Application of analogy learning in softball batting: Comparing novice and intermediate players

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This field-based study developed and implemented analogy instructions for softball batting, and examined batting performance outcomes. A focus-group discussion involving a coach and a number of team captains of a collegiate-level softball team identified the typical instructions used for batting (i.e. explicit) and developed an analogy instruction that combined these rules in one biomechanical metaphor (i.e. swing your bat like you are breaking a tree in front of you with an axe). Forty collegiate-level club players (20 novice, 20 intermediate) were assigned to either an analogy learning or an explicit learning group and took part in six training sessions. Batting performance was assessed using a standardised criteria-based rating scale in single-task conditions before and after training, and a dual-task condition after training. The findings show that the novice, but not the intermediate players, displayed significant improvements in batting performance after training. Novices who received the analogy instruction displayed stable batting performance in a dual-task condition, but novices who received explicit instructions, and intermediate players who received the analogy instruction, displayed batting performance decrements. The findings suggest that the benefits of analogy instructions are evident only in novices; learners' previous experiences must, therefore, be carefully considered when developing coaching and instruction programmes.

Keywords: analogy learning, coaching, instruction, softball, batting

Introduction

The process of acquiring movement skills has been traditionally described to begin with a cognitive stage during which individuals utilize and accumulate rule-based knowledge to monitor and control actions (Fitts & Posner, 1967). As one progresses to an autonomous stage, performance is carried out with little reliance on rules to facilitate movement performance. Based upon this classic definition, substantial sports research has examined skill learning through a cognitive lens. With an intention to promote the most efficient progression to an autonomous stage, researchers have developed various approaches to training movement skills. A number of paradigms are based on the dichotomy of implicit and explicit motor learning. While explicit motor learning is a process that is consistent with traditional rule-based approaches to skill learning, implicit motor learning avoids a rule-based approach in order to promote skill learning with minimal accumulation of declarative knowledge (Masters, 1992).

It has been argued that implicit motor learning results in more efficient movement performance, because fewer attention resources are used to process the technical elements of the skill. Implicitly learnt motor skills have also been shown to be robust when performers are subjected to dual-task demands (e.g. Liao & Masters, 2001), high-pressure situations (e.g. Hardy, Mullen, & Martin, 2001), or physiologically fatiguing activities (e.g. Poolton, Masters, & Maxwell, 2007a). For instance, Liao and Masters (2001) showed that a biomechanical metaphor promoted implicit learning of a table tennis forehand topspin and that skill performance tended to be robust when a concurrent secondary task was included. This apparent advantage has been linked to the theory of reinvestment, which posits that performance breakdown can occur when attempts to gain optimal control of movements lead to conscious task processing through the use of previously acquired explicit knowledge (Masters, 1992; Masters & Maxwell, 2008). As a means to counter reinvestment, implicit motor learning paradigms have been designed to prevent accumulation of rule-based knowledge about the motor skill, thereby reducing the likelihood of consciously monitoring and controlling movement.

There has been great interest in applying implicit motor learning approaches to real-world conditions, primarily in sports and physical education (van der Kamp et al., 2015), but also in rehabilitation (e.g. Capio, Poolton, Sit, Holmstrom, & Masters, 2013; Kleynen et al., 2015) and surgical training (e.g. Malhotra et al., 2015; Winning, Malhotra, & Masters, 2018). It is important to note, however, that implicit motor learning is not always advantageous across conditions. Liao and Masters (2001), for example, reported that implicit and explicit learners acquired skills at similar rates, while Poolton and colleagues (2007a) found comparable retention of skills by explicit and implicit learners.

Some implicit motor learning approaches seek to deliberately limit accrual of declarative knowledge by interfering with working memory. For example, the first attempts to cause implicit motor learning used a simultaneously performed secondary task to occupy working memory, thus disrupting active hypothesis testing (Masters, 1992; MacMahon & Masters, 2002). Hypothesis testing is also unlikely to occur if fewer practice errors are experienced (i.e. errorless learning; see Capio et al., 2013; Maxwell, Masters, Kerr, & Weedon, 2001). However, these techniques can be difficult to use effectively in practical coaching settings (Bobrownicki, MacPherson, Coleman, Collins, & Sproule, 2015). An alternative approach, analogy learning, might be more feasible when coaches wish to facilitate implicit motor learning.

