Does neuromotor training accelerate football-specific decision making outcomes in professional football players over two seasons?

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Headline

In professional football, each position has a predefined strategic role where aptitude is measured by game-related statistics of productivity (1). The ability of a specific player to meet the demands of their role is considered to be a function of several physiological, visual-motor reaction speed, and perceptual- cognitive capability measures (2). To date, however, only one study has related player-specific characteristics to game-related performance measures in professional football players. McGill et al. reported that stability, agility, and flexibility were associated with minutes played, assists, rebounds, blocked shots, and steals per basketball game (3). However, the specific roles of visual-motor reaction speed and perceptual-cognitive capability to game-related measures of performance in professional football players are unknown.

Aim of the study

The purpose of this study was to determine the relationship between visual tracking speeds (VTS) on football- specific decision making measures of performance.

Subjects

De-identified data from a convenience sample of offence (n = 5; 26.8 ± 2.9 years) and defense (n = 6; 23.2 ± 2.6 years; range: 19.4–30.7 years) players under contract to play for 2 major Super League football clubs completed testing at the beginning of the season. Players gave their informed consent as part of their sport requirements. We used Wyscout (hudl inc us) analytics platform to collect data about the players. Wyscout provide video analysis tool and digital databases regarding performances and matches for coaches, teams and players dealing with football business. The purpose is to allow them have a detailed sight of a large number of athletes about individual performances, patterns of play and tactical strategy.

Methodology

Eleven professional football players were tested and has been confirmed their baseline before the 2017-18 season for the Greek Super League. Visual tracking speed was obtained from 1 core session (20 trials) of the multiple objects tracking multiple object tracking (MOT) test. Performance in VTS was compared with football-specific measures of performance. In detail, the parameters collected were total actions when team is winning-successful (AST), total actions when team is losing-successful (ALS), total actions when playing with a yellow card (AYC), total actions when not playing with a yellow card (ANC), dribbles total (DT), through passes (TO), forward passes (FP) and assists (ASS). During the regular football season. All performance measures were reported per 90 minutes played. Ethics approval has been obtained according the declaration of Helsinki.

All participants gave their written consent according to the protocols of the University of Athens Department of Physical education and sports science.

Visual tracking speed was assessed by the completion of 1 core session on the Neurotracker (NT; CogniSens Athletic, Inc., Montreal, Quebec, Canada) 3D MOT software by each player. As previously recommended, a core session consisted of 20 individual trials used to quantify spatial awareness by determining the player's threshold speed for effective perception and processing of visual information sources (4). For each trial, players were instructed to sit upright on a stool placed 7 feet in front of a projection screen with the size of the 3D volume space being 468 of visual angle at the level of the screen. All players wore specialized glasses to make the objects appear 3D in the simulator. Before each trial, a 3D transparent cube containing 8 identical yellow balls, measuring 5.5 inches in diameter, was presented on the screen. Four of these balls were randomly illuminated for 2 seconds before returning to the baseline yellow color. The player was instructed to track these 4 balls for the duration of the individual trial. During the trial, all 8 yellow balls moved simultaneously and individually throughout all regions of the cube for 8 seconds (5). The random, continuous movement patterns of each ball were only affected by collisions (impact and bounce) with the wall of the cube and the other balls. At the conclusion of 8 seconds, the balls were frozen in place and were each assigned a display number, 1 through 8, by the computer. The player was instructed to identify, by number, the 4 balls that were originally illuminated at the start of the trial. The speed at which the balls moved on the next trial was dependent on the correct identification of the illuminated balls and was adjusted between trials in a staircase (1 up 1 down) fashion, which has been previously demonstrated to be an efficient and reliable psychometric estimator (greater than maximum likelihood) in small experiments (less than 30 trials) (6). If the player correctly selected all 4 balls, the speed of the balls was increased. Otherwise, the speed of the balls was reduced for the next trial. At the end of the 20 trials, VTS was determined to be the fastest speed (in centimeter per second) at which the player could correctly identify, with 100% accuracy, all 4 illuminated balls. To avoid training effect confound (7), all players began their core session completely unfamiliar to the NT device.

