

A PERCEPTUAL CUE ON A MOVING OPPONENT IMPROVES THE LEARNING OF A MOTOR SKILL FROM AIKIDO

UMA DICA PERCEPTIVA SOBRE UM OPOONENTE EM MOVIMENTO MELHORA A APRENDIZAGEM DE UMA HABILIDADE MOTORA DO AIKIDO

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RESUMO

O efeito de diferentes dicas sobre a aprendizagem de uma habilidade motora do aikido foi investigado. Sessenta participantes, de ambos os sexos, com idade média de 14 anos, praticaram a tarefa *choku tsuki*, que consistia em acertar um alvo no peito de um oponente atacante com um bastão. Eles foram divididos em quatro grupos: relaxamento, com dica sobre a maneira relaxada como a tarefa deveria ser executada; quadril baixo, com dica sobre manter o quadril o mais baixo possível; perceptiva, com dica sobre o alvo circular localizado no peito do oponente enquanto ele levantava a espada para atacar; e controle, sem dicas. As variáveis dependentes incluíram medidas relacionadas aos objetivos da tarefa, padrão de movimento em relação aos componentes da tarefa e características cinemáticas. Apenas os grupos perceptivo e quadril baixo aprenderam a habilidade motora. Ainda, o grupo perceptivo obteve melhor desempenho que os demais grupos. A aprendizagem do *choku tsuki* foi aprimorada pela dica "estocar o alvo assim que levantar a espada", estabelecendo a sintonia perceptiva do aprendiz com o oponente em movimento. A aprendizagem também foi aprimorada pela dica "mantenha o quadril o mais baixo possível"; no entanto, em um nível inferior ao da dica perceptiva.

Palavras-chave: Comportamento. Artes marciais. Eficiência. Prática.

ABSTRACT

The effect of different instructional foci on the learning of a motor skill of aikido was investigated. Sixty participants from both sexes with an average age of 14 practiced *choku tsuki* task, which consisted of hitting a target on the chest of an attacking opponent with a stick. They were divided into four groups: relaxation, with a cue about the relaxed way in which the task should be performed; low hip, with a cue about maintaining hip displacement as low as possible; perceptive, with a cue at the circular target located on the chest of the opponent as they raised their sword to attack; and control, without cues. The dependent variables included measures related to the task goals, movement pattern relative to the task components and kinematic features. Only the perceptive and low hip groups learned the motor skill. The perceptive group obtained better overall performance than the other groups. Learning *choku tsuki* was improved by the instructional cue "strike target as soon as sword is raised", establishing the learner's perceptive attunement to the moving opponent. Learning was also enhanced by the cue "keep hips as low as possible"; however, at a lower level than that of the perceptive cue.

Keywords: Behaviour. Martial arts. Efficiency. Practice.

Introduction

How do people acquire motor skills? This question has been at the centre of understanding motor learning. It refers to the knowledge field required in understanding the mechanisms and processes underlying the acquisition of motor skills, as well as their influencing factors, such as instruction, feedback and practice regimes. Although the origins of the study of motor learning date back to the late nineteenth century^{1,2}, it was only from the late twentieth century that researchers intensified their interest in how their findings could contribute to an understanding of how motor skills could be best taught³⁻⁵.

This emerging concern had two main consequences. Firstly, there was a growing tendency to consider the ecological validity of motor skills in research studies and/or methods⁶⁻⁸. The main assumption here was that the utilisation of real-world tasks, such as sport-related

motor skills, would allow for an increased generalisation of findings for instructional settings^{9,10}. Secondly, it stimulated communication between those studying motor learning and movement pedagogy, promoting collaboration on the role of instruction on the skill learning process¹¹⁻¹⁶.

Instruction has been recognised as an essential procedure for promoting learning, as a way of communicating with the learner and/or leading them to understand the task goal and key aspects for successful performance¹⁷⁻¹⁹. In fact, it has been suggested that effectiveness of learning is closely related to the ability of the teacher to select and communicate the relevant information to the learner, such as providing cues^{20,21}. Unlike general or more extensive communications, a cue is a type of instruction that makes it possible to direct the learner's selective attention to aspects essential to successful performance, regardless their characteristics (e.g. learning stage)^{12,14-16}. The cues can be concise phrases, often one or two words (verbal), drawings, figures or gestures (visual) or manipulation of specific parts of the body (kinesthetic)²².

