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Exploración de la percepción cognitiva de los entrenadores sobre las tareas de entrenamiento de fútbol: un estudio basado en cuestionarios y una comparación con una herramienta marco para evaluar las demandas cognitivas en juegos reducidos

Exploring Coaches' Cognitive Perception of Football Training Tasks: A Questionnaire-Based Study and Comparison with a Framework Tool for Assessing Cognitive Demands in Small-Sided Games

Exploração da percepção cognitiva de tarefas de treino em futebol: Estudo baseado num questionário e comparação com uma ferramenta para avaliar e comparar as exigências cognitivas em jogos reduzidos

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RESUMEN

La función cognitiva es crucial en entornos de rendimiento competitivo debido al tipo de tareas y carga de trabajo involucradas. Sin embargo, aún se necesita determinar cómo toda la información ambiental en un entorno competitivo afecta la carga cognitiva. Por lo tanto, el objetivo fue investigar la percepción cognitiva de los entrenadores sobre las tareas de entrenamiento de fútbol, mediante el uso de un cuestionario y comparar los resultados con una herramienta de marco para evaluar las demandas cognitivas en juegos reducidos. Un total de 57 entrenadores de fútbol (a nivel nacional y regional) completaron un cuestionario para calificar las demandas cognitivas percibidas de doce situaciones diferentes de juegos en espacios reducidos. Las respuestas fueron hechas por cada entrenador a partir de un conjunto de alternativas proporcionadas por los autores utilizando una escala de uso de Likert de 10 puntos. La carga cognitiva durante los juegos reducidos se calculó mediante una ecuación que incluía el número de jugadores implicados en la tarea, la superficie ocupada por cada jugador y la duración del

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ejercicio. Los resultados del cuestionario mostraron que los entrenadores de nivel nacional presentaron resultados de correlación más altos, mostrando una alta concordancia entre la percepción de los entrenadores y los resultados de la carga cognitiva en comparación con los entrenadores de nivel regional. La relación establecida entre todas las variables mostró que la complejidad de las tareas aumenta utilizando formatos con mayor número de jugadores, áreas pequeñas y ejercicios de mayor duración. Por lo tanto, el marco de carga cognitiva puede ser una herramienta útil y sencilla para que los entrenadores evalúen las demandas cognitivas durante las sesiones de entrenamiento.

Palabras clave: fórmula de carga cognitiva; restricciones informativas; entrenadores; juegos reducidos.

ABSTRACT

Cognitive function is crucial in competitive performance environments due to the type of tasks and workload involved. Thus, the present study aimed to investigate coaches' cognitive perception of football training tasks, through the use of a questionnaire and compare the results with a framework tool to assess cognitive demands in small-sided games. A total of 57 football coaches (national and regional levels) filled out a questionnaire to rate the perceived cognitive demands of twelve different small-sided game situations. The answers were made by each coach from a set of alternatives supplied by the authors using a 10-point Likert use scale. The cognitive load during small-sided games was calculated using an equation that included the number of players involved in the task, the surface area occupied by each player, and the duration of the exercise. The questionnaire results have shown that national-level coaches presented higher correlation results showing a high agreement between coaches' perception and the cognitive load results when compared to regional-level coaches. The relationship established between all variables showed that the complexity of tasks increases using formats with a larger number of players, small areas, and bigger duration drills. Thus, the cognitive load framework may be a useful and simple tool to coaches assess the cognitive demands during training sessions.

Keywords: cognitive load formula; informational constraints; coaches; small-sided games.