Statistical Analysis

Data analysis was performed with the statistical package SPSS 26.0. Indicators of descriptive statistics, such as Mean, SD frequencies, were used for the analysis of variables, while the normal distribution was checked with the Shapiro-Wilk test, where it confirmed that the data followed the normal distribution ($p < 0.05$). For the comparison of the independent variables (period 1 vs period 2) the single-factor analysis of variance (ANOVA) with Bonferroni and Effect Size correction (n2) was used. The levels of influence according to Cohen (1988) are: 0.01 = small, 0.06 = medium, 0.13 = large. The significance level was set at $p < 0.05$ (7).

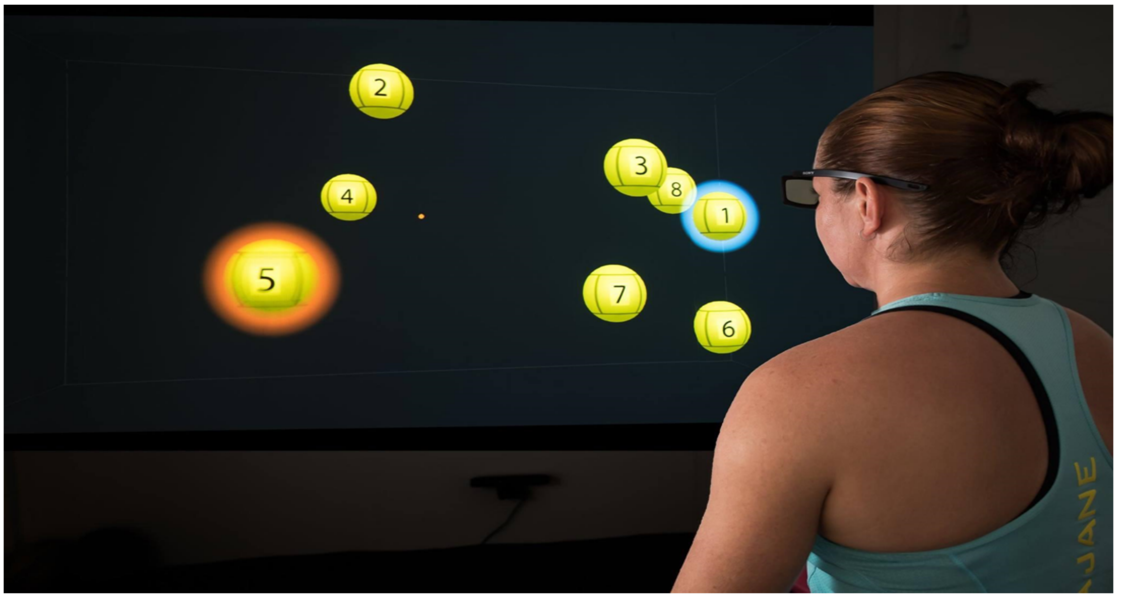

Fig. 1. Multiple object tracking exercise.

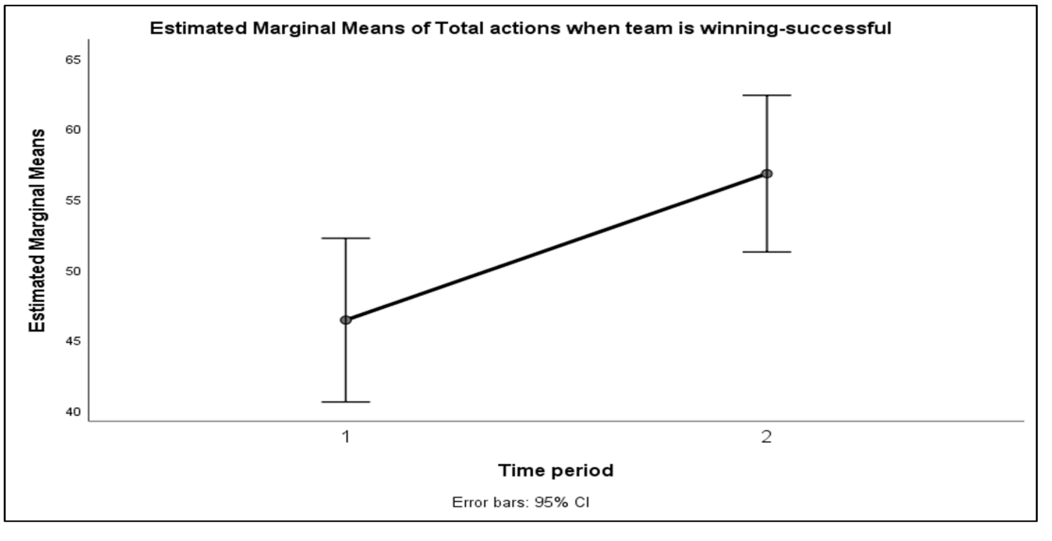

Fig. 2. Total action when team is winning.

