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ORIGINAL ARTICLE

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The Modulation of Verbal Information As a Factor Stimulating Conscious Differentiation of Kinaesthetic Sensations in the Aquatic Environment

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Key words: *kinaesthetic, verbal modulation, teaching*

Abstract

Background: *This study aims to find a relationship between the amplitude and duration of verbal information, and a conscious reaction to the kinaesthetic learner.*

Material/Methods: *Research participants in this study consisted of 40 children from elementary school No. 1 in Swidnica (Poland). The group consisted of 16 boys and 24 girls. The respondents' age ranged from 9 to 10 years. Children regularly attended swimming classes 3 times a week for 45 minutes. The method used for the research was the laboratory experiment method, where the aim was to assess the level of differentiation of kinaesthetic sensations in the aquatic environment. Study participants had to perform 10 repetitions of force differentiation of their upper limb adduction movements, under the influence of water resistance felt on the surface of the palm of their hands. The task was to move from the slightest perceptible drag force of water (sensory threshold), through intermediate values to the maximum strength.*

Results: *The results confirmed the hypothesis that the intentional modulation of verbal information affects the level of conscious differentiation force in the aquatic environment. The magnitude of the force registered during the measurements significantly correlated with the intensity of the amplitude of individual words and their duration.*

Conclusions: *The participants' conscious reactions were therefore a response to the teacher's intentional and planned actions. This issue is worth addressing in more detail in subsequent studies. Verbal information should be supplemented with suitably chosen content and then evaluated in terms of its effectiveness relating to the teaching process.*

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Introduction

A healthy human being is born with a number of tools needed to live and communicate. One of them is the voice. Every day we use our voice in order to communicate, impart information and express our emotions. During childhood we learn to respond to our parents' verbal information, which in addition to the content, consists of a particular tone and pitch suited to the situation. Such behaviour is carried into adult life and therefore vocal modulation enables us to emphasize the importance and nature of the information sent to the recipient. People tune and model their utterances intuitively, according to the situation. Intonation is an integral part of speech [1]. The intentional use of our acoustic capacities allows us to impact the recipient's intensity of focus and the means by which he or she memorises the given information [2]. Human speech is based on auditory impressions; that is, we respond only when we hear. The reception of auditory impressions, referred to as sound perception, is the ability to differentiate individual sounds based on their intensity, frequency and tone [3].

This paper raises the problem of the modulation of verbal information. The notion of modulation is understood as the changing amplitude and the delivery time of verbal instruction while the content and meaning of words remain unchanged. In the literature on the subject, attention is often given to verbal instruction and its role in the teaching process and the learning of motor function [4,5,6]. A common aspect of the studies was a qualitative approach to verbal information, which was directly linked to the achieved final results. An extremely important element that was subject to research was the analysis of the content of 'utterances' and its impact on the effectiveness of learning motor actions [7].

In the conducted experiments, verbal information was introduced to raise awareness of the kinaesthetic experience. The results confirmed the assumptions that verbal information increases the effectiveness of the learning process for children aged 10–11 years. Zatoń noted the close link between the content of individual words (associated with realizing the energetic elements of movement) and the effectiveness of the process of teaching and learning [6]. Since the main means of providing information in physical education classes is speech, the teachers' development of this activity influences the effectiveness of the learning process of motor functions [8,6].

In human communication, the content of verbal information constitutes an average of 7% of the total transfer, while the dominant role is played by body language 55% and voice intonation 38% [9] Verbal communication involves the exchange of information during speech (reading, writing and listening). Any verbal statement should reflect a clear structure, appropriate choice of words, and reasonably simple sentence structure. In everyday life we often adapt the manner and form of verbal expression to the existing circumstances. People can shorten and extend their words unconsciously or utter their words faster and louder in order to emphasize their importance. The intensity and duration of the human voice is a phenomenon which we encounter in everyday verbal communication. Rarely, however, are such variations considered as deliberate actions.

Sounds of speech and their understanding are key elements of social life. They provide people with information about their surrounding environment and the processes that occur within it. They control human behaviour and as such become an integral part of life [10]. Intonation, stress, rhythm, the speed of speech and voice intensity, as well as the duration of the sounds are elements that in the literature are referred to as extra-linguistic communication which at the same time accompany verbal communication [11]. In the process of teaching motor functions, this deliberate use of such a wide range of meanings creates new opportunities for the control of kinaesthetic information. Our mind is inextricably linked with our body which collects information and externalizes our reactions through various mental processes [12]. Therefore, it is the ability to receive and process information that determines the quality of our motor actions.

The phenomenon of human physical activity is associated with the ability to differentiate kinaesthetic sensations. It has been proved that the factors determining these differentiation levels are closely linked to learning and improvement [13]. Research shows that the higher the level of kinaesthetic differentiation, the greater the achieved level of control movement. The impact of certain forces while moving in space and experiencing various associated stimuli shapes our perception of reality. In the literature there are particular terms which specify the areas of human physical activity. We are talking about the sensory experience of ice (skating), air (ski jumping), football (team games) and the sensory experience water (swimming). Rostkowska defines the experience of water as "the ability to impact with a particular force which is appropriate to the existing need," which developed over the course of many years of contact with the water environment [14].

