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Test Transferability of 3D-MOT Training on Soccer Specific Parameters

Original Research

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Abstract

Introduction: Three-dimensional motion object tracking (3D-MOT) is perceptual-cognitive tool which utilizes executive function to train athletes to ignore distractors and enhance processing speed and peripheral focus. The benefits of perceptual-cognitive training in professional level athletes have recently been investigated in multiple sports such as basketball, soccer, and archery, but conclusive evidence suggesting test transferability of 3D-MOT training is lacking. The purpose of this research was to examine the transferability of perceptual-cognitive training to on-field soccer performance parameters.
Methods: NCAA Division I women's soccer players (n=22) between the ages of 18-25 participated in the study. NeuroTracker, a 3D-MOT device to train athletes executive function and decision making, was utilized to test the athletes. After baseline testing for both groups to determine visual tracking speed (VTS), the experimental group completed 10 3D-MOT training sessions with NeuroTracker over four-weeks. Game performance data, successful action, passing percentage, and short-medium range passing percentage, was collected utilizing Wyscout video analysis software during the 2021 season.
Results: The mean VTS for the NeuroTracker training group significantly increased by 0.68 from pre-3D-MOT training to post-3D-MOT training ($p<0.001$) while the control group increased by 0.12 ($p = 0.034$). Analysis utilized an ANCOVA and observed no statistical significance for passing accuracy, successful action and short-medium passing accuracy ($p > 0.05$). However, the average in game passing-accuracy for the experimental group increased over the control group.
Conclusions: The effect of test transferability of 3D-MOT training on soccer specific parameters may be present, but causation of test transferability is not present within the current study. Further research is needed to investigate the cause-and-effect relationship of 3D-MOT training on soccer specific parameters while utilizing recruitment of multiple teams to increase sample sizes for similar investigations.

Key Words: Visual tracking speed (VTS), executive function, perceptual-cognitive processing, task transfer, soccer performance

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Introduction

Perceptual-cognitive training aims to improve an athlete's anticipation, decision-making, and on-field performance using sport-specific visual training [1] Alterations to synaptic connections can occur very shortly following perceptual-cognitive training causing significant functional gains five days post perceptual-cognitive training[2]. Because of these observed changes, perceptual-cognitive training programs have sparked great interest as evidence currently suggests training programs lead to increased processing speeds and visual attention. There are various interventions used to try to influence perceptual-cognitive functioning: pencil-and-paper type tasks, advanced computer or video game type programs, brain-computer interfaces, nutritional supplements, and pharmacological drugs [3]. The brain-computer interface cognitive interventions show robust effects for transferability to specific tasks; while other methods such as pencil-and-paper, show inconsistent effects of transferability and no reports of lasting effects [3]. The use of multiple object tracking training software has been shown by neurological evidence to improve attention, visual information processing speed, and working memory [4].

One such perceptual-cognitive training platform, NeuroTracker, utilizes a 3D-MOT system to stimulate a high number of brain networks including complex motion integration, dynamic, sustained attention processing, distributed attention processing, and working memory [5]. 3D-MOT utilizes a three-dimensional representation of moving objects which requires active processing and the simulation of the perceptual component of decision-making [4]. The multiple object tracking training stimulates the parietal and frontal regions of the cortex, which are primarily responsible for the attention shifts and eye movement during the training session [6]. The stimulation of the middle temporal complex is primarily due to motion perception [6]. Furthermore, 3D-MOT training sessions actively stimulate multiple brain pathways in the dorsal and ventral tracts involved in decision-making, which allude to its effectiveness in enhancing cognitive functioning in athletes [7].

Evidence suggests that the level of athletic performance corresponds to cognitive capacity for learning dynamic tasks [8]. An increase in processing speed and visual attention capability may lead to increased expertise in sport and an increase in sport specific performance measures. In relation to the context of sport with 3D-MOT training, studies have been conducted with National Basketball Association (NBA) athletes [9], professional soccer players [10], and archery athletes [11] to test transferability of perceptual-cognitive training to specific sports measurements. Mangine et al. [9] suggested a potential role for visual tracking speed performance to indicate and predict playmaking ability through analysis of sports parameters, but also suggested additional research in this space is warranted. Komarudin et al. [12] utilized university basketball players and demonstrated a positive correlation between visual tracking speed training and concentration. However, the study lacked conclusive evidence in suggesting that visual tracking speed training directly affects game performance. Research conducted with archery athletes showed an improvement in concentration following 3D-MOT training [11]. With an increase in perceptual-cognitive processing speeds and concentration, an athlete could potentially adapt and respond to high-pressure demands more effectively in a competitive environment [12].

