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VERBAL INSTRUCTIONS ON LEARNING THE FRONT-CRAWL: EMPHASIZING A SINGLE COMPONENT OR THE INTERACTION BETWEEN COMPONENTS?

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ABSTRACT

Purpose. In Front-Crawl swimming stroke, the interaction between two of its components, i.e. arm stroke and breathing, affects the performance of the motor skill as a whole and therefore can be considered a critical aspect of the skill. The purpose of our study was to investigate if a verbal instruction emphasizing this interaction could lead to learning gains when provided along with video demonstrations. **Methods.** Participants (children) were randomly assigned to three experimental groups according to the type of verbal instruction provided. Component and Interaction groups received their specific instructions along with video demonstrations of a model execution of the Front-Crawl. The Control group watched the same video, but received no further instruction concerning the movement pattern. In the Acquisition phase (AQ) all groups performed 160 trials (organized in 4 sessions) of the task that consisted in swimming 8 meters the Front-Crawl at a comfortable velocity. To assess learning gains, a retention test (RT) and a transfer test (TR) were carried out one week after the end of the AQ. **Results.** Regarding RT and TR, the one-way ANOVA on the movement pattern score showed a significant difference between groups, with post-hoc tests revealing that the Interaction group achieved higher score than the Control group. **Conclusions.** The results reveal that enhancing aspects of a video demonstration with verbal instruction improves learning gains of the Front-Crawl in children. Additionally, the results suggest that providing verbal instructions about the interaction between stroke and breathing might promote learning gains, compared to providing instructions about the stroke component individually.

Key words: motor learning, swimming, observational learning, verbal cues, ecological validity

Introduction

Efficient performance in Front-Crawl swimming has been associated with the pattern of interaction between the action of the arms in skilled swimmers [1]. The importance given to this pattern of interaction is due to the fact that it modifies the ability to produce propulsion and, therefore, a swimmer's efficient forward movement [2]. Although the arm stroke is the most investigated component of the Front-Crawl, since it produces about 90% of the swimming propulsion [3, 4], when considering the learning process it is essential to take other components into account [5]. A beginner, still refining their movement pattern, performs relatively inefficient body movements that generate more hydrodynamic resistance compared to an experienced swimmer [6].

In addition to emphasizing aspects that have the potential to produce hydrodynamic resistance, considering that the other components, besides the arm stroke, can also emphasize effects that one component has on another one, i.e. interdependence between them. For example, breathing can affect arm stroke efficiency [7–9]. In less skilled swimmers, breathing affects the relationship between the arms increasing the discontinuity of the forward movement [8, 9]. Furthermore, breathing can modify the timing [7], as well as the symmetry between arm strokes [8] in less proficient swimmers. Thus, considering the importance of the stroke to produce propulsion, the interdependence between arm strokes and breathing is a determinant factor of the swimming performance. In this sense, one could argue that the learning of the Front-Crawl could be enhanced by the use of instructions highlighting the interaction between these two components. Moreover, if the aim of an instruction is to convey information about 'what to do'and 'how to do it' [10], critical elements should be included to guide the learner towards an optimal movement pattern. In the case of the Front-Crawl, although breathing and arm strokes can be clearly identified as important components because of their contribution to performance (as shown above), it is not clear how they should be addressed during the learning phase is taking place. In other words, although their importance and interdependence is hard to question when it comes to performance, it is not clear whether the interaction between them is a critical element worth highlighting when the motor skill 'Front-Crawl' is being learned.

Studies investigating the effect of verbal instructions on the learning of complex motor skills are scarce. Regarding the effect an instruction emphasizing interac-

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tion can have in the learning of a motor skill, Masser [11] conducted an experiment to investigate the effects of two verbal instructions (cues) on the learning of the forward roll. Two groups received either of the two cues: 'forehead on knees' or 'keep yourself in a tight ball'. Both groups practiced the motor skill for three weeks and were tested two months after the end of an acquisition period (retention test). The group receiving the cue considering the interaction between two body parts ('forehead on knees') showed superior performance in the retention test. In a study carried out by Wulf and Weigelt [12], participants learned how to perform oscillatory movements on a ski simulator. Specifically, the task involved moving the platform of the ski simulator rhythmically as far as possible left and right. The results indicated that the group receiving verbal instruction about the mechanical principles of the skill (the moment one should apply force on the platform to maximize performance) showed lower movement amplitude (worse performance) than the group without this instruction. The authors concluded that providing verbal instruction about mechanical principles of the skill considered difficult to verbalize can be detrimental to learning. In this sense, in order to be effective, a verbal instruction should not only highlight the critical aspect of the skill being learned, but also be structured in a way that is meaningful to the learners.