This type of sensation depends on two factors: congenital and acquired properties of sensitivity to touch. Research conducted in the swimming pool at the Department of Physical Education in Wroclaw drew attention to the power of communication in the process of creating awareness of kinaesthetic sensations in the aquatic environment. It has been established that there is a relationship between the quantity, form and quality of communication and the effectiveness of teaching. It has also been found that students often do not realize their mistakes despite the knowledge of appropriate movement patterns. This mechanism probably involves an inadequate assessment of perceptual information, which is caused by a distortion of the relationship between unconscious and conscious aspects of perception [15] At this point, the task of the teacher is not viewed as an indication of error, but a change in the student's perception of his/her own body in the water. Modification of the spatial behaviour of students is made possible by the tactual and verbal transfer of information which creates an awareness of kinaesthetic sensations [16].

Intentional modulation of the teacher's verbal instructions is the next step in the search for methods which develop kinaesthetic sensitivity. In the process of teaching motor functions in water, the sender of messages can consciously direct the strength and duration of verbal communications.

The aim of this study was to find a relationship between the amplitude and duration of verbal information, and a conscious reaction from the kinaesthetic learner. This was raised under the premise of two hypotheses:

- The planned teacher's voice modulation affects the level of conscious differentiation of the force sensation in the water.
- There is a relationship between the duration of verbal information and the magnitude of force differentiation in the aquatic environment.

Material and Method

Research subjects

Research participants in this study consisted of 40 children from elementary school No. 1 in Swidnica (Poland). The group consisted of 16 boys and 24 girls. The respondents' age ranged from 9 to 10 years. Children regularly attended swimming classes 3 times a week for 45 minutes.

The method used for the research was the laboratory experiment method, where the aim was to assess the level of differentiation of kinaesthetic sensations in the aquatic environment. Study participants had to perform 10 repetitions of force differentiation of their upper limb adduction movements, under the influence of water resistance felt on the surface of the palm of their hands. The task was to move from the slightest perceptible drag force of water (sensory threshold), through intermediate values to the maximum strength. Before the measurements were determined, all the respondents were informed exactly how to perform the task.

Measurements were performed twice while maintaining the same conditions. The only difference was a verbal message relating to the planned voice modulation (independent variable), which was handed to pupils during the second test. The amplitude and duration of the verbal information had been planned and increased in value (Figure 1). Its aim was to focus respondents on changes in the volume of the perceived strength on the surfaces of the rotating arms.

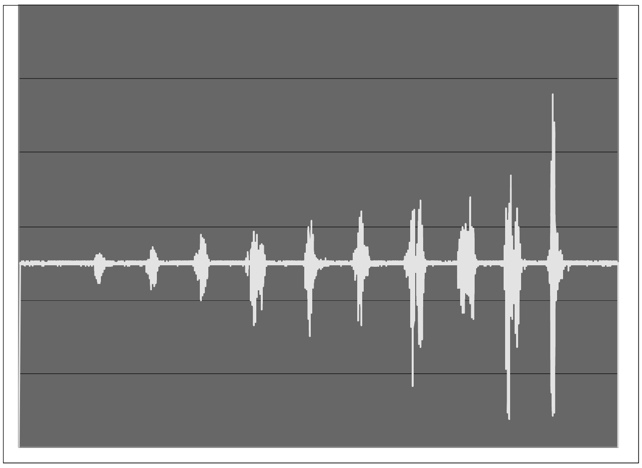

Fig. 1. The course of amplitude changes in the voice of verbal information

It should be noted that this experiment used verbal information of a neutral character in order to ensure that the modulation levels remained free from emotional content. The researcher spoke Polish numerals ranging from one to ten.

The method for determining the level of conscious differentiation capacity of kinaesthetic sensations in the water

Research was carried out directly in the shallow end of the pool using a device called a 'kinesthesiometer'. This device was created in the workshop of movement research at the University of Physical Education in Wroclaw. It was constructed and designed according to the original idea which complies with the standard PN-EN ISO-9001-2001. The apparatus allows for the registration of conscious motor actions in water, as measured by changes in the amount of force per time unit and the spatial structure movement (Figure 2).

