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# THE EFFECT OF CONCURRENT VISUAL FEEDBACK ON CONTROLLING SWIMMING SPEED

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**Abstract**

***Introduction.*** Developing the ability to control the speed of swimming is an important part of swimming training. Maintaining a defined constant speed makes it possible for the athlete to swim economically at a low physiological cost. The aim of this study was to determine the effect of concurrent visual feedback transmitted by the Leader device on the control of swimming speed in a single exercise test. ***Material and methods.*** The study involved a group of expert swimmers (n = 20). Prior to the experiment, the race time for the 100 m distance was determined for each of the participants. In the experiment, the participants swam the distance of 100 m without feedback and with visual feedback. In both variants, the task of the participants was to swim the test distance in a time as close as possible to the time designated prior to the experiment. In the first version of the experiment (without feedback), the participants swam the test distance without receiving real-time feedback on their swimming speed. In the second version (with visual feedback), the participants followed a beam of light moving across the bottom of the swimming pool, generated by the Leader device. ***Results.*** During swimming with visual feedback, the 100 m race time was significantly closer to the time designated. The difference between the pre-determined time and the time obtained was significantly statistically lower during swimming with visual feedback (p = 0.00002). ***Conclusions.*** Concurrently transmitting visual feedback to athletes improves their control of swimming speed. The Leader device has proven useful in controlling swimming speed.

**Key words:** motor control, concurrent feedback, visual information, swimming speed

## Introduction

This paper deals with the optimisation of the process of improving swimming technique from the point of view of mechanics and energetics. Important insights concerning this process have stemmed from new lines of research [1, 2, 3]. Many recent studies have undertaken issues related to the processing of information, recognising it as an important aspect in learning and improving swimming technique [4, 5]. The foundation of the development process of improved swimming technique is the classical theory of information. This theory assumes that information received from the environment is processed on the way between the receptor and the effector, which results in the formation of a motor response [6]. This means that the swimmer responds to information from exteroceptors (hearing and vision) and proprioceptors (vestibular receptors in the muscles, joints, and skin). Therefore, one of the key roles of the teacher or trainer in the process of learning and technique improvement is to provide feedback regarding the level of the swimmer's control of their motor function. Feedback is sensory information that results from movement [6]. There are two types of feedback: intrinsic (integral) and extrinsic [6]. Intrinsic feedback is the sensory information arising as a result of physical activity by means of sensory mechanisms (exteroceptors and proprioceptors). Information that derives from the receptors allows for movement regulation as well as the adjustment of motor task completion to the desired model of physical activity. However, not always does the information obtained impact on the proper execution of a motor task.

This happens in particular when the motor action is performed under difficult conditions, for example in a water environment in which the athlete's perception is impaired. In such situations, extrinsic feedback becomes indispensable [7, 8]. Extrinsic feedback (augmented feedback) is generated after the completion of a motor activity and is transmitted by a third party [9, 10]. Augmented feedback is added to that typically received in the task [6]. One of the functions of extrinsic information is supplementing the information derived from internal sources. Extrinsic feedback can also be motivating and reinforcing, and it may help raise the level of performance of physical activities. Examples of extrinsic feedback include verbal communication, gestures, video display, and timer display [4, 11, 12, 13]. It may be transmitted by means of verbal and non-verbal communication, such as facial expressions or body language [14, 15]. The teaching and improvement of swimming technique is effective when extrinsic feedback is transmitted in three forms: words, images, and actions. There are several distinct types of feedback which are categorised according to the time of its transmission: concurrent feedback (provided during continuous motor tasks), immediate feedback (provided during non-continuous motor

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tasks) and delayed (transmitted after the completion of the motor action) [6]. Research has proven that the most effective feedback is immediate feedback [6, 16, 17, 18].

Due to the existence of several factors disrupting communication while providing instruction on how to improve swimming skills (the noise, head submerged in the water, swimming caps, etc.), special devices have been created in order to improve the quality of feedback transmission [4, 5, 19, 20]. One such tool is the optical fibre device Leader (Kuca Ltd., PL), which gives the swimmer added feedback: the light beam provides the swimmer with information on the swimming speed. Developing the ability to control the speed of swimming is an important part of swimming training. Swimming with a defined constant speed helps athletes swim more economically and allows them to do so at a low physiological cost. Therefore, the development of a method that allows for the acquisition and improvement of this skill is an important issue in optimising swimming training.

The aim of this study was to determine the effect of concurrent visual feedback transmitted by the Leader device on the control of swimming speed in a single exercise test. An additional objective was to confirm the usability of the Leader device in swimming training. We hypothesised that concurrent visual feedback would improve the control of swimming speed.