Analogy learning

Motor analogies provide a powerful tool with which to influence the way people move (see Masters & Poolton, 2012, for a review). An analogy is delivered as an instruction; however, the complex rules that would normally be provided explicitly by the coach are concealed within the analogy as a biomechanical metaphor (Masters, 2000). For example, a person learning a basketball free throw can be instructed with a number of rules about how to throw correctly, which requires working memory involvement and conscious information processing; alternatively, a person can be told to 'shoot as if you are trying to put cookies into a cookie jar on a high shelf" (e.g. Krause, Meyer, & Meyer, 2008). This simple analogy has been shown to effectively convey the fundamentals of the free throw movement without the need for additional verbal guidance (Lam, Maxwell, & Masters, 2009).

Besides the basketball free throw, sport-specific analogy instructions have been designed and tested in a number of sports, including the forehand topspin shot in table tennis – 'move the bat as though it is travelling up the side of a mountain' (Koedijker et al., 2011; Liao & Masters, 2001; Poolton, Masters, & Maxwell, 2006); breaststroke in swimming – 'glide two seconds with your arms outstretched' (Komar, Chow, Chollet, & Seifert, 2014; Komar, Potdevin, Chollet, & Seifert, 2018); and the push pass in hockey – 'move the stick as if you are sloshing a bucket of water over the floor' (van Duijn, Hoskens, & Masters, 2019). Most of the studies, however, have been laboratory-based, leaving the question of practical utility when coaching generally unanswered. An exception is a study by Schücker and colleagues (2010), which used analogy instructions to train a full golf swing over a six-week training period, with the aim to obtain official permission to play golf.[1] In this study, however, a number of analogy instructions were used instead of a single metaphor as has been typically used in other work. The authors believed that a single metaphor would not encapsulate all of the aspects of a golf swing. Effectively, this means that the volume of instructions (and thereby the corresponding cognitive requirements) was not lower for the analogy approach.

[1] Official permission to play golf is required in Germany and is obtained by passing standard tests that are designed separately for indoor and outdoor conditions.

The range of sports in which analogy instructions have been tested suggests great potential for analogy learning as an approach that can be applied in different contexts. This current study contributes to this growing base of applications by testing analogy learning in softball batting. Besides the new sports context, this study contributes to field-based evidence, which is currently lacking, as the study is situated in the training programme of a collegiate level softball club. Such evidence is crucial for transforming research findings to useful insights that can be applied in coaching and teaching.

The evidence supporting analogy learning has been largely relevant to novices (e.g. Lam, et al., 2009; Liao & Masters, 2001; Poolton, et al., 2006). However, the reality on the field, particularly at collegiate club levels, is that players will often have some experience prior to embarking on further training. Consequently, they are not novices, yet they need further instruction to improve their skills. We have yet to verify whether a bout of analogy learning would be useful for those who might already have declarative knowledge associated with the skill. To contribute to a better understanding of suitable approaches for players with different levels of experience, this study compares novices and relatively experienced players.

An important factor in players' acquisition of skills is self-efficacy, which refers to ''beliefs in one's capabilities to organize and execute the course of action required to produce given attainments'' (Bandura, 1997, p.3). Implicit motor learning approaches have been suggested to promote learners' self-efficacy (van der Kamp, Duivenvoorde, Kok, & Hilvoorde, 2015); however, there has been limited empirical evidence of this, especially in relation to motor performance following bouts of implicit learning. Liao and Masters (2001) determined that confidence was associated with motor performance for explicit learners but not for implicit learners. They interpreted this as evidence that implicit learners acquired less metaknowledge of the acquired movement skills compared to explicit learners. Despite such lack of knowledge amongst implicit learners, self-efficacy could be enhanced as performance accomplishments have been identified as the most important contributing factor (Bandura, 1997). Change in self-efficacy, however, has been largely unexamined in the context of implicit motor learning. With the knowledge that higher self-efficacy has consistently been associated with better sports performance and greater task engagement (McAuley & Blissmer, 2002), it is of value to verify the impact of motor learning approaches on self-efficacy. Whilst self-efficacy has been examined in different skills acquisition contexts (e.g. Stevens, Anderson, Dwyer, & Williams, 2012), it has yet to be examined alongside motor performance following an analogy approach.