Given this concept, soccer requires high levels of dynamic movement and cognitive intuition, forcing athletes to make decisions rapidly in order to maintain a high-level of performance. There is clearly defined positive correlation between 3D-MOT training and visual tracking speed increases, but research showing test transferability of 3D-MOT training to sports specific measures is lacking. With lack of conclusive evidence to demonstrate a positive effect of 3D-MOT training on sport specific measures, the justification for additional research within this paradigm is required to examine the effect of 3D-MOT training over the course of a NCAA Division I Women's Team Fall season on soccer specific parameters. Therefore, the purpose of this research is to examine the transferability of perceptual-cognitive training to on-field soccer performance.

Scientific Methods

Participants

The study utilized 22 players on an NCAA Division I women's soccer team during the Fall 2021 season. The team was randomly assigned to two groups: experimental training group (n = 12) or control group (n = 10). There were similar number of forwards, midfielders, defenders, and goalies in each group. Players were excluded from VTS analysis if they sustained a season ending injury or did not complete the post-session (n = 5). When examining in-game performance parameters, players were further excluded if they played less than 20 minutes per game or played in less than 75% of the games. All participants signed an informed consent form prior to the start of the study and approval from the University of Mississippi's Institutional Review Board was obtained.

Protocol

NeuroTracker 3D-MOT Testing

NeuroTracker is a 3D-MOT perceptual-cognitive training software the players performed their baseline and 10 core sessions over the course of four-weeks. Athletes were seated 8 feet away from the 8-foot-wide projector screen in a dark, quiet room. They also wore 3D-glasses. Participants were familiarized with NT with 3 practice trials to ensure they understood the format of the sessions. One session of NT contains 20 trials. The baseline starting speed for all athletes was 0.68 m/s. All sessions of NT were 6-8 minutes long. A session begins with 8 yellow balls in a 3D cube. Four of the 8 balls illuminated briefly before returning back to normal. These four balls tracked are the same for the entire duration of the session. The 8 balls then began moving around the cube for eight seconds before freezing and being labeled 1-8. The athletes would tell the researcher which of the four balls they believed were the first four originally illuminated and the researcher reiterated it back to the athletes to ensure they selected the proper four. The four original balls will then illuminate again and the next trial started and followed this pattern for all 20 trials. If the athlete correctly identified the four balls, the speed would increase and if they were incorrect the speed would decrease following this staircase effect for the duration of the session. Following each session, the athletes would get their visual tracking speed, percent correctness, consistency and fastest trial speed.

