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Research article

Effect of Different Attentional Instructions on the Acquisition of a Serial Movement Task

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Abstract
Recent research in attentional focus of instruction has predominantly over-emphasized the investigation of discrete and continuous skills rather than serial skills. The purpose of this study was therefore to examine the effect of different attentional focus instructions on learning a serial skill task (i.e., taekwondo routine) in novice learners. It was predicted that the use of movement outcome instructions could enhance the learning of a serial skill as previously supported in studies examining the acquisition of discrete and continuous skills. Thirteen female participants were recruited for this study and were assigned to either movement form condition - control group (n = 7) or movement outcome condition – treatment group (n = 6). All participants underwent 12 practice sessions over an 8-week period with their respective instructional conditions with each session lasting 30 minutes. Video recording of the serial skill tasks (hand techniques, kicking techniques and 10-step routine) were captured at "the-twelfth-training session", "after 1-week", and "after 1-month". It was found that more participants in the treatment group obtained a higher score in all three serial skill tasks, especially in Mastery component of 'Kicking' techniques at 'after 1-week' ($p < 0.05$, $r = 0.57$). This study suggested that movement outcome instructions have positive medium effect on balance control for serial skill task, especially in kicking actions.

Key words: Focus of attention, serial skill tasks, taekwondo routine.

Introduction

Instructions play an important role in enhancing skill learning. The impact of effective instructions can lead to significant changes to the internal processes that occur at the neural and muscular subsystems when learner acquires a movement skill (Davids et al., 2008). Such effective learning due to the presentation of suitable instructions can result in changes to performance that is relatively persistent and adaptable to varying performance contexts (Davids et al., 2008). Undoubtedly, verbal instruction is effective as a form of task constraints that guide learners to shape the emergence of coordinated action and encourage learner's exploratory behaviour (Davids et al., 2008).

In a learning environment, teachers and coaches normally use verbal instructions with cue words/phrases to direct learners' attention to certain components such as the limbs' position to the movement, the analogy of the movement or any external objects in the environment during practice (Ehrlenspiel, 2001). Interestingly, the advantages of using instructions that direct learner's attention to the outcome of their movement on the environment (external focus) has been widely reported in learning compared to movement form (internal focus) on specific parts of the body (i.e., limb segments) (Peh et al., 2011). One example of instructions with an emphasis on the movement outcome, that can result in positive learning and eliciting an external focus of attention, is the use of metaphors or analogies (Lam at al., 2009; Poolton et al., 2006). Masters (2000) further suggested that analogy learning reduces multiple task-relevant "rules" into a single "analogical rule", which promotes implicit learning and reduce the conscious explicit processing of task relevant information.

Theoretically, movement outcome/external focus of attention instructions is seen to be beneficial because there are strong suggestions that the coordination of multiple degrees of freedom is not directed by conscious intentions. Emergence of coordination occurs under self-organization processes that are underpinned by the dynamic interactions among constraints (e.g., performer, task and environment) (Chow and Atencio, 2012). Under the self-organising properties of the central nervous system, learners emerge, dissolve, and reformulate movement spontaneously to form new patterns that are better suited for the changed conditions (Lee, 2011). Based on the ideas of action-effect representations in the motor system, learners have better advantages in learning when they focus externally towards movement outcomes especially on effect-relevant dimension (i.e., use of external focus of attention) as compared to an internal focus of attention where learners pay attention to the form of the movement (Prinz, 1990).

On the other hand, movement form/internal focus of attention has been seen as generating negative impact on skill learning or performance that are associated with explicit control, greater conscious control over the spatial targets and the sequence of the movements (Lohse et al., 2010). Ehrlenspiel (2001) further suggested that a nodal point control strategy (internal focus) leads to increased muscular activity and freezing of degrees of freedom of the movements. It is believed that the conscious control of a movement leads to constraining of the motor system by intervening automatic process that would "normally" regulate movement coordination effectively (Schűker et al., 2009).

Despite the unfavourable results reported in relation to the effect of movement form/internal focus of attention, some studies found that novices benefited from instructions that directed attention to the stepwise moni-

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toring of specific part of the movement (see Schűker et al., 2009), which is akin to an internal focus of attention instructional constraint. For example, it was found that movement form/internal focus of attention was beneficial and did not affect the performance in novice or low skill golfers (Beilock et al., 2002; Ford et al., 2005; Perkins-Ceccato et al., 2003; Uehara et al., 2008). A recent study undertaken by James (2012) indicated that movement form/internal focus of attention instruction in learning movement form was beneficial if the movement requires minimum demands for attuning movement to the environment.

One of the key research gaps for current research investigating attention focus is an over-emphasis on examining discrete and continuous skills rather than serial skills. For example, Wulf and colleagues have conducted studies in volleyball (Wulf et al., 2002), golf (Perkins-Ceccato et.al., 2003) and soccer (Wulf et al., 2010); Zentgraf and Munzert (2009) in juggling performance; Schűker and colleagues examined the physiological changes in running (Schűker et al., 2009); Uehara et al. (2008) in soccer chip; Marchant and colleagues in novice dart throwing (Marchant et al., 2007) and isokinetic bicep curls (Marchant et al., 2006); Al-Abood and colleagues investigated the verbal instruction and visual search in basketball free throw shooting (Al-Abood et al., 2002); Lohse et al. (2010) investigated the kinematic aspect and EMG in dart throwing; Porter et al. (2010) in agility performance.