## Material and methods

### *Participants*

The participants of the study were twenty expert swimmers (age: 19.30 ± 3.95 years, height: 178.20 ± 9.44 cm, weight: 71.60 ± 13.89 kg). The subjects had been engaging in regular swimming training for 7.35 ± 3.20 years. The swimmers were members of the city swimming team. The participants were not divided into groups according to gender. All the subjects gave written informed consent for participating in the research. The study was approved by the Senate Research Ethics Committee of the University School of Physical Education in Wrocław.

### *Measurement*

The visual feedback which guided the swimming speed was transmitted by the Leader device (Kuca Ltd., PL) (fig. 1), consisting of two parts: a controller and a run-time system. The controller is composed of a digital circuit with a voltage of 4 to 7 V. It provides a rectangular generating signal and start/stop signal. It is 6 V battery-powered, so it poses no danger to the swimmer. Used in the working version, the model (R1) consists of a starter

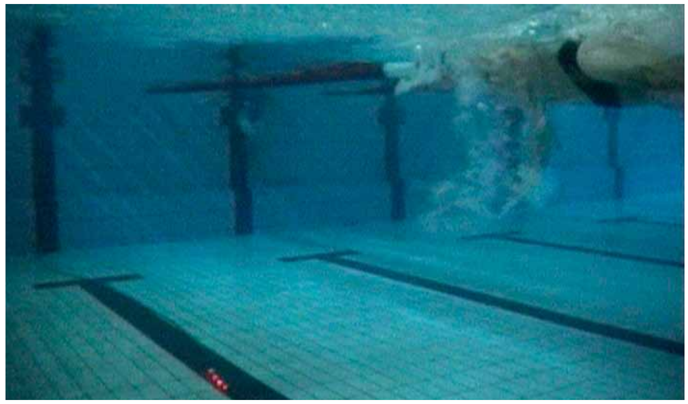

**Figure 2.** Leader device (Kuca Ltd., PL) installed on the floor of the pool

module, on which the swimming speed or pulse is set in real time and from which the speed can be read. The speed of the spot or pulse can be changed at any time. The cable connects the controller with the run-time system. The system has the form of an arterial tube with LEDs. The LEDs inside the tube are spaced at intervals of a few centimetres and connected by cable with the controller. This makes it possible for them to light up one after the other. The run-time system consists of five segments, which enables the adjustment of the speed according to need. The unit is installed by unwinding the arterial tube from the reel and laying it on the bottom of the pool, along with securing the whole system with weights (fig. 2).

### *Procedure*

The experiment was carried out at a 25 m long indoor swimming pool. Prior to the experiment, the swimming time for the 100 m test distance was established for each of the participants. The swimming time was determined based on a participant's personal best for the 100 m distance in freestyle, to which an additional 10 seconds were added. Adding 10 seconds to the personal best 100 m time guaranteed that the swimmers would swim with moderate intensity. Then, all the participants performed the experiment in two versions (without feedback and with visual feedback). In both variants, the participants were to swim the crawl stroke in a time as close as possible to the time designated prior to the experiment. In the first scenario (without feedback), the participants swam the test distance without receiving real-time feedback on their swimming speed. In the

a b

**Figure 1.** Leader device (Kuca Ltd., PL): a) controller, b) arterial tube with LEDs

second variant (with visual feedback), each participant followed the beam of light moving across the pool floor generated by the Leader device (Kuca Ltd., PL). The beam of light covered the test distance in exactly the time determined prior to the experiment. The time it took the swimmers to cover the test distance was measured electronically by means of the Colorado start system (Colorado Time System, USA) with an accuracy of 0.01 s. After each trial, the time differences between the time determined for each participant and the real time of covering the test distance in both variants were calculated. The time differences obtained for all of the participants were averaged and subjected to further statistical analyses to determine significance.

### *Statistical analysis*

Statistical analyses were performed with regard to the difference between the pre-determined swimming time and the real time of covering the test distance under the two conditions (without feedback and with visual feedback) (tab. 1). A t-test for dependent samples was used to determine differences that were statistically significant, at the $p = 0.05$ level of statistical significance. All of the calculations were made using Statistica 9.0 (StatSoft, USA).