The aim of the present study was to investigate whether a verbal instruction emphasizing the critical aspect of the Front-Crawl – i.e. the interaction between arm stroke and breathing – could lead to learning gains when provided along with video demonstrations. Specifically, the verbal instruction emphasizing the component 'stroke' was given to the Component group and the verbal instruction emphasizing the interaction between the components 'stroke' and 'breathing' (i.e. the *moment* during the stroke cycle in which the two components can be meaningfully linked together) was given to the Interaction group. Both groups received these instructions in addition to watching a video demonstration of the model task execution. Control group watched the same video, but received no further instruction concerning the movement pattern that characterizes the Front-Crawl.

Considering the interdependence between the components 'stroke' and 'breathing', we expected to observe better learning (retention and transfer) of the movement pattern for the Interaction group. Furthermore, we expected that both groups receiving verbal instruction (Interaction and Component), in addition to the video demonstration, would show better learning (retention and transfer) of the movement pattern than the group receiving only the video demonstration (Control group).

Material and methods

Participants

An invitation to participate in the research was published in a local newspaper of Atibaia city – State of São Paulo – and in leaflets distributed to private and public schools. We employed the following inclusion criteria: chronological age between 12 and 13 years, no prior experience with the task, and ability to perform basic aquatic skills: buoyancy, submersion and blow bubbles with the whole face in the water – respiratory control [13]. Reporting fear of water was an exclusion criterion. Out of the group of 90 children attending the initial meeting, 53 agreed to participate, but only 21 took part in the study submitting consent forms signed by their parents. There was only one dropout during the study, totaling 20 participants (8 boys and 12 girls, mean age = 12 years old, *SD* = 0.63) – Figure 1. The study was approved by the local Ethics Committee of the School of Physical Education and Sport – University of São Paulo.

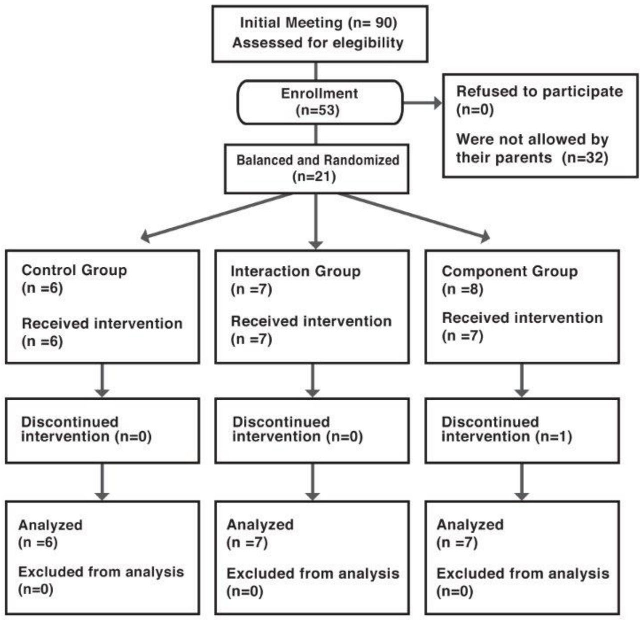

Figure 1. Flow diagram of participants' recruitment

Task and procedures

Participants were randomly assigned to three experimental groups, according to the verbal instruction provided. The Component group received instruction emphasizing only the 'arm stroke' component: 'push the water back with your hand'. This verbal instruction was the same employed by Freudenheim et al. [14].

The verbal instruction provided to the Interaction group based on the one received by the Component group, but emphasized the interaction between 'stroke' and 'breathing'. Specifically, the *moment* in the stroke cycle in which breathing should take place was added to the previous instruction: 'push the water back with your hand and, at the end of the arm stroke, turn your face to breathe'. Participants allocated in the Control group did not receive any verbal instruction concerning the movement pattern. It is important to clarify that the instructions mentioned above were provided in Portuguese using ordinary expressions.

