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The Effect of a Short-term PETTLEP Imagery Intervention on a Cognitive Task

Caroline J. Wright* Dave K. Smith†

*University of Chester, caroline.wright@chester.ac.uk
†University of Chester, d.smith@chester.ac.uk

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Caroline J. Wright and Dave K. Smith

Abstract

Based on neuroscience research, the PETTLEP model was developed by Holmes and Collins (2001). The model provides imagery guidelines which identify seven key factors (physical, environment, task, timing, learning, emotion, perspective) that should be included when developing interventions to maximise functional equivalence. This study explored the effect of a short-term PETTLEP imagery intervention, compared to 'traditional' imagery, on a computer game: Need for Speed Underground 2 (EA games). Eighty participants were randomly assigned to one of four groups: PETTLEP imagery group, 'traditional' imagery group, physical practice group and control group. After three practice attempts, pre-tests consisted of five attempts at the game. The game involved completing timed laps by manoeuvring a vehicle around a track using the computer's arrow keys. The PETTLEP group completed individualised response training, and then performed imagery sitting in front of the computer screen and repeatedly imaging themselves completing the task. The 'traditional' imagery group was sat in a separate room, given individualised stimulus training and instructed to relax and close their eyes during imagery. The physical practice group performed the actual task. Each intervention lasted for forty-five minutes, immediately followed by the post-test, which again consisted of five attempts at the game. A group x test ANOVA showed that the PETTLEP imagery group and physical practice group both improved significantly from pre-test to post-test ($p<0.05$). However, there was no significant difference in the magnitude of their improvements. The traditional imagery and control groups showed no increase in performance from pre-test to post-test ($p>0.05$). The results strongly support the use of PETTLEP in enhancing performance on a cognitive task. Contrary to previous studies, PETTLEP was as effective as physical practice. This finding could have important implications for athletes returning from injury, suffering from over-training and for use in pre-performance routines. Therefore, sports psychologists should maximise the functional equivalence of their imagery interventions to have the greatest positive effect on performance on such cognitive tasks, at least in the short term. Future research needs to focus on applying short-term PETTLEP interventions to different tasks, varying in cognitive complexity. Assessing the effectiveness of PETTLEP imagery used in various combinations with physical practice would also be a useful addition to the literature.

KEYWORDS: PETTLEP, imagery, cognitive, computer

Introduction

In recent years, imagery researchers have become increasingly interested in the mechanisms behind imagery's performance-enhancing effects and how these can be maximized. It has also transpired through neuroscience research that a "functional equivalence" exists between imagery and performance of a skill or movement, as they are both triggered by the same neurophysiological processes (Decety & Jeannerod, 1996). As a result of this finding, Holmes and Collins (2001) developed the PETTLEP model. The model aims to provide guidelines for imagery interventions that result in a higher level of functional equivalence existing between imagery and actual performance. PETTLEP is an acronym, with each letter standing for a practical consideration to be made when devising an imagery intervention. These are Physical, Environment, Task, Timing, Learning, Emotion and Perspective.

