Original Article

Analogy versus explicit and implicit learning of a volleyball skill for novices: The effect on motor performance and self-efficacy

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Abstract:

To date, research concerning analogy, implicit and explicit instruction has focused on perceptual or motor skills with limited attention directed toward psychological skills such as self-efficacy or their interaction with motor skill performance. The present study investigated the effect of analogy, implicit and explicit methods on the acquisition and retention of a volleyball motor skill (reception), and self-efficacy for novices. Eighty female novices, aged from 10 to 11 years, were randomly selected and assigned to four equal groups (three experimental and one control). A pre-test, three different intervention programs of 12 training units (4 weeks X 3 times per week), according to the different learning methods, a post-test, and a retention test were conducted. Volleyball reception skill was measured via a field test (Wulf, McConnel, Gärtner & Schwarz, 2002), and self-efficacy was measured via a questionnaire (Theodorakis, 1996). A two-way (4 groups X 3 tests) mixed factorial analysis of variance (ANOVA) and a post hoc Tukey test were used to analyze the data. The results showed that all three methods improved both motor skill and self-efficacy of novices over time. Comparing groups showed that the analogy learning group achieved the highest score in the retention test for both motor performance and self-efficacy. Moreover, the implicit group was better than the explicit and the control group. Analogy learning seems to be a promising instructional method for the improvement of both motor skills and self-efficacy. The participants in the analogy and implicit learning groups probably had limited access to declarative knowledge and, according to the “reinvestment hypothesis”, they did not overload their working memory and did not block the automated process of performance. Additionally, when analogy learners received instructions to imitate a familiar form of movement pattern, this created a sense of success and pleasure which probably positively influenced their self-efficacy. Conversely, according to the “optimal theory”, the improved self-efficacy of the analogy learners probably positively influenced the goal-setting procedure, which led to higher motivation and better performance. These results suggest that the analogy learning method has a positive effect on self-efficacy, which has been overlooked by previous studies in the motor learning literature, and is also positively correlated with motor skill performance.

Key Words: feedback instructions, motor development, early stages of learning, meta-knowledge.

Introduction

Researchers, instructors, and coaches are looking for the best instructional methods in order to help their athletes optimize their sport performance. A number of studies in the motor learning literature have provided evidence on the crucial role of working memory during the learning process, and even now there is a controversy concerning the different effects of traditional-explicit instruction versus the implicit or analogy methods for the acquisition and retention of sport skills (Bobrownicki, Macpherson, Collins, Sproule, 2019; Kal, Prosée, Winters, van der Kamp, 2018; Lola, Tzetzis, & Zetou, 2012; Masters, & Maxwell, 2008; Poolton, Masters, & Maxwell, 2007; Maxwell, Masters, Eves, 2000).

The explicit learning method is the most common training method, used by coaches especially for novices. In this mode of instruction, the coach sets out clear rules and gives verbal instructions on how to execute a particular movement or skill. The acquisition of knowledge via the explicit learning process results in consciously accessible declarative knowledge that can be articulated (Tzetzis, & Lola, 2010). Explicit learners also develop meta-knowledge (knowledge about our knowledge) about their sport ability (McKay, 2002). Access to meta-knowledge apparently affects the individual's self-confidence or self-efficacy, and could become a factor of success or failure in sports (Liao & Masters, 2001). However, it has been shown that the explicit use of rules places a heavy load on working memory resources. These limitations, under some conditions, will impede learning since working memory is extremely limited in both capacity and duration (Maxwell, Masters, & Eves, 2003).