However, investigations in relation to the impact of attentional focus instructions on serial skills have received little attention in motor control and learning research. To our knowledge, only one study conducted by Lawrence et al. (2011) to examine the effect of attentional focus of instructions on a simple serial skill (five simple movements in a routine) They concluded that both attentional focus instructions neither benefited nor degraded learning in form-based task.

The paucity of empirical investigations on serial skills provide the impetus to undertake the current investigation, especially for serial sports tasks that involves multi-articular movements (e.g., gymnastic- floor routine, taekwondo & karate) (see Lawrence et al., 2011). This study seeks to understand the effectiveness of attentional focus of instructions on more complex routines in a serial task. The purpose of this study was to determine the difference in effectiveness between traditionally used instructions of attention (internal focus) and movement outcome of instructions (external focus) on learning a serial task in taekwondo. It is predicted that the modified instructions focusing on movement outcome can enhance the learning of a serial skill as it allows learners to exploit the self-organisation processes present in such a learning context, as previously supported in studies examining the acquisition of discrete and continuous skills.

Methods

Participants

Thirteen novice female adults (aged 30.7 ± 4.6 years), with no prior experience in taekwondo (TKD) or any form of martial arts, were recruited for the study. Two centralised training centers, located in the Northern and Southern regions of Singapore, were used for all training sessions. The participants recruited via convenient sampling through the North center were assigned to control group, focused on movement form (MF) of instructions (n =7); while the participants in the South center were assigned to treatment group, focused on movement outcome (MO) of instructions (n = 6). Movement form condition was considered as the control group because traditionally, teaching of taekwondo focuses heavily on the movement form (Internal focus) of the learner with strong emphasis on techniques execution with lengthy instructions (Little and Wong, 1999). For example, some of the instructions like, “Extend the leg from the knee, pointing the foot to use the instep as the striking surface.” and “At full extension, the hip and shoulder should be in line with the target, while the kicking foot and knee should have passed through it.”, specifically has strong associations with movement form (White, 2006).

In addition, both groups of participants were not informed of the presence of any other instructions that were provided to other participants. No information was also made available to the participants that their instructions were beneficial or not beneficial. They were only required to follow their respective instructions. This was to prevent the “special treatment” (belief effect) felt by the participants, which could lead to false belief that could enhance performance (see Beedie, 2007). They were required to specifically learn and perform at their best by using the given instructions. Voluntary and informed consent were obtained from all participants, and the procedures used in the study were in accordance with the participating institution’s ethical guidelines.

Apparatus and task

Taekwondo belts, chairs, coloured tapes and markers were used as part of the treatment group’s instructional package, which incorporate key elements of external focus type of attention instructions. Kicking pads were used by participants of both treatment and control groups as targets to practice punching and kicking.

Participants were asked to perform a series of hand techniques; kicking techniques and a 10-step routine (Table 1) and all movements for the TKD task were recorded by two video cameras (Sony- HDR-HC7, 6.1 megapixels). The cameras were placed 3m at the sagittal and 6m at the frontal planes from where the participant stood before the performance of the serial skill task, to capture the movements that occurred in these two planes. No pre-test session was conducted because there was no means or relevant test to determine the kicking and punching motions associated with the TKD serial task at entry level. This is also aligned to how actual TKD training is facilitated where no assessment is provided prior to undertaking such training. Since the task was novel to all participants, it was accepted that the participants were at the same entry level for this particular serial task.

Procedure

Training sessions

Participants were required to undergo twelve practices sessions to learn a 10-step taekwondo routine (seeTable 2)

Table 1. Instructional cues & phrase.

Discrete Skills		Movement Form	Movement Outcome
Lead hand punch (fighting stance)		1. Point shoulder towards target 2. Extend the elbow straight out. 3. Contact with the 1st two knuckles 4. Lock the elbow and wrist at the moment of impact.	1. Hit in a straight line with the fist 2. Aim the fist to the nose of your image in the mirror
Reverse hand punch (fighting stance)		1. Pivot the ball of the rear foot with slight knee bend. 2. Point the shoulder of the punching hand towards the target. 3. Extend the elbow and hit with the 1st two knuckles. 4. Lock the elbow and wrist at the moment of impact.	1. Flick your belt strap from right to left 2. Hit in a straight line with the fist 3. Aim the fist to the nose of your image in the mirror
Lead hand Hook Punch (Fighting stance)		1. Trunk rotates to the right. 2. Left shoulder rotates outwards 3. Flexed elbow during swing 4. Lock the elbow and wrist at the moment of impact.	1. Hook the punch above barrier 2. Flick your belt strap to the right
Front thrust kick		1. Lift kicking leg where knee is slightly above the hip. 2. Extend the knee forward 3. Contact with the ball of the foot at full knee extension	1. Contact barrier with knee 2. Strike target with foot
Turning kick		1. Pivot supporting leg on the ball of the foot with slight knee bend 2. Lift the kicking leg in a flexed position with knee above hip. 3. Keep the heel in line with the hip and shoulder. 4. Foot plantar flexed and travel across the midline of your body 5. Flex knee after contact	1. Belt needs to travel from right to left 2. Clear barrier with shank above it 3. Strike target with foot in a snap-like motion
Shuffle forward		1. Lift up front leg slightly from the floor. 2. Move forward with the front leg and land with the ball of your foot. 3. Slide the ball of the rear foot slightly forward.	1. Front leg slides over a colour marker on the floor.
Sliding turning kick		1. Move the rear first. 2. Lift up the kicking knee as the rear foot approaches the front foot. 3. Keep thigh level with hip during preparation 4. Foot plantar flexed and travel across the midline of your body 5. Flex knee after contact	1. Shift rear foot towards coloured tape 2. Clear barrier with shank of the front leg above it Contact target with foot in a snap-like motion
Sliding front kick		1. Move the rear leg first. 2. Lift up the kicking knee as the rear foot approaches the front foot. 3. Keep knee level with hip during preparation 4. Extend the knee forward 5. Contact with the ball of the foot at full knee extension	1. Shift rear foot towards coloured tape 2. Contact barrier with front knee. 3. Strike target with foot