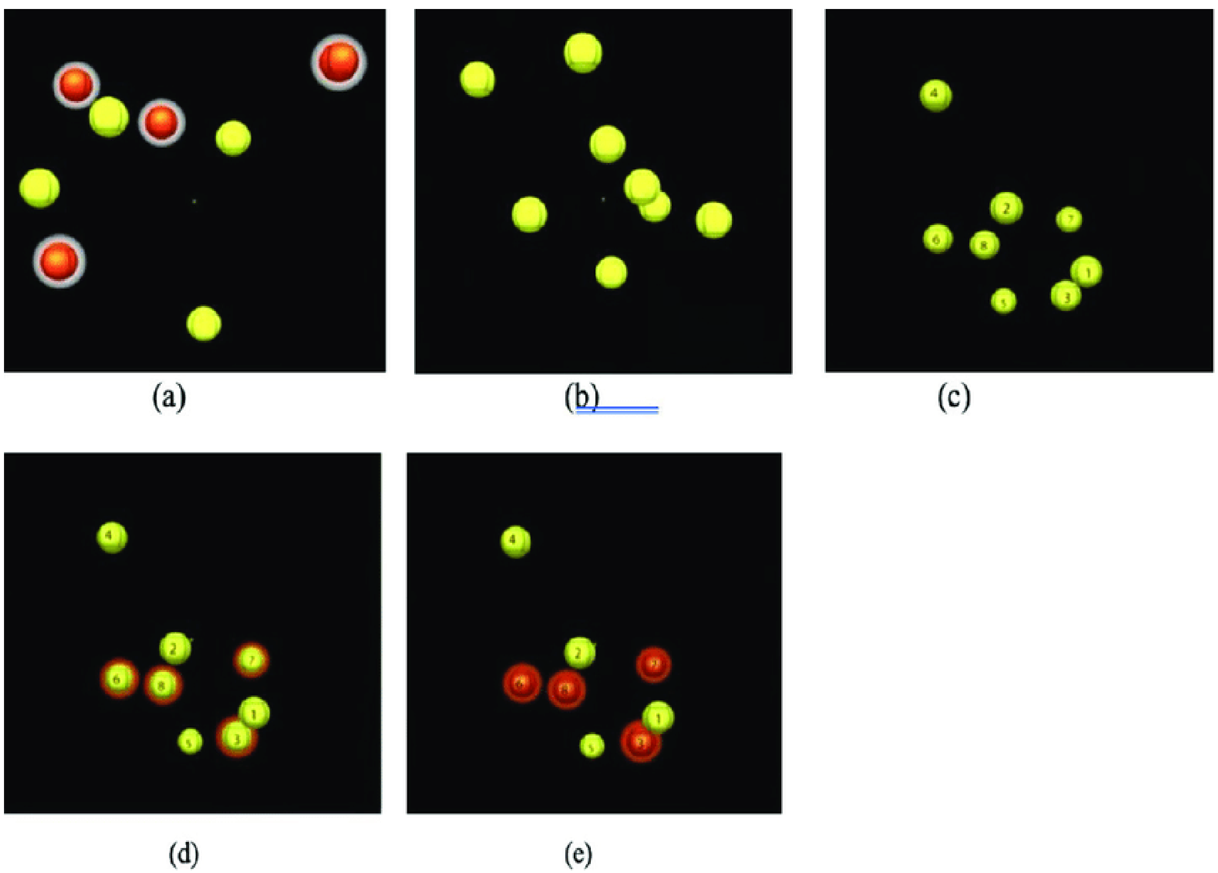

Figure. 1 NeuroTracker single trial stages [4]. (a) Four of the eight balls are illuminated that will be tracked. (b)The balls return to normal and move around the cube for approximately 6-8 seconds. (c) The balls freeze and are label 1-8. (d) Four of the eight balls are identified by the athlete which they believe were the original four they were tracking. (e) Feedback identifying the four balls that were correct.

Wyscout

Wyscout is a soccer-specific performance analysis system utilized by the team that provided match reports for the team and each individual player on the team for every action performed over the duration of the season. The games are recorded utilizing Spiideo, a camera-system that provides a full panorama and auto-follow view that is uploaded to Wyscout and a match report is produced within 24-hours. Individual player metrics that were collected from Wyscout were successful actions, Short-medium passing accuracy and overall passing accuracy. Successful actions are defined as total number of successful actions (passing, heading, defending, dribbling, etc.) divided by total actions within the game. Short-medium length passing accuracy are passes within 40 meters of the player.

Procedures
Prior to the start of the season all athletes performed a baseline session of Neurotracker. Following baseline testing athletes were assigned to a control (n=12) and experimental group (n=10) to examine the training impact of the platform. To examine the transferability to in game performance measures, the first two games of the season served as baseline values for the in-game performance metrics of interest. The following week athletes in the experimental group began four-week of NT training comprised of 2-3 session a week performing 10 total sessions. After the four-weeks of training, the following 2 games served as the post-test measures for their in-game performance.

Statistical Analysis
Pre- and post-game data were averaged between the two matches before and after the four-weeks of training. An analysis of covariance (ANCOVA) was conducted for the successful action, passing accuracy, and short-medium passing accuracy change. The post-score was utilized, while the pre-score was used as a covariate for the NeuroTracker and Control groups. An independent sample t-test was used for VTS pre and post four-weeks to compare group scores. Significance was test at $p < 0.05$. Data was analyzed with IMB SPSS statistics 27.