A different learning method that overcomes the problem of overloading of working memory is implicit learning. According to this method, learners do not receive rules on executing skills. Many researchers argue for the role of unconscious (implicit) processing in learning motor skills (Bobrownicki, Macpherson, Collins, Sproule, 2019; Tse, Wong, Masters, 2017) or perceptual skills (Farrow & Abernethy, 2002; Tzetzis, & Lola, 2015). as opposed to conscious (explicit) processing (Masters, Poolton, Maxwell, & Raab 2008; Maxwell, Masters, & Eves, 2000; Poolton, Masters, & Maxwell, 2007). During the implicit learning method, the instructor does not give rules of execution but distracts the attention of the trainees using a secondary stimulus, (Jackson & Farrow, 2005; Williams, Ward & Chapman, 2003; Votsis, Tzetzis, Hatzitaki, Grouios, 2009), in order to develop procedural knowledge, bypassing working memory processing (Masters, 1992; Kleynen, Braun, Bleijlevens, Lexis, Rasquin, Halfens, et al., 2014). Thus, motor skills which are learned implicitly are thought to be less reliant on declarative knowledge than skills which are learned explicitly (Maxwell, Masters, Eves, 2000), and instead capitalize more strongly on automatic processes (Chauvel, Maquestiaux, Hartley, Joubert, Didierjean, Masters, 2012). However, some problems arise from the implementation of implicit learning methods, such as the lack of execution rules, which novices need in the early stages of learning (Masters, 1992; Maxwell, Masters, & Eves, 2000), and the impracticability of application in the field, due to the secondary stimulus (Poolton, Masters, & Maxwell, 2006).

Masters (2000) tried to reconcile the theoretical and practical issues of the explicit and implicit learning methods, proposing the analogy mode of instruction. Analogy learning is a mode of implicit learning that combines the advantages of the implicit and explicit methods. According to this learning method, the rules are hidden in the form of metaphors (analogies). Analogies disguise many of the technical rules ordinarily provided by explicit instruction (Masters, 2000). It is not an unknown method for coaches, since they often draw on analogies in order to help their athletes understand the skills to be learned (Tzetzis & Lola, 2015). For example, a basketball player may be instructed to put his/her hand in the cookie jar when shooting or a golfer may instructed to swing the club like a pendulum when putting (Poolton et. al, 2006). Swimming coaches may teach their students to 'kick like a dolphin' when they learn the butterfly swimming stroke (Andy, Wong, & Masters, 2017). Using analogy instruction is probably very helpful for novices to easily understand the techniques required to perform the skill effectively (Tse, Wong, Whitehill, & Masters, 2016). However, Kal, Prosée, Winters and van der Kamp (2018) in their systematic review suggest that the superiority of one or the other method in improving sport performance is still unclear and recommend further research. Using analogy instruction could help novices to easily understand the technique required to perform the skill effectively (Tse, Wong, Whitehill, & Masters, 2016). Many researchers mention that participants who learn motor tasks via the analogy method report fewer task-relevant rules (Koedijker et al. 2011; Lam, Maxwell, & Masters, 2009a; Lam et al., 2009b; Liao & Masters, 2001; Poolton et al., 2006), exhibit no deficits in performance or kinematic variables (Lam et al., 2009b), and perform without disruption under stress (Lam et al., 2009a) or dual-task conditions (Koedijker et al., 2011; Lam et al., 2009b; Liao & Masters, 2001). However, findings on the effect of the analogy learning method are not consistent (Gröpel & Mesagno, 2017), since some researchers report better performance under pressure conditions compared to explicit methods (Lam, Maxwell, & Masters, 2009b; Liao & Masters, 2001), but others do not find similar effects (Schücker, Ebbing, & Hagemann, 2010). Bobrownicki, MacPherson, Coleman, Collins, & Sproule (2015) report that an important methodological issue when comparing explicit and analogy learning methods arose from the type of instruction, or the reduced volume of instructions of the analogy learning method compared to the explicit one, and recommended future studies to explore the impact of explicit instructions in their leanest possible configuration.