All groups, including the Control group, watched a video that showed a model execution of the Front-Crawl Stroke. This procedure was adopted considering the evidence supporting that verbal instruction combined with demonstration leads to more learning gains than when provided alone [15–18].

The experiment consisted of four phases: Entry Test (ET), Acquisition phase (AQ), Retention Test (RT) and Transfer Test (TR). Each AQ and test trials consisted in leaving an underwater platform, swimming 8 meters using the Front-Crawl at a comfortable velocity, and finishing the trial touching the edge of the pool. Participants performed all AQ and test trials individually, and were recorded performing the task with a camera Sony Cyber-Shot DSC-H9 (640 × 480 @30Hz) positioned laterally to the direction of the forward movement.

Before starting the ET, all participants were familiarized with the research environment by swimming freely from the starting platform to the edge of the pool three times. The ET consisted of five trials in which the participants were told to swim using the Front-Crawl – 'as they knew it' – without watching the video demonstration. This procedure aimed to ensure that all participants were in a similar condition before starting the experiment. The AQ consisted of four practice sessions (AQ1, AQ2, AQ3, and AQ4), ranging from two to three times a week, according to the availability of each participant. Each session comprised eight sets of five trials, with twenty seconds of interval between the trials and two minutes between the sets. In the AQ all groups performed a total of 160 practice trials.

Before starting each practice session, participants completed three trials of familiarization as described above, and then the video demonstration was shown three times. The verbal instructions for the Component and Interaction groups were provided at the beginning of each AQ session, between the video presentations and in the interval before each set of trials. At the end of each AQ session the Borg Scale of Perceived Exertion was applied to verify the fatigue level of the participants. Participants in the Interaction and Component groups were also asked to complete an attention questionnaire at the end of each session in which they answered 'yes' or 'no' to the question whether they had paid attention to the instructions provided. After the last practice session (AQ4), participants were instructed not to practice the task for a week. The RT, performed after this one-week interval, consisted of 10 trials with the same procedures as in the AQ but without any verbal instruction concerning the movement pattern or video demonstration. Before the test, participants were asked to recall the verbal instructions and video demonstrations provided in the AQ to perform the Front-Crawl. The TR began fifteen minutes after the end of the RT and followed the RT procedures, with no verbal instruction or demonstration provided. However, in the TR all participants were asked to swim as fast as possible in each trial, performing two sets of five trials and resting for one minute between the trials and five minutes between the sets. After the TR, participants' height and weight were measured.

Measures

The score regarding the movement pattern (Score) and the time needed to complete the task were the dependent measures of interest. The Score was obtained from a Front-Crawl Stroke checklist [19]. The referred checklist includes an additional item that allows the evaluation of the head position, and removes items related to water entry, buoyancy and movement combinations from the originally proposed checklist. These changes aimed a better evaluation of the Front-Crawl stroke by minimizing items related to water adaptation. Arm propulsion and arm recovery were also merged in one new item that evaluates arm actions. Therefore, the checklist used in this study appraises the actions of five components of the Front Crawl: body position, head position, breathing, arm actions and leg actions.

The recordings of the third and fourth stroke cycle of each trial were analyzed according to the checklist. Each Front-Crawl component was assessed and rated on a scale rating ranging from 1 to 5, corresponding to the least efficient movement pattern and the most efficient movement pattern, respectively. The percentage of occurrence of each rating, in each block, was multiplied by its corresponding relative ratio, from one to five, resulting in 5 values, one for each component. The Score of each participant, varying from a minimum of 100 to a maximum of 500, was produced by the sum of these 5 values, per block of trials.

All recorded trials were analyzed by one swimming coach expert using the above mentioned checklist. To evaluate intra-observer reliability, the expert reassessed all the ET trials one month after the first assessment. Reliability was measured with the Inter-Observer Agreement procedure – IOA – resulting in an agreement of 0.90.

The time needed to complete the task was registered by the experimenter with a digital chronometer, beginning when the participant left the starting platform and finishing when they reached the edge of the pool.