Table 1. Performance variables description between season 1 and season 2.

Variables	Season 1 (n=11)		Season 2 (n=11)		p
	Mean	SD	Mean	SD	
1 Total actions when team is winning-successful	46.38	13.78	56.79	13.20	< 0.01
2 Total actions when team is losing-successful	47.71	11.55	54.00	9.82	< 0.001
3 Total actions when playing with a yellow card	68.63	15.50	64.50	12.63	> 0.05
4 Total actions when not playing with a yellow card	68.79	12.81	77.04	10.51	< 0.05
5 Dribbles Total	7.08	2.22	7.54	2.28	> 0.05
6 Through Passes	5.54	2.32	7.17	1.55	< 0.05
7 Forward passes	10.29	2.37	13.96	3.00	< 0.001
8 Assists	1.54	1.22	2.58	1.28	< 0.01

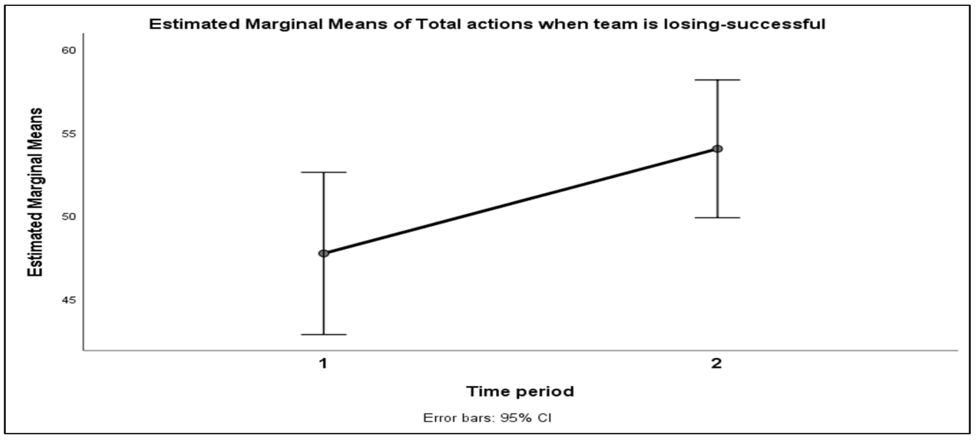

Fig. 3. Total actions when the team is losing.

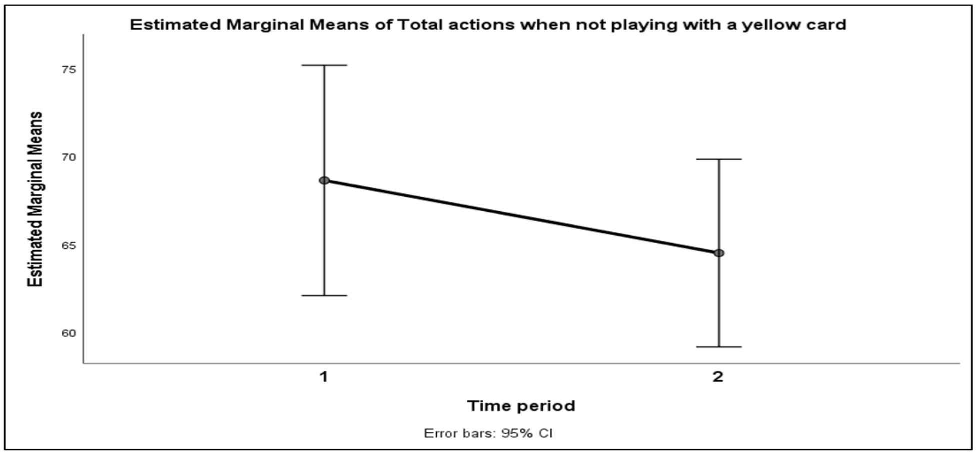

Fig. 4. Actions with yellow card.