Physical refers to the athlete's physical experience when completing their imagery. In order for functional equivalence to be maximized, athletes should attempt to physically replicate their actual performance whilst completing their imagery. This element of the intervention could include standing in the correct stance, wearing the correct clothing and holding any implements that may be used during performance. Incorporating such physical aspects was shown to have a larger effect on performance than a more traditional imagery intervention in a recent study focusing on hockey flick performance (Smith, Wright, Allsopp & Westhead, 2007). The Environment component refers to the surroundings when the athlete is completing his or her imagery. These should be as similar as possible to the actual performance or competition environment. Where it is not possible to achieve this, photographs or video tapes of the venue could aid the athlete. The Task component refers to the similarity of the task being imaged to the actual task being performed. Wherever possible, these should be identical in nature and subsequently, this factor may need to be reviewed and updated regularly as the athlete's efficiency at performing the task is improved. The Timing component of the PETTLEP model refers to the imagery being completed at the correct pace (i.e., the pace at which the action would be completed). This "real time" pace will serve to maximize the functional equivalence of the imagery intervention, as timing is often a crucial part of performing sports skills. However, some authors suggest that imaging in slow motion may be useful if the performer is new to the skill or trying to alter a bad technique (Syer & Connolly, 1984). Therefore, imaging in real time may be only sensible when the performer has a degree of mastery that is necessary in performing the skill he or she is imaging. Learning refers to the need to update the imagery intervention on a regular basis, to ensure that functional equivalence is maintained. This element is particularly important when an athlete becomes more proficient at completing the skill, or when an athlete is returning from injury and needs to relearn sections of the skill. The Emotion component involves encouraging the athlete to include all of the emotions that they would typically feel during performance of a task, such as excitement. These responses may depend on the circumstances and the emotions may need to be included to different degrees. For example, an athlete may experience more excitement when competing in the National championships than in a local event and this difference would need to be reflected in their imagery intervention. The Perspective component refers to whether the athlete completes the imagery from an internal (first person) perspective, or an external (third person) perspective. Whilst the paradigm of functional equivalence would suggest that an internal perspective would be most beneficial, research has shown that for certain tasks an external perspective is preferable (Hardy & Callow, 1999; White & Hardy, 1995). It has also been shown that more advanced performers will be able to switch from one perspective to another (cf. Smith, Collins, & Hale, 1998) and, in doing this, gain advantages from using both perspectives.

Clearly, therefore, some elements of the PETTLEP model (e.g., Perspective) have been researched more than others (e.g., Emotion). However, only one published study has tested the model as a whole. Smith et al. (2007) completed two studies focusing on a hockey penalty flick and a gymnastics beam skill. In the hockey flick task, they found that as more PETTLEP components were introduced in the imagery intervention, there was a stronger effect on performance. With the gymnastics beam skill, they found that the physical practice and PETTLEP groups improved significantly from pre-test to post-test, with no significant difference between them. Additionally, they found that the stimulus only and control groups did not improve significantly from pre-test to post-test. The effect sizes for this study were large for the physical practice group and PETTLEP imagery group and moderate for the stimulus only group. Although the study described above tested the model with sporting tasks, it has not yet been tested with a cognitive task or over a short period of time. Therefore, that was the aim of the present study.

Feltz and Landers (1983) pointed out that motor tasks lie on a continuum ranging from those with slight cognitive elements to those which are primarily cognitive in nature. However, the literature is unclear as to which type of tasks benefit most from imagery. Some studies have shown that imagery is more effective for motor tasks, where large muscle groups are involved in completing the movement (e.g. Ryan & Simons, 1981). Contrasting research has shown that imagery is more effective with more cognitive tasks, which require a high level of decision-making (Wrisberg & Ragsdale, 1979).

In their meta-analysis, Feltz and Landers (1983) concluded that the imagery-performance relationship was larger for cognitive tasks (average effect size of 1.44; classified as large by Thomas, Nelson, & Silverman, 2005), compared to .43 for motor tasks (moderate) and .20 for strength tasks (small). These effect sizes indicated that cognitive tasks may benefit most from an imagery intervention. However, the results were based on studies employing predominately traditional imagery methods and, therefore, it is possible that the use of PETTLEP imagery may increase the effect size on a cognitive task.

The early stages of learning are more cognitive, as the performer is still not performing autonomously, and research has found that imagery is more effective during this time period (Wrisberg & Ragsdale, 1979). Therefore, some researchers believe that because imagery is more effective in the early cognitive stages of learning, then this supports the cognitive component of the task (Decety & Ingvar, 1990; Schmidt, 1975). This is a view supported by the fields of neuroscience and cognitive psychology, which are the fields from which the PETTLEP model is derived.

Wrisberg and Ragsdale (1979) compared the effect of imagery on two tasks that required differing levels of cognitive demand: a stability platform and the McCloy (1942, cited in Wrisberg & Ragsdale, 1979) blocks test of multiple response. The results showed that, in the balance stabilometer task, the physical practice group spent a significantly greater time in balance than the mental practice group, which did not differ significantly from the control group. For the blocks test, the results demonstrated that completion time for the physical practice and mental practice groups was significantly shorter than for the control group. Furthermore, there was no significant difference in the scores of these two groups. The authors explained that the results supported the idea that tasks with a substantial cognitive element could benefit from mental rehearsal to a greater degree than tasks involving motor cues (Wrisberg & Ragsdale, 1979). The method of this study gives little detail about the particulars of the imagery employed and therefore, the level of functional equivalence of the intervention cannot be established. Also, although the cognitive element varied between these two tasks, there was still a high decision making component required in the completion of both of them. However, the results do seem to suggest that imagery is very useful with more cognitive tasks, such as the one used in the present study.