Data analysis

Homogeneity of variance (Levene's test) and sphericity (Mauchly's test) were verified before performing all analyses. One-way ANOVAs with repeated measures were performed for both dependent measures, for each group and block (sessions) of the AQ (AQ1-AQ4) to verify performance improvements in practice. One-way ANOVAs were also performed for the anthropometric measures and for both dependent measures to compare groups in each test (ET, RT and TR). Sequential *t*-tests with False Discovery Rate correction [20] were employed as *post hoc* tests. Significance level was set at $\alpha = 0.05$.

The Borg Scale of Perceived Exertion data did not meet the assumptions for parametric analysis and the Kruskal-Wallis tests were carried out to verify the differences in perceived exertion. Data were organized, analyzed and plotted using R, a language and environment for statistical computing [21].

Results

Complementary measures

With respect to the attention questionnaire, all participants of the Component and Interaction groups reported paying attention to the verbal instructions provided.

No differences between groups were detected in perceived exertion (Borg Scale of Perceived Exertion) in any experimental phases, indicating comparable fatigue for all groups. Additionally, no differences between groups were found regarding height or weight, indicating that those anthropometric measures were similar for all groups.

Movement Pattern

No differences were found between groups in the ET, $F(2,17) = 0.06$, $p > 0.05$, $\eta^2_G < 0.01$, indicating equivalent movement pattern at the beginning of the experiment for all groups (Figure 2).

With respect to the AQ, no differences were detected between blocks of trials in the Component or the Control group, $F(4, 24) = 1.98$, $p > 0.05$, $\eta^2_G = 0.18$ and $F(4, 20) = 2.4$, $p > 0.05$, $\eta^2_G = 0.20$, respectively. Conversely, a difference between blocks was detected in the Interaction group, $F(4, 24) = 9.12$, $p < 0.05$, $\eta^2_G = 0.39$. The post hoc test revealed a lower Score in the first block compared to all the remaining blocks, indicating that participants in the Interaction group enhanced their performance in the AQ. As shown in Figure 3, throughout the AQ, the Interaction group ceased receiving '1' (the lowest rating in the movement pattern checklist), reduced the percentage of '2' and '3' and increased the percentage of '4' and '5', suggesting a distinctive improvement in the movement pattern for this group compared to both Control and Component groups.

With regard to the RT, one-way ANOVA on the Score found a significant difference between groups, $F(2, 17) = 3.72$, $p < 0.05$, $\eta^2_G = 0.30$, with post hoc tests revealing that the Interaction group achieved higher Score than the Control group. As can be seen in Figure 3, the Interaction group showed a lower percentage of low and intermediate ratings ('1', '2' and '3') and a greater percentage of higher ratings ('4' and '5') compared to the other groups. Similar results were found for the TR. Specifically, a difference between groups was found, $F(2, 17) = 4.49$, $p < 0.05$, $\eta^2_G = 0.34$, and post hoc tests indicated that the Interaction group achieved higher Score than the Control group. Despite the lack of statistical significance between the Score in the RT and the TR (Figure 2), a qualitative comparison between the Interaction and the Component groups reveals that the Component group showed a greater percentage of lower ratings compared to the Interaction group (Figure 3), which suggests a better movement pattern of the participants in the Interaction group.

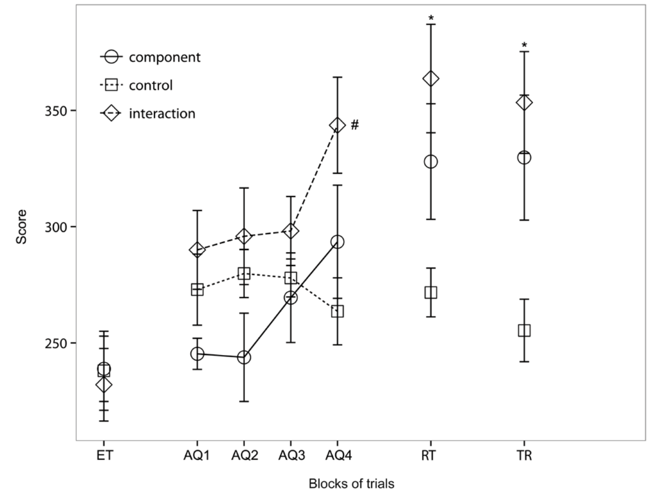

Figure 2. Movement pattern Score in all experimental phases – ET: entry test; AQ1-AQ4: first to fourth acquisition blocks; RT: retention test; TR: transfer test.
significant differences between blocks;
* significant differences between groups