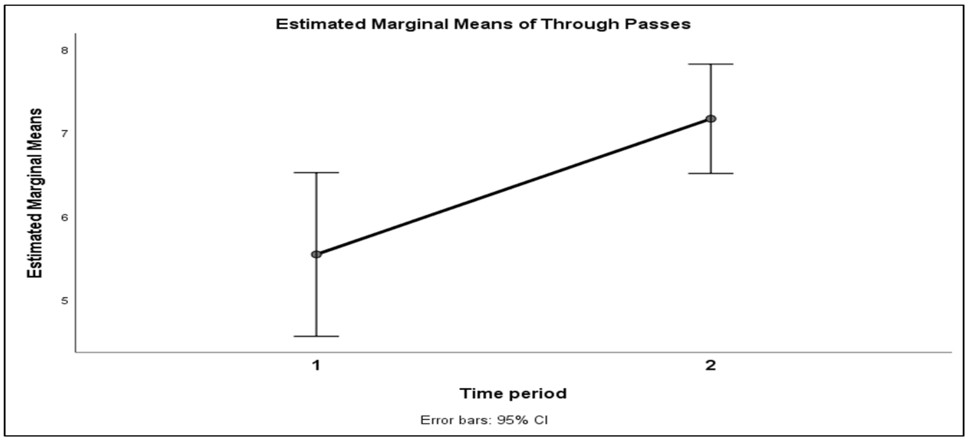

Fig. 5. Through passes.

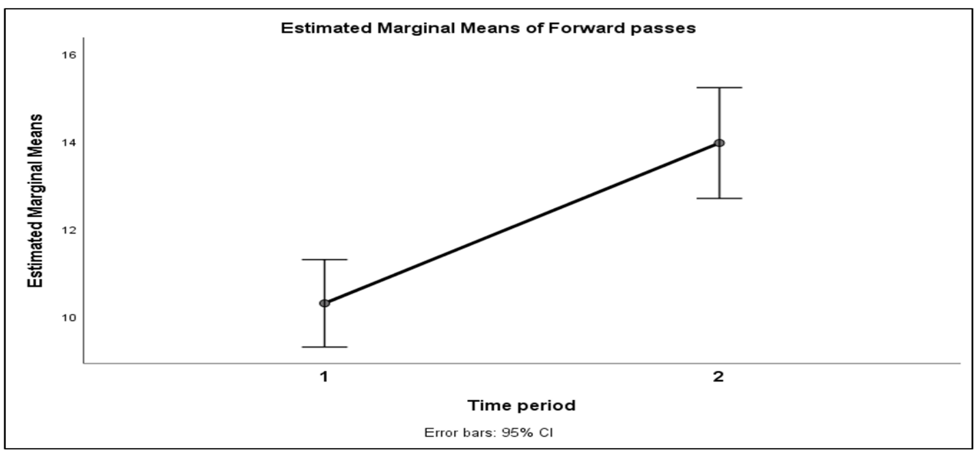

Fig. 6. Forward passes.

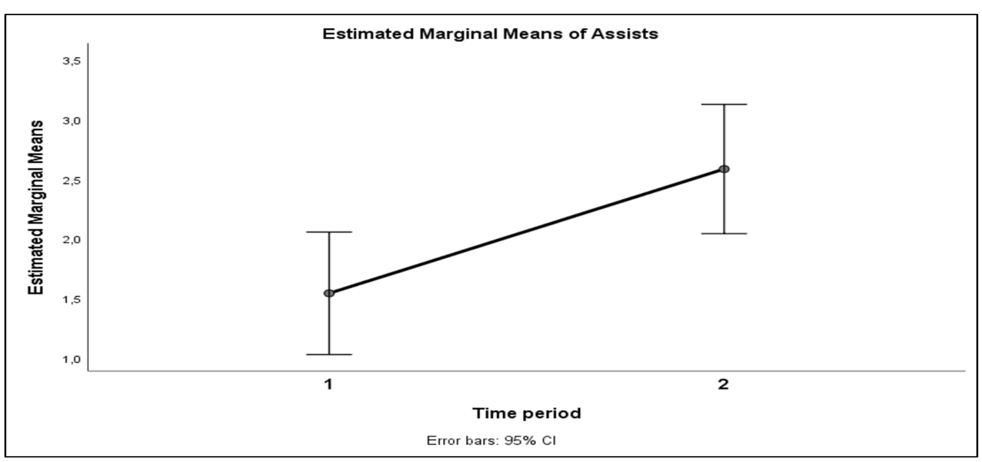

Fig. 7. Assists.