Results
The baseline VTS scores between groups were not significantly different at baseline (NT: 1.04 ± 0.32 vs CON: 1.00 ± 0.41; p=0.794). Following the 4-week the NT group (n = 10) significantly increased their VTS compared to their baseline scores (Pre: 1.04 ± 0.32 vs Post: 1.94 ± 0.51, $p < 0.001$) and compared to the control group (n = 12) post scores (NT: 1.94 ± 0.51 vs CON: 1.17 ± 0.30; p = 0.002).

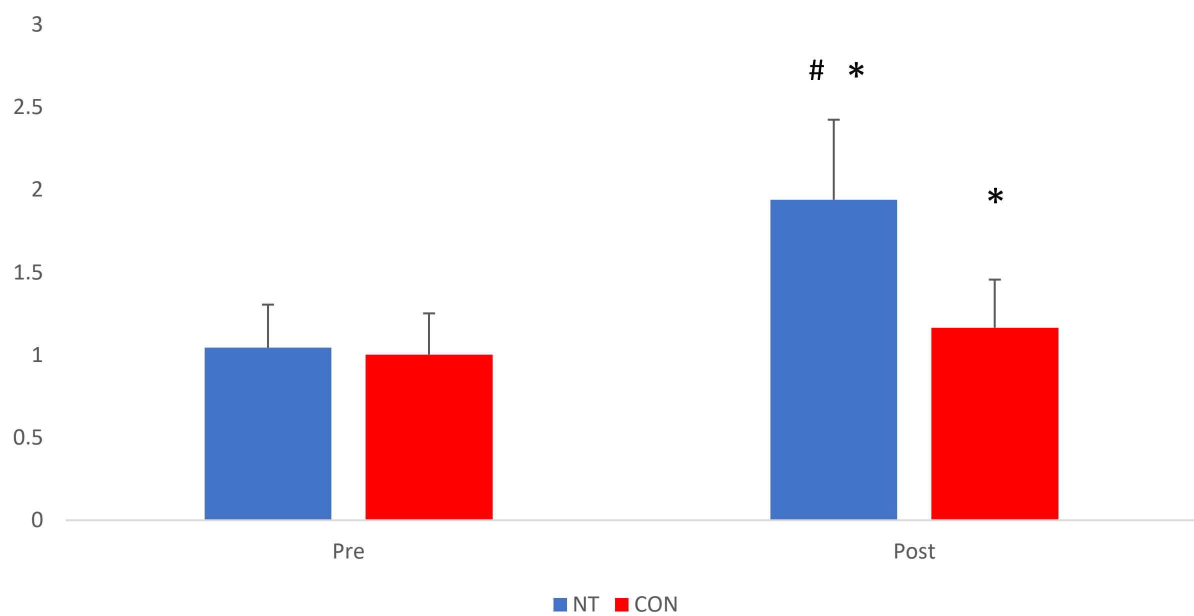

Figure 2. Average VTS pre-training and post-training for NT group (n=10) and control group (n=12). * indicates significant differences between pre and post score. # indicates significant difference between group scores. VTS significantly increases post-test for both groups after 4 weeks. VTS was significantly greater in the NT group compared to the control group post-test.

For the in-game performance measures only, of the 22 athletes, 9 were excluded due to not meeting the minutes played criteria and the goalkeepers were also excluded. When comparing in-game performance there were no significant difference between groups (Table 1). Both the NT and CON group improved their passing accuracy, but NT group saw greater, but non-significant increase in passing accuracy (p = 0.304) (Fig. 3a). The same non-significant trend was observed for successful actions with both groups improving but the NT group having an overall greater increase (p = 0.454) (Fig. 3b). Short-medium passing accuracy improved similarly among both groups (p = 0.846) (Fig 3c).

Table 1. Pre, post and net change in passing accuracy, successful actions and short-medium passing accuracy.