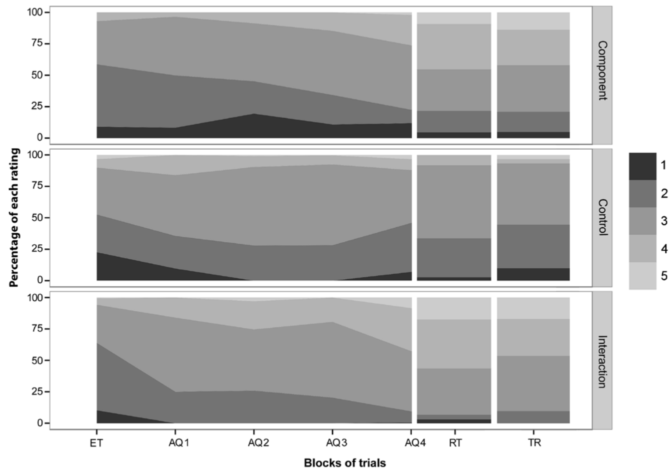

Figure 3. Percentage of ratings assigned to participants (ranging from 1 to 5) in all experimental phases – ET: entry test; AQ1-AQ4: first to fourth acquisition blocks; RT: retention test; TR: transfer test

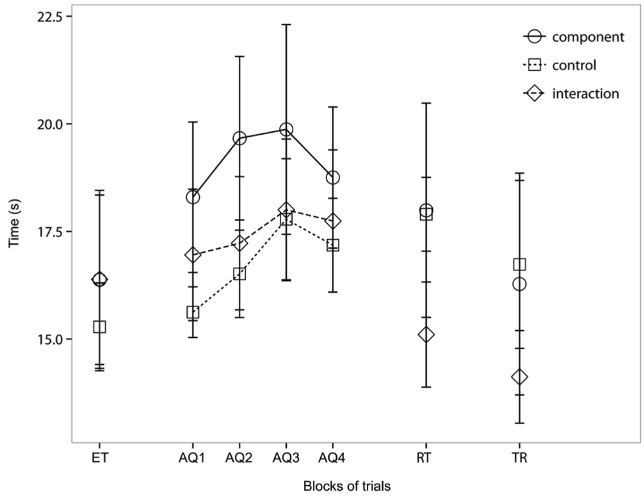

Figure 4. Mean time needed to complete the task in all experimental phases – ET: entry test; AQ1-AQ4: first to fourth acquisition blocks; RT: retention test; TR: transfer test

Time to complete the task

With respect to the ET, one-way ANOVA found no differences between groups in the time needed to complete the task, $F(2, 17) = 0.11$, $p > 0.05$, $\eta^2_G = 0.01$, indicating that all participants began the experiment swimming with similar efficiency. With regard to the AQ, repeated measures ANOVA found no differences in the time needed to complete the task for the Component and Interaction groups, $F(4, 24) = 2.13$, $p > 0.05$, $\eta^2_G = 0.06$ and $F(4, 24) = 1.04$, $p > 0.05$, $\eta^2_G = 0.01$, respectively. A difference between blocks was found for the Control group, $F(4, 20) = 5.29$, $p < 0.05$, $\eta^2_G = 0.13$, but the post hoc test was unable to locate the differences. Although the Interaction group showed better performance compared to both Control and Component groups in the RT and TR tests (Figure 4), one-way ANOVA found no differences between groups regarding the time needed to complete the task.