Recently, such interactions have been extended to the martial arts. Specifically, motor skill learning has been investigated by considering the traditional teaching knowledge of *senseis* in judo, and those from motor learning²³⁻²⁶. For instance, Gomes *et al.*²⁴ investigated the effect of practice regime on the learning of *o soto gari*. Four practice groups were studied: (a) static traditional; (b) in motion traditional; (c) whole practice with pre-kuzushi; and (d) progressive parts with pre-kuzushi. No between-group differences were found, indicating that both traditional and task-related knowledge improved the learning of *o soto gari*. Overall, these studies indicated that learning judo motor skills can be optimised by different practice conditions, and that there is a sequence of movement components to be considered in terms of instructional feedback in order to promote learning.

Notwithstanding the advances provided by the foregoing studies, martial arts include several combat disciplines with distinct characteristics and requirements, which need to be more fully understood. For instance, aikido is a martial art whose motor skills predominantly involve counter-attacking, and most of these are characterised by circular motions in which the performer keeps themselves from the attack line and utilises the opponent's own forces and displacement. From the aikido's point of view, "to keep the hips down" and "to relax completely" have been suggested to be essential aspects for successful performances²⁷. This is because they allow the performer to defend itself through a broad base of balance and without using much muscle strength, respectively. However, these essential aspects have still not been investigated from the point of view of the scientific method. Therefore, this study investigated the effect of instructional foci (cues) relating to relaxation and low hips on the learning of aikido motor skills.

In addition, a perceptive cue that directed the learner's attention to the moving opponent was also investigated by considering the open nature of aikido's motor skills. Since the attention of the learner should be directed to key aspects of the task considering its nature/specificity^{12,28-35}, and the aikido's essence is on the utilisation of the opponent's own forces and displacement, it was hypothesised that the learning of an aikido motor skill would be most improved by a perceptive instructional focus, rather than those for relaxation and hip down instruction.

Method

Participants

Sixty right-handed volunteers, both male ($n = 32$) and female ($n = 28$), with an average age of 14.1 ± 0.4 years took part in this experiment. Written consent was obtained from each participant. Those who were involved in the systematic practice of any martial art were excluded from the study. This study received approval from the local ethics committee at the

University of São Paulo, Brazil, under the number 20022018.

Task and materials

The task to be learnt was *choku tsuki* from aikido (Figure 1). Using a stick (*jo*), participants had to hit the centre of a 11cm diameter circular target on the chest of a virtual opponent that attacked them with a wooden sword (*bokken*). They were required to hit the target while the attacking opponent was holding the *bokken* above their head. This task was selected because it was one of the first motor skills to be taught in aikido, it was a motivating and challenging task, and it was a clear and achievable goal²⁷.