The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure has shown that implicitly learned motor skills remain stable under psychological pressure and concurrent cognitive demands (Poolton, Masters, & Maxwell, 2007). It could be argued that the psychological skills play a significant role in the implementation of the above methods. Lewthwaite and Wulf (2017) state that several studies of novice, experienced, and expert performers (Rosenqvist & Skans 2015; Stoate, Wulf & Lewthwaite, 2012), demonstrated the impact of a sense of success on subsequent performance. According to the "Optimal Theory" (Lewthwaite & Wulf, 2017), previous achievements in sport performance establish a sense of self-efficacy (Bandura, 1977; Newland, Newton, Finch, Harbke, & Podlog, 2013), and previously positive outcomes give rise to positive expectations for future successful performances (Lewthwaite & Wulf, 2017). Self-efficacy is described by Bandura (1977) as the belief and judgment which a person has in regard to his/her ability to execute specific actions relative to the achievement of specific outcomes. Generally, individuals with high levels of self-efficacy attempt new performances in future trials, expend their effort on these performances and commonly display increased success in future motor skills (Gao, Kosma, & Harrison, 2009). Self-efficacy could be a prospective predictor of motor performance (Rosenqvist, & Skans, 2015) and learning (retention and/or transfer of skill) (Pascua, Wulf, & Lewthwaite, 2015; Stevens, Anderson, O'Dwyer, & Williams, 2012). The positive effects of self-efficacy on performance in sport and exercise settings are well established, since it is linked with superior performance (Feltz et al., 2008; Saemi, Porter, Ghotbi-Varzaneh, Zarghami, Maleki, 2012). However, there has been limited research into the effects of the implicit or the analogy learning methods on self-efficacy and subsequent sport performance.

The early development of self-efficacy beliefs is very important especially for beginners (Rogaleva, Malkin, Khaerzamanova, & Mamaeva, 2019). There is a clear relationship between perceived mastery of performance and feedback in motor performance with self-efficacy (Ferrari, Borges, Teixeira, & Marques, 2018; Tzetzis, Votsis, & Kourtessis, 2008; Escartí, & Guzmán, 1999; Balagour, Bray, & Dada, 2004; Mahoney, Devonport, & Lane, 2008; Saemi et al., 2012). Several researchers (Baker, Côté, & Deakin, 2005) have investigated the effect of different programs of instruction, by differentiating the level of motor skill performance, showing that guidance and deliberate practice - the type and frequency of stimuli an individual receives in order to achieve sport expertise - play an important role in the improvement of sport performance.

Most of the research on the effectiveness of implicit vs explicit or analogy instructional methods has been conducted on perceptual and motor skills (Kal, Prosée, Winters, van der Kamp, 2018; Lola, Tzetzis, & Zetou, 2012; Masters, & Maxwell, 2008; Poolton, Masters, & Maxwell, 2007; Maxwell, Masters, Eves, 2000). Very few researchers have investigated the effect of implicit learning on both motor and psychological skills in novices (Stevens, Anderson, O'Dwyer, Williams, 2012). The purpose of the present study is to compare the effectiveness of explicit, implicit and analogy learning on both motor and psychological skills, such as self-efficacy, in novice participants. The results will not only give theoretical answers but also add a practical dimension and provide a real methodological tool for coaches. The researchers also attempted to reduce the methodological weaknesses of authentic research and to present clear results from a direct comparison among the most effective motor skill training methods for novices.

It was hypothesized that if novices improve their sport performance and if they attribute this performance to their abilities, then their self-efficacy beliefs will probably be strengthened and their performance will probably be improved. Conversely, perceptions of failure will weaken their self-efficacy beliefs. The method which improves both motor and self-efficacy will be a useful training tool for instructors and coaches.

Material & methods

Participants

The participants were 80 female novices, aged from 10 to 11 years ($M_{age}=10.48$, $SD=0.911$) with very little volleyball experience (4 training sessions), all following regular exercise and newly enrolled in volleyball clubs. All individuals participated in the study voluntarily, while being in perfect health (regarding motor, pathological, perceptual or psychological issues), as confirmed by a medical team. Participants were randomly selected and divided into four (4) evenly matched groups (analogy group, implicit group, explicit group, control group), consisting of 20 individuals each. Three of the groups were experimental groups; each of them trained using one the aforementioned methods: a) explicit method via traditional training, b) implicit method via distraction task, c) analogy via metaphors. The fourth group served as the control group, which participated in the testing procedures but practiced different volleyball skills. All ethical guidelines and participants' anonymity were adhered to throughout the study.

Experimental design

All groups were measured in a pre-test on accuracy of reception skill after the opponent's serve. The three experimental groups (implicit, explicit, analogy) followed an intervention program consisting of 12 training units (4 weeks X 3 times per week). This was followed by a post-test measurement. A retention test was conducted a week later. The self-efficacy questionnaire was distributed to the participants before each test (pre-test, post-test, retention test).

