ORIGINAL ARTICLE

The variability of visual choice reaction time to different colours in male non-athletes and *qwan ki do* elite athletes

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A Study Design
B Data Collection
C Statistical Analysis
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Abstract

Background and Study Aim: The fight competitions within qwan ki do request visual choice reaction time (VCRT) in relation to specific colours – commonly red, blue or white. The cognitive purpose of this research is the potential differences between the values of VCRT to red, blue and white stimuli, among male elite athletes within the qwan ki do martial art, at the level of the upper limbs. The application aim there are the potential differences between these subjects and non-athletes, in order to recommended of possible training adjustments.

Material and Methods: We collected data from 53 male subjects, aged between 19 and 36 years, divided into two groups: the control group (group 1) comprised 46 physical education and sport students (without being performance athletes); the second group comprised seven elite athletes within qwan ki do, members of the Romanian national team, which have attended the latest edition of the European Championship. We have used six computer-based tests, in order to compare the visual choice reaction time (VCRT) to various colours (red, white and blue).

Results: The values of VCRT are most of the times considerably lower in elite qwan ki do athletes, for both hands, in almost all combinations of colours of the six tests, thus highlighting the important effects of long-term training. Among these athletes, no significant differences were found between tests/colours, for both hands, thus suggesting that there are efficient adaptations concerning VCRT to the red dots on the blue background and vice versa.

Conclusions: Practically, the values of VCRT in the athletes within our study are not influenced by any of the colours used. In this case, combat efficiency is not significantly influenced by the variable colours of the protective equipment's worn by the opponents. This aspect may be highlighted in the selection process, as well as in the assessment and schedule for sports training as a neuromuscular indicator of the training level.

Keywords: combat sports • computer-based test • martial arts • training

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INTRODUCTION

Reaction time – is the time from the occurrence of stimulus to the first initiation of movement of the relevant segment of the body [17].

Reaction time – *noun* the interval of time between the application of a stimulus and The first indication of response [18].

Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [18].

Choice reaction time (CRT) expresses, to the largest extent, the ability of the central nervous system of generating a proper motor response to the emerging stimulus as quickly as possible. CRT to visual stimuli (VCRT) is directly related to the efficiency of certain physiological and biochemical processes at the level of the visual analyzers, through which it receives, conveys and encodes the signals subsequently passed onto the brain [1].

VCRT is a determining component in combat sports, thus even in martial arts; its optimal values favouring an effective motor response to the movements made by the opponent [2]. In scientific literature, a series of data confirm a shortening of the VCRT among martial arts practitioners (in karate, *qwan ki do*, taekwondo, wushu), in both the upper limbs and the lower limbs, due to specific training [2, 3-5].

On the other hand, the competitive system within *qwan ki do*, concerning combat events, requests VCRT in relation to certain colours. Hence, the most commonly used ones are red, blue or white protective equipment's (gloves, ankle pads, plastrons). As such, we have considered it useful to point out the values of VCRT to stimuli with these colours.

A series of studies in this respect attest that visual simple reaction time (VSRT) is significantly shorter to red stimuli, compared to green, blue or yellow ones [6-11]. Specialists explain this aspect through the trichromatic theory, based on the number of cone cells excited by a certain colour and then sending nervous impulses. According to it, most such cells (over 70%) are excited by the red colour, while the green and blue colours activate less than 20% of them [11, 12].

Concerning martial arts, the scarce data within scientific literature have made us conclude that among athletes within the martial art of taekwondo [13], VCRT was lower in red stimuli, compared to the blue colour. In addition, a study on karate athletes [14] suggests that the values of VCRT to red stimuli are significantly lower compared to green stimuli. We mention that we failed to find similar studies in the *qwan ki do* a martial art.

Consequently, taking into account the aforementioned particularities, the cognitive purpose of this research is the potential differences between the values of visual choice reaction time (VCRT) to red, blue and white stimuli, among elite athletes within the *qwan ki do* martial art, at the level of the upper limbs. The application aim there are the potential differences between these subjects and non-athletes, in order to recommended training adjustments.

MATERIAL AND METHODS

Participants

In order to carry out the research, we have collected data from a total of 53 male subjects, with ages ranging between 19 and 36 years old, divided into two groups, as follows (Table 1): the control group (group 1) comprised 46 physical education and sport students, (without being performance athletes); the second group comprised 7 elite athletes within *qwan ki do*, all of the members of the Romanian national team, which have attended the latest edition of a major competition, the European Championship (Gandia, Spain). We included all seven male athletes from the Romanian team who participated successfully in fight competitions. We mention that all seven athletes have a great competitive experience of over 12 years.

None of the subjects tested suffers from any acute or chronic illness, takes any medication, has smoked or drunk alcohol throughout the tests.

