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# ANALYSIS OF PREVIOUS PERCEPTUAL AND MOTOR EXPERIENCE IN BREASTSTROKE KICK LEARNING

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ABSTRACT
One of the variables that influence motor learning is the learner's previous experience, which may provide perceptual and motor elements to be transferred to a novel motor skill. For swimming skills, several motor experiences may prove effective. **Purpose.** The aim was to analyse the influence of previous experience in playing in water, swimming lessons, and music or dance lessons on learning the breaststroke kick. **Methods.** The study involved 39 Physical Education students possessing basic swimming skills, but not the breaststroke, who performed 400 acquisition trials followed by 50 retention and 50 transfer trials, during which stroke index as well as rhythmic and spatial configuration indices were mapped, and answered a yes/no questionnaire regarding previous experience. Data were analysed by ANOVA ($p = 0.05$) and the effect size (Cohen's $d \geq 0.8$ indicating large effect size). **Results.** The whole sample improved their stroke index and spatial configuration index, but not their rhythmic configuration index. Although differences between groups were not significant, two types of experience showed large practical effects on learning: childhood water playing experience only showed major practically relevant positive effects, and no experience in any of the three fields hampered the learning process. **Conclusions.** The results point towards diverse impact of previous experience regarding rhythmic activities, swimming lessons, and especially with playing in water during childhood, on learning the breaststroke kick.

**Key words:** breaststroke kick, motor learning, previous experience

## Introduction

One of the variables that may improve motor skill learning is previous experience, since existing perceptual and motor experiences can be transferred to the skill to be learnt [1–3]. This transfer is most likely to happen between similar skills, but can happen between skills that do not bear any similarity. In this case, it is implicit knowledge of underlying principles that govern both skills that can facilitate learning.

So, several motor pattern similarities can be found between swimming skills and terrestrial locomotor abilities, such as walking and crawling [4], which are exploited by first teaching skills that show such similarities, like alternate swimming skills as the front crawl, before teaching simultaneous strokes like the breaststroke that do have less motor pattern similarities with other strokes [5]. Especially the breaststroke kick does not bear any similarity to other leg kick propulsion techniques, which presumably is one of the reasons for the breaststroke to be considered as one of the most difficult stroke techniques to be learnt.

Notwithstanding, perceptual similarities between swimming techniques possibly bear greater potential of transfer from previous experience to skill learning, since the principles underlying propulsion in supporting and propelling the body in water are mostly the same in all propulsion techniques. In order to promote novel swimming skill learning, such perceptual similarities can be provided by any experience with support and propulsion actions in water, independently whether these actions bear any pattern similarities with the technique to be learnt or not. This rationale drives most methods used in teaching swimming skills: hence, the most productive setting for acquiring this experience should be formal swimming lessons.

On the other hand, such perceptual experience may be provided not only by formal swimming lessons, but also by playing in water, which may even provide large opportunity to perceive the interaction between the body and the water. So, playing in water is supposed to impact the learning of novel swimming skills, such as the breaststroke kick, in a similar way as experience in formal swimming lessons [6].

However, there is little research on the relationships between previous experience, especially with water as an environment, and swimming skill learning. Whitney, Vetter and Wolpert [7] as well as Patrick et al. [8] showed that previous perceptual experience impacts motor learning of laboratory skills (manual and locomotor), but both authors stress the need of research into real life settings. Investigation regarding infant swimming points towards an acceleration in motor development [9–11], but does not allow conclusions about the possible transfer of knowledge that might help when it comes to swimming skill learning. Following the same line of thinking, formal swimming lessons supposedly also provide such perceptual and

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motor experiences and so individuals that underwent formal swimming lessons should also benefit from transfer of perceptual experience to novel swimming skills.