RESUMO

A função cognitiva é crucial em ambientes de desempenho competitivo devido ao tipo de tarefas e carga de trabalho envolvidas. No entanto, ainda precisa ser determinado como todas as informações ambientais em contexto competitivo afetam a carga cognitiva. Assim, o objetivo deste estudo foi investigar a percepção cognitiva de treinadores sobre tarefas de treino de futebol, através de um questionário e comparando os resultados com um instrumento para avaliar as exigências cognitivas durante jogos reduzidos. Um total de 57 treinadores de futebol (nível nacional e regional) preencheram um questionário para avaliar as exigências cognitivas de doze situações diferentes jogos-reduzido. As respostas foram dadas por cada treinador a partir de um conjunto de alternativas fornecidas pelos autores utilizando uma escala de Likert de 10 pontos. A carga cognitiva durante pequenos jogos foi calculada através de uma equação que incluía o número de jogadores envolvidos na tarefa, a área de superfície ocupada por cada jogador e a duração do exercício. Os resultados do questionário mostraram que os treinadores de nível nacional apresentaram resultados de correlação mais elevados, mostrando uma alta concordância entre a percepção dos treinadores e os resultados de carga cognitiva em comparação com os treinadores de nível regional. A relação estabelecida entre todas as variáveis mostrou que a complexidade das tarefas aumenta utilizando formatos com maior número de jogadores, áreas pequenas e exercícios de maior duração. Portanto, esta ferramenta para avaliar a carga cognitiva pode ser uma forma útil e simples para os treinadores avaliarem as exigências cognitivas durante as sessões de treino.

Palavras chave: fórmula da carga cognitiva; restrições informativas; treinadores; jogos reduzidos.

INTRODUCTION

Association football is an invasion team sport, where two teams dynamically compete in both space and time aiming to gain an advantage over the opposing team by being able to progress on the field and create goal-scoring opportunities, while preventing the opposing team from doing the same (Zurutuza & Castellano, 2020). Under this perspective, association football performance is characterized by cooperative and competitive interactions between players and teams (Passos et al., 2016). The development of such tendencies is dependent upon the players' ability to exploit the available information from the environment to support the emergence of the goal-directed behaviours. Accordingly, players couple their actions in space and time to the information available, and so, successful performances in association football requires that the players explore, identify and use the most relevant cues available (Travassos et al., 2012). For example, to perform a successful pass, the player in possession must perceive the available space to where his teammate is moving and apply a certain speed and direction to the ball that allows the teammate to receive the ball without being intercepted by a defender. Based on these considerations, and to improve players' performance, training tasks must present the same perceptual-motor landscape that the players face during competitive performances (Brink et al., 2014).

While the technological advancement has allowed increasing the knowledge in relation to the players' physical demands and on how players respond to different constraints (Clavijo et al., 2018) in turn, research addressing appropriate procedures to measure and understand the cognitive load on the players is scarce. Accordingly, players decisions are dependent on their ability to interact with the surrounding information to unfold the emergence of functional movement behaviours (Vilar et al., 2014), requiring cognitive processes, which as consequence has a cognitive load. Past reports have shown that players may experience mental fatigue when exposed to periods of demanding cognitive activity (Badin et al., 2016). Under mental fatigue, the available research has shown impaired technical actions (Badin et al., 2016) and tactical behaviours (Coutinho et al., 2015), which is likely to result from a lower ability to identify and use the relevant cues from the environment (Boksem et al., 2006), as well as from a

slower and worst decision-making process (Smith et al., 2016). From this perspective, measuring and understanding the cognitive load imposed by different tasks on the players is of paramount importance to allow coaches to adjust the cognitive load during the week.

Cognitive load refers to the mental effort required to complete a task (Peñalosa et al., 2022). From a neurocognitive perspective, understanding cognitive load is critical because it can affect our ability to learn, solve problems, and perform tasks efficiently (Romine et al., 2020; Zghibi et al., 2021). Despite the importance of this concept, an in-depth analysis of cognitive load still needs to be provided. Cognitive load can be defined as the amount of mental effort required to complete a task. This effort is divided into three types of cognitive load: intrinsic, external, and germane (Choi & Kim, 2021). Intrinsic cognitive load refers to the effort required to understand the content of a task. Extraneous cognitive load is the effort required to manage distractions or irrelevant information. Germane cognitive load refers to integrating new information into existing knowledge. Cognitive load can be studied and measured in several ways. One method involves measuring brain activity using neuroimaging techniques such as functional magnetic resonance imaging (fMRI) or electroencephalography (EEG) (Yu et al., 2023). Another method involves measuring response times or accuracy in cognitive tasks (Musculus et al., 2022). A third method involves self-report measures, where participants rate the difficulty of a task on a scale (Minkley et al., 2021). Different types of tasks may involve varying levels of cognitive load. For example, tasks that require memorization or problem-solving typically involve a higher cognitive load than tasks that involve simple recall. In addition, the complexity of the task, the amount of information to be processed, and the level of novelty can affect cognitive load (Kuo et al., 2023). It is important to note that each person plays different role in interacting with tasks. Two individuals may have different levels of cognitive load when performing the same task due to differences in their prior knowledge, working memory capacity, and cognitive processing skills.