	Pre	Pre	Δ Change	Pre	Pre	Δ Change
Passing Accuracy	63.2 ± 8.0%	71.1 ± 12.4%	8.5 ± 18.1%	61.3 ± 11.1%	64.8 ± 10.0%	3.5 ± 12.5%
Successful Actions	50.2 ± 13.4%	58.4 ± 12.0%	8.2 ± 13.9%	49.7 ± 8.5%	54.0 ± 9.5%	4.2 ± 7.0%
Short-medium Passing	68.1 ± 8.7%	77.1 ± 12.0%	9.0 ± 20.1%	68.3 ± 11.1%	76.1 ± 9.8%	7.8 ± 18.6%

Data are Means ± SD

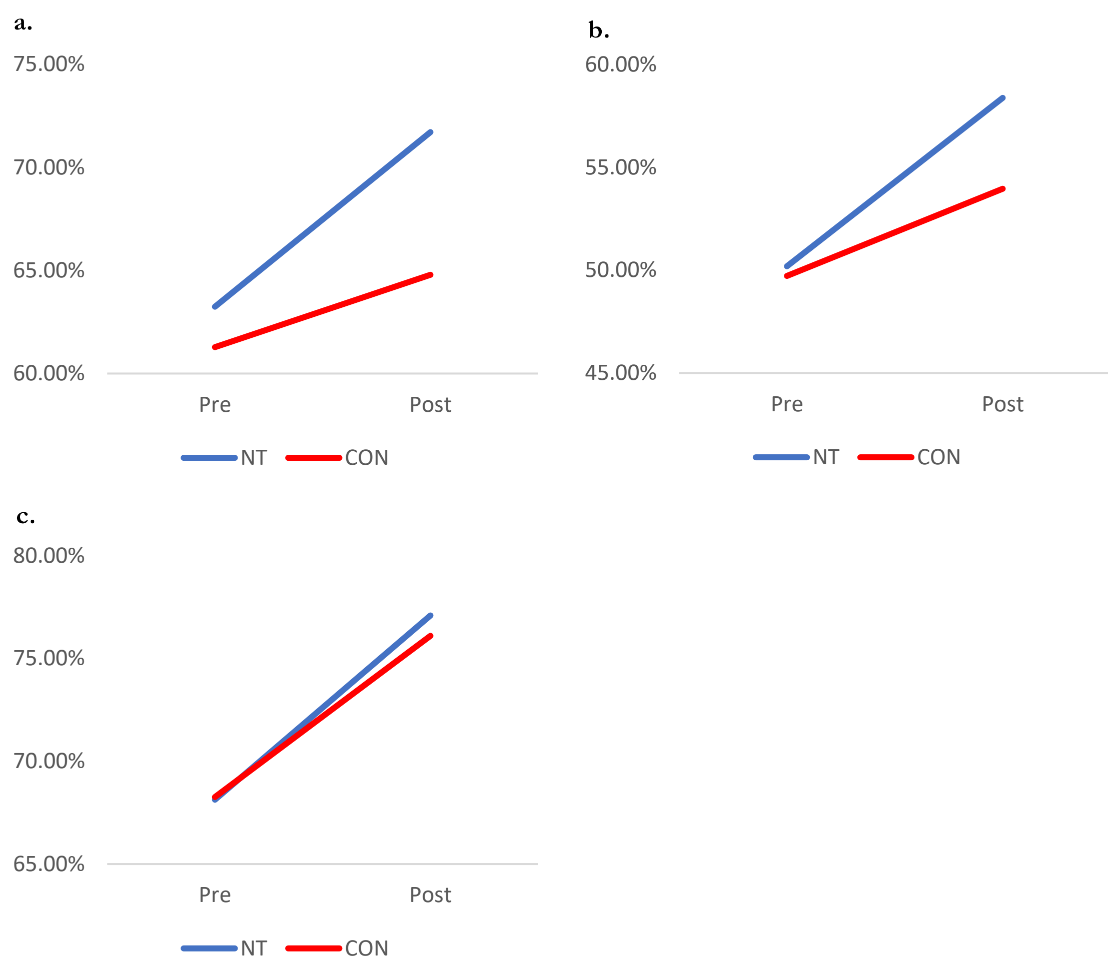

Figure 3. Comparison of pre and post in-games performance metric values between the NeuroTracker and Control group for a. passing accuracy (p = 0.304) b. successful actions (p = 0.454) and c. short-medium passing accuracy between groups (p = 0.846).

When examining the net change VTS and net change in performance metrics, there were no significant correlations between the change in VTS from pre to post and passing accuracy (r = 0.236, p =0.437), short-medium passing accuracy (r = 0.04, p = 0.901) or successful actions (r = -0.22, p = 0.947).