Besides experience directly related to motor skills in water, there are other fields of experience that might impact swimming skill learning, such as rhythm focused activities (dancing, playing music). One of the features that distinguishes a motor skill from others is its rhythmic structure [1, 2], which includes not only relative timing (the temporal length of each of its components in relation to the total duration of the pattern), but also the typical distribution of emphases and pauses (contraction and relaxation) along the pattern [2, 12]. This rhythmic configuration is one of the first features acquired by a learner and decisive for success in the first performance attempts [2]. Swimming techniques are skills in which the rhythmic structure is especially critical for skilled performance, given that it is indispensable for producing propulsion in the water environment, because it ensures that force is applied in the exactly best possible moment of the pattern. This is especially relevant in breaststroke kicking, as pointed out by Seifert and Chollet [13] and Barbosa and colleagues [14]. During the learning process, information about the rhythmic structure of a skill can be acquired either from the instruction provided by a teacher or model, or from implicit learning about the interaction of the learner's body with the water. However, in this case, too, specific experience presumably facilitates the learner's perception of rhythmic structures in this interaction and its results on performance. Thus, previous experience in rhythm based activities, like playing music or dancing, in which the perception of rhythmical structures is constantly required, will presumably also facilitate the acquisition of a skill whose rhythmic structure is unfamiliar [2], since perceptual experience is subject to transfer, too [1].

Therefore, better rhythmic perception should implicate easier detection of rhythmic structures in a novel skill. The relation between rhythm perception in general and learning the rhythm of a new motor skill was shown in the tennis serve and slalom skiing by Rieder, Balschbach and Payer [15]. Their experiment showed better learning of the target pattern in both skills if participants first performed rhythmic exercises involving spatial and/or rhythmic patterns even if those patterns did not resemble the target pattern. In a similar study, Wang and Hart [16] found that learners that not only underwent the usual teaching process of the butterfly stroke, but, in addition, listened to an audio file displaying the sound of the water splashing during an expert butterfly performance, did learn more effectively than the control group that had not listened to the audio file.

Based on these thoughts, and considering that research regarding previous experience and its relation to swimming skill learning is scarce, the present study aims to analyse the influence of three types of previous experience on learning the breaststroke kick: childhood play in water, formal swimming lessons, and rhythmic activities. The hypothesis was that participants that declare having experiences in any of these fields, alone or combined, would show differentiated learning behaviours along the breaststroke kick learning process.

## Material and methods

The sample was intentionally chosen between PE students due to the fact that this population usually brings along heterogeneous experiences from diversified environments, which allows to suppose a widespread range of previous motor experiences without any selectivity regarding specific abilities[1]. Thirty-nine students from initial semesters volunteered for the study (20 men and 19 women aged 21.2 ± 3.9 years) and declared that they could create propulsion by motor action when floating in chest deep water, even if not by formal stroke technique, and did not know the breaststroke[2]. All participants signed informed consent forms, as approved by the University's Ethics Committee.

In the first part of the study, participants performed 400 acquisition trials of the breaststroke kick in prone position (4 blocks of 50 trials on one day and another 4 blocks two days later) followed by 50 retention and 50 transfer trials, the latter in supine position, another two days later. All trials were conducted in a heated indoor pool, 0.90 to 1.50 m deep, within a spatial reference system 2 m wide and 15 m long, consisting of two parallel custom-made lane lines indicating distance from the starting wall in 10 cm intervals (see Figure 1). For all trials, participants used a floating device ("pool noodle") under their arms and shoulders along all trials, and pull buoys between their thighs for starting every set of 10 trials (the device was released with the beginning of the first trial) to start in the horizontal body position. Before each set of 10 trials, participants were allowed to access information about the skill (video demonstration by a skilled model or auditory verbal description displayed on a netbook, repeated as many times as required by the participant), but no feedback was given. All trials were videotaped for further analysis. The first and last block of five trial sets on each of both days during acquisition phase, as well as all retention and transfer trials, were analysed with Kinovea software (www.kinovea.org), mapping three major performance parameters.

Subsequently, data about previous experience were collected on a retrospective questionnaire, prepared specifically for this study, in which participants were asked to tick whether (a) they had experience in music, dance or similar rhythmic motor activities lessons, (b) and/or formal swimming lessons, both for at least 40 hours over six months or more, and (c) if they had played in water during childhood, as long as this playing action had taken place in water deeper than 90 cm (pool, lake, river or seafront) for at least 30 days a year from four years of age on.