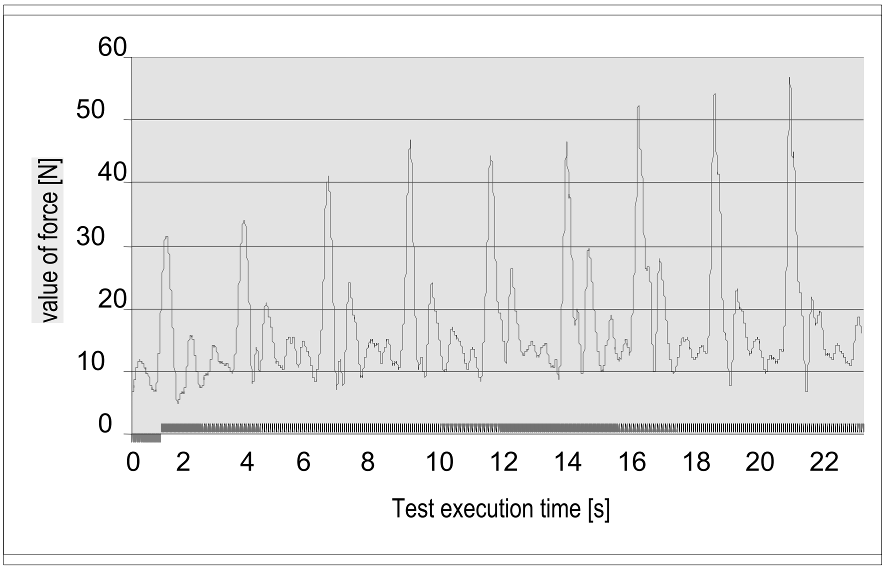

Fig. 2. Changes of force per unit of time recorded during a single test

The force of deliberate muscle strength production activates the upper limbs in the shoulder, which begin to move in a plane transverse to the long axis of the body. The resulting difference in pressure between the surface of the inner and outer arms and the moving mass of water cause a force which consequently presses the participant's body to the force plate [17]. It can therefore be assumed that the force recorded by the sensor platforms is the result of the test subject's deliberate action.

The experimental apparatus includes:

- a seat to act as a force plate. The resistor sensors placed inside record changes in the size of the elastic stress components. These sensors are widely used in industrial metrology (The participants' stable sitting position ensures breathing comfort).
- metal handle with a tool for regulating the depth of the platform's immersion in water to the nearest 1 cm.
- PC, which allows registration of signals from the sensors.
- analogue-digital card MG 2001.
- mounting straps 2 pieces (they stabilize the subject's position).

The various components of the device are presented in Figure 3.

Fig. 3. All elements of the device

Differentiation Indicator

In order to indicate the level of conscious differentiation capacity of kinaesthetic sensations in the aquatic environment, the method of mathematical analysis was adopted. The maximum force value was distinguished in each repetition, thereby indicating individual courses of force distribution over time and its minimum and maximum value (Table 1).

Tab. 1. Average values and the minimum and maximum attainable force. Participant 2

Participant 2	Minimum Value F[N]	Intermediate Values F[N]								Maximum Value F[N]
Maximum attainable force	24.78	30.76	27.09	32.59	57.7	43.7	61.15	37.47	40.28	85.57

To order the collected information, it was compared with the standard distribution of the tested characteristics. Therefore, the next step in the analysis was to determine the standard course of force differentiation in water. The variable in this particular case was limited only to the magnitude of the force. It was hypothetically assumed that:

- The model course of differentiation consists of 10 different values of gradient strength with a constant increase.
- The recorded minimum and maximum value of the force determines the thresholds of sensation.

Given these assumptions, the gradient force has a value equal to:

$$G = \frac{F\min - F\max}{n-1}$$

where *n* is the value of the maximum attainable force.

The following average force values express a finite sequence of:

$$Fn = n + G$$

Figure 4 depicts a graphical representation of the model and the actual course of force differentiation in water.

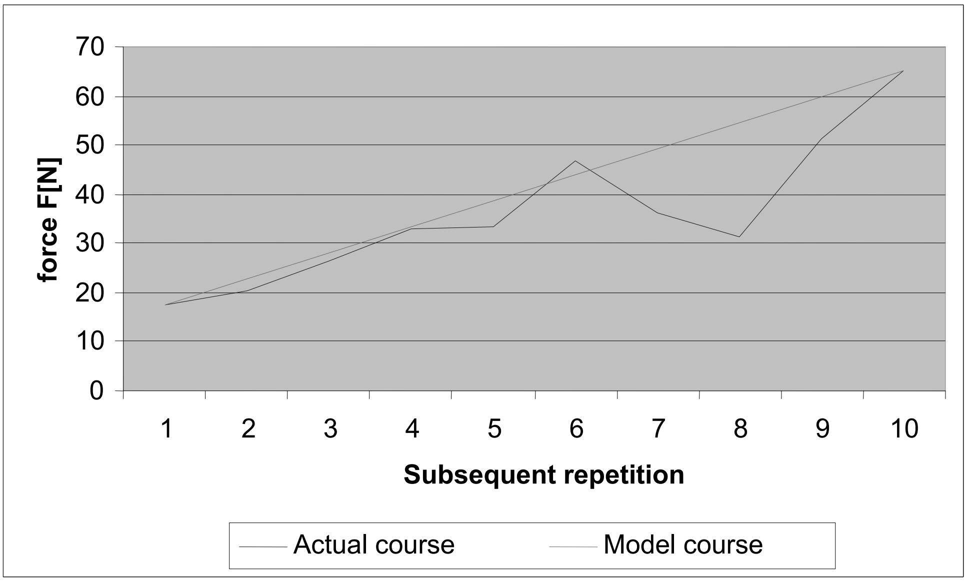

Fig. 4. The course of the actual and model distribution of the parameters tested

Obtaining a mathematical model was the starting point for calculating the index. Both courses were compared by calculating the mean square error (mathematical) of measurements [18].