Some attempts have been developed to understand and measure the task difficulty and complexity (Machado et al., 2019). For example, Travassos et al.

(2014) explored the task difficulty by accounting the number of opponents in the task divided by the available number of opportunities for action by the player in possession ((number of opponents/number of action possibilities) x100). For instance, during a 2vs2 situation to score on one small goal per team, the number of opponents would be 2, while the available actions for the player in possession would pass the ball to the teammate, dribble or shot to the goal resulting in task difficulty (2/3*100) of ~67%. While this approach provided important insight regarding how coaches might measure the task difficulty, in turn, it does not account for the overall amount of information that players should take into consideration neither to the available space or task duration. Therefore, the present study aimed to investigate coaches' cognitive perception of football training tasks, through the use of questionnaire and compare the results with a framework tool to assess cognitive demands in small-sided games.

MATERIAL AND METHODS

Participants

Fifty-seven Portuguese football coaches (regional level: $n = 30$, age 34.6 ± 7.9 y, coaching experience 6.4 ± 4.0 y; national level: $n = 27$, age 37.1 ± 8.4 y, coaching experience 10.4 ± 6.3 y).

Instruments and Variables

Cognitive Load

The cognitive load (CL) during small-sided games was calculated using a new framework developed by the authors tool that considered the number of players involved in the task, the surface area occupied by each player and the duration of the exercise, according to the following equation:

$$CL = \left(\frac{\frac{c \cdot p}{m \cdot o} + 2 \cdot f}{\frac{a}{f}} t \right) + 50$$

where c is the number of dyads between all players involved in the task, p is the total number of players, m is the number of teammates, o is the number of opponents, f is the difference of the number teammates and opponents ($m-o$), a is the total area of exercise in meters, and t the duration of exercise in minutes. When the number of teammates presents inferiority over the opponents, f should be multiplied by -1 , while when the number is superior to the number of opponents, f is maintained positive. A value of 50 arbitrary units is added to the equation as a process of normalization (Welkowitz et al., 2006).

A simulation of 19 small-sided games situation considering 3 different field dimensions and 3 different tasks time duration were performed to understand the distribution of the CL values across the different scenarios.

Procedure

Coaches filled out a questionnaire to rate the perceived cognitive perception of football in 12 small-sided game situations. In addition, we ensure the reliability and validity of coaches' assessments of

cognitive demand by providing explicit definitions and guidelines for what constitutes cognitive demand in the context of the study. Each coach provided answers from a set of alternatives on a 10-point Likert use scale. The questionnaire results were compared to the cognitive load results for assessing cognitive demands in small-sided games. In addition, the answers were compared to a cognitive load formula to assess their accuracy. Informed consent was obtained from participants, and anonymity was guaranteed, with data being used solely for scientific purposes. The study received approval from the local Ethics Committee (coded 1230/CEIH/2020) under the Declaration of Helsinki principles.

Statistical Analysis

The Correlation research design was used to check the association between CL formula results and the questionnaire results of cognitive demands perceived by coaches, individually for the same 12 small-sided games situations.

