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OBJECT SIZE DETECTION AND SENSORIMOTOR PERFORMANCE IN STRIKING MARTIAL ARTISTS: AN EXPLORATORY FACTOR ANALYSIS

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Reakcja na zmiany wielkości obiektu i sprawność sensomotoryczna u zawodników sportów walki: eksploracyjna analiza czynnikowa

Streszczenie

W sportach walki o charakterze uderzeniowym zawodnicy muszą szybko przetwarzać informacje wzrokowe i precyzyjnie na nie reagować. Celem badania była eksploracyjna analiza zależności między wskaźnikami sensomotorycznymi i percepcyjnymi, w tym reakcją na zmiany wielkości obiektu, w zadaniach o różnym poziomie wymagań poznawczych. W badaniu uczestniczyło 25 mężczyzn uprawiających sporty walki o charakterze uderzeniowym (wiek: $18,4 \pm 3,5$ roku; staż treningowy: 8–10 lat). Zastosowano następujące typy testów: Size Test, Visuomotor Choice Reaction, Reaction RMO Pro, Reaction Go/No-Go, Spatial Perception oraz STMemory. Zmienne pogrupowano w dwa zestawy zadań o niższych i wyższych wymaganiach poznawczych, a następnie przeprowadzono oddzielne eks-

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ploracyjne analizy czynnikowe metodą Principal Axis Factoring. W zestawie o niższych wymaganiach poznawczych przedstawiono eksploracyjne rozwiązanie dwuczynnikowe. Najwyższy ładunek na PA1 uzyskał Spatial Perception (Etap 1) ($0,87$; $h^2 = 0,76$), a Size Test uzyskał ładunek $0,72$ ($h^2 = 0,54$), natomiast Reaction RMO Pro (Etap 1) łądował się głównie na PA2 ($-0,65$). W zestawie o wyższych wymaganiach poznawczych uzyskano rozwiązanie jednoczynnikowe; najwyższy ładunek uzyskał Spatial Perception (Etap 4) ($0,85$; $h^2 = 0,73$), a STMemory (Etap 5) uzyskał ładunek ujemny ($-0,67$; $h^2 = 0,45$). Wyniki wskazują, że Size Test współzmienia się z innymi wskaźnikami percepcyjnymi i sensomotorycznymi.

Słowa kluczowe: percepcja wzrokowa; sporty walki; testy psychofizjologiczne; zdolności poznawcze; czas reakcji.

Abstract

In striking martial arts, athletes must rapidly process visual information and respond precisely. This study explored the latent structure of sensorimotor and perceptual measures, including responses to changes in object size, across tasks differing in cognitive demands. Twenty-five male striking martial artists participated (age: 18.4 ± 3.5 years; training experience: 8–10 years). Testing included the Size Test, Visuomotor Choice Reaction, Reaction RMO Pro, Reaction Go/No-Go, Spatial Perception, and STMemory. Variables were grouped into lower- and higher-demand task sets. Separate exploratory factor analyses using Principal Axis Factoring were performed. In the lower-demand set, an exploratory two-factor PAF solution was examined. Spatial Perception (Stage 1) loaded highest on PA1 (0.87 ; $h^2 = 0.76$), followed by the Size Test (0.72 ; $h^2 = 0.54$), while Reaction RMO Pro (Stage 1) loaded primarily on PA2 (-0.65). In the higher-demand set, a single-factor solution was obtained; Spatial Perception (Stage 4) showed the highest positive loading (0.85 ; $h^2 = 0.73$), whereas STMemory (Stage 5) loaded negatively (-0.67 ; $h^2 = 0.45$). These exploratory findings indicate that Size Test performance covaries with spatial-perceptual and other sensorimotor measures, with patterns differing by task demand.

Keywords: visual perception; martial arts; psychophysiological testing; cognitive abilities; reaction time.