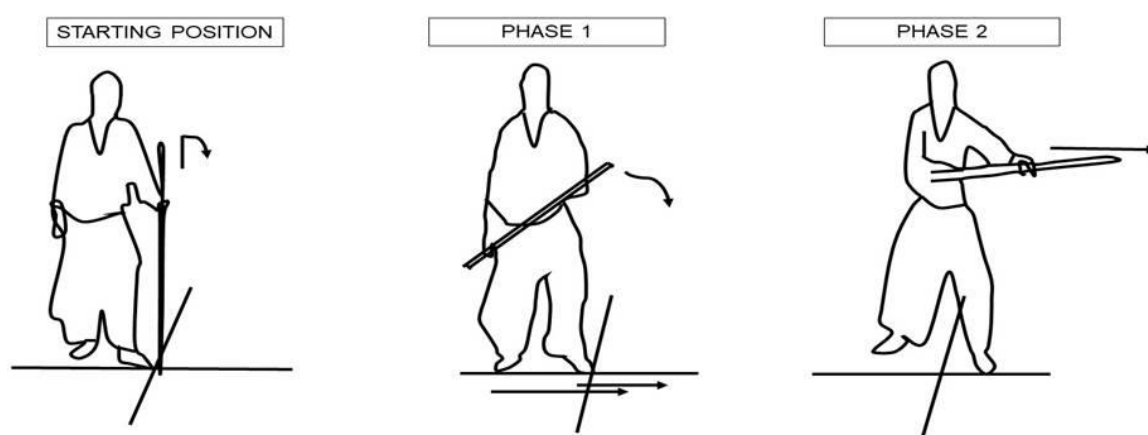


Figure 1. Illustration of *choku tsuki* from aikido

Source: The authors

Materials included: (a) an aikido stick (*jo*), 1.30 m in length, 2.5 cm in diameter and weighing 500 g (SeBogu Sports Store Ltda. ME, São Paulo, Brazil); (b) an aikido stick (*bo*), 1.79 m in length, 2.5 cm in diameter and weighing 900 g for the transfer test (SeBogu Sports Store Ltda. ME, São Paulo, Brazil); (c) a laser pointer (Logitech Inc., São Paulo, Brazil) fixed to the tip of the stick with double-sided tape (Scotch, São Paulo, Brazil), for easier hit location assessment; (d) two GoPro Hero3 digital cameras (GoPro Inc., São Paulo, Brazil) used for capturing the overall performance, movement pattern and kinematic measures, with camera 1 being positioned on the right side of the participant, at a distance of 2.10 m and a height of 1.10 m, and camera 2 being positioned on a left posterior diagonal to the participant, at a distance of 6 m and a height of 1.45 m; (e) a computer (Dell Inc., São Paulo, Brazil) that allowed the participant to watch a video showing the procedure performed by an expert in aikido; and (f) a DataShow (Epson America Inc., São Paulo, Brazil) for projecting the moving opponent.

Design and procedures

Participants were randomly assigned into four cue groups: relaxation cue ($n = 15$), which received verbal ("head up and loose joints") and visual information (image that directed their attention to the relaxed way in which an expert model performed the task); low hip cue ($n = 15$), which received the verbal ("keep hips as low as possible") and the visual information (image that directed their attention to hip displacement as low as possible); perceptive cue ($n = 15$), which received the verbal ("strike target as soon as sword is raised") and the visual information (image that directed their attention to the circular target located on the chest of the opponent as he raised his sword to attack); and, control ($n = 15$), which received no cue. In sum, the cue was verbalised while the experimenter directed the participant's visual attention to the relevant aspect of the movement, by observing the expert model.

The experiment involved two phases, acquisition and transfer. Acquisition took place over two consecutive days in which participants performed three blocks of thirty trials per day. Intervals between trials and blocks were five seconds and one minute, respectively. The transfer test occurred 10 minutes after the last block ended. It involved 10 trials with a modified wooden stick (*bo*). The choice for the transfer test was due to the characteristic of the sample. It was observed that there would be loss of subjects if a retention test was performed later. Also, the choice for this transfer test, in particular (use of the *bo*) came with the forms previously tested in a pilot study, in which it was agreed that the use of the *bo* would be the most practical to apply with the subjects.

Prior to acquisition, participants received general instructions about the task, which consisted of participant watching a video in which an aikido expert (black belt) performed the *choku tsuki*. In this video, the expert performed the motor skill twice, once at normal speed and then in slow motion. After that, participant watched the video again and, during the slow motion demonstration researcher described what was being done by the video specialist and made it clear that the *choku tsuki* task was a counterattack motor skill. This way of presenting general instruction to participants was previously tested during the pilot study. Then, specific cues were provided once to each group at the beginning of each block of trials. General verbal instruction was accompanied by watching a thirty second video (visual instruction) of an expert performing *choku tsuki* at a slow and regular speed. These instructional procedures were repeated at the beginning of each day. Participants were positioned in relation to the cameras, and performed five trials for familiarisation with the experimental situation. This allowed them to check the velocity with which the target moved, and to adjust their counter-attacking movements. The content and focus of the cues, the number of trials, and the design of the learning test were determined based on pilot studies.

Measures

The dependent variables included measures related to the task goal (overall performance) and movement pattern (task component checklist and kinematic).

(a) Overall performance. Since the task was to hit the center of a target, while the attacking opponent was holding a wooden sword above its head, overall performance was determined by two main measures: (1) target error (TE), which was the difference (cm) between the target center and the hit location; and (2) sword hilt positioning error (SHE), which was the difference (cm) between the sword hilt positioning at the target hit and its position centrally above the head. In order to obtain SHE, it was known that the opponent's sword hilt should be at a distance of 10cm from the top of the image screen that was projected on the wall. Thus, through this measure, it was observed whether the opponent's sword hilt was at the ideal counterattack point when the participant made the target hit. Thus, overall performance (OP) = SHE + TE. Based on this measure, scores nearer to zero represented better performance by the participant.