Mapping of Stroke Index

Since stroke efficiency is the most significant aim when learning a swimming skill, as the main learning outcome index, the stroke index was calculated by multiplying swimming speed by distance per stroke along a given number of strokes [17]. For measuring swimming distance and speed, the trial set video was displayed using Kinovea software, and the moment in which the knees or hips began to flex for the second kick was determined as the onset moment of that kick. Then, the number of kicks was counted to mark the onset moment of the tenth kick. For each of these two moments, the distance from the starting wall was obtained by tracing a straight line between two points on the lane lines equally distant from the starting wall which would pass through a previously defined reference point on the participant's body (usually the intersection of spinal column and swimsuit waistband or neckline; see Figure 1). The difference between these two points gave the distance covered along eight kicks, and the difference between the two frame times exhibited by the software (Figure 1) gave the time elapsed for these eight kicks. Based on these data, the stroke index was calculated for every trial, each trial comprising in average ten kicks, by dividing the mean swimming speed per stroke by the mean stroke length [17]. After repeating this procedure for each trial set, the mean stroke index for each trial block during acquisition phase (A1, A2, A3, A4) and for retention and transfer trials was calculated.


Figure 1. Kinovea screen showing the method of obtaining the distance and time of a particular trial set. The smaller frames show the onset moments of the second and tenth kicks, with the respective time elapsed. The bigger frame shows the straight line drawn to obtain the distance from the starting wall in the onset moment of the tenth kick. In this moment, the reference point is located at 6 m (mark on the lane line) + 8.54 cm (obtained by interpolating the real distance from the distance shown on the screen) = 6.09 m from the starting wall, and the time elapsed between both moments in this trial was 17.27–1.70 = 15.56 s. As the distance from the starting wall at second kick onset, obtained by the same procedure as for the tenth kick onset, was 1.05 m, the swimming speed along eight kicks was (6.09 m – 1.05 m =) 5.04 m / 15.56 s = 0.3239 m/s.

Mapping of spatial configuration

As a second parameter, the spatial configuration pattern was mapped, which quantifies how well the participant's execution of the kick matches the ideal kick pattern, as suggested by major swimming technique textbooks [18–20]. For this comparison, the presence or absence of four spatial configuration indicators was checked for each of the kicks considered for stroke index calculation: (a) simultaneous and symmetric flexion of knees, (b) simultaneous and symmetric abduction of feet, (c) simultaneous and symmetrical extension of knees (even if not complete), and (d) simultaneous and symmetrical adduction of feet (even if not complete). For every indicator detected in a kick in this exact sequence, 0.25 points would be recorded, in which a certain overlap between the phases would be considered acceptable without reducing the score. Based on these scores, the overall score for each trial set was obtained by dividing the total amount of points scored by the number of kicks performed in that particular trial set, and then calculated the mean value for the five trial sets in each trial block. This would result in a final trial block score between 0.00 (for complete absence of any of the spatial configuration marks in all kicks performed in that trial) and 1.00 (presence of all spatial configuration marks in all kicks).

Mapping of rhythmic configuration

The same procedure was followed for mapping the rhythmic configuration index. As neither swimming manuals nor scientific papers provide any information about the typical rhythmic pattern of the breaststroke kick, as reference was taken the average rhythmic configuration as shown by three elite breaststroke swimmers in technique videos [21, 22]. The analysis of these videos showed the following rhythmic structure, comprising both relative timing (relation between duration of each movement phase and duration of the whole movement cycle) and acceleration as a sign of application of force: the movement cycle begins with moderate acceleration of feet displacement during flexion of knees and/or hips and abduction of feet, followed by increasing speed during leg extension and adduction, and finishes with a gliding phase (pause) between leg adduction and the beginning of the next knee or hip flexion. Analysing the presence or absence of each of these indicators in every trial, following the same procedure as for the spatial configuration index, for each trial block, a mean rhythmical configuration index between 0.00 and 1.00 was obtained.