Introduction

The ability of martial artists to process visual information during competitive bouts enables them to anticipate opponents' actions and respond in a timely manner. The quality of visual input affects the efficacy of decision-making in competitive scenarios. Practical combat experience enhances athletes' repertoire of visual patterns and corresponding actions, which in turn improves response speed (Korobeynikov et al., 2023; Mann et al., 2007; Tropin et al., 2021). Skilled athletes display distinctive characteristics in visual information processing, often involving the use of peripheral vision. For instance, football players gather visual cues not only through foveal (central) vision but also by optimally engaging peripheral vision (Williams & Davids, 1998). Peripheral vision allows visual information to be processed outside the central area of gaze and plays an important role in visually guided behaviour in dynamic environments (Vater et al., 2022). In striking martial arts, experts can use gaze-anchoring strat-

egies that support the use of peripheral visual information (Hausegger et al., 2019). More generally, visual reaction time increases with stimulus eccentricity under controlled conditions (Schiefer et al., 2001).

Research has demonstrated that elite athletes perform with remarkable accuracy and success in fast-paced, complex sporting tasks (Starkes & Ericsson, 2003). Achieving elite-level performance requires strong cognitive abilities. Athlete perception is shaped by the interplay between the physical characteristics of sports stimuli and the athlete's perceptual and cognitive capabilities (Gray, 2014). Perceptual-cognitive expertise in sport is shaped by sport-specific experience and the ability to extract task-relevant visual information efficiently (Mann et al., 2007; Gray, 2014). According to information processing theory, an increase in incoming information significantly elevates cognitive load, thereby necessitating greater cognitive resource allocation (Frey, 2018). High-level athletes possess more specialized cognitive resources and exhibit greater cognitive processing efficiency compared to less experienced athletes and non-athletes (Podrigalo et al., 2023; Wei et al., 2017).

Martial arts practitioners operate in environments that demand rapid situational assessment and effective responses (Martínez del Quel & Bennett, 2019). As in any combat sport, the primary objective is to execute effective offensive and counteroffensive techniques while avoiding counterstrikes that necessitate highly developed visuomotor coordination. Visuomotor coordination refers to the brain's ability to receive and analyse visual information and respond with coordinated motor actions (du Toit et al., 2011). Athletes with well-developed visuomotor coordination are more capable of performing timely combinations of hand and foot strikes from appropriate distances (Myroshnychenko et al., 2020; Putra et al., 2023).

Psychophysiological tests involving visual stimuli assess visual sensitivity and reaction latency (Kalén et al., 2021; Romanenko et al., 2022). This study hypothesized that skilled martial artists' responses to object size variation are primarily driven by cognitive factors, particularly attention retention, size memory, and visual change recognition. Consequently, the aim was to explore the latent structure of sensorimotor and perceptual measures, including responses to object size changes, across tasks differing in cognitive demands.

Materials and Methods

Participants

The study involved 25 male athletes specializing in striking martial arts (mean age = 18.4 years, SD = 3.5; age range: 15-23 years), each with 8-10 years

of consistent training experience. All participants were informed about the nature and procedures of the study, the voluntary nature of participation, and their right to withdraw at any time without providing a reason. At the time of data collection, all participants were in good health. The study protocol was reviewed and approved by the Committee on Bioethics and Scientific Research of the Kharkiv State Academy of Physical Culture (Protocol No. 24, August 27, 2025), prior to participant recruitment and data collection. Written informed consent was obtained from all adult participants. For participants under 18 years of age, written informed consent was obtained from a parent or legal guardian, and assent was obtained from the participants before testing. The study was conducted in accordance with the Declaration of Helsinki and applicable national ethical regulations.

Procedure

Psychophysiological testing was conducted using tablet-based applications developed for iOS platforms. The following tests were used: Size Test (reaction to object size change), Visuomotor Choice Reaction, Reaction RMO Pro (reaction to a moving object), Reaction Go/No-Go, Spatial Perception, Test STMemory (short-term visual memory). Previous studies have provided validation evidence for the Visuomotor Choice Reaction, Reaction RMO Pro, Reaction Go/No-Go, and Spatial Perception tests (Romanenko et al., 2022, 2024a, 2024b, 2025). The Size Test and Test STMemory have also been applied in previous peer-reviewed studies of cognitive and psychophysiological characteristics in athletes (Tropin et al., 2026).