All statistical analyses were conducted using the statistical package for the social sciences (SPSS,

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version 26.0, SPSS Inc, Chicago, IL, USA). The Shapiro-Wilk Test of Normality indicated that assumptions of normality were guaranteed. Therefore, a correlation research design through Pearson's product was used to check association between CL and perceived ratings of cognitive demands of 12 small-sided games situations. The magnitude of the correlation was determined as trivial: $r < 0.1$; low: 0.1–0.3; moderate: 0.3–0.5; large: 0.5–0.7; very large: 0.7–0.9; nearly perfect > 0.9 ; and perfect: 1 (Cumming, G., 2012). The level of significance was set at $p < 0.05$.

RESULTS

Comparing CL formula results and the questionnaire results of cognitive demands perceived by coaches showed that national-level coaches presented higher correlation results showing a high agreement between coaches' perception and the CL results (see Figures 1 and 2). National-level coaches showed consistent results with the formula in small-sided game situations with more players. However, in opposition, less experienced coaches underestimate CL of formats with more players.

Figure 1

Correlation analysis between CL formula and the questionnaire results of cognitive demands perceived by coaches, individually for the same 12 small-sided games situations.

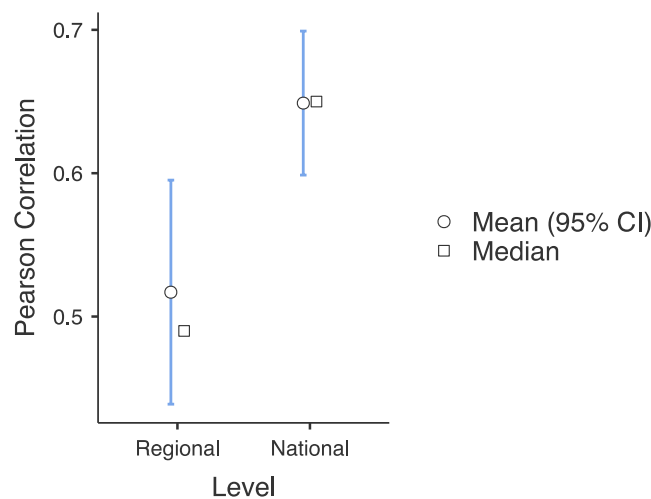
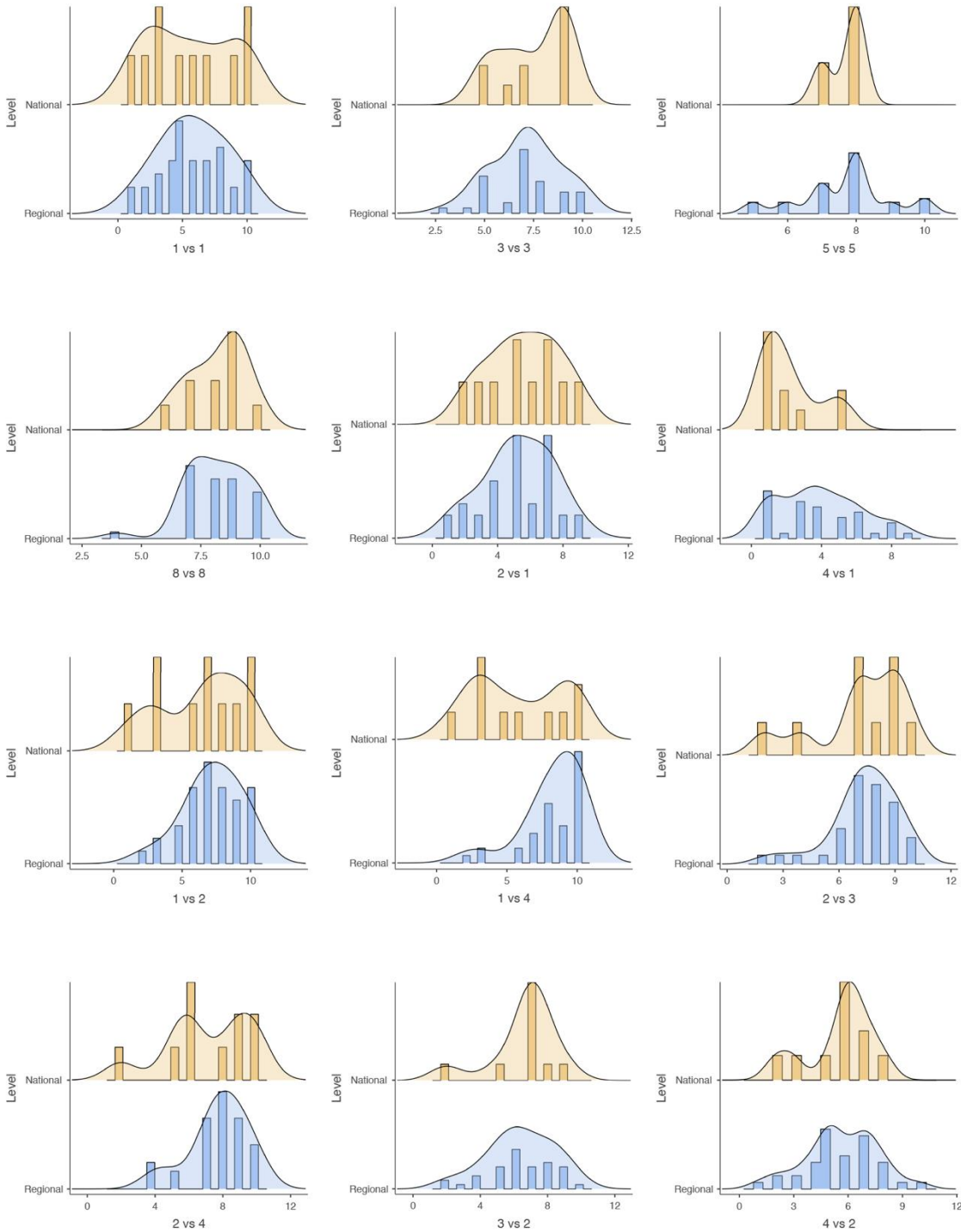