in groups of three to five. Each session lasted about 30 minutes and the twelve practice sessions took place over an 8 weeks period. The 10-step taekwondo routine consisted of 3 hand- and 4 kicking techniques. The researcher, who is also a certified TKD instructor with more than 10-years' experience in coaching, presented the cues and taught all the training sessions for both groups. All practice lessons followed strictly to the pre-planned practice programme designed by the research team. Lessons were validated by certified TKD instructors from a taekwondo

training institute to ascertain that the lessons were effectively delivered based on the lesson structure planned for both groups.

See Table 1 for the specific verbal descriptions, underlined cues, and demonstrations of the skill presented to both groups. All underlined cues were highlighted to explicitly emphasize the importance of the respective cues to both groups' participants by the researcher during the training sessions. The verbal description and cues to control group's participants were solely focused on the movement form (specific body parts) and regular check was performed to ensure they did not focus on the external apparatus (e.g., target location on the pads).

Prior to the introduction of a new set of skills for each session, the researcher would provide a brief revision of the learnt movements from the previous session. The researcher would only demonstrate once for the previously taught skill together with verbal descriptions and the underlined cues. Participants were given 5-minutes to practice the previously taught skills under the supervision of the researcher, and feedback based on the allocated attentional instructions would be provided by the researcher when and where necessary (based on the cues previously taught). No extraneous feedback beyond the instructions allocated for the attentional focus conditions were provided in all the practice sessions.

For every training session, the researcher would remind the participants to focus on the underlined cue words and phrases that were presented to them earlier based on their respective attentional focus conditions (Table 1). Furthermore, researcher also performed regular verbal checks on the cues that the respective participants were supposed to focus on every 10 minutes. In this procedure, participants were asked to repeat the underlined cue words to the researcher to reinforce the importance of their respective attentional instructions.

Data collection

A total of three video recording sessions took place at "the-twelfth-training", "after 1-week" and "after 1-month" respectively. All performance was recorded by two video cameras, which were placed at the sagittal and frontal planes of the participant. For the first recording, the usual training routine was carried out at the twelfth training session and participants were given half an hour rest before the recording of the routine execution by the participants. Participants were asked to perform three trials of each routine for hand techniques, kicking techniques and the complete 10-step routine. Participants were given a 3-minute rest period after three trials for each routine.

Participants were told not to have any practices before the 2nd recording (retention 1), and 3rd recording (retention 2), which took place a week and 1-month after the twelfth training session respectively. The recording process for the 2nd and 3rd retention sessions was the same as the first recording session. Participants reported that they did not practice at all after the 1st recording session. At the start of the 2nd and 3rd retention sessions, the researcher performed only one demonstration for hand techniques, kicking techniques and 10-step routine with the objective to refresh the participants' memory of the sequences. Thereafter, participants were asked to recall and use their respective underline cue words to perform all routines. Participants were informed that the emphasis on measuring performance was not about the recall proficiency of the routine but rather on the movement pattern proficiency of the TKD techniques.

Table 2. Intervention programme.

Discrete skills	Serial Skills
1. Lead hand punch (fighting stance)	1. Lead hand punch + Reverse hand Punch 2. (fighting stance)
2. Reverse hand punch (fighting stance)	3. Shuffle forward lead hand punch+ reverse 4. punch+ lead hand hook punch
3. Shuffle forward	5. Turning Kick + Front Thrust Kick at 90°
4. Lead hand Hook Punch (Fighting stance)	6. Sliding front thrust kick + shuffle forward 7. lead hand punch + reverse punch
5. Front thrust kick	8. Turning kick + Sliding turning kick
6. Turning Kick	
7. Sliding turning kick	
8. Sliding front kick	

Session 1	Discrete skill 1 and 2	Serial skill 1
Session 2	Revision Discrete skill 3 and 4	Serial skill 2
Session 3	Revision Discrete skill 5 and 6	Serial skill 3
Session 4	Revision Discrete skill 7 and 8	Serial skill 4
Session 5	Revision on all discrete skills	Serial skill 5
Session 6	Discrete skill 1, 2, 3 and 4	Serial skill 1, 2 and 3
Session 7	Discrete skill 5,6, 7 and 8	Serial skill 4 and 5
Session 8	Serial skill 1 to 5	
Session 9	Discrete skill 1-7	
Session 10	Serial skill 1-5	
Session 11	Whole routine	
Session 12	Whole routine	