Size Test – participants were required to respond immediately to increases or decreases in the size of a visual object (an outline square). The object gradually increased (up to 1.5×) or decreased (to 0.5×) in size. Premature responses were marked as errors. A total of 20 trials were completed.

Visuomotor Choice Reaction – the test included four stages. The First Stage – response to coloured stimuli; the Second Stage – response to coloured stimuli under distracting visual signals; the Third Stage – response to 3D geometric figures; the Fourth Stage – response to 3D geometric figures under distracting visual signals. Participants completed 10 trials per stage (40 trials in total).

Reaction RMO Pro – participants completed three stages of increasing difficulty. The task involved stopping a blue circle at a designated location. The stimulus appeared and moved from random screen positions at a constant speed. In Stage 1, the stimulus moved slowly; in Stage 2, the speed increased 1.5 times, and in Stage 3, distracting objects were introduced (with random motion, colour, speed, and brightness), increasing the visual processing load. Each stage comprised 20 trials (60 trials total).

Reaction Go/No-Go – participants responded with both hands. A visual stimulus (a blue circle) increased in size from zero to match a white circle. Two scenarios followed: the stimulus either disappeared or continued growing. Participants were to respond only when the stimulus exceeded the white circle's boundary. A total of 20 trials were performed.

Spatial Perception – the test involved comparing pairs of geometric figures across four stages: the First Stage – 2D shapes (e.g., square, rhombus, hexagon, circle, triangle) rotated randomly; the Second Stage – 3D shapes (e.g., cube, cylinder, sphere, hexagonal prism, octahedron) rotated in 3D space; the Third Stage – rotating 3D shapes followed by a stationary comparison; the Fourth Stage – same as Stage 3, but with visual distractors present. Participants indicated "Correct" if the figures matched or "Incorrect" if they differed. Each stage consisted of 20 trials (80 trials total).

Test STMemory – the short-term visual memory test included five stages of 10 trials each. In Stage 1, the first five trials required a response to a single monochromatic stimulus by remembering its location and selecting the correct circle. In subsequent trials and stages, the number of simultaneously presented and differently coloured stimuli increased by one per stage. By Stage 5, participants were required to memorize the positions of five stimuli and respond accordingly.

The test results were divided into two groups. The Size Test results were included in both groups due to their relevance across cognitive load levels. Group 1 included test stages with minimal cognitive load: Stage 1 of Visuomotor Choice Reaction (response to simple coloured stimuli); Stage 1 of Reaction RMO Pro (slow-moving visual stimulus); Stage 3 of Test STMemory (memorization of 3 visual stimulus locations); Stage 1 of Spatial Perception (recognition of 2D geometric shapes). Group 2 included test stages with high cognitive load: Stage 4 of Visuomotor Choice Reaction (3D geometric shapes with visual distractors); Stage 3 of Reaction RMO Pro (faster stimulus with visual distractors); Stage 5 of Test STMemory (memorization of 5 visual stimulus locations); Stage 4 of Spatial Perception (3D shape recognition with distractors). Additionally, Reaction Go/No-Go, characterized by substantial cognitive demands, was included in this group.

Statistical Analysis

The statistical analysis of the collected data was conducted using RStudio (version 2024.12.1+563) and Numbers (version 14.4). Descriptive statistics are presented as the mean, standard deviation, first and third quartiles, and median. To explore the latent structure of the psychophysiological indicators, separate exploratory factor analyses were performed for the two task sets using Principal Axis Factoring (PAF). PAF was used to estimate latent factors based on the shared variance among the observed variables. Factor retention was evaluated

using the eigenvalue-greater-than-one criterion and parallel analysis. For the lower-demand task set, two eigenvalues exceeded 1 (1.93 and 1.60), suggesting a two-factor solution according to the Kaiser criterion; however, parallel analysis did not support factor retention. Therefore, the two-factor solution for this task set was treated as exploratory and interpreted cautiously. For the higher-demand task set, both the eigenvalue-greater-than-one criterion (first eigenvalue = 3.04) and parallel analysis supported a one-factor solution. An oblimin rotation was applied to the two-factor solution; rotation was not applicable to the one-factor solution. Bartlett's test of sphericity was used to assess whether the observed correlation matrix differed significantly from an identity matrix (Johnson & Wichern, 2007), and the Kaiser-Meyer-Olkin (KMO) measure was calculated to assess sampling adequacy. Given the small sample size ($n = 25$), the factor-analytic results were considered exploratory and potentially sample-sensitive.