Softball batting

There has been relatively limited skills acquisition research into softball batting compared to sports like golf or baseball (Flyger, Button, & Rishiraj, 2006). To the best of our knowledge, this is the first application of analogy learning in softball batting. Biomechanically, softball batting requires weight shifting, hip rotation, shoulder rotation, arm rotation, and elbow extension (Welch, Banks, Cook, & Draovitch, 1995). The nature of the task also includes recognition, reaction, and adjustment to the oncoming ball, adding to the complexity. Moreover, softball batting takes place in an open loop such that adjustments may be limited once the stimulus is released (Rose & Christina, 2006). Instructions are therefore critical for batters to manage the relatively complex task demands. Explicit instructions are likely to be effective in promoting biomechanically correct movements, but cognitive processing of the rules for movement is likely to compete with the information processing demands related to the pitched ball. We therefore suggest that analogy learning is a viable alternative form of instruction, because the movement instructions can be delivered as a single biomechanical metaphor (Liao & Masters, 2001). When movement instructions are processed as a single analogy, cognitive resources should be free to manage the perceptual demands of the skill (i.e. recognition, reaction and adjustment to the pitched ball).

This current study applied analogy learning to softball batting, and examined skill performance as the outcome. Because self-efficacy is believed to interact with cognitive and training factors (Feltz & Lirgg, 2001), this study also examined its relationship with skill performance. The main aims of this study were to (a) develop an analogy relevant for softball batting and (b) compare batting performance following analogy learning by novice and intermediate players.

Typical coaching instructions (i.e. explicit) were identified, and analogy instructions were developed through a focus-group discussion with previous and present team captains, and a team coach of a collegiate-level softball club. The instructions were used to train novice and intermediate players. We expected improved batting performance from pre- to post-training in both analogy and explicit training conditions. Improvement was expected to be greater for the novices compared to the intermediate players, because they had more room for improvement and there is a potential "ceiling" effect for intermediate players. In the presence of a secondary cognitive task, which was expected to reduce the amount of cognitive resources available to support execution of batting, we expected analogy learners to display robust skill performance while explicit learners were expected to display performance decrements. We also expected that self-efficacy would be positively associated with change in skill performance regardless of level of experience or instructions received.

Materials and methods

Participants

A priori power analysis using G*Power 3.1 for repeated measures analysis of variance (ANOVA; within-between interactions, four groups, three measurements) determined that to achieve 85% power, alpha of 0.05, with expected effect size of 0.28 (Liao & Masters, 2001), the required sample size was 36. Participants consisted of members of a collegiate softball team, and the sample size (n = 40, 14 males and 26 females) was ultimately determined by the number of players who were interested and committed to an actual training programme that consisted of six sessions over three weeks. The participants' ages ranged from 18 to 25 years (mean 21.00, s = 1.40). Recruited participants were categorised as either (a) intermediate players (n = 20) who had one to two years of experience playing collegiate-level softball, or (b) novice players (n = 20) who had less than 10 hours of batting experience. Within each subgroup (i.e. intermediate, novice), participants were allocated to either an analogy or an explicit instruction condition according to the sequence of recruitment (i.e. participants were assigned to the analogy or explicit condition alternately as they signed up for the study). Hence, four training groups were formed (n = 10 per group): analogy-intermediate, explicit-intermediate, analogy-novice, and explicit-novice. While the sex distribution across the groups was not equal, the difference was not statistically significant ($\chi^2 = 0.44$, $p = 0.930$). All procedures were reviewed and approved by the institutional ethics review committee, and all participants provided informed consent to join the study.

Instructions

To develop content-valid instructions for softball batting, a focus-group discussion was conducted. The focus-group participants consisted of one coach, two past team captains and one current team captain of a collegiate-level softball team. The coach had 20 years of experience in coaching softball; the previous team captains had three years of experience in playing softball; and the current team captain had two years of experience. Drawing from their experiences in training and practicing softball batting, the participants came to a consensus that an eight-point set of explicit instructions was representative of the typical instructions given on the field (see Table 1).