### Assignment to experience groups

Subsequently, based on the questionnaire answers, participants were arranged in the following experience groups, according to their experience in one or more fields:

- Without Experience in any of the three fields (WE) – *N* = 3
- Water Playing experience Only (PO) – *N* = 7
- Rhythmic activities experience Only (RO) – *N* = 6
- Water Playing and swimming Lessons experience (PL) – *N* = 6
- Water Playing and Rhythmic activities experience (PR) – *N* = 7
- Water Playing, Rhythmic activities and swimming Lessons experience (PRL) – *N* = 10

For each of these groups, the three indices obtained by video analyses were arranged for statistical analysis, comprising descriptive analysis and two way ANOVA with the significance level set to $p = 0.05$. For effect size, Cohen's *d* was calculated. Descriptive and variance statistics were run on SPSS© (IBM Corp.) version 21.0.00, and effect size calculated as proposed by Coe [23]. The effect size values were rated as indicating small (between 0.2 and 0.5), medium (between 0.5 and 0.8) and high practical relevance (above 0.8), following Ellis [24].

## Results

### Evolution of outcome indices in the whole sample

In the first trial block, no difference was found between groups regarding the outcome indices: one factor Anova for stroke index yielded $F(5, 33) = 1.452$; $p = 0.232$, for spatial configuration index $F(5, 33) = 1.469$; $p = 0.226$ and for rhythmical configuration index $F(5, 33) = 0.631$; $p = 0.677$.

Regarding the whole sample ($N = 39$), stroke indices did show an evolution over all trials ($F(5, 165) = 22.081$; $p < 0.001$): from a mean stroke index of 0.052 $m^2/s$ in the first acquisition trial block the index went up to 0.124 $m^2/s$ in the last acquisition trial block, was maintained during retention (0.123 $m^2/s$) and decreased to 0.070 $m^2/s$ in the transfer test. Spatial configuration index increased significantly between trial blocks ($F(5, 165) = 5.140$; $p = 0.003$) rising from 0.850 in the first to 0.981 in the last acquisition trial, and kept in retention (0.975) and transfer test (0.965). Rhythm configuration index did not increase along all trials from beginning of acquisition until transfer block ($F(5, 165) = 0.699$; $p = 0.572$). Regarding interaction between index evolution and experience groups, no significant interactions were found along trial blocks: $F(5, 165) = 1.463$; $p = 0.135$ for stroke index, $F(5, 165) = 1.165$; $p = 0.314$ for spatial configuration index and $F(5, 165) = 0.606$; $p = 0.881$ for rhythm configuration index.

### Behaviour of learning curves by experience groups

When analysed separately, the learning curves regarding all three outcome measures ascended in almost all experience groups from beginning to retention test, as shown by Figures 2, 3, and 4.

However, the differences between groups in every single trial block depicted by the learning curves (Figures 2, 3 and 4) failed to show significance ($p = 0.05$). In other words, there is no statistical difference between the experience groups regarding their learning of the breaststroke kick, thus rejecting the hypothesis.