Results

The analysis of psychophysiological indicators in combat sports athletes revealed consistent patterns across tests assessing reaction speed, spatial perception, and short-term memory. The results were grouped into two sets based on the type and sequence of psychophysiological tasks. The first group consisted of test tasks characterised by a relatively low level of cognitive load. This group included the reaction to changes in object size (Stage 1), the visuomotor choice reaction (Stage 1), the reaction to a moving object (Stage 1), the spatial perception test (Stage 1), and the short-term visual memory test (Stage 3). Descriptive statistics for these psychophysiological indicators are presented in Table 1.

Table 1
First Group of Psychophysiological Performance Indicators

Tests	Mean	SD	1st Quarter	Median	3rd Quarter
Size Test (ms)	854.4	82.3	795.6	841.8	889.3
Visuomotor Choice Reaction (Stage 1) (ms)	627.4	63.7	588.8	600.1	672.3
Reaction RMO Pro (Stage 1) (ms)	30.4	17.6	19.51	25.68	33.5
Spatial Perception (Stage 1) (ms)	634.6	105.1	570.2	631.4	671.0
Test STMemory (Stage 3) (%)	95.3	3.6	93.3	96.7	96.7

Note: Size test – reaction to object size change; Visuomotor Choice Reaction – choice reaction; Reaction RMO Pro – reaction to a moving object; Spatial Perception – spatial perception; Test STMemory – short-term visual memory.

Similarly, the second group of tests, which required a higher degree of cognitive control and selective attention, showed longer mean reaction times and lower accuracy in tasks involving short-term visual memory (Table 2).

Table 2
Second Group of Psychophysiological Performance Indicators

Tests	Mean	SD	1st Quarter	Median	3rd Quarter
Size Test (ms)	854.4	82.3	795.6	841.8	889.3
Visuomotor Choice Reaction (Stage 4) (ms)	870.2	91.6	816.7	849.7	929.8
Reaction Go/No-go (ms)	334.4	30.3	312.8	329.1	354.0
Reaction RMO Pro (Stage 3) (ms)	29.4	12.8	21.9	28.6	33.2
Spatial Perception (Stage 4) (ms)	724.0	106.6	645.7	715.0	776.7
Test STMemory (Stage 5) (%)	82.5	8.7	78.0	82.0	88.00

Note: Size test – reaction to object size change; Visuomotor Choice Reaction – choice reaction; Reaction Go/No-go – differentiation reaction; Reaction RMO Pro – reaction to a moving object; Spatial Perception – spatial perception; Test STMemory – short-term visual memory.

To identify the latent structures underlying these results, exploratory factor analysis was performed separately for each group of indicators. For the lower-demand task set, Bartlett's test of sphericity was significant, $\chi^2(10) = 23.41$, $p = 0.0093$, and the overall KMO value was 0.59. Two eigenvalues exceeded 1 (1.93 and 1.60), whereas parallel analysis did not support factor retention. Accordingly, the following two-factor PAF solution is presented as exploratory and should be interpreted cautiously. For the higher-demand task set, Bartlett's test was also significant, $\chi^2(15) = 41.32$, $p < 0.001$, and the overall KMO value was 0.74. Both the eigenvalue-greater-than-one criterion (first eigenvalue = 3.04) and parallel analysis supported retention of one factor. The results of the factor analysis for the first group indicate that the *Size test* demonstrated a strong loading on factor PA1 (0.72) and a weak loading on PA2 (-0.16), with the factors explaining 54% of the variance in the variable. The Visuomotor Choice Reaction (Stage 1) showed a weak loading on PA1 (0.36) and a moderate positive loading with PA2 (0.59), with the factors explaining 48% of the variance. The Reaction RMO Pro (Stage 1) displayed a weak positive loading on PA1 (0.11) and a relatively strong negative loading on PA2 (-0.65), with 44% of the variance explained. Spatial Perception (Stage 1) demonstrated a strong positive loading on PA1 (0.87) and a weak loading on PA2 (0.07), accounting for the highest variance (76%) among the variables. Short-term Visual Memory showed a weak loading on PA1 (-0.31) and a moderate positive loading on PA2 (0.53), with 38% of the variance explained (see Table 3).