$$SBM = \sqrt{\frac{\sum_{2}^{9}(Xi - Xr)^2}{n-1}}$$

Where:
SBM – average mathematical error.
Xi – force value of the model distribution.
Xr – force value of the actual distribution.
n – number of repetitions.

Additionally, the number of sets of the maximum attainable forces has been established **in the real course**. For this purpose, the statistical coefficient of variation was used, which implies that the differences which did not exceed 10% of the sample value are not important. This means that if the differences between consecutive measurements of force do not exceed 10%, they can be allotted to elements of the same set. For each of the studied participants, a particular number of sets was allocated, which has been given a natural number L = (1,2, ... 10).

Based on the acquired data, an index was established which indicates the level of conscious differentiation capacity of kinaesthetic sensations in the water environment. This index is indicated with the letter K. The numerical value ratio is expressed by the formula:

$$K = \frac{SBM}{L}$$

Where:
SBM – average value of a mathematical error.
L – number of sets of the maximum attainable force.
K index values are given in units of force [N].

Method of analysis of verbal information

For the analysis of verbal information, digital recording sound equipment was used. All words were recorded and stored in the WAV format. Registration was made in a laboratory with the assistance of special equipment consisting of a microphone and an oscilloscope RIGOOL DS 1000E with built-in digital memory. The phenomenon of sound – voice gives rise to the subjective auditory impression and has measurable physical characteristics: pitch, intensity, tone and duration. The pitch depends on the acoustic oscillation frequency, the intensity on the vibration amplitude, the tone on the amount, pitch and intensity of each sound, as determined by the physical structure of the sound source. The duration of sound – an acoustic phenomenon – measured in seconds is the total running time of the acoustic wave through a specified point [3]. A computer analysis of the sounds has allowed for the determination of the parameters for each of the spoken words. A sample recording of a single word is presented in Figure 5.

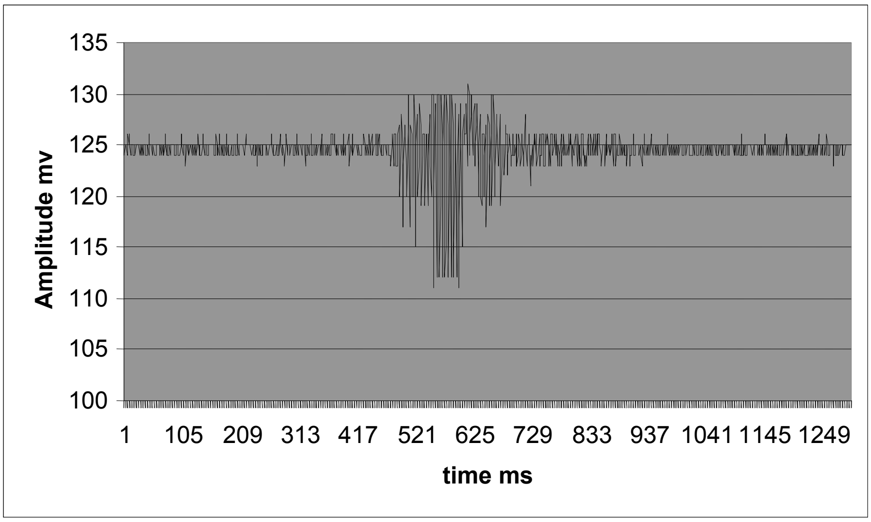

Fig. 5. Digital analysis of the modulation of the sound for the numeral "one"

The amplitude and duration of verbal information, which relate to the phenomenon of modulation, were subject to assessment. Data on the recorded parameters is provided for the amplitude in mv, and the time in seconds.

Statistical Methods

Two statistical analyses were selected and implemented in the article in order to verify the hypothesis. An intra-group analysis of changes under the influence of an independent variable was selected based on ANOVA for systems with repetitive measurements. In such a manner, the homogeneity of variance hypothesis in subsequent measurements was rejected.

In order to determine the strength of the relationship between the measured physical characteristics of verbal information and the kinesthetic behavior of a human being in water, Pearson's linear correlation analysis was used. This ratio has been selected due to the size of the group, which included more than 30 people. It enabled the following aspects to be determined:

- the statistical significance of the results
- the strength of the relationship between the measured characteristics
- the direction of the relationship.