Discussion

The present study aimed to investigate whether verbal instructions focusing on different elements of the Front-Crawl would affect the learning of the motor skill. The study was based upon two premises: (1) a verbal instruction provided along with demonstrations of the motor skill being learned is more efficient if constituted by critical elements of this motor skill; (2) the interdependence between breathing and stroke can be considered a critical element of the Front-Crawl, given the effect the former has on the latter [7–9]. Thus, we expected to observe better learning of the movement pattern (retention and transfer) in the group receiving instruction about the interaction between those two components (stroke and breathing) compared to receiving the instruction focusing on the stroke component alone. Furthermore, we expected that receiving verbal instruction, in addition to the video demonstration, would lead to better learning compared to receiving the video demonstration only (Control group).

Anthropometric measurements and the Borg Scale of Perceived Exertion indicate that the possible effects of the independent variable cannot be attributed to sample heterogeneity or differences in the effort required by each specific condition.

With regard to the AQ, results indicate that providing verbal instructions focusing on different elements of the Front-Crawl did not affect the acquisition process since there was no difference between groups during this phase. However, participants of the Interaction group improved their movement pattern between the first and last session of the AQ, which was not observed in the other groups. This improvement underscores the increasing number of higher ratings obtained by the Interaction group, while the other groups, despite performing the same number of trials, obtained lower ratings during the AQ.

With regard to the RT and TR tests, the results indicate that providing verbal instruction focusing on the interaction between arm stroke and breathing brings learning gains compared to the presentation of the video demonstration only. Most studies investigating the relationship between demonstration and motor performance adopted Bandura's Social Learning Theory [22], which suggests that learners form a cognitive representation of a motor skill through observing a model, and that this representation subsequently guide their motor performance. However, our results indicate that the demonstration itself does not suffice to form this cognitive representation of the Front-Crawl. Specifically, the group receiving only the video demonstration showed no improvement in performance during the AQ phase, maintaining the same level of performance during the RT and TR tests. An explanation for this result is that participants failed to extract the relevant information from the model to benefit in practice. Our findings corroborate previous studies investigating the effects of providing verbal instructions and demonstrations which showed that demonstration combined with verbal instruction leads to better learning than when provided separately [15–18].

The combined use of instruction and demonstration as a way of guiding learners to an optimal motor performance was shown to benefit the learner only when part of what is being learned is already in the learner's repertoire [10]. Our results do not corroborate with this statement, since all participants of the present study had no previous experience with the experimental task (Front-Crawl) and those who received demonstration associated with verbal instruction showed learning gains. One explanation for this incongruence is that the tasks used in previous studies [12, 23, 24] had a lower degree of complexity compared to the Front-Crawl. In this sense, it is reasonable to suppose that as task complexity increases, also the need of information to guide the learner to key aspects of the skill increases.

The verbal instruction provided to the Interaction group was longer than the one provided to the Component group. In this sense, one could argue that this could overload the learner's attentional resources, especially in the initial phase of learning [12]. However, our results do not give support to this interpretation, since the participants in the Interaction group not only did not show any impairment at the beginning of the AQ compared to the other groups, but improved their movement pattern during the AQ phase, which was not observed for the other groups.

With respect to our prediction that the effectiveness of the instruction would depend on whether critical aspects of the motor skill being learned are included [11, 25], the lack of statistical difference between the Component and Interaction groups fails to strongly support this hypothesis. Nevertheless, a descriptive analysis of the ratings obtained by those groups – during the AQ and both tests – suggests that the group receiving instruction about the interaction between stroke and breathing showed qualitatively superior movement pattern compared to the one receiving instruction about the stroke component only. Additionally, inferential analysis indicated that the groups completed the task within similar time, both during the AQ and in the RT and TR tests. Nevertheless, descriptive results indicate that the Interaction group needed less time to complete the task in the TR and RT tests, which suggests that the qualitatively better movement pattern was also the more efficient in the displacement of the swimmer. Considered together, these results do not rule out the hypothesis that instructions including critical aspects of the motor skills benefits learning, especially those with interdependence between the components, as is the case of the Front-Crawl. This issue, in this sense, remains open and should be tackled in future studies.

Conclusions

The results of this study clearly indicate that enhancing aspects of a video demonstration with a verbal instruction improves learning of the Front-Crawl in children, compared to providing video demonstration only. Additionally, there were indications that providing verbal instructions about the interaction between the components of stroke and breathing might promote better learning gains compared to the instructions about the stroke component alone.

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