Table 3

Factor Analysis Results – First Group

Tests	PA1	PA2	h²	u²	com
Size Test	0.72	-0.16	0.54	0.46	1.1
Visuomotor Choice Reaction (Stage 1)	0.36	0.59	0.48	0.52	1.6
Reaction RMO Pro (Stage 1)	0.11	-0.65	0.44	0.56	1.1
Spatial Perception (Stage 1)	0.87	0.07	0.76	0.24	1.0
Test STMemory (Stage 3)	-0.31	0.53	0.38	0.62	1.6

Note: Size test – reaction to object size change; Visuomotor Choice Reaction – choice reaction; Reaction RMO Pro – reaction to a moving object; Spatial Perception – spatial perception; Test STMemory – short-term visual memory; com – complexity of the variable (i.e., the number of factors the variable loads on); h² – communality; u² – uniqueness.

The complexity indicators (com) for Visuomotor Choice Reaction (Stage 1) and Test STMemory (Stage 3) suggest that the results of these tests are influenced by two factors. In contrast, the outcomes of the remaining tests are associated with a single factor: Size test and Spatial Perception (Stage 1) load solely on PA1, while Reaction RMO Pro (Stage 1) loads exclusively on PA2. Notably, factor PA1 exhibited a higher loading (Sum of Squared Loadings = 1.51), indicating that it accounts for a greater proportion of variance compared to PA2 (Sum of Squared Loadings = 1.09). The inter-factor correlation ($r = -0.01$) indicated a negligible association between PA1 and PA2.

The factor model for the first group yielded the following fit indices: Root Mean Square of Residuals (RMSR) = 0.01; Root Mean Square Error of Approximation (RMSEA) = 0; Tucker-Lewis Index (TLI) = 1.808; Bayesian Information Criterion (BIC) = -3.19.

The results of the factor analysis for the second group reveal that the Size Test and Visuomotor Choice Reaction (Stage 4) both show substantial loadings on factor PA1 (0.59), with communalities ($h^2=0.35$) for each variable (Table 4).

The highest proportion of variance explained ($h^2=0.73$) and the strongest factor loading on PA1 (0.85) were found in the Spatial Perception test (Stage 4), suggesting that this test is highly representative of the latent construct. Conversely, Test STMemory (Stage 5) demonstrated a substantial negative loading on PA1 (-0.67), indicating an inverse relationship: the higher the short-term visual memory performance in Stage 5, the shorter the reaction time values in other tests such as Go/No-go, Size test, Choice Reaction (Stage 4), and Spatial Perception (Stage 4). The Reaction RMO Pro (Stage 3) exhibited the lowest proportion of variance explained (23%) and a relatively moderate loading on PA1 (0.48), suggesting a weaker association with the identified factor. The factor model for the second group yielded the following fit indices: Root Mean Square of Residuals (RMSR) = 0.07; Root Mean Square Error of Approximation (RMSEA)

= 0; Tucker-Lewis Index (TLI) = 1.182; Bayesian Information Criterion (BIC) = -22.70.

Table 4
Factor Analysis Results – Second Group

Tests	PA1	h ²	u ²	com
Size Test	0.59	0.35	0.65	1
Visuomotor Choice Reaction (Stage 4)	0.59	0.35	0.65	1
Reaction Go/No-go	0.64	0.41	0.59	1
Reaction RMO Pro (Stage 3)	0.48	0.23	0.77	1
Spatial Perception (Stage 4)	0.85	0.73	0.27	1
Test STMemory (Stage 5)	-0.67	0.45	0.55	1

Note: Size test – reaction to changes in object size; Visuomotor Choice Reaction – choice reaction; Reaction Go/No-go – response inhibition; Reaction RMO Pro – reaction to a moving object; Spatial Perception – spatial perception; Test STMemory – short-term visual memory.