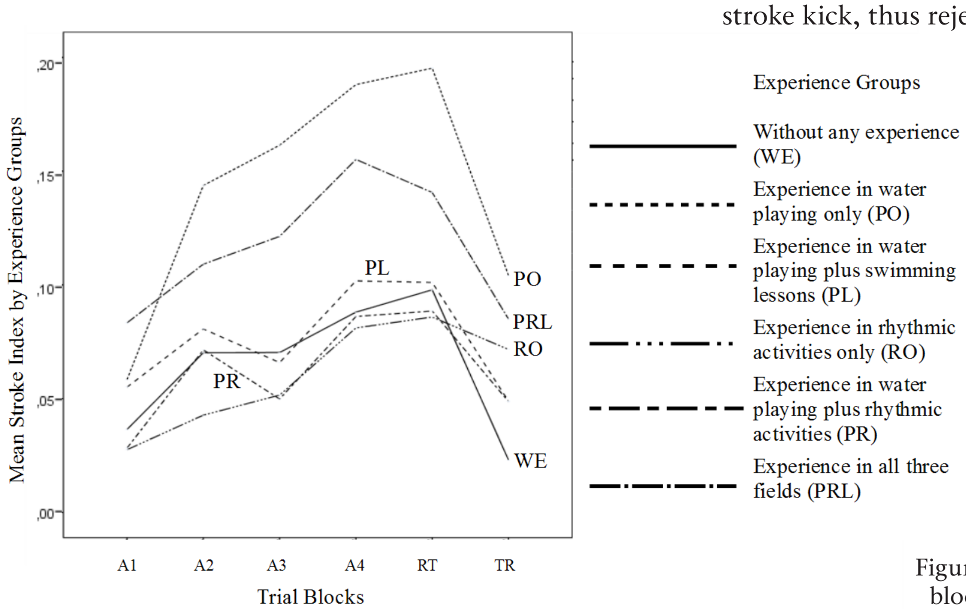


Figure 2. Mean stroke indices along trial blocks for different experience groups

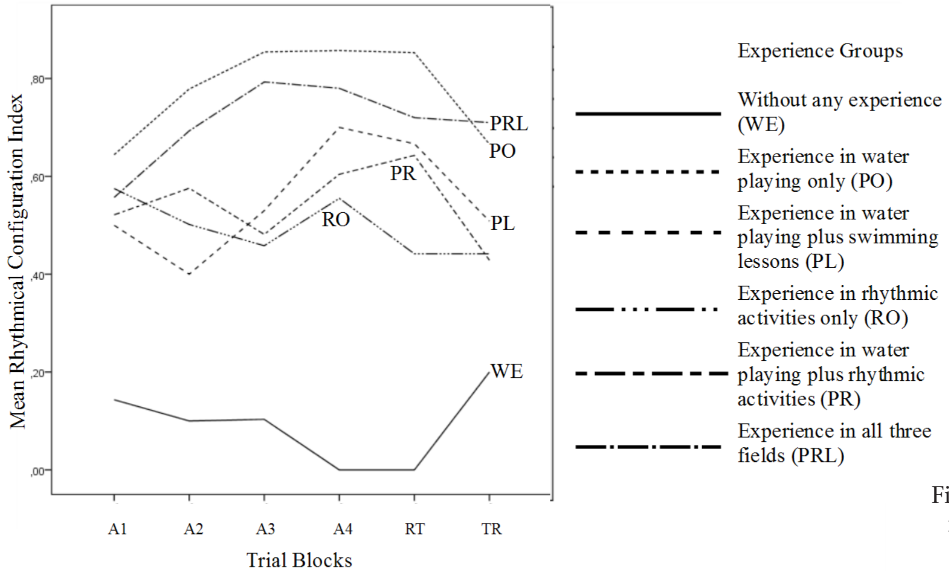


Figure 3. Mean rhythmic configuration index along trial blocks for different experience groups