The exact results of the statistical analysis are presented in the 'Results' section of the article.

Results

In order to verify the hypotheses, it is important to determine:

- the K index in the first and second test,

- the amplitude of the intensity of verbal information,
- the number of sets of the maximum attainable force in each test,
- duration of verbal information.

The value of the K index

Index values for K from the first and second test were compared (Table 2).

Tab. 2. Average, coefficient of slope and coefficient of variation with standard deviations and maximum and minimum values of K ratio

Ratio K	Average	Median	Standard deviation	Coefficient slope	Min	Max	Coefficient Variability
First measurement	0.44	0.38	0.31	1.59	0.11	1.35	75 %
Second measurement	0.15	0.15	0.05	0.55	0.05	0.30	59 %

The differences appeared significant for F (1.40) = 47.0827 p <0.005. An identified lack of equality between the mean values suggests that for all participants the measured parameter differed in the first and the second study, which is confirmed by the graphs through their mean values (Figure 6).

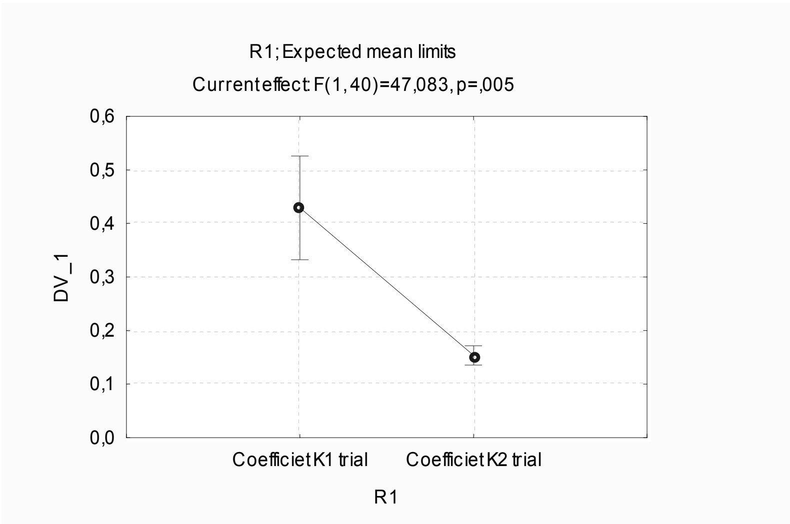

Fig. 6 Graphical Interpretation of the variance analysis results

The average value of K, along with its range (min-max) decreased by almost 3 times. In both measurements, we observe a significant variation of the measured parameters.

The reduction of the index value of K in the second measurement clearly showed the strong effect of the independent variable. It can therefore be assumed that the teacher's intentional modulation of verbal information affects the level of force differentiation capacity in the water environment.

The amplitude of the voice and the duration of verbal information

The amplitude of each of the spoken words assumes an increasing course within the range of 12 to 230 mV (Figure 7). The average value of voice volume was 76.6 mV and the standard deviation s equalled 63.02 mV.

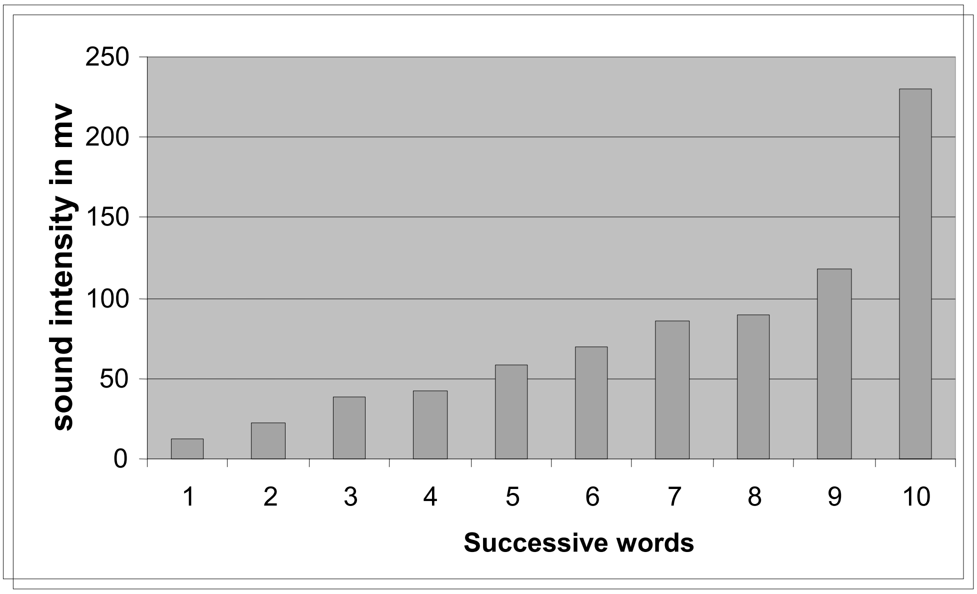

Fig. 7. The amplitude of the voice of the words uttered in succession

The observed differences in the intensity of the voice are characterized by a distinct upward and right slant, with the coefficient of the variation v=82%. The increasing amplitude of the sounds was intended to raise the participants' awareness of changes to the intensity of the force they were in contact with. Spoken words lasted from 0.38s to 1.12s (Figure 8). The results of the time analysis are characterized by a normal distribution, and the coefficient of variation was 29%. The average time of the sound was s=0.78 with the standard deviation s=0.23s.