Discussion

At the cognitive level, all types of sports are characterized by a strong involvement of executive functions and attention (Kalén et al., 2021; Polevaia-Secareanu et al., 2025; Tropin et al., 2023). Team sports significantly demand sustained attention due to the duration of matches and the precision of responses required (Heppe et al., 2016; Williams & Davids, 1998). Martial arts rely heavily on motor vigilance and speed, as well as on sustained attention and self-regulation (Bajkowski & Cynarski, 2024; Volodchenko et al., 2017). Evidence suggests that martial arts training may influence specific components of executive function. In particular, judo training has been shown to affect neurocognitive indices of response inhibition in preadolescent children (Ludyga et al., 2021). A systematic review has shown that athletes engaged in open-skill sports (e.g., team sports, combat sports) demonstrate higher levels of executive functions than those participating in closed-skill sports (e.g., gymnastics, swimming, athletics, archery, shooting) (Heilmann et al., 2022; Lai et al., 2024; Ren et al., 2025).

Visual perception is determined by two types of processes: the light falling on the retina and the attention shaped by task conditions (Ware, 2020). Vision is one of the key senses for gathering environmental information, and its importance is universally acknowledged in various activities. Specific visual skills are critical to performance in many sports (Wang et al., 2022; Omar et al., 2017). Visual information is essential for executive functions, as the eyes collect data that the brain processes to form a clear understanding of the environment (Knöllner et al., 2022; Mahlangu et al., 2024).

Athletes' visual skills are commonly divided into two main categories: visual "hardware" and visual "software." Hardware refers primarily to optometric and ocular functions such as visual acuity, depth perception, accommodation, fusion flexibility, colour vision, and contrast sensitivity, whereas software encompasses perceptual-cognitive and visuomotor processes such as visual reaction time, peripheral awareness, and eye–hand–body coordination (Poltavski et al., 2021).

The study of martial artists' responses to object size changes was conducted using the "Size test" application developed in Swift 5. This test requires the athlete to react instantly to any changes in the size of an object (a contour square), which may slowly increase (up to 1.5 times its size) or decrease (down to 0.5 times). Unlike classic reaction time tests that involve instantaneous stimulus presentation, this test gradually changes the size of the visual stimulus. The animation of object resizing was implemented using the *curveEaseInOut* function, which enables acceleration-based animation. This reflects real-world physical processes, where objects typically begin movement with acceleration due to applied force analogous to a martial artist initiating motion toward an opponent. Motion perception is a crucial aspect of human cognition, encompassing the detection of spatial and temporal changes in object positions (Barton, 2021). In the "Size test," the visual stimulus gradually changes its size, requiring perceptual attention and sensitivity to visual information flow. The faster an athlete detects the size change, the better their visual discrimination. The average reaction time recorded in this study was 854.4 ms, indicating complex cognitive processing and a greater need for information accumulation prior to decision-making. Previous studies (Romanenko et al., 2024a; Romanenko et al., 2025) have similarly demonstrated that increased cognitive load impacts reaction times in martial artists.

An analysis of reaction time values under increased cognitive load revealed that results generally worsened across most tests. An exception was found in the moving object detection test. In the second set of results, a slight improvement in reaction time was observed at the third testing stage (29.4 ms) compared to the first stage (30.4 ms). This pattern was also reported by Romanenko et al. (2024a), who hypothesized that improved reaction time at stage three was related to the visual stimulus speed ($v = 94.5 \text{ mm/s}$), which aligns with the motor patterns of striking martial artists and is more favourable for adaptation. Reaction time deterioration in the second group of results is attributed, first, to the presence of distracting visual stimuli and, second, to increased test complexity. For example, the fifth stage of the short-term visual memory test required remembering the location of five visual stimuli, while the fourth stage of the spatial perception test involved reacting to dynamic three-dimensional geometric shapes. This group also included results from the Go/No-Go test, performed with both hands and requiring significant attention and a balance of excitatory and inhibitory processes (Romanenko et al., 2024b).