## Results

**Table 1.** Differences in the time of covering the test distance under the two conditions (without feedback and with visual feedback). Δ is the absolute value of the difference between the pre-determined time and the time obtained

| No. | Pre-determined time (s) | Time obtained without feedback (s) | Time obtained with feedback (s) | Δ without feedback (s) | Δ with feedback (s) |
|---|---|---|---|---|---|
| 1 | 63 | 59.76 | 61.4 | 3.24 | 1.6 |
| 2 | 65 | 67.2 | 63.8 | 2.2 | 1.2 |
| 3 | 71 | 73.08 | 71.26 | 2.08 | 0.26 |
| 4 | 67 | 68.71 | 66.41 | 1.71 | 0.59 |
| 5 | 61 | 58.72 | 60.79 | 2.28 | 0.21 |
| 6 | 64 | 60.42 | 63.8 | 3.58 | 0.2 |
| 7 | 64 | 69.12 | 63.66 | 5.12 | 0.34 |
| 8 | 62 | 62.64 | 61.78 | 0.64 | 0.22 |
| 9 | 66 | 67.2 | 65.41 | 1.2 | 0.59 |
| 10 | 72 | 67.57 | 71.7 | 4.43 | 0.3 |
| 11 | 76 | 81.54 | 77.32 | 5.54 | 1.32 |
| 12 | 77 | 80.8 | 80.88 | 3.8 | 3.88 |
| 13 | 64 | 68.2 | 65.37 | 4.2 | 1.37 |
| 14 | 70 | 73.1 | 70.76 | 3.1 | 0.76 |
| 15 | 72 | 74.02 | 73.36 | 2.02 | 1.36 |
| 16 | 80 | 86.01 | 82.64 | 6.01 | 2.64 |
| 17 | 77 | 75.16 | 76.95 | 1.84 | 0.05 |
| 18 | 70 | 68.45 | 69.7 | 1.55 | 0.3 |
| 19 | 67 | 66.32 | 67.8 | 0.68 | 0.8 |
| 20 | 67 | 63.54 | 67.8 | 3.46 | 0.8 |
| | | | On average: 2.93 ± 1.57 0.94 ± 0.94 | | |
| | | | Test - t: P = 0.00002 | | |

The average difference between the pre-determined time and the time obtained during swimming with visual feedback was 0.94 (± 0.94). The average difference between the pre-determined time and the time recorded during swimming without visual feedback was 2.93 (± 1.57) (tab. 1). The difference between the pre-determined time and the time recorded was significantly statistically lower for swimming with visual feedback ($p = 0.00002$) (tab. 1).

## Discussion

The aim of this study was to determine the effect of concurrent visual feedback on the control of swimming speed in a single exercise test. It was hypothesised that the use of visual feedback transmitted concurrently would improve the control of swimming speed.

The study refers to the classical theory of education and the improvement of motor skills [21], in which information (verbal, visual, and sensory-kinesthetic) determines the effectiveness of performing physical activities. The optimisation of human movement from the point of view of information theory has become the subject of interest of many research studies [8, 15, 22], including those related to swimming [23]. Over the years, information has played an increasingly important role in research concerning the human motor sphere. The majority of the experiments conducted so far have involved mainly the influence of the quantity and frequency of information on the appropriateness of motor task performance as well as the duration of the teaching and improvement process [24, 25]. Authors have claimed that feedback is an important element of improving of motor function. Verbal transfer has been recognised as the most effective source of information [26]; however, due to communication barriers prevailing in the aquatic environment, it is of limited use in swimming training. That is why visual information is instrumental in teaching motor skills in swimming. Providing information on swimming speed plays a particularly important role in the training process, especially when the goal is to use it purely as a training stimulus.

Physical training is a dynamic process that requires an individual approach to the body of the person trained. Achieving better training results often requires searching for new methods and means of training. The use of visual feedback is one way to optimise the training process. Swimming at a rate imposed by the moving beam allows the swimmer to maintain the determined training-specific swimming speed. This makes it possible for them to accomplish the aim of the training which stems from physiological studies. Setting an individual rate of swimming which is to be maintained during the training is the key to optimisation and increases the chance of fast adaptation. For example, if the training goal is swimming with a rate corresponding to the aerobic threshold, the use of visual feedback can allow the swimmer to perform the task at the desired intensity. The lack of visual feedback, on the other hand, may cause them to swim at a different rate than the selected training rate.

## Conclusions

Controlling and adjusting swimming speed in real time allows the swimmer to perform movement with the desired intensity, which has been determined according to the goal of the training. The use of visual feedback transmitted concurrently improves the control of swimming speed. Such feedback can be provided by means of the Leader device, whose usefulness for controlling swimming speed in real time has been confirmed in the experiment. It is worth stressing that the device can be used in swimming training without restricting the movement of the swimmer, which has a positive effect on their achievement.

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