Another study using the balance stabilometer was conducted by Ryan and Simons (1982). They focused on comparing participants claiming to be able to image to those claiming not to be able to image. The participant groups were then split evenly across two interventions. Half of each group were instructed to image and half of each group were not instructed to image. The results showed that both groups asked to use imagery had a greater mean change than the groups not instructed to use imagery, whether or not they had claimed to be able to image. Results from follow up questionnaires showed that the participants who reported stronger imagery (visual and kinaesthetic) performed better than those who reported weaker visual and kinaesthetic imagery (Ryan & Simons, 1982). These findings seem to support the PETTLEP model, as generating strong visual and kinaesthetic imagery may have increased the functional equivalence of the intervention, leading to a higher final performance score. The PETTLEP model also advocates the use of kinaesthetic sensations during the imagery process in an attempt to achieve functional equivalence (Holmes & Collins, 2001).

Many other studies have focused specifically on more cognitively based tasks. In 1991, Hird, Landers, Thomas and Horan completed a study focusing on a motor and cognitive task. The cognitive task used was a pegboard and participants were instructed to complete both an imagery script and actual physical practice (in differing ratios) of these tasks. They found that all groups (aside from the control group) combining imagery with physical practice significantly improved their performance from pre-test to post-test. To further establish the meaning of these findings, the authors calculated effect sizes and found that for the cognitive (pegboard) task, the effect size was 1.06, which differs little from the average effect size for cognitive tasks of 1.44 presented by Feltz and Landers (1983) in their meta-analysis. In fact, the largest performance effect size examined by Feltz and Landers was apparent with a cognitive task (Perry, 1939) and had an effect size of 2.44. However, the work of Hird et al. (1991), and the meta-analysis of Feltz and Landers (1983) were completed prior to the development of the PETTLEP model and, therefore, may not have included some factors which would have made the imagery more functionally equivalent, such as completing the imagery in the same stance and environment as actual performance. Therefore, functionally equivalent imagery may produce larger effects than those presented by Feltz and Landers (1983) and Hird et al. (1991) for cognitive tasks, an issue that merits further investigation.

More recently, Smith and Collins (2004) completed a study focusing on a cognitive task: the computerized barrier knock-down. They compared a physical practice group, a stimulus and response group, a stimulus only group and a control group. Following the interventions, they found that the time taken to complete the task decreased significantly in the physical practice and stimulus and response imagery group, but not in the stimulus only imagery and control groups. Furthermore, the late CNV (a negative brain potential which occurs in the brain immediately prior to movement) was apparent prior to real and imagined movement in the stimulus and response imagery group, but not in the stimulus only imagery group. This finding has strong implications for the present study, as it indicates that the same neurological processes are occurring more consistently prior to imagery that includes both stimulus and response propositions. Therefore, by maximizing the functional equivalence of the imagery, a greater performance effect is apparent.

In summary, many researchers have explored the effect of imagery on cognitive tasks (Hird et al., 1991, Smith & Collins, 2004; Wrisberg & Ragsdale, 1979). Although the studies appear to have incorporated differing levels of functional equivalence, for example, the inclusion of emotions or response propositions, the PETTLEP model has not been systematically tested using a cognitive task. Therefore, this was the aim of the present study. This study, once again, compared PETTLEP based imagery to traditional imagery and physical practice to assess the effectiveness of the three interventions. A control group was included to assess any habitual effects that may have occurred. Also, as the intervention was carried out immediately prior to performance, implications may be apparent for the use of PETTLEP imagery as part of a pre-performance routine.

Based on the previous research reviewed above, it was hypothesized that the traditional imagery, PETTLEP imagery and physical practice groups would show a greater performance increase than the control group. We also hypothesized that the PETTLEP imagery group would improve to a greater degree than the traditional imagery group. Additionally, we hypothesized that the physical practice group would show the largest improvement in performance, and improve to a greater degree than the other three groups.