Data reduction and analysis

Three certified coaches, who are at least at the 4th Dan level with more than 10 years of experience in coaching, viewed the tapes independently and rated the movement patterns on the score sheet (see Appendix A). The scoring was based on the assessment rubrics (see Appendix B). All the coaches have no knowledge of the training conditions for the groups and the sequences of recording. In addition, all three coaches were provided with a familiarisation session where they rated sample participants' performances together with the researcher. In the familiarisation session, videos of four different levels of Taekwondo students (green, blue, red and black) were presented to the raters and the coaches were required to provide scores on the score sheets based on a rubric for such assessment (see Appendix B). All the coaches were provided with ample opportunities to seek clarifications with the researcher to ensure that they fully understood all aspects of the assessment procedures.

The assessment components were designed based on the assessment guidelines from the World Taekwondo Federation (WTF), where assessment components were categorised into three categories – Accuracy, Mastery and Presentation (Table 3). The scoring scale was referenced to the Ellenband Gymnastic rating scales, ranges from 0 – 3 points (see Morrow et al., 2003). The rationale for adopting the gymnastics' rating scales is due to the similarity between the TKD task and the gymnastic routines in terms of the serialised nature of the task. In sports such as gymnastic and taekwondo Poomsae (Pattern form – a set of predetermined routine) competition, performance raw scores are given by the judges and performers are ranked according to the scores. As it is an individual performance event, the ranking system used in this study would be more relevant and closer to the nature of the sport. Thus, the statistical analysis would focus on the mean ranks in both groups.

Table 3. Assessment Components

Category	Sub-category
Accuracy	Target point
	Kinetic Chain of Movement
	Contact Point of the hand
	Alignment of Body Position (Shoulder,waist and knee)
Mastery	Volume of Movement (Range of starting and ending movement)
	Balance
	Power & Speed
Presentation	Coordination of Rhythm & Tempo
	Expression of KI (Energetic Expression)

Prior to undertaking statistical analysis, inter-rater reliability (IRR) was measured through two-way consistency average-measures intra-class correlation (ICC). The aim of performing IRR was to determine the consistency in the ratings between assessors, particularly, similarity in rank order. The cut-offs for ratings of agreement based on ICC values are: poor for less than 0.40; fair for values between 0.40 and 0.59; good for values between 0.60 and 0.74; and excellent for more than 0.75 (Hallgren, 2012).

Performance raw scores (sum of accuracy, mastery and presentation scores) and the categories scores were normally distributed and the variances were not significantly different, which indicated that the assumption of homogeneity was met. However, non-parametric tests were used for ranking the data based on the actual scores (rank 1 for the lowest score with the next highest score being rank 2, and so on) given by the raters; group with large rank indicated more high scorers in a specific test (Field, 2009). Mann- Whitney test, an equivalent to the independent t-test, was used to compare between two groups, control and treatment, for 3 sessions - the 12th-training- session, after 1-week and then after 1-month. Subsequently, Friedman's ANOVA was used to compare the differences between several tests (the 12th-training-session, after 1-week and after 1-month).

The Statistical Programme for Social Sciences (SPSS) software version 18.0 was used for statistical analysis. The accepted level of significance was set at $p< 0.05$ for all the analysis. However, post hoc test would be performed using Wilcoxon signed-rank test and a Bonferroni correction was applied with all effects reported at .017(0.05/ 3 tests) when the Friedman's ANOVA analysis was significant ($p<0.05$). Results were reported as means ± standard error (SE) for the descriptive data; z-score (z) and F-Statistic/Chi-square (X^2) for Mann Whitney (U) test.

The effect size estimate (r) was calculated based on z value of non-parametric tests. The sign of calculated effect size estimate does not contain much information, thus absolute value was reported (Field, 2009). An effect size of 0.1 is considered small, an effect size of 0.3 medium and an effect size of 0.5, large (see Field, 2009; see Fritz et al., 2012).

Results

Inter-rater reliability

There was an excellent agreement among assessors at the 12th-training-session (0.75, $p < 0.05$) and good agreement was found at "after 1-week" (0.69, $p < 0.05$) and "after 1-month" (0.62, $p < 0.05$) (Hallgren, 2012).

Serial skills performance scores

Performance scores of each serial skill is the sum of the scores from the three main categories – Accuracy, Mastery and Presentation. Performance raw scores (Mean± SE) of both control and treatment groups for all three serial skill tasks are shown in Figure 1. Mann-Whitney U test showed no significant differences between control and treatment groups in hand techniques, kicking techniques and 10-step routine.

However, a significant medium effect of group in "Mastery" category, where treatment group has higher mean rank scores in kicking techniques at after 1-week, $U= 7.0$, $z = -2.04$, $p < 0.05$, $r = 0.57$ (see Figure 2).