Results

The results showed that in most variables there was a statistically significant improvement in the second measurement period (season 2) of the examined variables ($p < 0.05$), while in the variables total actions when playing with a yellow card and Dribbles (figures 2-7). Total no statistically significant differences were observed. More specifically, in the variable Total actions when team is winning-successful, a significant increase in performance was observed with mean 56.79 ± 13.20 of the second period compared to Mean 46.38 ± 13.78 of the first period ($F(23) = 12.062$), $p < 0.05$ (table 1).

Discussion

The results of our investigation indicate that VTS is most likely related to the athletes' ability to see and respond to various stimuli on the football ground. Neural activity in brain areas involved in the planning and execution of eye movements predicts the outcome of an upcoming perceptual decision (8). Many real-world decisions, such as whether to swing at a football pitch, are accompanied by characteristic eye-movement behavior. In consequence, possessing greater VTS may result in more positive plays as reflected by greater rate for accumulating AST and STL, and AST in relation to turnovers across an entire regular season (9). Furthermore, defenders and midfielders seem to possess a faster speed threshold for tracking multiple objects throughout a wide 3D space along with greater productivity in game-related measures of ball control. These findings seem to be the first to demonstrate the assessment of VTS in football players and relate them to game-related measures of productivity. Previously, professional basket, hockey, and rugby players were shown to have greater speed threshold values than amateur athletes and nonathletic control subjects (3). These results were the first to suggest that enhanced tracking capability is a discerning measure for predicting or evaluating athletic performance. Our data support the work of Faubert et al. and also suggest that VTS may be able to differentiate between positions among athletes as our results showed that the basketball players who are most responsible for ball control and passing (e.g., backcourt players) possessed significantly faster speed threshold scores and a greater AST/TO than the other players (6). Although our data also showed a likely positive relationship between VTS and TO, it was not as strong as the relationships between VTS and AST and between VTS and AST/TO. Potentially, the increase in TO rate is the consequence of more attempts being made to make positive plays. Alternatively, the VTS capability of the opposition may also play a contributing role. As such, future exploration into these hypotheses is warranted.

Taking into account the supposition that both isolation and overload needs for perceptual-cognitive conditioning appear to be inadequately attended to, a key value of perceptual-cognitive training is that it appears to be an ideal fit with sport science driven training methodology (10). Advantages may be accentuated compared with physical or skill based isolation and overload regimes. This may principally be because neuroplasticity appears to provide scope for significant functional gains within very short periods of training stimulation; indeed, evidence has been presented for activation-dependent cortical plasticity producing neuroanatomical structural changes within 5 days of intervention (11,12). Other possible qualities include training sessions that can be applied in acute packets (6–8 min per session), precise control of training quantity over time, and accurately recorded measurement and monitoring of the training process. For example, neural-population activity in the motor cortex measured using magneto encephalography has been shown to gradually build up several seconds before execution of a choice response, and to be usable to read out and predict observers' choices in a yes/no motion-detection task. Decision-related modulation has also been found during motor execution. In an earlier study, when a hand movement was perturbed just prior to the choice response, the muscular reflex gain of the perturbed arm was modulated by motion-coherence strength, reflecting ongoing decision formation.

One challenge to obtaining data from competitive elite teams is the lack of control on usage, mainly through inconsistency of use at both individual and team levels (often influenced by hectic competition schedules and time on the road). Not surprisingly, this is a challenge inherent to any sports science driven studies that are conducted with elite teams across different sports as well as continents, and who are in the early stages of assimilating a new training approach (13). As of yet, it has been difficult to ascertain any upper limits on improvements with sustained long-term training. Anecdotally, improvement curves do appear to plateau over time, yet no ceiling has been found, even across those elite athletes who have trained beyond 40 sessions. Inconsistency of use has, however, allowed retention of gains to be examined, and losses of perceptual-cognitive form over extended breaks from training (1–2 months) have appeared negligible (14). While there can be significant fluctuations in thresholds from session to session, once threshold averages over three sessions or more increase, they appear to remain stable on a three-session basis (which may hypothetically be especially useful for concussion assessments). Similarly, positive training gains appear to remain even when athletes complete sessions interspersed by 2 or more weeks at a time (15).