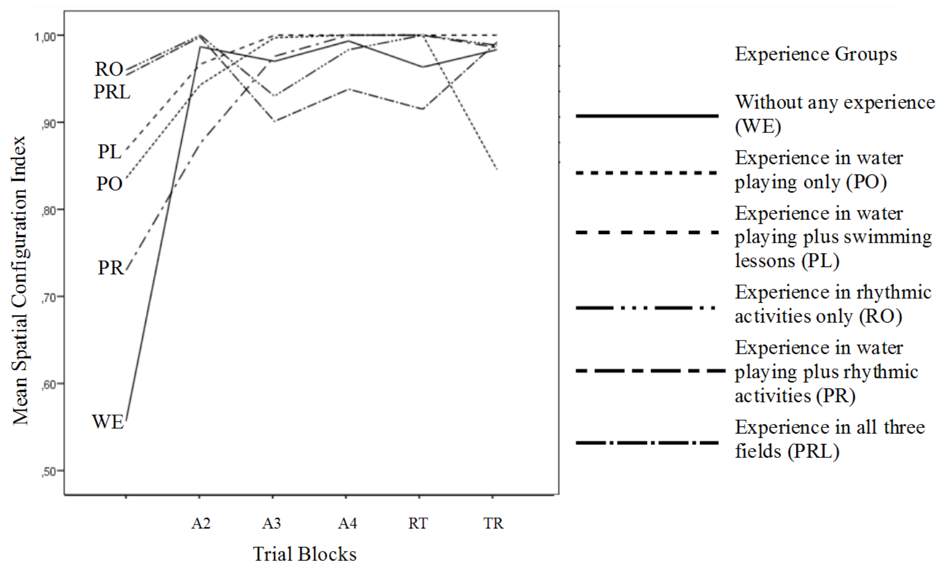


Figure 4. Mean spatial configuration index along trial blocks for different experience groups

The strong theoretical background, however, instigated to look further into the data. Since statistical significance has been questioned for behavioural studies [25], effect sizes were investigated, as suggested by Coe [23], regarding the differences between every two experience groups at a time, in each trial block, for all indices.

These calculations resulted in a very large number of values, which are presented in summary, restricting the analysis to the frequency of Cohen's *d* values above 0.8, which indicate a large practical effect, in every single comparison between one experience group and all others, regarding all three indices, in every single trial block. Table 1 shows these frequencies.

The group that shows the highest frequency of large effect sizes, in comparison to all other groups, is the without experience group. Once the no experience at all group shows the lowest indices in several trial blocks and indices, this indicates that no experience at all in any of the three fields tends to impair the breaststroke kick learning, compared to all other experience constellations, alone or combined.

Comparisons between the all three experience group and all other groups show low frequencies of large effect sizes. This points out that all these experiences, alone or combined, tend to impact the breaststroke kick learning.

The only experience group to stand out from the others, regarding the frequency of large effect size values in comparisons with other groups, is the water playing only group, which shows, in the retention test, three times larger frequencies of effect size values than any other comparison of one of the groups with any other, except the no experience at all group. This indicates a tendency towards the water playing only group showing a distinct behaviour of their learning curve compared to all other groups. As this group's learning curves in several trial blocks shows higher indices than those of other groups (although not statistically significant), this can be seen as a tendency towards facilitation of learning

Table 1. Frequencies of Cohen's *d* values indicating large effect sizes (> 0.8) in comparisons between experience groups, per trial block (A1 to A4: acquisition trials, RT – retention test, TR – transfer test). Frequencies add up large effect size values for stroke index, rhythmic configuration index and spatial configuration index, for every experience group, compared to all other groups

| | A1 | A2 | A3 | A4 | RT | TR | Total A1 to TR |
|---|---|---|---|---|---|---|---|
| Water playing only | 2 | 4 | 9 | 5 | 6 | 1 | 27 |
| Water playing plus swimming lessons | 1 | 0 | 1 | 2 | 2 | 1 | 7 |
| All three experiences | 4 | 0 | 0 | 0 | 0 | 0 | 4 |
| Water playing plus rhythmic activities | 4 | 1 | 1 | 2 | 2 | 0 | 10 |
| Rhythmic activities only | 3 | 1 | 1 | 2 | 2 | 0 | 9 |
| Without any experience | 5 | 4 | 8 | 10 | 10 | 4 | 41 |
| Total per trial block | 19 | 10 | 20 | 21 | 22 | 6 | |

the breaststroke kick when the learner played in the water during childhood.

Very few large effect size values were found for the comparison between the water playing plus swimming lessons group, and all other groups, including the water playing only group. This indicates a minor relevance of differences regarding the learning outcome between the water playing only group and the water playing plus swimming lessons group. Thus, swimming lessons plus water playing seems to impact on learning the breaststroke kick less than the water playing experience alone.