Table 1. Subjects of the research.

Characteristic	Group 1 students	Group 2 elite *qwan ki do* athletes
Number of subjects	46	7
Age (years)	20.2 ±1.7	31.7 ±5.9

Investigation of the visual choice reaction time

We note that the tests were carried out in the same conditions for all the subjects. In order to avoid the recorded values being affected by nervous or muscular fatigue, we have agreed that the subjects would have to have slept enough the night before. In addition, we have recorded the results in the timeframe 10-12 AM.

Method of measuring the visual choice reaction time to different colours

The method of measuring visual choice reaction time [2] was based on involving both the dominant and non-dominant hands into the task (40 measurements).

In order to measure visual choice reaction time (indirect method), we used a computer and an adapted keyboard. The keyboard features four buttons close together, forming a square. The design software allows recording and storing reaction times and also processing the results. The program was set to allow the emergence of a randomly coloured dot in one of the four corners of the screen. When it appears, the subject – using the same set of fingers attached and the dominant or non-dominant hand – presses as soon as possible the appropriate white button on the keyboard, as follows: if the dot appears in the top left or bottom left, use the left hand, pressing the appropriate white button on the keyboard; if the dot appears in the top right or bottom right, use the right hand, pressing the appropriate white button on the keyboard.

In order to identify the potential differences between the values of visual choice reaction time (VCRT) to red, blue and white stimuli, we have used six different protocols, taking into account all possible combinations between the colours red, blue and white: test 1 – red dots, white background; test 2 – blue dots, white background; test 3 – white dots, red background; test 4 – blue dots, red background; test 5 – white dots, blue background; test 6 – red dots, blue background.

Assignation

The six tests aim to compare the visual choice reaction time, using both dominant and non-dominant hands in the task. We have chosen this method because, in a martial arts fight, the athletes must usually react with the appropriate arm, depending on the opponent's actions.

Statistical analyses

For statistical processing, we used the *IBM SPSS Statistics 20* in the following situations: *ANOVA for repeated measures*, for VCRT in the six tests, between groups, in both hands; *Paired-Samples T-Test*, for VCRT between the six tests, as well as between the dominant and the non-dominant hand, in each group. Concerning the comparison between groups, in each particular test, the results are presented as follows (using *ANOVA for repeated measures*).

The significance level for all analyses was set at $p<0.05$. The data in the Tables below are expressed as mean ± SEM (standard error mean).

Ethics

The research protocol was in accordance with the ethical standards of the Helsinki Declaration. We obtained the consent of all the subjects within the study.

RESULTS

The comparison of all the results using *ANOVA for repeated measures* has highlighted, in the *Tests of*

Table 2. The values of VCRT (ms) and the significance (p) for students in physical education and elite *qwan ki do* athletes, in *Test 1 – red dots, white background* (both dominant and non-dominant hands in the task). Data are expressed in means (± SEM).

Test	Group 1 students		Group 2 elite *qwan ki do* athletes	
	Dominant hand	Non-dominant hand	Dominant hand	Non-dominant hand
1 red dots, white background	408.02 (±7.4)	404.3 (±6.8)	364.4 (±12.3)*	361.8 (±7.5)*
Between the two groups	p = 0.018			

* denotes significantly ($p < 0.05$) different from Group 1.

Table 3. The values of VCRT (ms) and the significance (p) for students in physical education and elite *qwan ki do* athletes, in *Test 2 – blue dots, white background* (both dominant and non-dominant hands in the task). Data are expressed in means (±SEM).

Test	Group 1 students		Group 2 elite *qwan ki do* athletes	
	Dominant hand	Non-dominant hand	Dominant hand	Non-dominant hand
2 blue dots, white background	405.3 (±6.3)	403.1 (±6.3)	363 (±11.5)*	353 (±8.5)*
Between the two groups	p = 0.005			

* denotes significantly (p < 0.05) different from Group 1.

Between-Subjects Effects, overall, significant differences between the two groups (p = 0.009).

Test 1 – Red dots, white background

The statistical analysis (*Tests of Between-Subjects Effects*) in test 1 reveals that significant differences have been found upon comparing VCRT for the dominant and non-dominant hand, between the two groups (p = 0.018). In particular, significant differences were found between the two groups, concerning both the dominant hand (p = 0.033) and the non-dominant hand (p = 0.021) (Table 2).

Test 2 – Blue dots, white background

The statistical analysis (*Tests of Between-Subjects Effects*) in test 2 reveals that significant differences have been found upon comparing VCRT for the dominant and non-dominant hand, between the two groups (p = 0.005). In particular, significant differences were found between the two groups, both concerning the dominant hand (p = 0.015), and the non-dominant hand (p = 0.004) (Table 3).