(b) Movement pattern components. These were analysed by a checklist containing eleven items, divided into starting position (SP) and initial (phase 1) and final (phase 2) movements of the upper and lower limbs (Table 1). This checklist was created and its content was validated by 17 aikido experts (black belts), and it was also validated for reproducibility by four aikido experts (black belts). The intra-rater correlation coefficient value was $r = 0.9$, $p < 0.05$.

Table 1. Checklist of *choku tsuki* movement pattern

STARTING POSITION	PHASE 1 UPPER LIMBS	PHASE 1 LOWER LIMBS	PHASE 2 UPPER LIMBS	PHASE 2 LOWER LIMBS
Left leg forward, with base in triangle shape, due to position of feet.	Left hand pushes the stick, along with hip, so that it begins to change from vertical to horizontal. Right hand assists in shifting position of stick.	Left leg moves forward.	Right hand pushes stick forward, aided by the movement of the hips, and the left hand loosens slightly so that the stick slides through it, performing the hit.	Right leg follows the movement of the left leg, which went forward.
	Right hand holds tip of stick that was placed on ground.	Left knee should be flexed, and right knee may also be flexed.	Both hands perform a twisting motion. Right hand rotates stick to the left and inwards, and left hand turns stick to the right and outwards.	Left knee should be flexed, and right knee may also be flexed.
	Right hand pulls stick back simultaneously with aid of hip movement. Left hand remains still.		Right elbow should end movement flexed at a 90° angle. Left elbow should end movement extended, at an angle of 180°.	

Source: Authors

Analysis consisted of watching the performance of participants from video footage and assigning a score for each item: 9, if it was performed completely; 3, if it was only partially performed; and 1, if it was not performed. Thus, scores for each item in the block of trials varied from 10 to 90. From these scores, a rate of movement pattern performance (RMP) was calculated as $RMP = \Sigma S \div SP$, where S refers to the sum of scores in blocks of ten trials and SP is the maximum possible score to be achieved for this same block. The arithmetic mean involving all items determined the general rate of movement pattern performance (GR). Therefore, the closer GR was to 1, the better the movement pattern performance.

(c) Kinematic measures. Using Kinovea Video Editor 0.8.15 software, the following measures were obtained from the calibrated environment: (1) distance between crist iliac and floor (m), obtained by mean from the hip distance to the ground in the two phases of the movement; (2) peak strike velocity (m/s), obtained by tracking the tip of the stick (performed automatically by the Kinovea software); (3) stick displacement (m), obtained through tracking the tip of the stick (performed automatically by the Kinovea software); and (4) difference between upper and lower limb movement times (upper and lower limbs synchronisation; s).

Data analysis

Statistical procedures were preceded by analyses of the nature of the data, by assessing sampling size and proximity of mean and median values for each group. A mixed model analysis of variance (ANOVA) 4 x 3 (groups x blocks) was run with data from the overall performance, movement pattern, and kinematic measures. For this purpose, first (baseline) and last acquisition blocks, and transfer blocks were considered. Significant observed effects were followed up using Tukey's honestly significant difference (HSD) post-hoc test. As an indicator of effect size partial eta squared (η^2) was used. For all analyses, the level of significance was set at $p < 0.05$, using Statistica® 12 software (StatSoft Inc., Tulsa, OK, USA).

Results

Overall performance

A 4 x 3 mixed model ANOVA revealed main effects of interaction between groups and

blocks of trials [$F(6, 112) = 1282.55$, $p < 0.01$, $\eta^2 = 0.98$, $1-\beta = .99$]. The Tukey's HSD test showed that perceptive and low hip groups reduced the error from baseline to last acquisition block and transfer ($p < 0.01$). It also showed that the perceptive group had a lower error to the low hip, relaxation and control groups for the last acquisition block and transfer ($p < 0.01$), and that the low hip group had a lower error to the relaxation and control groups ($p < 0.01$).

Movement pattern

A 4 x 3 mixed model ANOVA revealed main effects for interaction between groups and blocks of trials [$F(6, 112) = 3939.00$, $p < 0.01$, $\eta^2 = 0.99$, $1-\beta = .99$]. Tukey's HSD test showed that all groups increased their rate of movement pattern performance from baseline to the last acquisition block and transfer ($p < 0.01$). Furthermore, it was verified that low hip group had a higher rate than the perceptive, relaxation and control groups in the last acquisition block and transfer ($p < 0.01$), and the perceptive group had a higher rate than the relaxation and control groups ($p < 0.01$).