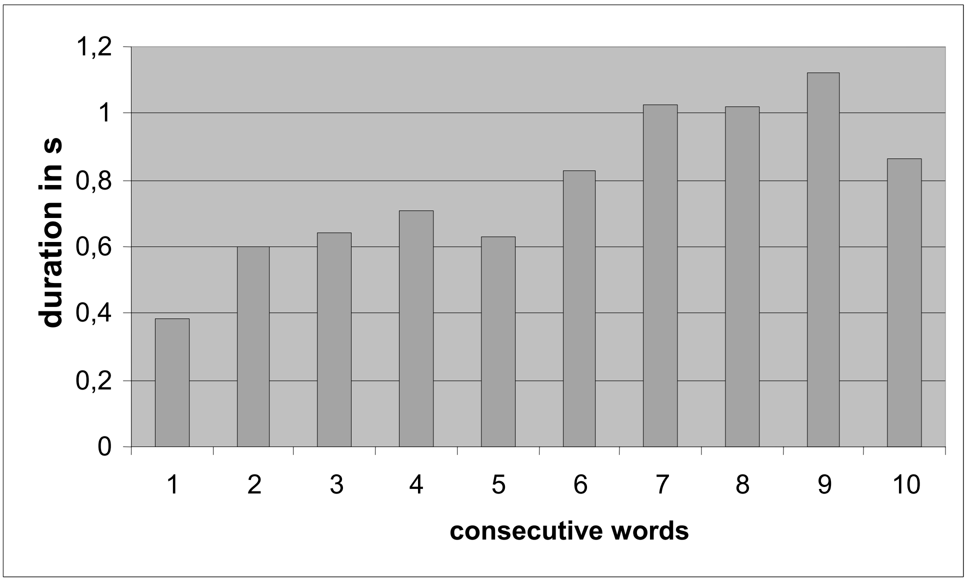

Fig. 8. The duration of each verbal information

The relationship between the amplitude of verbal information and the ability level of conscious kinaesthetic differentiation in the water environment

Pearson's correlation was made between the amplitude of the voice and the average maximum attainable force. The resulting dependency graph is illustrated in Figure 9.

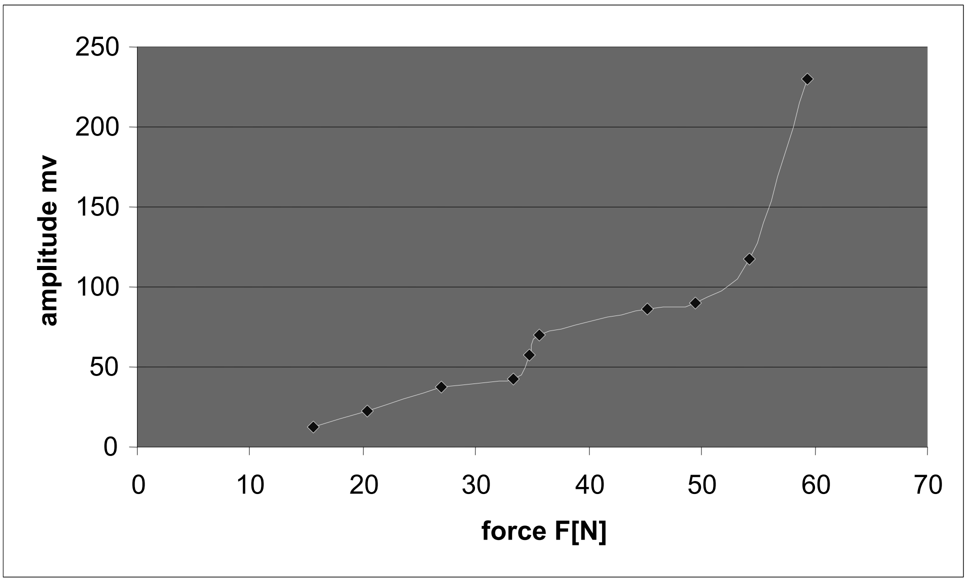

Fig. 9. The relationship between the range of differentiation and the amplitude of the voice power

The correlation coefficient of the measured traits was r=0.92. This result clearly demonstrates a positive relationship. Variation in the amplitude of the voice is accompanied by changes in the force differentiation in the water environment. The greater the amplitude, the greater the force. It was also examined whether there is a link between the number of sets of the maximum attainable force and the presence of modulated verbal information. The average number of sets was calculated in the first test at 5.11 (L I) and under the influence of verbal stimulation it increased to 7.34 (L II), the model value was indicated by the number M=10 (Figure 10).