Test 3 – White dots, red background

The statistical analysis (*Tests of Between-Subjects Effects*) in test 3 reveals that significant differences have been found upon comparing VCRT for the dominant and non-dominant hand, between the two groups (p = 0.037). In particular, differences very close to or at the *threshold level* of statistical significance were found (p = 0.05), between the two groups, concerning both the dominant hand (p = 0.052) and the non-dominant hand (p = 0.05) (Table 4).

Test 4 – Blue dots, red background

The statistical analysis (*Tests of Between-Subjects Effects*) in test 4 reveals that significant differences have been found upon comparing VCRT for the dominant and non-dominant hand, between the two groups (p = 0.023). More precisely, significant differences were found between the two groups, concerning the dominant hand (p = 0.01). No significant differences were pointed out between the two groups in the non-dominant hand (p = 0.096) (Table 5).

Test 5 – White dots, blue background

The statistical analysis (*Tests of Between-Subjects Effects*) in test 5 reveals that significant differences have been found upon comparing VCRT for the dominant and non-dominant hand, between the two groups (p = 0.043). In particular, significant differences were found between the two groups, concerning the dominant hand

Table 4. The values of VCRT (ms) and the significance (p) for students in physical education and elite *qwan ki do* athletes, in *Test 3 – white dots, red background* (both dominant and non-dominant hands in the task). Data are expressed in means (±SEM).

Test	Group 1 students		Group 2 elite *qwan ki do* athletes	
	Dominant hand	Non-dominant hand	Dominant hand	Non-dominant hand
3 white dots, red background	407.1 (±7.3)	405.9 (±6.9)	367.7 (±15.6)	368.4 (±14.6)
Between the two groups	p = 0.037			

Table 5. The values of VCRT (ms) and the significance (p) for students in physical education and elite *qwan ki do* athletes, in *Test 4 – blue dots, red background* (both dominant and non-dominant hands in the task). Data are expressed in means (±SEM).

Test	Group 1 students		Group 2 elite *qwan ki do* athletes	
	Dominant hand	Non-dominant hand	Dominant hand	Non-dominant hand
4 blue dots, red background	415.04 (±6.5)	412.7 (±6.7)	368 (±13.5)*	382.5 (±9.4)
Between the two groups	p = 0.023			

* denotes significantly (p < 0.05) different from Group 1 - the dominant hand.

(p = 0.037). No significant differences were pointed out between the two groups in the non-dominant hand (p = 0.099) (Table 6).

Test 6 – Red dots, blue background

The statistical analysis (*Tests of Between-Subjects Effects*) in test 6 reveals that significant differences have been found upon comparing VCRT for the dominant and non-dominant hand, between the two groups (p = 0.009). In particular, significant differences were found between the two groups, concerning both the dominant hand (p = 0.02) and the non-dominant hand (p = 0.01) (Table 7).

Consequently, in most situations (8 out of 12), the values of VCRT are significantly different between the two groups within the study (p<0.05). In two other situations (*Test 3 – White dots, red background*, dominant and non-dominant hand), the differences between groups actually ranged around the *threshold* value of statistical significance (p = 0.05) (Table 4).

No significant differences were found between groups in *Test 4 – Blue dots, red background*, in the non-dominant hand (p = 0.096, Table 5), or *Test 5 – White dots, blue background*, also in the non-dominant hand (p = 0.099) (Table 6).

Table 6. The values of VCRT (ms) and the significance (p) for students in physical education and elite *qwan ki do* athletes, in *Test 5 – white dots, blue background* (both dominant and non-dominant hands in the task). Data are expressed in means (±SEM).

Test	Group 1 students		Group 2 elite *qwan ki do* athletes	
	Dominant hand	Non-dominant hand	Dominant hand	Non-dominant hand
5 white dots, blue background	405.2 (±6.4)	408.5 (±7.3)	367.5 (±14.06) *	375.8 (±10.03)
Between the two groups	p = 0.043			

* denotes significantly (p < 0.05) different from Group 1 - the dominant hand.

Table 7. The values of VCRT (ms) and the significance (p) for students in physical education and elite *qwan ki do* athletes, in *Test 6 – red dots, blue background* (both dominant and non-dominant hands in the task). Data are expressed in means (±SEM).

Test	Group 1 students		Group 2 elite *qwan ki do* athletes	
	Dominant hand	Non-dominant hand	Dominant hand	Non-dominant hand
6 red dots, blue background	415.06 (±7.1)	406.3 (±6.5)	369 (±13.5)*	360.8 (±8.6)*
Between the two groups	p = 0.009			

* denotes significantly (p < 0.05) different from Group 1.

On the other hand, the statistical analysis has compared by using the *Paired-Samples T Test* the values of VCRT between the six tests, as well as between the dominant hand and the non-dominant hand, in each group individually.