Retention

The Friedman's ANOVA showed significant decrease over the three tests in mean rank of 10-step routine (Control: X^2 (2) = 10.89, $p < 0.05$; Treatment: X^2 (2) = 10.33, $p < 0.05$); kicking techniques (Control: X^2 (2) = 8.07, $p <$

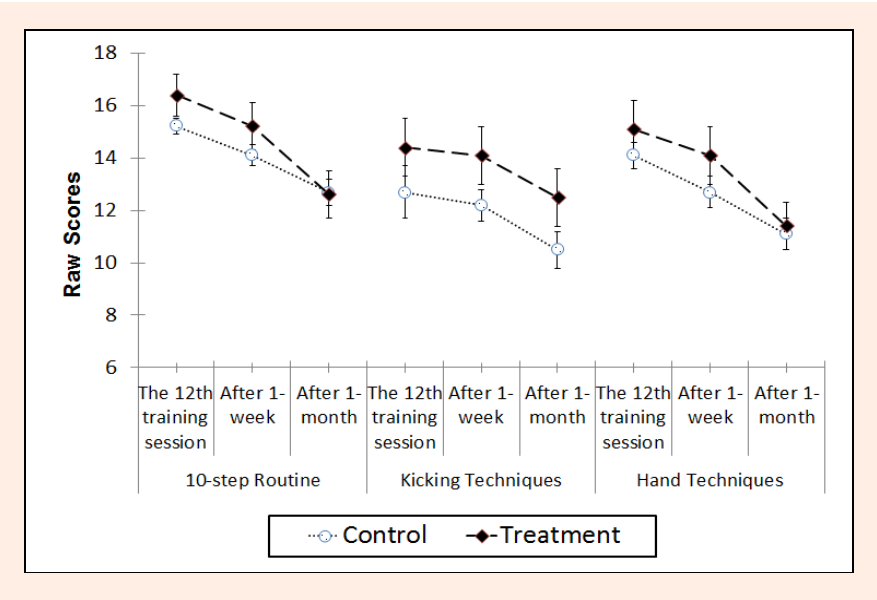

Figure 1. Descriptive data (Mean±SE) of overall components for all the serial skills performance.

0.05; Treatment: X^2 (2) = 9.24, p < 0.05); hand techniques (Control: X^2 (2) = 10.29, p < 0.05; Treatment: X^2 (2) = 10.33, p < 0.05).

A post hoc test, Wilcoxon signed-rank test, was further administered to determine differences between sessions. In Figure 3(a), it showed a significant large effect of time for the mean rank scores of the control group at "after 1-week" and "after 1-month" for 10-step routine (z = -2.384, p =0.017, *r* = 0.66) and kicking techniques (z = -2.388, p=0.017, *r* = 0.66. Post-hoc test revealed that the decrement in treatment group between sessions was not significant (see Figure 3(b)).

Individuals' performance raw scores

See Figures 4(a) and (b) for the performance raw scores of each individual for the "10-step-routine". From Figures 4(a) and (b), it can be seen that participants' performance from control condition were bunched together over a smaller range compared to treatment group participants, where the data was scattered over a bigger range. When the values of standard deviations (SD) in both conditions were examined, control group participants (The 12th-training-session- 2.68; after 1-week- 1.65, and after 1-month - 1.87) had about half of the values compared to participants from treatment group (The 12th-training-session- 2.79; after 1-week - 2.68; after 1-month - 2.61).

Discussion

The purpose of the study was to determine the difference in effectiveness between traditionally used instruction of attention in taekwondo and the movement outcome of instructions in learning a serial skill task among novice adult learners. We predicted that novices might benefit more from instructions focusing on movement outcome (MO) (treatment group) to a greater extent than traditionally used instructions emphasizing movement form (MF) (control group) in taekwondo serial skill tasks based on previous findings from discrete and continuous skills.

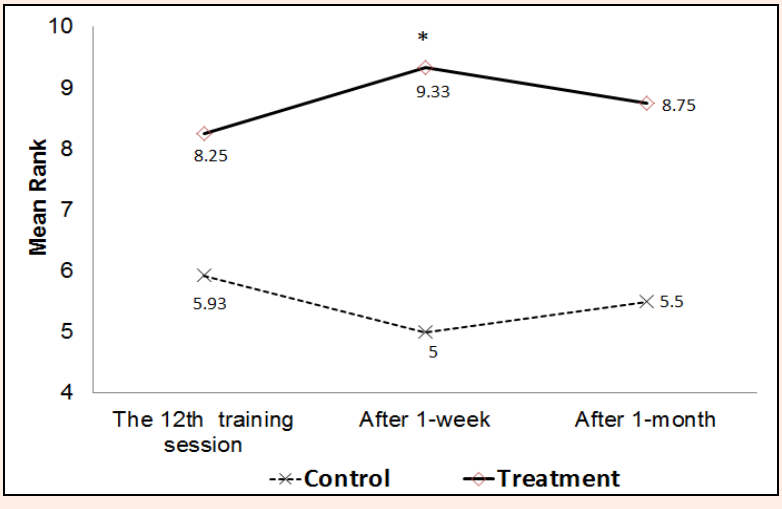

Figure 2. Mean rank score of "Mastery" component for the kicking techniques. * S ignificant difference from control group (p< 0.05).