Kinematic measures

A 4 x 3 mixed model ANOVAs revealed main effects for interaction between groups and blocks of trials for the following measures: distance between hips and floor [$F(6, 112) = 133.50$, $p < 0.01$, $\eta^2 = 0.87$, $1-\beta = .99$], peak strike velocity [$F(6, 112) = 117.70$, $p < 0.01$, $\eta^2 = 0.86$, $1-\beta = .99$], stick displacement [$F(6, 112) = 1217.20$, $p < 0.01$, $\eta^2 = 0.98$, $1-\beta = .99$] and difference between upper and lower limb movement times [$F(6, 112) = 266.99$, $p < 0.01$, $\eta^2 = 0.99$, $1-\beta = .99$].

Regarding the distance between the hips and the floor, Tukey's HSD test showed that it was diminished for the low hip group from baseline to the last acquisition block and transfer, and its distance was lower than for the other groups ($p < 0.01$). For peak strike velocity, Tukey's HSD test showed that all groups increased it from baseline to the last acquisition block and transfer. Furthermore, the perceptive group had a higher peak strike velocity than the low hip, control and relaxation groups in these last two blocks ($p < 0.01$). In this same vein, the low hip group was superior to the relaxation and control groups ($p < 0.01$). Concerning stick displacement, the perceptive and low hip groups increased the distance from baseline to the last acquisition block and transfer. In addition, the perceptive group had a higher stick displacement than the low hip group, and both had superior values to the relaxation and control groups in the last two blocks ($p < 0.01$). Finally, the post-hoc test showed that the low hip and perceptive groups had a diminished difference between upper and lower limb movement times (i.e., increased synchrony) from baseline to the last acquisition block and transfer. In addition, the low hip group had a lower time than the perceptive group, and both had lower times compared to the relaxation and control groups ($p < 0.01$) (Figure 2).

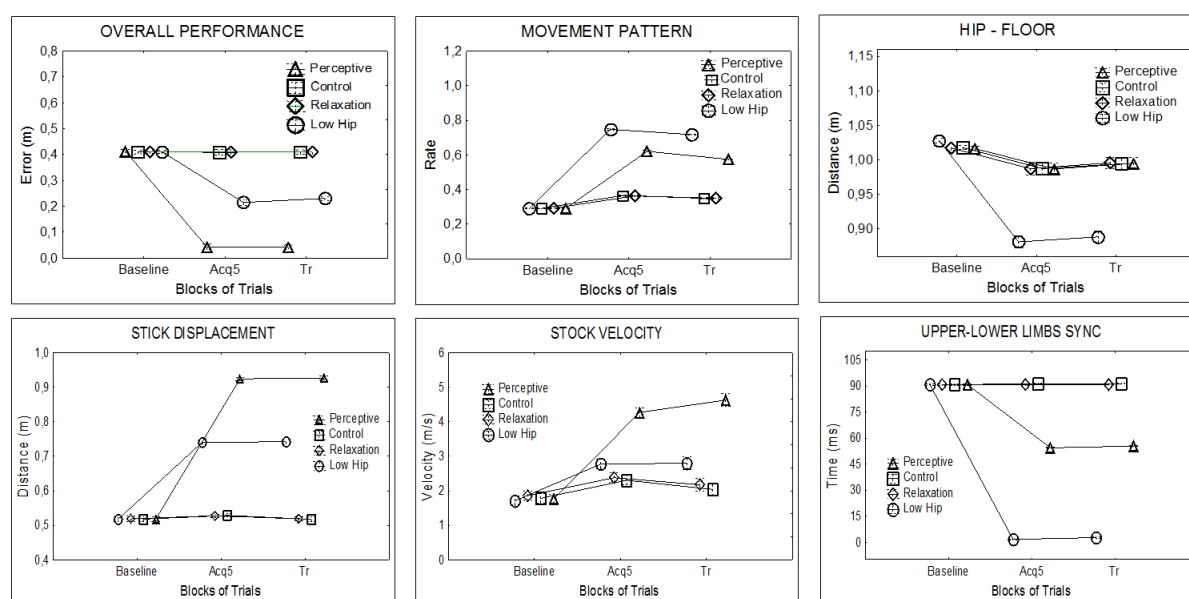


Figure 2. Means of overall performance, movement pattern components and kinematic measures (distance between hips and floor, peak strike velocity, stick displacement and upper and lower limbs synchronization), of the relaxation, low hip, perceptive control groups, in blocks of trials (baseline, last acquisition and transfer)

Source: Authors

Discussion

This study investigated the effect of perception, relaxation and low hip instructional foci on the learning of an aikido motor skill, *choku tsuki*. Only the perceptive and low hip groups learned the motor skill, as they showed improvement in overall performance from beginning to end of the acquisition phase and maintained it in the transfer test. In addition, the perceptive group showed better overall performance than the other groups.