Hence, concerning the dominant hand, significant differences were found between the tests 2 and 4 (p = 0.01), between the tests 4 and 5 (p = 0.007), as well as between the tests 5 and 6 (p = 0.033), in the group of students (group 1). The shortest values of the VCRT were recorded in *test 2 (red dots, white background)* and *test 5 (white dots, blue background)*, while the longest values in *test 4 (blue dots, red background)* and *test 6 (red dots, blue background)*. At the same time, in the group of elite *qwan ki do* athletes (group 2) no significant differences were found (p>0.05), in the dominant hand, between all the six tests.

At the same time, in the non-dominant hand, no significant differences were found between the six tests, in both groups, with one exception: between the tests *2* (*red dots, white background*) and *4 (blue dots, red background)*, in group 2 (p = 0.005).

Furthermore, upon comparing VCRT between the dominant and non-dominant hand, in each test, we have not found significant differences (p> 0.05) in either of the groups.

Likewise, the average values of errors are reduced for both groups, and the differences between them are insignificant (p>0.05).

DISCUSSION

Overall, our findings confirm some previous studies [2, 4, 15] in the sense that long-term practice of martial arts entails the significant shortening of choice reaction time, in both the dominant and the non-dominant sector. This effect is most likely due to a shortening of the conduction time in the brain [16]. Specifically, the relatively similar values between the two groups in *test 4 (blue dots, red background*) in the non-dominant hand, where p>0.05, suggests a possible difficulty in long-term adaptation through a shortening of the VCRT in this combination of colours, in elite *qwan ki do* athletes.

In addition, according to the results obtained in the six tests, VCRT is not significantly different for the dominant hand versus the non-dominant hand, in both groups, thus confirming a previous study concerning reaction time in the *qwan ki do* martial art [2].

The analysis of the difference between tests in the same group highlights – concerning the dominant hand – that the group of students displays certain significant differences between the tests, with difficulties concerning VCRT in the combinations red dots with blue background, as well as blue dots with red background, probably due to the difficulty of perceiving these colours simultaneously.

This reality may suggest that VCRT among non-athletes is lower when the stimuli (dots-background) are in the combinations white-red and vice versa, as well as white-blue and vice versa.

At the same time, in elite *qwan ki do* athletes no significant differences were found between tests/colours, in the dominant hand, thus failing to confirm partially, certain previous studies [8, 10, 11] and thus suggesting efficient adaptations concerning VCRT, too, to the red dots on blue background and vice versa. In case of these athletes, long-term specific training may determine, in this combination of red-blue stimuli: 1) a higher compensating shortening of conduction time in the brain (even for processing and elaborating the proper motor response); 2) other manifested physiological and/or biochemical adaptations related to the reception and conveyance of impulses at the level of optical analyzer and at intra-cerebral level, (such aspects may represent hypotheses for subsequent studies); 3) both effects.

In what regards the differences between tests/colours in the non-dominant hand, they are statistically significant only in one case, between the tests *2* (*red dots, white background*) and *4 (blue dots, red background)*, in the group of elite athletes, thus suggesting a more modest adaptive effect, probably due to the contents of choice reaction time training to these colours, in the conditions of the functional inequality of cerebral hemispheres.

CONCLUSIONS

VCRT to red, blue and white stimuli is very important within combat competitions pertaining to the *qwan ki do* a martial art, for at least three reasons:

• the protective equipment's (gloves, leg pads, plastrons, breastplates) used to have these colours, and athletes use mainly the red and blue colours;
• the colour of the combat surface is dominantly blue;
• in competition halls, the background perceived by athletes is dominated by blue and red.

Consequently, the investigation of VCRT in these colours highlighted a series of useful aspects in the future. Thus, we have concluded that the values of these indicators are most of the times considerably lower in elite *qwan ki do* athletes, for both hands, in almost all combinations of colours of the six tests, thus highlighting the important effects of long-term training. In addition, the rather similar low values between the two hands among these athletes are most probably due to the involvement of both upper limbs during training effort (especially during the technical and tactical training), and they favour higher efficiency in competitive combat. From this perspective, the low values of VCRT in these colours – similar in both upper limbs – may represent a sports selection criterion in this martial art.

On the other hand, what appears to be a deficit among non-athletes through the determination of VCRT (we refer here to the response difficulty in the red-blue combinations) is not also displayed by the group of elite athletes. The particularities of their physiological and/or biochemical adaptations in this direction may represent future research topics. Practically, the values of VCRT in the athletes within our study are not influenced by any of the colours used. In this case, combat efficiency is not significantly influenced by the variable colours of the protective equipment's worn by the opponents. This aspect may be highlighted in the selection process, as well as in the assessment and schedule for sports training as a neuromuscular indicator of the training level.

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