## Discussion

Although the stroke indices of the water playing group show no statistical difference to other groups, effect size values suggest that the difference between the experience in water playing only group and the other groups might bear considerable practical relevance. Higher index values, together with large effect size values, point towards higher positive impact of experience with playing in the water during childhood, on the breaststroke kick learning, whereas formal swimming lessons showed outcome similar to all other fields of experience. Especially regarding swimming lessons experience, which should, by common sense thinking, add positively to water playing experience, the present findings conversely point towards a hampering effect of swimming lessons on breaststroke kick learning.

These findings might be explicable by two reasons: on one hand, in the questionnaire, the number of lessons stated as a criterion for ticking "yes" was 40 hours over the course of six months or less. Although, normally, this amount of practice, about two lessons per week for half a year, is enough for a reasonable performance in basic strokes, it may not offer sufficiently widespread experience for assembling enough implicit knowledge to develop perceptual competence in a way to allow transfer to novel skills.

Another possible explanation can be found in current teaching practice: in Brazilian swimming schools, teachers usually focus on the proper execution of a stroke technique as described in swimming manuals. Deviations from this ideal stroke pattern are weeded out as errors, and emphasis is given to drills that lead directly to that objective [26]. Over the last years, new tendencies in teaching have recommended such diversification, although primarily for advanced training [27–29]. These proposals are in line with Rosalie and Mueller's thoughts [3], and support the opinion that traditional teaching practice, which focuses mainly on swimming techniques, deserves rethinking, as suggested, for example, by Freudenheim and Madureira [26].

The present results are in line with several empirical and theoretical findings [6, 29, 30], which suggest that diversified aquatic experiences allow learners to build a solid basis for later learning of swimming techniques. This will enable the learner to develop his own form of interaction with the water, both in floating and propulsion [26], which can develop into a swimming technique that is tailored to suit his or her individual features.

Experience with rhythmic activities did not lead to differentiated learning curves in this study, in a certain way contradicting the findings of Rieder, Balschbach and Payer [15] and Wang and Hart [16]. The perceptual and motor experience acquired in the perception and reproduction of rhythmic structures in music and dance lessons did not impact on learning of a motor skill with marked rhythmic structure; the practical relevance of such experience, separately or in addition to water playing, was even less than that of water playing alone. However, the benefits of previous rhythmic activities may be more or less pronounced, depending on individual engagement in these activities. Another difference between the present study and the former research may lie in the delay: the rhythmic activities provided by both Rieder, Balschbach and Payer [15] and Wang and Hart [16] took place immediately before learning the novel skill, which was not the case in the present study.

However, these results should be taken with a grain of salt, considering that groups were not equally distributed over the sample. Furthermore, participants had to rely on their memory to answer the questionnaire, a remembrance that may not ever depict reality. Future research might be able to find more reliable indicators for this feature, for example, within a longitudinal study.

## Conclusions

The aim of the present study was to gain insight into the relations between previous experiences in swimming and rhythmical activities lessons, as well as in playing in the water during childhood, and the breaststroke kick learning. For this, three outcome parameters were mapped: stroke index, as well as spatial and rhythmic configuration indices.

Differences between experience groups proved not to be significant, but experience in playing in the water showed effect size values indicating high practical relevance of this previous experience on the course of the breaststroke kick learning curves, even when compared to experience in combined water playing plus swimming lessons experience, whereas effect size values of comparison between experience in other fields, alone or combined, indicated small practical relevance of each of these experiences for the breaststroke kick learning. These findings emphasize the relevance of widespread motor and perceptual experience in water, accumulated over the course of body-water interaction, such as it is naturally built up during children's play in water, which has been appointed as relevant in literature [6, 20, 26–30], but has rarely been addressed in research.

Therefore, current teaching practice should be revised regarding the relevance of widely spread motor and perceptual experience for efficient stroke learning.

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**Endnotes**

[1] Brazilian PE students normally are not submitted to motor tests for admission, so it is quite common that students in initial semesters do not show superior multidisciplinary motor experience, although some of them may exhibit outstanding motor abilities in specific sports.

[2] In normal swimming courses, teachers commonly teach first the front crawl and the back stroke, putting the breaststroke off so that many pupils don't even get as far as the breaststroke during several months of swimming lessons.

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