These results support the proposed hypothesis. As previously described, effects of instructional cues are closely related to the information to be transmitted and the nature of the task. As for many human motor skills, *choku tsuki* involves the interaction of several components: starting position, upper limbs phase 1, lower limbs phase 1, upper limbs phase 2 and lower limbs phase 2. As each component of the motor skill has a specific function³⁶ we could assume that each of them could be a focus of instruction, as an essential aspect of performance. In fact, this has been the focus of numerous research on tips developed over the past decades, that is, they have manipulated the learner's attention in relation to some aspect of the movement pattern. Moreover, it is important to note that their emphasis has been on the learning or performance of closed motor skills (e.g. gym, dance, swimming)^{30,31,37,38}. According to Edwards¹⁷, this refers to a skill in which action occurs in a stable and predictable environment. However, the successful use of instructional cues depends on how well they are designed and implemented^{12,20,36}. In this regard, knowledge of the task is fundamental for establishing a hierarchy of learner needs to improve performance. Thus, despite the importance of the above components, the participants work to strike a moving opponent. Therefore, it seems that the aim of the *choku tsuki* (to defend by counter-attacking based on the opponent's movement) should be considered as the main instructional focus through cues^{12,20,33}. It is interesting to note that, although there are recognized teaching suggestions considering the open nature of motor skills, that is, those performed in unstable environments (e.g. baseball, tennis, volleyball), little attention was paid to them in terms of research³⁹.

It is possible that the cue “strike target as soon as sword is raised” enhanced the perceptive attunement of the participant to the moving opponent, so that they were able to make the appropriate adjustments with adequate timing and accuracy. This could explain the main kinematic differences between the perceptive group and all the other groups, peak strike velocity and stick displacement. The attentional focus on the moving opponent might have induced the participants in the perceive group to increase the velocity and amplitude of their movements more than those in the remaining groups, facilitating the hit on the opponent while its sword was moving up or down. One could say that the displacement amplitude and velocity of the stick were a function of the velocity by which the opponent was attacked. To put it in another way, decisions on how to perform were made on the basis of what was perceived¹⁹.

Interestingly, the instructional cue for the low hip group was also beneficial for learning, although to a lesser extent than the perceptive cue. In this case, it was possible that the cue “keep hips as low as possible” directed the attention of the participant to the movement base. This lowered the centre of gravity by diminishing the distance between the hips and the floor, in comparison to those in the relaxation and control groups. This might have resulted in an increase in the base of support and balance control during the performance of *choku tsuki*²⁷. In fact, the maintenance of a low centre of gravity within a strong base of support has been related to control of balance, which allows individuals to adopt various postures, react to various external disturbances and use anticipatory postural adjustments preceding voluntary movements⁴⁰⁻⁴³.

A question that remains is why the relaxation cue did not affected motor skill learning. Based on aikido literature, this would have encouraged the participant to not use too much muscle strength, so they could focus solely on the opponent²⁷. Maybe, instead of directing the attention of participants to a relaxed mode, such as when the model performed the skill, the cue “head up and loose joints” could have led them to pay attention to the relationship between specific body parts, such as shoulders and ears. As such, an alternative cue for performing the motor skill in a relaxed manner could be investigated. This could also be pointed out as a limitation of this study, since was not possible to access, in fact, whether the subjects were relaxed or not during performance of the *choku tsuki*. The way in which this aspect was observed was something very subjective.

Conclusions

This study showed that the learning of *choku tsuki* from aikido benefited from an instructional cue “strike target as soon as sword is raised”, which increased the perceptive attunement of the learner to the moving opponent. Learning also took place with the cue “keep hips as low as possible”; however, but at a lower level than that with the perceptive cue. These results indicated that *senseis* should teach motor skills emphasising, firstly, the key characteristics of the moving opponent with regard to the purpose of the learner’s motor skills, and secondly, the basis that allows motor skills to be performed with proper balance control. For generalisation of these conclusions further studies will be required, including those trying to replicate our findings in different contexts as well. Further investigations should also analyse whether an alternative cue for relaxation would affect the learning of motor skills associated with aikido.

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