Figure 2

Representation of questionnaire results of cognitive demands perceived by 57 football coaches (national and regional levels) according 12 football training tasks.



Regarding the different unbalanced formats, results shown that both coaches find it difficult to interpret cognitive demands, not showing results consistent with the formula.

DISCUSSION

The present study aimed to investigate coaches' cognitive perception of football training tasks through a questionnaire and compare the results with a framework tool to assess cognitive load in small-sided games. To our knowledge, this is the first study that proposes and establishes the relationship between a method that assesses the cognitive demands and ratings of cognitive demands perceived by coaches.

The present study showed significant correlations between cognitive demands perceived by coaches of different levels and CL formula results. Accordingly, high-level coaches presented a large correlation, showing a high agreement between coaches' perception and CL results. These findings may be linked to the suggestion that expert coaches have a complex interaction of knowledge and memory based on training experience and reflection (Nash & Collins, 2006), to differentiate the prominent information compared to less qualified coaches easily. The analysis of the questionnaire, results presented in figure 2, showed that coaches with lower-level qualifications presented more difficulties characterizing cognitive demands once the distribution of responses was wider. Thus, unlike national coaches, there is a tendency to overestimate some formats, e.g., 4 versus 1, or underestimate others, like 2 versus 3. These results seem to suggest that lower-level coaches pay more attention to the numerical scenario (i.e., being matched or in unbalanced situations) rather than the number of players involved (e.g., 4 vs 1, 2 vs 1, 3 vs 2). Overall, the present study has shown different results between coaches' perceptions of different levels and CL results.

On the other hand, lower-level coaches presented more difficulties characterizing cognitive demands once the distribution of questionnaire responses was wider. During team sports, coaches tend to interpret the demands of different dimensions differently, underestimating, for example, the physical demands (Macpherson et al., 2019). For example, Kraft et al. (2020) revealed that coaches tend to overestimate

task demands as they do not have information that external clues can see. Brink et al. (2014) also showed that the coach's perception of the training load differs from that of the players. This highlights the potential usefulness of the CL in quantifying the cognitive demands when considering real practice situations, helping coaches to limit the effects of their perception of training demands.