An independent researcher, experienced in developing analogy instructions for motor learning contexts, provided background knowledge on analogy learning for the focus-group participants. Using examples of other analogies for sports-related tasks as a starting point (e.g. forehand topspin analogy; Poolton, Masters, & Maxwell, 2007b), a discussion was facilitated to develop the analogy instruction. Each participant proposed an analogy instruction for softball batting. The suitability and merits of the instructions, including points of relevance and understanding by the softball club players, were discussed at length until a final analogy instruction was agreed upon. The following analogy instruction was identified: "swing your bat like you are breaking a tree in front of you with an axe". The analogy instruction and the process through which it was developed, were then reviewed by a team of two independent skills acquisition researchers and the first author of this study.

Insert Table 1 about here

Training

The study was implemented within the context of an actual training programme of a collegiate-level softball team. Besides the softball batting training conducted in the study, participants received the same amount of fitness and endurance training as other members of the team (i.e. 90 minutes training, twice/week).

Softball batting training consisted of six sessions over a period of three weeks (i.e. twice/week). In each training session, participants hit a total of 150 balls (25 balls/set x 6 sets), totalling 900 balls over the six-session training period. The interval between two consecutive balls in each set was five seconds, and the rest interval between two consecutive sets was two minutes, which allowed sufficient recovery to avoid fatigue. Instructions (analogy or explicit) were provided verbally, and presented visually as printed text, to each participant before the start of each set. They were also reminded that they were not to share the instructions that they received with their team mates.

In the first session, balls were placed on a tee stand and participants had to bat the ball towards a practice net located at a two-meter distance to the front of his or her position. In the second session, the senior pitcher of the collegiate team was designated to pitch the balls at constant conditions for all participants. The designated pitcher stood 2.5 meters away and at 45 degrees diagonal to the participant, and pitched balls towards the participant's strike zone. The strike zone is defined as the volume of space between the top of the participant's knees and the midpoint of his or her torso (International Softball Federation, 2014). The pitcher aimed to pitch the balls at a relatively constant speed across trials and participants. In the third session, a pitching machine was positioned at a distance of 13.10 m (43 feet) from the participant. This is the standard distance between the pitcher and the batter for international women's softball (International Softball Federation, 2014). Plastic balls of the same size as a standard softball were pitched by the machine at a speed of 72.42 kph (45 mph) towards the participant's strike zone. These conditions were maintained across the remaining training sessions (i.e. fourth, fifth, and sixth sessions).

Testing

Pre-test and post-test conditions were similar to those of the last training session, wherein a machine pitched balls from a standard distance (13.10 m), and at standard speed (72.42 kph) towards the participant's strike zone. The test consisted of 30 balls, pitched at five-second intervals. Participants were instructed to try their best to bat the balls. Batting performance was rated using the Softball Batting Performance Rating Scale, which had been adapted by Krane and colleagues (1994) from the original scale developed by Lowe (1973), and used in a study that examined batting performance in relation to anxiety and situation criticality. The rating scale categorises each hit as one of nine types (see Table 2 for operational definitions), with ratings ranging from one to eight - higher scores represent better performance. From 30 trials, a participant may therefore have a minimum score of 30, and a maximum score of 240.

Strikeout definitions were modified because each pitch was rated, whereas three pitches per rating had been used in a previous study that used the scale (Krane, et al., 1994). Ratings were performed by a collegiate level team captain from a different league who was unfamiliar with the study participants, and naive to the study aims and training conditions. Prior to testing, the rater was trained on using the scale, and scored ten collegiate softball players (non-participants) concurrently with the third author of this study. Inter-rater agreement was above 90% prior to testing. No performance feedback was given to participants following the pre-test and post-test sessions.

After each of the testing sessions, participants were asked to evaluate their batting self-efficacy using a visual analogue scale, which provided a continuum for participants to mark their response. Visual analogue scales have been found to be valid measures of a range of psychological constructs, such as visual experience of movement (Rausch & Zehetleitner, 2014), anxiety (Davey, Barratt, Butow, & Deeks, 2007), and mood (Kontou, Thomas, & Lincoln, 2012). A visual analogue scale is particularly suitable when the question is along a single dimension (Rausch & Zehetleimer, 2014). In this study, participants were asked a single question – how well they could perform softball batting – to which they responded by marking a line on a standard sized line (i.e. 10cm) without scale markings. Labels were provided on the scale only for the extremes (i.e. 'lowest performance' corresponded to 0 cm, 'highest performance' corresponded to 10cm). Participants' marks on the visual analogue scale were measured in cm and were converted to percentage, such that 100% represented the highest rating, marked at the 10 cm point on the visual analogue scale.