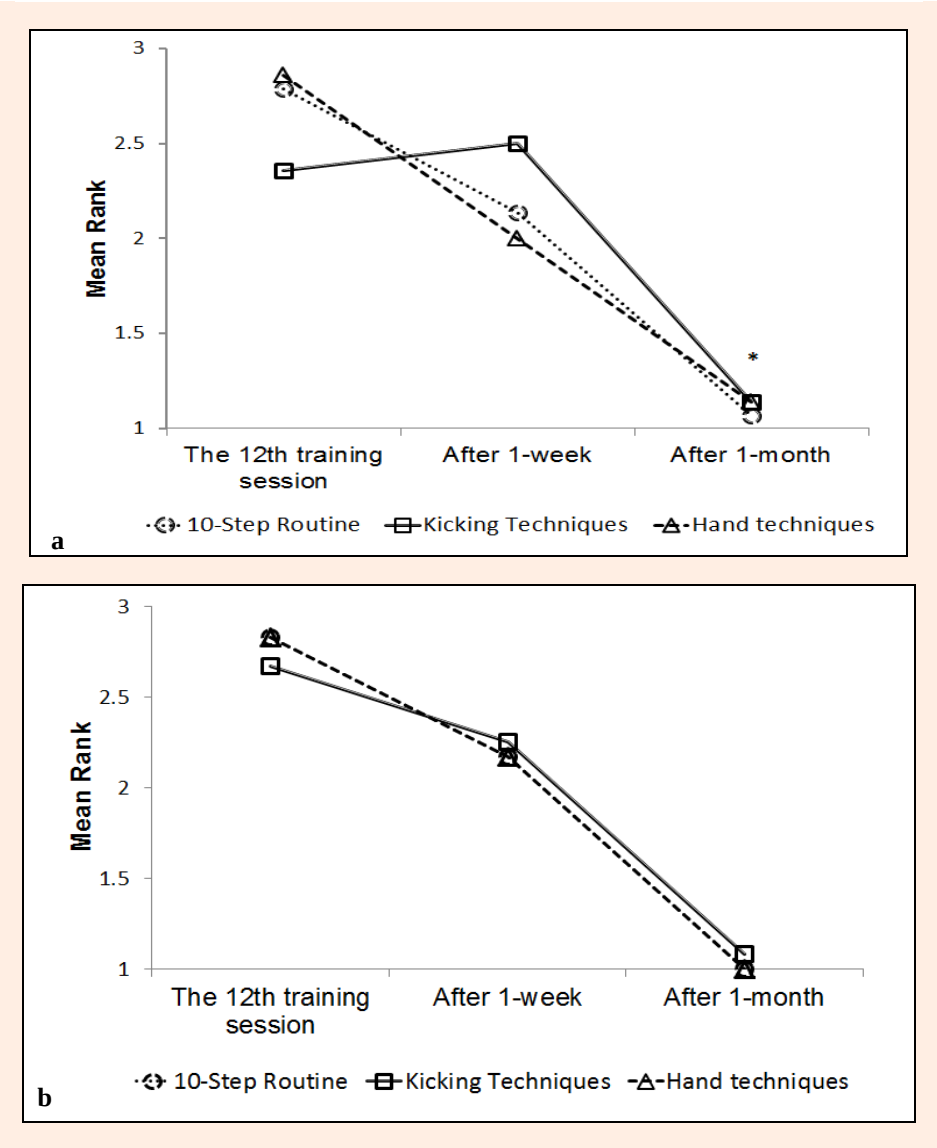

Figure 3. (a) Mean rank of serial skills performance of the control group during the "the 12th training session", "After 1-week" and "After 1-month". (b) Mean rank of serial skills performance of the treatment group during the "the 12th Training session", "After 1-week" and "After 1-month". * Significant difference from "After 1-week" in both 10-step routine and kicking techniques (p = 0.017)

Results from the present study provided minimal evidence of learning advantages for those directing their attention to the movement outcome as compared to movement form. The only significant result observed in this study was the "Mastery" category of the kicking techniques in the treatment group (see Figure 2). In addition, an interesting observation was seen in the inter-rater reliability (IRR), where the IRR values declined over time from high to moderate levels. It is not known if performance decrement has any impact on the judges' perception and rating of performance, which in turn may have an effect on the validity of the ratings. Future studies could be undertaken to examine if and how inter-raters' reliability may be impacted in judging lower skilled performances in similar contexts.

The major finding from this study is similar to some extent with those reported by Lawrence and colleagues' (2011) where no learning benefits were established with either internal (MF) or external focus (MO) of attention instructions for gymnastic floor exercises. It is noteworthy that the amount of time allocated to practice that differed greatly from the present study, where a total practice time of 6-hours (12 lessons x 30 minutes) was spent by the participants compared to four trials of practice in the study by Lawrence and colleagues. Thus, it was possible that the greater amount of practice time in the current study contributed to the slight positive effect (r = 0.57) seen in the treatment group. Researchers may want to consider longer period of practice time in learning a serial skill task.