Intervention program

The three experimental groups participated in an intervention program consisting of 12 training units (4 weeks X 3 times per week). All learning groups practiced the same volleyball motor skill (motor performance evaluating the direction of the reception skill), but the coaches used a different training method in each group. The explicit training group received explicit instructions and rules of execution. The implicit learning group received no rules, but they were distracted via a secondary task (Jackson & Farrow, 2005; Williams, Ward & Chapman, 2003). The analogy learning trainees received instructions via analogies/metaphors, encompassing several technical rules; verbal instruction was usually provided in the form of a metaphor related to the movement. All participants had only internal (visual) feedback on their performance. The participants in the control group practiced other volleyball skills without instructions.

Assessment tool

Evaluation of motor performance via the direction of reception skill: in order to evaluate motor performance via the direction of reception skill, Wulf, McConnel, Gärtner, and Schwarz's (2002) tests were used on the field, in real conditions. A high-level athlete performed a serve directly to the participant and the goal for each participant was to send the ball as close as possible to the target. The executions were evaluated according to the deviation from the target. Perfect aiming was worth 3 points and off-target aiming was 0 points (Fig 1). Each participant made 20 attempts to receive the opponent's serve.

S=server, P=passer, R=receiver

Fig 1. Evaluation of motor performance evaluating the direction of reception skill.

Self-efficacy evaluation: The researchers used the self-efficacy questionnaire (Theodorakis 1996). The questionnaire consisted of five (5) items (e.g. “How sure you are that you will target 8/10, 6/10,...2/10 trials?” (1=not sure to 10=absolutely sure), on a Likert scale. The more points a participant scored, the greater his/her sense of self-efficacy.

Statistical analysis

Mixed two-way Anova factor analysis (4 groups X 4 tests) was conducted to find the effects among the “tests” and the “group” factors on reception motor skill and self-efficacy. Further differences were examined using a post hoc Tukey test ($p < 0.05$).

Results

Evaluation of the direction of reception skill (motor performance): there was a statistically significant main effect ($F_{(3,228)}=475.87$, $p < 0.05$) among the three (3) tests (pre-test, post-test, retention test) on motor performance. Specifically, all the experimental groups (analogy, implicit, explicit) improved their mean scores from the pre-test to the post-test, while there was no significant difference from the post-test to the retention-test. About the control group, mean motor performance did not significantly improve from the pre-test to the post-test and the retention test.

There was a statistically significant main effect ($F_{(3,76)}=578.77$, $p < 0.05$) among the four (4) groups (analogy, implicit, explicit, control) on motor performance. Specifically, the results from the pre-test to the post-test and the retention test showed that: the analogy group scored highest, followed by the implicit group, the explicit group and the control group.

There was a statistically significant interaction ($F_{(9,228)}=91.75$, $p < 0.05$) among the three (3) tests (pre-test, post-test, retention test) and the four (4) groups (analogy, implicit, explicit, control) on motor performance. The results are summarized in the table below (Table 1).

Table 1. Analysis of variance of “group” and “test” factors on motor performance, evaluating the direction of reception skill.

	SS	df	MS	F	Sig.	η^2
Test	65.15	3	21.71	475.87	0.000	0.994
Group	22.22	3	7.40	578.77	0.000	0.996
Test * Group	37.68	9	4.18	91.75	0.000	0.996

A post hoc Tukey test was conducted in order to examine further differences: results are presented below (Table 2 and Fig 2).

Table 2. Post hoc Tukey test regarding the main effects on “motor performance”, evaluating the direction of reception skill, among “groups” and “tests”.

	EXPLICIT (EX)		ANALOGY (AN)		IMPLICIT (IM)		CONTROL (CO)		Post hoc
	M	SD	M	SD	M	SD	M	SD	
Pre-test (pre)	1.4	1.4	1.31	1.4	1.3	0.12	1.3	0.14	IM=AN=EX=CO
Post-test (post)	2.11	0.1	2.99	0.11	2.6	0.14	1.2	0.05	AN>IM>EX>CO
Retention (ret)	2.13	0.14	3.00	0.09	2.6	0.11	1.4	0.12	AN>IM>EX>CO
Post hoc	Pre < Post Post = Ret		Pre < Post Post = Ret		Pre < Post Post = Ret		Pre = Post, Post = Ret

Fig 2. Evaluation of the direction of reception skill: means of motor performance, evaluating the direction of reception skill, among “groups” and “tests”.