After a 5-minute rest following the post-test, a dual-task testing condition was additionally performed. Because attentional capacity is limited, batting performance that is reliant on conscious processing of instructions may be compromised by a secondary task that also requires conscious processing (e.g. Abernethy, Masters, Maxwell, van der Kamp, &

Jackson, 2007). In the dual-task condition, participants were asked to perform a tone counting task while simultaneously batting in the same conditions as the post-test. The tone-counting task has been successfully used to occupy cognitive resources in previous motor learning studies (e.g. Maxwell, Masters, & Eves, 2000; Zhu, Yeung, Poolton, Lee, Leung, & Masters, 2015). High-pitched (1000 Hz) and low-pitched (500 Hz) tones were presented in a randomized order at intervals of 1000ms through headphones. Participants were instructed to count the number of high-pitched tones throughout the 30 test trials. Secondary task performance was calculated as percentage accuracy (number of high-pitched tones reported against actual number of high-pitched tones presented).

Insert Table 2 about here

Data Analysis

Normality of data was tested using the Shapiro-Wilk test, which showed that batting performance scores and self-efficacy ratings were normally distributed (all p's > 0.05). To examine the effect of the instructions on skill performance of novice and intermediate players, a mixed-model 3 (test: pre-test, post-test, dual-task) x 4 (group: analogy-novice, explicit-novice, analogy-intermediate, explicit-intermediate) analysis of variance (ANOVA) was performed on batting scores. Mauchly's test confirmed that the sphericity assumption was not violated ($p = 0.216$). To examine change in self-efficacy following training, a mixed-model 2 (test: pre-test, post-test) x 4 (group) ANOVA was performed on self-efficacy scores. Significant main effects and interactions were followed up by group-level repeated measures ANOVAs and paired samples t-tests with Bonferroni corrections. One-way ANOVAs were used to compare the secondary task performance of the four groups. Statistical significance was set at $p < 0.05$. All tests were performed using SPSS 25.0.

Results

Batting performance

Figure 1 illustrates batting performance of the instruction groups during the pre-test, post-test, and dual-task condition. Within-subjects, a significant main effect of test was found ($F(2, 72) = 12.768$, $p < 0.001$, $\eta^2 = 0.262$), indicating that the batting performance of participants changed across the three tests (i.e. pre-test, post-test, dual-task). A significant interaction was found between test and group ($F(6, 72) = 8.684$, $p < 0.001$, $\eta^2 = 0.420$). Follow-up tests showed significant main effects of test for the analogy-novice ($F(8, 2) = 7.61$, $p = 0.010$, $\eta^2 = 0.86$), explicit-novice ($F(8, 2) = 13.30$, $p = 0.003$, $\eta^2 = 0.77$) and analogy-intermediate groups ($F(8, 2) = 10.64$, $p = 0.006$, $\eta^2 = 0.73$), but not for the explicit-intermediate group ($F(8, 2) = 0.84$, $p = 0.550$, $\eta^2 = 0.14$).

Paired comparisons showed that batting performance of the analogy-novice group improved from pre-test to post-test ($t(9) = -3.49$, $p = 0.007$), and did not change from post-test to dual-task ($t(9) = -0.47$, $p = 0.650$). Batting performance of the explicit-novice group improved from pre-test to post-test ($t(9) = -5.17$, $p = 0.001$), but deteriorated from post-test to dual-task ($t(9) = 3.61$, $p = 0.006$). There was no change in the batting performance of the analogy-intermediate group from pre-test to post-test ($t(9) = 0.02$, $p = 0.990$), but there was a deterioration in performance from post-test to dual-task ($t(9) = 3.09$, $p = 0.010$). There were no significant changes in the batting performance of the explicit intermediate group (p's > 0.05).

Between-subjects, a significant main effect of group was found ($F(3, 36) = 7.142$, $p = 0.001$, $\eta^2 = 0.373$). Pairwise comparisons of estimated marginal means showed significant differences when the analogy-novice group was compared to the analogy-intermediate ($p = 0.006$) and the explicit-intermediate ($p = 0.033$) groups. Significant differences were also found between the explicit-novice and analogy-intermediate groups (p = 0.007), and the explicit-novice and explicit-intermediate groups (p = 0.041).