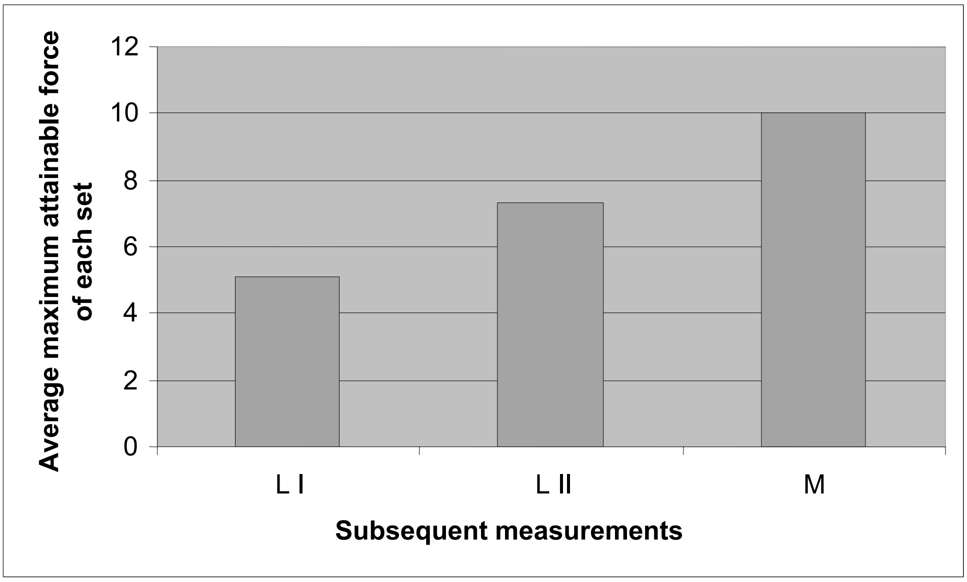

Fig. 10. The average number of L I, L II, M

It was clearly observed that there was an increase in the L number by 2.23 in the second test. There is therefore a relationship between the value of L and changes in the amplitude of the voice in verbal communication. A later comparison related to the duration of verbal information and the course of the maximum attainable force. The duration of the word depends not only on the form of expression but also on its phonetic structure. While analysing the data, it was determined that there is a correlation r=0.87, which confirms the hypothesis about the link between the duration of the word and the level of differentiation (Figure 11).

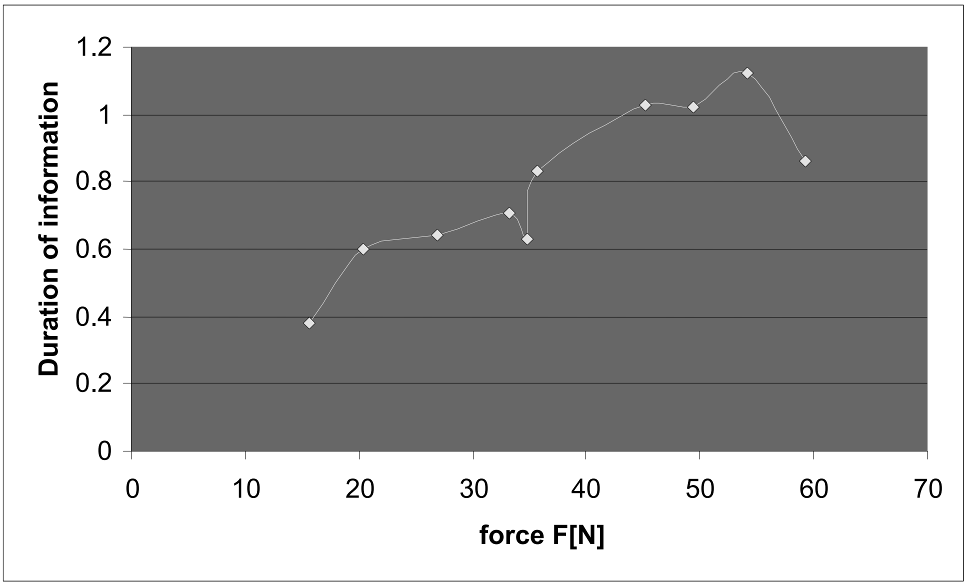

Fig. 11. The relationship between the duration of individual verbal information and the value of the maximum attainable force differentiation

Discussion

The results confirmed the hypothesis that voice modulation during the transmission of information affects the level of conscious differentiation of kinaesthetic sensations in the aquatic environment. In such a case, can we therefore speak about the process of controlling and regulating sensations? Certainly, kinaesthetic abilities change during the teaching and learning of motor actions [19,20], which leads to an improvement in the ability to receive sensations generated by the body's movement system [21]. A high level of sensitivity also facilitates the mastery of new motor actions [7]. But can we influence an individual's ability to differentiate sensations? This problem was investigated by Professor Krystyna Zatoń. In her research she noted a relationship between the intentional preparation of students to receive sensory information from the aquatic environment and the effectiveness of teaching [7]. For students who were stimulated with the information that heightened their awareness of kinaesthetic sensations, there was a marked increase in their kinaesthetic abilities. It was also found that there is a correlation between the quality of verbal transfer and the speed at which motor skills are learnt.