Balance is an important aspect of taekwondo movements especially in kicking, as the loss of balance can lead to ineffectiveness of the kick and put oneself in danger (Kovacich, 2005). The significant result with moderate effect size (r = 0.57) in "Mastery" category at "after 1-week" suggests that participants using instructions emphasizing movement outcome outperformed their control condition participants by more than half of a stan-

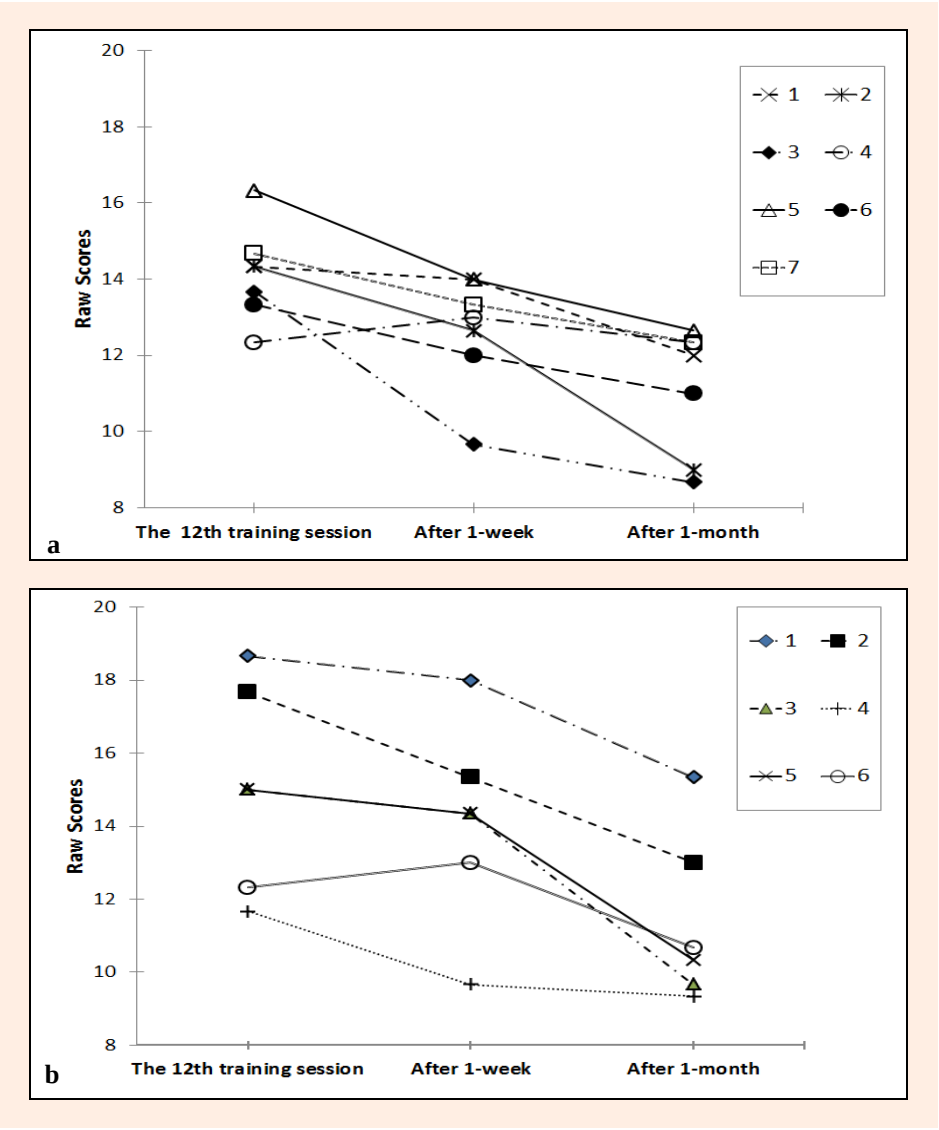

Figure 4. (a) Individuals' performance raw scores of control group individuals for 10-step routine. (b) Individuals' performance raw scores of the treatment group individuals for 10-step routine

dard deviation using pertinent instructional constraints (e.g., "Contact barrier with knee" and "strike target with foot in a snap-like motion") to enhance balance control and more effective movement forms during the kicking actions. Past studies which examined the use of external focus of attentional instruction, with an emphasis on movement outcome, have further supported such instructions as the preferential instructional constraint for postural balance during static, dynamic and suprapostural tasks (see Laufer et al., 2007; McNevin and Wulf, 2002; McNevin et al., 2003; Wulf et al., 2001a; 2004). Emphasis on movement outcome allows the learners to explore and search for coordinated movement patterns as well as to promote an automatic mode of movement control (Poolton et al., 2006). This self-organising process (i.e., each system spontaneously adjusting and adapting to each other) is believed to be enhanced with movement outcome instructions in regulating the balance, searching for functional solutions as well as the movements (Davids et al, 2008; Peh et al, 2011)

The nature of the taekwondo task itself presents a challenge for learners to direct their attention to the movement outcome (i.e., an external focus of attention) as compared to other discrete task like hitting a ball ("focus on the trajectory of the ball"). However, creative manipulation of task constraints like the use of relevant external apparatus within the movement outcome instructions can contribute to the positive learning effects especially in kicking actions. Furthermore, the use of instructions focusing on movement outcome in this study had relatively shorter movement descriptions as compared to the lengthy instructional cues that are typically used in taekwondo practice (Little and Wong, 1999). The difference in volume of the received instructions by both groups might be an important factor that impacted the current study's findings as treatment group received lesser number of instructions. Poolton et al. (2006) found that when similar amount of instructions were used by movement form and movement outcome participants, the latter still outperformed the earlier. Nevertheless, it is important to investigate whether the quantity of instructions in relation to varied attentional focus have an important impact on learning serial skills in future studies.