Discussion

The first aim was to examine trainability of VTS over the course of four-weeks during a NCAA Division I Women's Soccer season. The second aim was to examine test transferability of 3D-MOT training to soccer specific parameters. The results of the current investigation did not see a statistically significant difference between the experimental and control groups regarding in-game performance metrics. Interestingly, high levels of performance on measures of visual processing speed and visual attention have been correlated in professional levels of sport [13] . The improvement in VTS for the experimental group during the four-week experiment could be caused by the innate ability of professional and collegiate level athletes to perform faster and more accurately on decision-making tasks than their non-athletic or lesser athletic counterparts [14]. Professional athletes have been shown to start at a higher NeuroTracker speed threshold compared to amateur athletes and non-athletes [8]. There were no significant differences between the NT and CON group at baseline suggesting any difference occurred from the training and not athlete status. The average VTS between pre-3D-MOT training and post-3D-MOT training for the experimental group increased by 0.88 while the average VTS for the control group increased by 0.15 (Figure 1). Improvement in VTS throughout the 10-session 3D-MOT training was critical to try and prove test transferability of perceptual-cognitive training on the sports specific parameters. The cause for increase in visual tracking speed can be due to neural tissue reorganization. Alterations to the neuronal pathways can occur quickly (within 5 days) post perceptual-cognitive training [1].

These results are in agreement with previous research using university basketball players that did not demonstrate VTS training directly affecting game performance in basketball [12]. The positive nonsignificant increase in passing-accuracy had a similar trend with previous research conducted except other studies reaching significance. Previous research showed that there was a significant 15% improvement in passing-accuracy in soccer players performing 3D-MOT training in comparison to the control group [4]. However, the previous study utilized a controlled environment instead of competitive match play during a season. Similar to the current investigation, a limited sample size was utilized given the unique population with university athletes. Given the limitations as a secondary aim piloting the transferability, there may be practical applications to the in-game performance results. Although non-significant, there was an increase between pre-passing percentage averages and post-passing percentage averages (Table 1). Increasing passing-accuracy can inadvertently lead to increased time of possession of the ball. In the Euro 2000 competition, successful teams had longer bouts of possession within a game than unsuccessful teams [15]. In the English Premier League, teams with more success were found to have longer possessions than unsuccessful teams [16]. Further, in the analysis of 288 matches in the UEFA Champions League from 2007-2010, winners had the highest percentage of successful passes compared to teams that lost or tied, and winners had the highest amount of ball possession compared to teams that lost or tied [15]. Similarly, with the team utilized for this study, across the 22-game season, the difference between games won compared to loss or tied was a 4% difference in passing accuracy and possession. The control group for the four-week experiment showed improvement in passing-accuracy, short and medium range passing, and successful actions between pre- and post-average measurements (Table 1). The cause for the improvement in the control group is unknown but could likely be due to natural improvement in passing percentage as a season progresses due to acclimation to a game setting and better understanding of teammates and movement patterns. The improvement could also have been influenced by the level of competition across the games that were utilized.

Komarudin et al. [12] conducted a study with university-aged basketball players and additionally found that the control group saw similar playing performance measure improvements compared to the experimental group. While improvement in control group playing performance measures is prevalent, the net change for the control group for all sports specific parameters was not as large as the net change for the experimental group. Similar to Komarudin et al. [12], statistical significance within this study for all sports specific parameters was not present, but an effect between perceptual-cognitive training and sports specific parameters is evident.

Conclusions

Although there were no significant differences in any of the three-performance metrics examined, there is potential practical application of the results found. If there is transferability this could indicate a performance advance. As demonstrated, VTS can be trained, further research is needed regarding task-transferability of NT. There is evidence to suggest a potential benefit in performance due to increase peripheral vision and improved executive function in situation processing on the field [17]. Sample size was a clear limitation of this study in investigating task-transferability to in-game performance with only 6 in the NT group and 7 in the CON group; however, this is common when using high level athletes and this was a pilot study and not the primary aim of this study. Potentially multiple sites at comparable competition levels could be utilized to expand the sample size for future projects. Additionally, the research platform can be expanded to include other collegiate athletes during competition season. A comparison can then be made between sports on the effectiveness of the perceptual-cognitive training program within the training paradigm across the sport.

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