The analysis of the questionnaire of national-level coaches showed an increase in CL when formats show an increase in the number of players. Accordingly, higher-level coaches may perceive the increase in the number of players as an increase in the available information that the players should consider before deciding. That is, players sustain their positioning and actions on the relevant information from the environment, such as teammates' and opponents' positioning, ball location, or goals position (Díaz-García et al., 2023; González-Rodenas et al., 2021). When coaches manipulate the key task constraints presented on the task, such as increasing the number of players, they are likely modifying the information that players may use (Coutinho et al., 2017). Under this perspective, increasing the number of players during SSG may also increase the available opportunities for action, and consequently leading to higher CL (Ouertatani et al., 2022). While higher-level coaches may have a clear perspective on the impact of increasing the number of players, on the other hand, less experienced coaches seem to underestimate CL of formats with a higher number of players. As previously mentioned, lower-level coaches may rely more on their perception of the complexity of having balanced / unbalanced scenarios than on the number of players involved in the task. Generally, these results suggest that the national-level coaches' answers are in line with CL results, classifying the formats with a larger number of players as more demanding. In contrast, less experienced coaches may use this formula to quantify the CL during SSG.

SSG, under an unbalanced number of players, is often used during training sessions to reproduce the game's physical, technical, and tactical demands (Aguiar et al., 2012). The manipulation of the number of opponents and teammates promotes the exploration of different behaviors leading to the improvement of functional collective behaviors (Gonçalves et al., 2018). When considering the

numerical relations, past research has found that higher unbalance conditions (i.e., a difference of more than 2 players between teams) contributed to lower physical demands (Torres-Ronda et al., 2015) and more regular and compact behaviors by the team in inferiority (Gonçalves et al., 2016). In contrast, the higher physical demands and similar positioning behaviors compared to balanced situations found when playing with only one player (Silva et al., 2014) may suggest that the underloaded team attempt to compensate the absence of one player. The results from the formula used in this study seem to capture the complex nature of interactions found in such unbalanced scenarios, as higher CL was found under inferiority situations, mainly in high-inferiority scenarios. However, the analysis of questionnaire results regarding several unbalanced formats showed that both groups' coaches needed help interpreting cognitive demands. These findings may be related to coaches' perceptions of players' possibilities for action according to the numerical situation (i.e., high inferiority, 1 vs 3, 1 vs 4, 2 vs 4; inferiority, 1 vs 2, 2 vs 3, 3 vs 4; high superiority, 3 vs 1, 4 vs 1, 4 vs 2; low inferiority, 2 vs 1, 3 vs 2 and 4 vs 3). For example, the regional-level coaches pointed out that the 1 vs 4 situation was high cognitive demanding, possibly, by taking into consideration only the amount of opponents, while the national-level coaches did not report the same rating that may result from considering that the player may have fewer options than drop down and attempt to limit the space to the ball carrier. Considering that the formula captured the differences in numerical relations, it may be considered an excellent tool to complement the tactical and technical capacity of the coaches, giving more objective information about the demands of the tasks.

As with most studies, the current study design is subject to limitations that can be addressed in future research. Therefore, future studies should investigate coaches' perception of all football manipulation tasks on players' cognitive performance and consider players' expertise level and their perception of task demands. Additionally, studies should address different variables, such as the area and duration of tasks, to understand better the influence of different small-sided game regimens on cognitive demands.

CONCLUSIONS

Considering that players support their actions on information, exposure to this information for a higher period may lead to a higher CL, as identified by the cognitive load. In addition, the results also showed lower cognitive values in unbalanced SSG formats when in superiority condition, even in higher-duration tasks. When playing in superiority, the team adopts a more stable and regular positioning where they pass the ball more often to move the defenders and create space. In this respect, it may be possible that this behavior would increase the fatigue on the underloaded team, which becomes more evident with more time on the task. As so, it may be expected that lower cognitive demands are found when playing in superiority, even during a higher time.

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