Insert Figure 1 about here

Secondary task performance

One-way ANOVA showed no significant between group differences for the tone-counting task ($F(3, 36) = 1.40$, $p = 0.26$), with mean percentage accuracy across all participants 91.60% (s = 9.4).

Self-efficacy

A significant within-subjects effect of test was found ($F(1, 36) = 11.170$, $p = 0.002$, $\eta^2 = 0.237$); self-efficacy improved from pre-test to post-test (see Figure 2). An interaction was not evident between test and group ($F(3, 36) = 1.378$, $p = 0.265$, $\eta^2 = 0.103$), indicating no effect of the group on the changes in participants' self-efficacy. Between subjects, the main effect of group was not significant ($F(3, 36) = 2.489$, $p = 0.076$, $\eta^2 = 0.172$).

Insert Figure 2 about here

Discussion

This study aimed to apply analogy learning to softball batting and examine skill performance outcomes, comparing novices and intermediate players. Performance was measured using an established criteria-based rating scale, which has been developed specifically for softball batting (Krane, et al., 1994; Lowe, 1973). As expected, novices displayed improvements in performance regardless of the instructions that they received. While the trends suggest some improvement in performance of intermediate players, changes from pre-test to post-test were not significant in the analogy or the explicit learning groups despite completing 900 trials over six training sessions. Task difficulty needs to be optimal for skill levels of learners in order to promote improved performance (Guadagnoli & Lee, 2004); in this case, it is possible that the practice conditions were not optimal for intermediate players. It may also be the case that the practice dosage was not sufficient to promote further improvement for non-novices. On the other hand, novice players presumably had greater room for improvement, so practice – regardless of instructions – improved performance.

Underlying mechanisms

The advantage of implicit motor learning approaches, such as analogy instruction, manifests in circumstances during which there are competing demands for cognitive resources (Lam, et al., 2009; Poolton, et al., 2006). We expected that analogy learners would display robust performance during the dual-task condition in this study, whereas explicit learners would display disrupted performance. Our findings confirm this for novices, as those in the analogy learning condition displayed stable batting performance, while those who learnt explicitly showed worse batting performance, in the dual-task compared to the single-task post-test condition. Similar to studies of basketball free throwing (Lam et al., 2009) and table tennis (Koedijker et al., 2008), no differences were found in performance of the secondary task across analogy and explicit learners. Participants displayed high accuracy at the tone-counting task, so it appears that they conscientiously and effectively engaged in the secondary task, but with differing impacts on performance of the batting task. Novice analogy learners did not display an advantage over novice explicit learners at post-test and, as expected, the benefits only became evident when competing cognitive demands were present. As the theory of reinvestment posits, the availability of explicit knowledge enables conscious processing of skill performance, which ultimately leads to breakdown (Maxwell, Masters, & Poolton, 2006). Considering this, the explicit learners were provided explicit knowledge to reinvest whereas the analogy learners were not, which may explain the greater tendency for performance breakdown. We note, however, that the novice learners may not have reached an autonomous stage of performance, in which case, alternative explanations would account for the advantage demonstrated by novice analogy learners.

Masters and Liao (2003) proposed that the underlying mechanism of analogy learning is a process in which relevant and discrete pieces of information are integrated into a single representation (i.e. referred to as 'chunking'). If such were the case, the novices would have had adequate cognitive resources to manage the demands generated by the secondary task without an impact on their batting performance, presumably because the relevant information for batting was 'chunked' in the analogy instruction. This advantage is particularly useful for baseball coaches, who need to train novices to display robust batting skills, and at the same time, process information related to recognition, reaction, and adjustment to the oncoming ball.

It is also possible that the apparent benefits of analogy instruction for novices in this study are a function of the volume of instructions. This being a field-based study, we endeavoured to compare the analogy instruction to the typical coaching instructions being deployed in the softball club. Consequently, this meant that the single analogy instruction was compared to a set of eight explicit instructions. We therefore acknowledge that the differences in training outcomes could be due to variations in cognitive requirements caused by the volume of instructions. Related to this, Schucker et al. (2010) used multiple analogy instructions for a golf swing, equivalent in volume to explicit instructions, and found no differences in performance by learners following a six-week training period. Nevertheless, we note that Bobrownicki and colleagues (2015) have argued that the strength of analogies in applied contexts is that they potentially deliver relevant movement instructions in a concise package. From this perspective, the value of analogy learning in coaching and instruction is probably linked to cognitive efficiency. While we do not have empirical evidence of cognitive efficiency in this current study, recent work by van Duijn et al. (2019) offers evidence from electroencephalography (EEG) suggesting that analogy instructions promote cognitive, rather than psychomotor, efficiency among novices. Future work could explore methodologies that measure cognitive efficiency in field-based research, as EEG is generally more suitable for laboratory-based experiments.