Retention tests are often used in motor learning

studies to examine the effect of instructions in helping learners to retain practiced skills (see Wulf, 2007). It is observed that control group's performance dropped significantly after 1 month without any training. Despite the novelty of the situation and/or the greater task difficulty encountered in retention tests such as the absence of external-focus stimuli – belts, chairs, barriers etc, treatment group's participants outperformed control group participants in all the three serial skill tasks (see Figures 3a and 3b). In relation to data for individual performance (see Figures 4a and b), larger extremes, i.e. the highest and the lowest scores, were observed in treatment group as compared to control group. Treatment group participants also demonstrated bigger range of standard deviations and this suggests that the individuals were exploring various solutions in search of the different functional ways to achieve the action goals. The use of movement outcome instructions has been purported to allow for exploration of different movement solutions to achieve the same outcome and therefore harnesses the inherent degeneracy (i.e., capacity of neurobiological systems to achieve the same or different outcomes in varying situations, with structurally different components of the musculo-skeletal sub-system) present in human neurobiological system (see Edelman and Gally, 2001; Hong and Newell, 2006; Peh et al. 2011). Such explorative behaviour could also indicate that perhaps, some individuals benefitted from movement outcome instructions but it may not be the case for everyone. Additional intra-individual analysis should be undertaken to better understand the individual's preference or rate-limiters in using different types of instructions. Furthermore, the most functional way of execution based on individual's interpretation of the instructions might not be inline with the assessment criteria (typically based on an optimal movement pattern for skilled performers), which could also account for some of the lower scores found in the treatment group participants.

On the other hand, the performance scores among the individual participants in the control group are more clustered and have fewer fluctuations. It is evident that the use of movement form instructions could have limited their exploration of their movements and interfered with the automatic control processes seen in movement control (Wulf and McNevin, 2003). From the Common-coding Theory and Constrained Action Hypothesis, it seems that the correspondence between movement programming and response is reduced when the learners are consciously attending to movements of the body. This in turn disturbs the organization of motor programming and interferes with normal automatic control processes. More recently, Land et al. (2013) further suggested that cognitive mechanisms could be the key mediator for the reported benefits of external focus attention effects although the specific cognitive mechanisms remain unknown.

However, Peh et al. (2011) also suggested that movement form instructions may not always be bad and that under certain task constraints (e.g., task that emphasizes movement form), it may encourage the acquisition of movement coordination. In addition, Uehara and colleagues (2008) also suggested that movement form instructions can benefit novice learners who are still engaged in assembling basic functional movement coordination patterns. Such an explanation could be relevant to why some participants in the control group condition benefitted from the movement form instructions after the twelfth session.

Based on Newell's (1986) model of motor learning (a framework for understanding the relationship between coordination and control), it is believed that the control group participants of this study might still be at the early stage of learning – Coordination, where they seek to find the stable movement patterns that they are trying to acquire through the use of the movement form instructions. The use of movement form instructions encouraged the participants to assemble their preferred basic, functional coordination to achieve specific motor tasks (Peh et al., 2011). It is possible that movement form instructions might still be useful for certain individuals due to their different inherent motor abilities and learning styles in learning movement form tasks. For example, some learners may still be exploring at the Coordination stage of learning to find an approximation of the movement and the use of movement outcome instructions may actually disrupt their learning. Peh et al. (2011) suggested that more intra-individual analyses should be undertaken and such analyses can better account for differences in individual rates of progression relating to learning.

Future studies could also examine learner's preference for either movement form or movement outcome instructions by determining performer's preferences using interviews; questionnaires to elicit such information (see Wulf et al., 2001b). It is also possible that the performer's "naturally" adopted focus of attention is directly correlated to the level of experience with a certain skill task, as well as perhaps the social situation in which the performance takes place (e.g., social acceptance of a sport for a certain gender, presence of and type of audience, or setting). In addition, the progression of the learners during practice should be noted in order to identify individuals' stages of learning. While the design of the presentation of instructions was intended to ensure that a belief effect is absent in relation to how participants perceive their instructions and its related effectiveness in learning the task, it might still be possible that the participants believed that their instructions were inadvertently beneficial. Future studies could explore research designs to eliminate this belief effect to more objectively determine the impact of either external or internal focus attentional instructions. For example, provide both types of instructions to participants and explore ways to check or control that they only use the required type of instructions at specific time context to better distinguish the effect of the different instructions provided.

Conclusion

In conclusion, the results of this study reveal some potentially enlightening differences between movement form and movement outcome instructions for learning a serial skill task. Treatment group condition achieved significant improvement in the "Mastery" category of the kicking

techniques at “after 1-week”. This suggests that movement outcome instructions have positive impact on balance control for kicking actions. Furthermore, longer period of practice time is crucial in learning a serial skill task in order to see the learning effect of both movement outcome and movement form instructions. However, individuals’ performance raw scores showed that individuals response differently towards the given instructions. Future empirical investigation could be undertaken to i) examine the relationship of both instructions with the individual rate of progression in learning; ii) compare the effectiveness of different type of attentional instructions and its interaction with the volume of instructions and the practice time in learning serial skills.

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Key points

- Movement outcome (MO) instructions have a positive impact on learning a serial task, especially in kicking actions.
- More functional coordination during movement executions for MO participants.
- Benefits for MO instructions may be individual specific.

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