Evaluation of self-efficacy: There was a statistically significant main effect ($F_{(3,228)}=1491,30, p<0.05$) on self-efficacy among the three (3) tests (pre-test, post-test, retention test). More specifically, all three groups (analogy, implicit, explicit) improved their average score from the pre-test to the post-test, and maintained their score during the retention test. The control group, on the other hand, showed no improvement among the tests.

There was a statistically significant main effect ($F_{(3,76)}=525,26, p<0.05$) on self-efficacy among the four (4) groups (analogy, implicit, explicit, control). More specifically, the retention test results showed that the analogy learning group scored highest, followed by the implicit learning group, the explicit learning group and the control group. Similarly, the results of the retention test showed that the analogy learning group scored highest, followed by the implicit learning group, the explicit learning group and the control group.

There was a statistically significant interaction ($F_{(9,228)}=294,47, p<0.05$) among the three (3) tests (pre-test, post-test, retention test) and the four (4) groups (analogy, implicit, explicit, control) on self-efficacy. The results are summarized in the table below (Table 3).

Table 3. Analysis of variance regarding the effect of different “groups” and “tests” on self-efficacy.

	SS	df	MS	F	Sig.	η^2
Test	551.25	2	183.75	1491.30	0.000	0.995
Group	252.07	2	84.02	525.26	0.000	0.994
Test * Group	326.55	7	36.28	294.47	0.000	0.997

Further differences were examined using a post hoc Tukey test: the results are presented below (Table 4 and Fig 3).

Table 4. Post hoc Tukey test on the main effects on self-efficacy, among “groups” and “tests”.

	EXPLICIT (EX)		ANALOGY (AN)		IMPLICIT (IM)		CONTROL (CO)		Post hoc
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Pre-test (pre)	2.67	0.11	2.73	0.23	2.73	0.18	2.67	0.17	IM=AN=EX=CO
Post-test (post)	5.61	0.14	8.87	0.25	8.33	0.11	2.58	0.15	AN>IM>EX>CO
Retention (ret)	5.92	0.17	8.89	0.27	8.51	0.13	2.73	0.13	AN>IM>EX>CO
Post hoc	Pre < Post, Post = ret		Pre < Post, Post = Ret		Pre < Post, Post = Ret		Pre = Post, Post = Ret

Fig 3. Evaluation of self-efficacy among “groups” and “tests”.

Discussion

The objective of the present study was to test the effect of implicit, explicit or analogy learning methods on motor performance and self-efficacy in novice participants. The conditions differed in the amount of task-relevant knowledge, and the procedural knowledge the participants developed. It was hypothesized that if participants achieved a good level of motor performance, they would also improve their self-efficacy level and vice versa.

All experimental groups improved both their motor performance and their self-efficacy across time, except the control group. Specifically, the analogy learning group improved its performance and self-efficacy over time. Participants in this group had to respond to metaphors familiar to them (Liao & Masters, 2001). They also developed procedural knowledge without overloading working memory or developing declarative knowledge. The implicit learning group participants also improved both their performance and self-efficacy over time. Many researchers have demonstrated the positive effect of implicit learning methods on motor skill performance and learning (Abswoudea, Buszardb, Kampd, & Steenbergen, 2020; Masters & Poolton, 2012; Wulf & Shea, 2002; Tzetzis, & Lola, 2015) and, according to the “reinvestment hypothesis” (Masters, 1992), this was attributed to procedural knowledge development (Baddeley, 2003) without memory overloading, which provides learners with greater resources in order to carry out more complex tasks. Finally, explicit learners also improved their performance over time through the development of declarative, followed by procedural knowledge, using the explicit instructions, which in turn improved self-efficacy. The improved motor performance of all the experimental groups had a positive effect on their self-efficacy levels. Due to the measurement process, participants in the experimental groups had internal (visual) feedback on their performance (score on target), giving them a great deal of information on their performance. Since the participants knew their performance level and probably compared to their goal, they may have developed a type of meta-knowledge, which in turn improved their self-efficacy (Liao & Masters, 2001). Additionally, their knowledge of their improvement increased their motivation for continued practice, and positively influenced how confident they felt about their abilities, and consequently their self-efficacy (Lee & Wishart, 2005; Simon & Bjork, 2001; Saemi et al. 2012). From the comparison among the three groups, it was found that the analogy group scored higher in both motor performance and self-efficacy than the implicit and the explicit groups. Similarly, the implicit group scored higher in both motor performance and self-efficacy than the explicit group.