As noted above, the two-factor PAF solution for the lower-demand task set should be regarded as exploratory, because parallel analysis did not support factor retention, although two eigenvalues exceeded 1. Within this exploratory solution, PA1 was characterized mainly by strong loadings of Spatial Perception (Stage 1) and the Size Test, suggesting a visual-perceptual dimension. PA2 was characterized by positive loadings of Visuomotor Choice Reaction (Stage 1) and Test STMemory (Stage 3), together with a negative loading of Reaction RMO Pro (Stage 1), indicating a pattern involving choice reaction, short-term visual memory, and moving-object response. Because lower Reaction RMO Pro values represent better performance, the negative loading indicates that higher PA2 scores were associated with shorter moving-object response times. However, the sign of a factor loading reflects the direction of association with the latent factor and should not itself be interpreted as a positive or negative contribution to performance. The choice reaction at the first stage of the Visuomotor Choice Reaction test reflects the processing of colour stimuli (Romanenko et al., 2022).

According to the present results, performance in the Size Test was associated with broader perceptual and sensorimotor processes in skilled martial artists. Sensitivity to changes in object size may be relevant to maintaining attention to an opponent's actions, controlling distance, and selecting an appropriate moment for action. Therefore, the Size Test may be considered an exploratory tool for characterizing and monitoring visual-perceptual performance in combat-sport athletes rather than as a validated predictor of future athletic success. Podrigalo et al. (2023) emphasized that the Size Test is accessible, specific, informative, cost-effective, and suitable for monitoring the condition of combat-sport athletes. Korobeynikov et al. (2023) identified associations between cognitive functions and the specific work capacity of elite boxers, including attention, visual perception speed, and operational and logical thinking. Further longitudinal research is required to determine whether Size Test performance has predictive value for athletic development or competitive performance.

Limitations and Future Research Directions

The main limitation of this study is the small sample size, which may limit the stability and reproducibility of the exploratory factor solution. In addition, the sample included only male striking martial artists, which restricts the generalizability of the findings. Finally, the cross-sectional and exploratory design does not allow conclusions regarding causality or the predictive value of the assessed measures for future sports performance.

Cognitive skills play an important role in sports performance. The observed patterns of sensorimotor responses across tasks with different cognitive demands may be useful for coaches and practitioners when characterizing percep-

tual and sensorimotor performance in experienced martial artists and may inform the design of future training and longitudinal studies. Further research in larger and more diverse samples is needed to determine whether these measures have predictive value for athletic development or performance.

Conclusions

Exploratory factor analysis indicated that performance in the Size Test co-varied with spatial-perceptual and other sensorimotor measures. In the exploratory two-factor solution for the lower-demand task set, the Size Test loaded substantially on the same factor as Spatial Perception, whereas the higher-demand task set showed a single-factor structure involving the Size Test, Spatial Perception, visuomotor choice reaction, response inhibition, reaction to a moving object, and short-term visual memory. These findings suggest that responses to changes in object size are related to broader perceptual and sensorimotor processes. Given the small sample size and exploratory design, these results should be interpreted cautiously and require confirmation in larger samples.

STATEMENT OF ETHICS

The study protocol was reviewed and approved by the Committee on Bioethics and Scientific Research of the Kharkiv State Academy of Physical Culture (Protocol No. 24, August 27, 2025), prior to participant recruitment and data collection. Written informed consent was obtained from all adult participants. For participants under 18 years of age, written informed consent was obtained from a parent or legal guardian, and assent was obtained from the participants before testing. The study was conducted in accordance with the Declaration of Helsinki and applicable national ethical regulations).

DECLARATION OF CONFLICTING INTERESTS

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AUTHORS' CONTRIBUTIONS

Vyacheslav Romanenko: Conceptualization, Data Curation, Investigation, Original Draft.
Yuri Tropin: Original Draft, Methodology, Analysis; Resources.

Yuliya Kovalenko: Review & Editing, Visualization, Validation.
Volodymyr Mikhalskyi: Methodology, Review & Editing, Analysis; Supervision.
Valerii Dzherelii: Analysis, Data Curation, Visualization; Project administration.
 All authors approved the final version of the manuscript.

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