Whilst we set out to verify whether a bout of analogy learning would be useful for non-novice learners, our findings make it difficult to draw conclusions on this. We did not find improvements following training amongst intermediate players, but we found that they displayed a different pattern of performance in relation to the dual-task condition – the intermediate explicit learners were stable and the intermediate analogy learners got worse. The intermediate players had previously received instructions that were comparable to the eight-point instructions used in the explicit training group. Analogy learning is thought to have the potential to enable learners to simplify previously established concepts related to the movement (Masters, 2000; Bobrownicki, Collins, Sproule, & MacPherson, 2018). However, the intermediate players in this study appear to have processed the analogy instruction as new information, and failed to make connections with their existing knowledge base. This was not apparent from pre-test to post-test as all intermediate players maintained their batting performance levels. The cognitive cost of introducing the analogy instruction to intermediate learners, who presumably have an existing knowledge established through previous instructions, became apparent in the dual-task condition. This suggests that the use of analogy instructions in coaching needs careful consideration, especially with reference to players' previous learning experiences and existing knowledge base. However, more research is needed to further examine the utility of analogy instructions for non-novice players, considering both cognitive efficiency (e.g. measured by EEG or alternative methods) and processing of instructions (i.e. controlling the volume of instructions).

The patterns displayed by intermediate learners also brings into focus the relevance of considering implicit and explicit learning approaches not in isolation. Poolton, Masters, and

Maxwell (2005) showed that the benefits afforded by an initial bout of implicit motor learning tend to be retained even when this is followed by a bout of explicit learning. Based on evidence from an errorless learning paradigm, they suggested that the initial stages of learning should be implicit so that skills are robust in the face of competing cognitive demands. Whether the same holds true in the case of an analogy learning paradigm has yet to be tested. In this study, a reverse sequence occurred, with intermediate players having prior explicit training. It appears that an initial explicit stage followed by analogy learning could lead to disadvantages that may be caused by additional cognitive processing requirements. Given that field conditions are such that collegiate club players may have varying learning experiences prior to training, future research needs to examine the effects of combinations and sequences of explicit and analogy learning approaches.

Self-efficacy

Cognisant that self-efficacy is an important factor to consider when developing coaching and physical education programmes (van der Kamp et al., 2015), we examined the effects of instruction on batting self-efficacy. The findings show that participants' self-efficacy improved following training, across novice and intermediate players and regardless of the instructions they received. It has been established that information about performance accomplishments forms the basis for self-efficacy levels (Bandura, 1997). In this study, no feedback about performance was provided to the participants. Nevertheless, they are likely to have gathered information from intrinsic feedback that was available in each practice trial (Magill & Anderson 2017). It is worth noting that self-efficacy increased even for intermediate players who actually did not show significant improvements in performance following training. We know that self-efficacy is a significant contributor to motivation and performance levels across a wide range of contexts (Bandura & Locke, 2003) and therefore sought to verify the suggestion that implicit motor learning could promote better self-efficacy (van der Kamp et al., 2015). The current study findings do not provide evidence for this, as it appears that the opportunity for practice, whether in explicit or implicit conditions, was sufficient to cause improvements in self-efficacy. It would be worth examining this further, using alternative implicit motor learning paradigms (e.g. errorless learning).

Limitations

In interpreting the findings of this study, it is also important to acknowledge a number of limitations. Batting performance was measured using a criteria-based qualitative scale. While the methodology ensured internal validity through standardised assessment, external validity may be limited and further research that uses objective measures (i.e. three-dimensional motion analysis) could add value. One of the training sessions employed a senior pitcher who attempted, as much as possible, to pitch balls at a constant speed towards participants. We acknowledge that this was subject to human limits, and would not have been as consistent as the pitching machine employed in the subsequent sessions.

