo, M. Á., & García-Calvo, T. (2021). Coach encouragement during soccer practices can influence players' mental and physical loads. *Journal of Human Kinetics*, 79, 277–288. <https://doi.org/10.2478/hukin-2021-0079>
- Filipas, L., Rossi, C., Codella, R., & Bonato, M. (2023). Mental fatigue ompairs second serve accuracy in tennis players. *Research Quarterly for Exercise and Sport*, 1–7. Advance online publication.  
<https://doi.org/10.1080/02701367.2023.2174488>
- García-Calvo, T., Pulido, J. J., Ponce-Bordón, J. C., López-Gajardo, M. Á., Teoldo Costa, I., & Díaz-García, J. (2021). Can rules in technical-tactical decisions influence on physical and mental load during soccer training? A pilot study. *International Journal of Environmental Research and Public Health*, 18(8), 4313.  
<https://doi.org/10.3390/ijerph18084313>
- Habay, J., Van Cutsem, J., Verschueren, J., De Bock, S., Proost, M., De Wachter,

- J., Tassignon, B., Meeusen, R., & Roelands, B. (2021). Mental fatigue and sport-specific psychomotor performance: A systematic review. *Sports medicine (Auckland, N.Z.)*, 51(7), 1527–1548. <https://doi.org/10.1007/s40279-021-01429-6>
- Ishii, A., Tanaka, M., & Watanabe, Y. (2014). Neural mechanisms of mental fatigue. *Reviews in the Neurosciences*, 25(4), 469–479. <https://doi.org/10.1515/revneuro-2014-0028>
- Le Mansec, Y., Pageaux, B., Nordez, A., Dorel, S., & Jubeau, M. (2018). Mental fatigue alters the speed and the accuracy of the ball in table tennis. *Journal of Sports Sciences*, 36(23), 2751–2759. <https://doi.org/10.1080/02640414.2017.1418647>
- Martín-Miguel, I., Escudero-Tena, A., Muñoz, D., Sánchez-Alcaraz, B. J. (2023). Performance analysis in padel: A systematic review. *Journal of Human Kinetics*, 89, In press. <https://doi.org/10.5114/jhk/168640>
- Ponce-Bordón, J.C., García-Calvo, T., López-Gajardo, M.A., Díaz-García, J., & González-Ponce, I. (2022). How does the manipulation of time pressure during soccer tasks influence physical load and mental fatigue? *Psychology of Sport and Exercise*, 63, 1-22. <https://doi.org/10.1016/j.psychsport.2022.102253>
- Proost, M., Habay, J., De Wachter, J., De Pauw, K., Rattray, B., Meeusen, R., Roelands, B., & Van Cutsem, J. (2022). How to tackle mental fatigue: A systematic review of potential countermeasures and their underlying mechanisms. *Sports Medicine (Auckland, N.Z.)*, 52(9), 2129–2158. <https://doi.org/10.1007/s40279-022-01678-z>
- Russell, S., Jenkins, D. G., Halson, S. L., Juliff, L. E., Connick, M. J., & Kelly, V. G. (2022). Mental fatigue over 2 elite netball seasons: A case for mental fatigue to be included in athlete self-report measures. *International Journal of Sports Physiology and Performance*, 17(2), 160–169. <https://doi.org/10.1123/ijsp.2021-0028>
- Smith, M. R., Chai, R., Nguyen, H. T., Marcora, S. M., & Coutts, A. J. (2019). Comparing the effects of three cognitive tasks on indicators of mental fatigue. *The Journal of Psychology*, 153(8), 759–783. <https://doi.org/10.1080/00223980.2019.1611530>
- Smith, M. R., Marcora, S. M., & Coutts, A. J. (2015). Mental fatigue impairs intermittent running performance. *Medicine and Science in Sports and Exercise*, 47(8), 1682–1690. <https://doi.org/10.1249/MSS.0000000000000592>
- Thompson, C. J., Fransen, J., Skorski, S., Smith, M. R., Meyer, T., Barrett, S., & Coutts, A. J. (2019). Mental fatigue in football: Is it time to shift the goalposts? An evaluation of the current methodology. *Sports Medicine (Auckland, N.Z.)*, 49(2), 177–183. <https://doi.org/10.1007/s40279-018-1016-z>
- Thompson, C. J., Noon, M., Towilson, C., Perry, J., Coutts, A. J., Harper, L. D., Skorski, S., Smith, M. R., Barrett, S., & Meyer, T. (2020). Understanding

the presence of mental fatigue in English academy soccer players. *Journal of Sports Sciences*, 38(13), 1524–1530.

<https://doi.org/10.1080/02640414.2020.1746597>

Van Cutsem, J., Marcora, S., De Pauw, K., Bailey, S., Meeusen, R., & Roelands, B. (2017). The effects of mental fatigue on physical performance: A systematic review. *Sports medicine (Auckland, N.Z.)*, 47(8), 1569–1588.

<https://doi.org/10.1007/s40279-016-0672-0>

Van Cutsem, J., Van Schuerbeek, P., Pattyn, N., Raeymaekers, H., De Mey, J., Meeusen, R., & Roelands, B. (2022). A drop in cognitive performance, whodunit? Subjective mental fatigue, brain deactivation or increased parasympathetic activity? It's complicated!. *Cortex; a journal devoted to the study of the nervous system and behavior*, 155, 30–45.

<https://doi.org/10.1016/j.cortex.2022.06.006>