Many of the brain areas involved in the control of eye movements also carry decision signals (16). In natural tasks, these decision signals are ultimately linked to the action outcome—for example, batters will only swing at pitches they judge to be hittable. Eye movements closely reflect task requirements and action goals and provide a continuous update of the action space (17). Decision accuracy in behavioral visual-discrimination tasks is typically related to task difficulty and signal strength (or noise level); for example, motion-discrimination performance scales with motion coherence (18). Congruently, task difficulty shapes neural activity during decision making. Single-unit recordings in macaque monkeys have shown that neural sensitivity in the middle temporal visual area (19) and superior colliculus are closely related to perceptual-discrimination performance. Interestingly, subsets of neurons in the supplementary eye field and frontal eye field take longer to decode more difficult perceptual decisions (300–475 ms) compared to easy decisions (175–190 ms) but reflect decision-outcome sensitively regardless of level of difficulty (20). Importantly, the accuracy of predicting decision outcomes based on neural recordings increases with increasing motion-signal strength and decreasing task difficulty (21). Moreover, saccades evoked by frontal-eye-field micro stimulation during perceptual decision making deviate toward the stimulus motion direction. For performance in the field, there appear to be three main possible advantages of increasing perceptual-cognitive thresholds. Firstly, there may be an expanded capability to perceive and process player movement patterns across a wider visual field (for example, being able to effectively monitor movements of four players instead of three) (22,23). This would therefore likely improve the foundation upon which tactical awareness and intelligent decision making are based (though not directly training these skills). Secondly, it may possibly improve the efficiency with which a sub threshold amount of player tracking is managed, in turn possibly freeing up resources for other attentional demands or simply relieving some of the pressure of sustained concentration. Finally, it may assist with dual perception tasks, such as reading key opponent body language without compromising awareness of surrounding player movements (16,23).

Our findings are also closely related to evidence showing that eye movements can be modulated by decision formation, and that decision making and motor output are closely related. For example, neural-population activity in the motor cortex measured using magneto encephalography has been shown to gradually build up several seconds before execution of a choice response, and to be usable to read out and predict observers' choices in a yes/no motion-detection task (24,25). Decision-related modulation has also been found during motor execution. In an earlier study, when a hand movement was perturbed just prior to the choice response, the muscular reflex gain of the perturbed arm was modulated by motion-coherence strength, reflecting ongoing decision formation (18,26).

Practical Applications

Considering the observed relationships between VTS and game-related measures of ball control, the findings of this investigation indicate a potentially important role in football player evaluation. Visual tracking speed is a measure of a player's ability to track multiple objects (i.e., teammates and opponents movements on the court) within a fastpaced dynamic setting, which would allow the player more time to appropriately respond to the demands of the given situation. Although preliminary and with not many subjects but data from a whole season, the data from our investigation suggest that greater VTS is related to game-related measures of ball control. Thus, the ability to evaluate a player's capability to perform in measures that are related to team success would prove beneficial for player recruitment and needs analysis.

Limitations of the study

In the future and cause the neuroscience topic is very popular the researchers need to base the same study on a larger sample size to end up with more accurate results and conclusions.

Conclusion

The present paper discusses our findings that are also closely related to evidence showing that eye movements and tracking abilities can be modulated by decision formation, and that decision making and motor output are closely related. Herein, we discussed the features of a perceptual-cognitive training program, suggested the potential benefits of such training, discussed what may be required by athletes to optimally process sports-related visual scenes at the perceptual-cognitive level, and proposed that this capacity may be trainable among high-level athletes. Understanding how humans make decisions in real-world tasks can therefore be significantly aided by evaluating eye-movement responses. Our findings provide a direct link between neural decision signatures and continuous eye-movement responses, thus demonstrating eye movements' capacity to serve as sensitive indicators of neural function outside of directly recording brain activity. It is hoped that future research will continue to investigate perceptual-cognitive training components and programs to further build the theoretical bases for such interventions and examine their efficacy.

Conflict of Interest

None.

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