Unlike most motor learning studies, we did not check for verbal declarative knowledge, because the constraints associated with the actual training context did not allow time for verbal reports to be collected. We acknowledge that this prevents us from definitively ruling out the possibility that participants in the explicit training conditions might have used significantly fewer than the eight explicit instructions provided. Nevertheless, we believe that the available evidence (e.g. Lam, et al., 2009; Masters, Poolton, Maxwell, & Raab, 2008; Poolton, et al., 2006) clearly shows a difference in accrued declarative knowledge as a consequence of analogy learning or explicit learning. Finally, analogies are known to be subject to nuances associated with the language and culture of the population for which it was designed (see Poolton, Masters, & Maxwell, 2007b). Hence, the analogy developed in this study needs to be re-examined in other population groups, and possibly modified as appropriate.

Conclusions

The application of motor learning research across sports, education, and rehabilitation continues to grow, as does evidence of the need for careful consideration of approaches and their suitability for learners. Analogy learning is one of many approaches – explicit and implicit – that could inform sport and physical education pedagogy, and could be used as a constraint to facilitate movement exploration by novices (Komar et al., 2018). By demonstrating an application of analogy learning in softball batting, this current study contributes to the evidence supporting the use of analogy learning, adding to the range of sports to which the approach has been applied to (Koedijker, et al., 2011; Komar, et al., 2014; Lam, et al., 2009). Furthermore, by comparing novice and intermediate players, the findings of this study suggest that analogy learning is not universally superior to typical explicit coaching approaches. It appears to be beneficial for novices, and further research is needed to examine the underlying mechanisms, particularly to understand the apparently different outcomes in those who have received previous instruction. At the outset, we asked whether a bout of analogy instruction would be beneficial for non-novices; our findings suggest otherwise. Based on current evidence, the decision to adopt one specific instruction approach needs to be informed by the characteristics of the learners. In other research, the suitability of explicit or implicit approaches appears to be influenced by learners' motor ability (Maxwell, Capio, & Masters, 2017), cognitive ability (van Abswoude, Santos-Vieira, van der Kamp, & Steenbergen, 2015) or personality (van Ginneken et al., 2017).

To conclude, this study tested an analogy for softball batting. The findings show that the benefits associated with implicit motor learning were apparent in novice learners, but not in intermediate learners with prior explicit training. Further research is recommended to gain a better understanding of analogy instructions in field conditions, where explicit and implicit learning might not occur in isolation. Ultimately, in the complex real world, coaching and instruction has to be designed to meet the needs of players whose knowledge, skills, dispositions and experience vary greatly.

Declaration of interest statement

The authors declare no conflict of interest.

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Tables

Table 1. Comparison of the analogy and explicit instructions.

Analogy	Explicit
Swing your bat like you are breaking a tree in front of you with an axe.	1. Initiate the movement by rotating your trunk. 2. Lead with your front arm for the bat to contact the ball. 3. Push the bat forward with your back arm. 4. Rotate your wrists to push the ball further. 5. Keep your elbows down. 6. Keep your trunk perpendicular to the ground. 7. Keep most of your weight at the back leg up until the bat makes contact with the ball. 8. Keep looking forward after batting.

Table 2. Operational definition and scores using the adapted softball batting performance rating scale (Krane, Douglas, & Rafeld, 1994).

Type of hit	Operational definition	Score
Strike-out looking	Participant calls a strike without swinging the bat.	1
Strike-out swinging	Participant swings and misses.	2
Hit by pitch	Participant is hit by the pitch.	4
Infield fly ball	Batted ball rises above the plane of the bat and travels into the infield.	5
Ground ball	Batted ball lands in the infield and bounces more than 4 times and rolls toward the outfield	5
Easy outfield fly ball	Batted ball rises above the plane of the bat and slowly travels to the outfield.	6
Hard ground ball	Batted ball lands in the infield and bounces no more than 3 times before it reaches the outfield; ball travels at high speed.	7
Hard fly ball	Batted ball rises above the plane of the bat and travels quickly into the air; ball lands in the outfield.	8
Hard line drive	Batted ball moves in the trajectory of a straight line; ball lands not more than once in the infield or first lands in the outfield.	8

Figure Legend

Figure 1 Batting performance of participants during the pretest, posttest, and dual-task condition.

Figure 2 Self-efficacy of participants at pretest and posttest.