Verbal information is the most common means of communication in the classroom for physical education [8]. The quality of this information largely depends on semantic and syntactic preparation of each form of expression. The sentence is the basic element of speech that serves to transmit the given content. Words which are used to construct a sentence do not always convey the entire message. Consequently, it is intonation that creates the sentence. Joseph Mayen [22] gives some simple examples: in a quiet conversation, when the intensity of the intonation is small, we will say, "Hurry up". As the level of excitement increases, the volume also increases, which leads to yelling, "Hurry up!!!". A similar situation is when we want to call someone: when a person is nearby, (for example, in the next room) we call: "Catherine!", whereas when the distance is greater, we shout: "Catherineeeee!". Is not only that we use a change in the intensity of volume, but also we modify the word phonetically, while at the same time extending the duration of the expression. Intonation of the teacher's expression is also linked to memorising the verbal messages, in their direct memory [23]. Research conducted on this kind of intonation and its impact on the memorization of simple sentences indicates that there is an existing relationship between the content of information and the way the message is transferred [1]. This demonstrates the great importance of communicative voice modulation. The results of the research implicitly draw attention to the problems associated with the students' ability to learn motor activities. Students with a lower level of kinaesthetic differentiation capacity have greater problems with the mastery of new motor actions. Therefore, the intentional stimulation of their kinaesthetic abilities can speed up the learning process.

Learning motor skills is based on increasing the effectiveness of the integration of sensory information. The processing of stimuli coming from the receptors of the nervous system is a complex process, one which requires the coordination of impressions received by the learners, both consciously and subconsciously. The quality of verbal information transferred from the teacher to the student has a significant impact on the effectiveness of learning. The form, the frequency of reinforcement and the content depth are factors that determine the effectiveness of the swimming technique [24]. However, excess of consciously received impressions from the receptors may be a factor that disrupts the process of teaching the acquisition of new skills [25]. The stimulation of the kinesthetic behaviors of the learner with an intensity of the modulation of verbal information appears to satisfy the assumptions of teaching effectiveness of both these (above mentioned) authors. Modulation additionally strengthens verbal information without engaging the student's consciousness. The studies described in the work were carried out in water, however, using a specialized test stand.

Moreover, the findings of Janelle et al. [26] are particularly significant to this research, having investigated the effect of verbal cues on the acquisition of football skills. It was found that the combination of verbal information with visual modeling no only enhances perceptual representation and retention of the modeled activities but also improves the learners' ability to reproduce the activity themselves. Learners who received verbal instruction in particular displayed less erroneous and more appropriate form across the acquisition, trial and retention stage when compared with learners from other groups [26]. As such, it is more than plausible to believe that the same results could be achieved while learning new skills in the water environment.

A major problem identified in the study was with assessing the kinaesthetic sensation differentiation levels, through the reception of various stimuli from the water environment, of those who received intentional preparation. Under the influence of sensory information that the respondents received on the surface of the palm of their hands, the participants were able to modify their movement. The main parameters used in the study of kinaesthetic ability were: repetitiveness of muscle strength, amplitude and range of motion and execution time [27]. All tests were conducted under laboratory conditions using specialized research frames. With the exception of earlier research carried out by this author [16], no additional literature made reference to tests conducted in water. Due to the specific conditions in which there is a didactic process, the placement of measurement apparatus in water seems to be justified.

Conclusions

The work undertaken to address the problem of stimulating the kinaesthetic differentiation capacity with verbal information, which is characterised by the intentional regulation of the intensity of the spoken word, is the continuation of research on methods which increase the awareness of kinaesthetic sensations. The aim of this research was to equip teachers with tools to diagnose and shape the level of sensory receptions in the aquatic environment, thereby increasing their ability to deliberately control the process of learning motor function in water. Knowledge of words and linguistic expressions, as well as their means of modulation, which is characteristic of the kinaesthetic system, will increase the effectiveness of communications between the teacher and students. As a result, teachers will be more effective in given teaching situations.

The results confirmed the hypothesis that the intentional modulation of verbal information affects the level of conscious differentiation force in the aquatic environment. The magnitude of the force registered during the measurements significantly correlated with the intensity of the amplitude of individual words and their duration. The participants' conscious reactions were therefore a response to the teacher's intentional and planned actions. This issue is worth addressing in more detail in subsequent studies. Verbal information should be supplemented with suitably chosen content and then evaluated in terms of its effectiveness relating to the teaching process.

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