The advantage of the analogy learning group was perhaps the familiarity they felt due to the type of instruction, which probably made the task “look easier”, creating a concept of successful execution (Liao & Masters, 2001) and a sense of pleasure. Bandura (1993) also argues that pleasure influences self-efficacy, especially in children. Feltz, Chow, and Hepler (2008) suggest that when performance standards meet the goals an individual has set out, the individual feels satisfied. The analogy learning participants probably felt satisfied because they felt that they had executed the task correctly; with no rules to recall, they exerted more effort and met their goals more effectively, boosting their self-efficacy.

Moreover, according to the “optimal theory”, improved self-efficacy probably influenced the participants’ goals and goal-setting procedure, leading to higher motivation and better performance (Lewthwaite & Wulf, 2017). Moritz, Feltz, Fahrbach, and Mack (2000) assert that self-efficacy facilitates motor skill learning

and performance, since successful performance improves one's belief in one's ability in successful execution. The reverse is also true: athletes with strong self-efficacy improve their sport performance because they possess a strong sense of self-efficacy and set more challenging goals in relation to the task (Bandura & Locke 2003), invest more effort into the task (Razon, Hutchinson, & Tenenbaum, 2011), and display higher levels of perseverance when faced with difficult situations (Feltz, Short, & Sullivan, 2008).

The implicit group participants scored lower than the analogy group. The implicit group participants had to execute a motor skill when their attention was distracted via backward counting (the secondary task). This distraction probably made the task more difficult for the novices. They had only a vague belief in their ability to execute the specific task, resulting in less meta-knowledge, less pleasure and lower self-efficacy levels than those noted in the analogy group.

The participants who practiced via the explicit method achieved lower scores, both in motor and self-efficacy testing, compared to the analogy and implicit method groups. The results confirmed the existing literature, according to which it seems that explicit learners try to recall the rules they learned during training, which seems to: a) overload working memory, b) block the automated learning process (Maxwell, Masters, & Eves, 2003, Tzetzis & Lola, 2015), c) decrease pleasure (Bandura, 1993), and d) probably decrease self-efficacy, too. The interaction effect showed that the differences among the groups were retained during all measurement periods (pre-test, post-test, retention test), and that the analogy group scored higher than the other two groups in both motor performance and self-efficacy. It is concluded that the analogy learning method had a positive effect on both motor performance and self-efficacy in novices.

This study is limited to the conditions implemented in this experiment: a) the three types of motor learning interventions (implicit, explicit, analogy), b) the measurement procedures, c) the type of motor skill, and d) the experience level of the participants (novices). Generalization to other conditions should be considered with caution.

Conclusions

The positive effects of self-efficacy on performance in sport and exercise settings are well established, since it is linked with superior performance. However, there has been limited research into the effects of the implicit, explicit or analogy learning methods on self-efficacy and subsequent sport performance. The present study investigated the effect of analogy, implicit and explicit methods on the acquisition and retention of a volleyball motor skill (reception) and self-efficacy in novices. The analogy learning training method is recommended for young novice volleyball players in order to improve their motor performance and subsequently their self-efficacy. Analogy learning interventions combine the benefits of implicit with those of explicit motor learning, especially in novices. The researchers attempted to present clear results and the practical applicability of the theory to proposed practice methods. The conclusions may be important for coaches concerning the use of different training methods in skill learning. This study is limited by the feedback models used for child novices for volleyball skills. It is not recommended to make any generalizations that go beyond the aim of the present research. Since the type of feedback is crucial to learning new motor skills and performance, future studies should focus on the stage of learning (novice or experienced), the type and complexity of the motor skill, the goal of the training (improvement of result or motor execution), learners' psychological maturity and learners' cognitive abilities, etc. Further research is required in order to make clear recommendations in different sport settings.

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