Method

Participants

Eighty participants (M = 20.00, SD = 3.00) were recruited from the undergraduate population at a university in the UK. None of the participants had previously received imagery training and all participants provided informed consent prior to participation.

Equipment

Movement Imagery Questionnaire – Revised (MIQ-R; Hall & Martin, 1997).

The MIQ-R is an eight-item inventory that assesses an individual's ability to perform visual and kinaesthetic imagery. The MIQ-R had acceptable concurrent validity when correlated with its earlier version, the MIQ, with r values of -.77, -.77 and -.87 for the visual subscale, kinaesthetic subscale, and overall score respectively (Hall & Martin, 1997). In this study, the MIQ-R was used as a screening tool. As per previous research (e.g., Smith & Collins, 2004) participants scoring lower than 16 (the mid-point, indicating moderate imagery ability) on either MIQ-R subscales were excluded from the study due to an apparent lack of ability to image.

Need for Speed Underground Computer Game (EA Games, Langley, UK).

This driving computer game was used. The participants were required to navigate a vehicle around a track using the arrow keys on the computer keyboard. The participants completed the demonstration track throughout the study, using the default settings provided by the computer. The default served to standardise the vehicle and settings used by each participant.

Procedure

The participants completed the MIQ-R and all scored over 16 on both subscales, meaning that no participants were excluded based on their MIQ-R scores. The participants were then randomly assigned to one of four groups, each consisting of twenty participants: a PETTLEP imagery group, a "traditional" imagery group, a physical practice group and a control group.

Prior to the administration of the intervention, a pre-test was carried out. This pre-test consisted of three practice circuits of the assigned track and then five recorded circuits. The track, vehicle selected and conditions were consistent for all participants. The time taken to complete each of the five circuits of the track was recorded and a mean value was calculated. This mean value was taken as the pre-test score. No time penalties were added if the participant's vehicle left the track, as this would naturally impede the progress and add time to the overall score. All participants were made aware of the procedure and scoring system prior to the testing.

Following the pre-test, the imagery interventions were introduced to the participants. The PETTLEP imagery group were given response training (Lang, Kozak, Miller, Levin & McLean, 1980). This training involved focusing the participants upon their actual and individual responses to the imagined situation, for example, their nervousness and anticipation at certain points of the circuit. As individual responses are the focus, the responses varied from participant to participant, as different participants responded to different elements of the task in different ways. The traditional imagery group received stimulus training, where the focus was on the stimuli, rather than the participant's response to the situation and, as a result, tended to be similar from participant to participant. The points raised included when the turns on the track were going to occur and the lighting in the room. Of course, it is possible that the traditional imagery group added their own responses, but these would not have been as structured as those completing response training.

The PETTLEP imagery group performed their imagery sitting at the same computer where the pre-test took place. They focused on the screen while they were completing their imagery, which showed the start screen and played the appropriate sounds. This setting ensured that the Environment factor was accounted for as it allowed them to hear the noise produced by the computer and other participants. The participants were also able to touch the keys on the keyboard (including the Physical component) to increase the kinaesthetic sensations. They were also instructed to image the specific skill in full (Task), in real time (Timing), and include any emotions that they associated with performance (Emotion), especially those highlighted by the response training. The Perspective component was already considered due to the position of the participants in relation to the screen and the view given to the participants on the screen. As the intervention took place over such a short period of time, it was not necessary to update the interventions during the testing period (Learning), although the participants were instructed to image the skill at their competence level, which would naturally improve over time. They imaged themselves performing circuits of the track for forty-five minutes, with short rests in between each circuit. Controlling the time, rather than the laps completed during the imagery, ensured that each participant was imaging for the same length of time, regardless of their average lap time.

The “traditional” imagery group was provided with a short relaxation procedure. They then performed their imagery whilst sat in a comfortable chair, with their eyes closed. Although this intervention incorporated some aspects of the PETTLEP model (i.e., imaging in real time, recreating emotions associated with performance) this was less strongly based on PETTLEP than the specific PETTLEP group. The physical practice group completed the task circuit for forty five minutes, using the same vehicle and computer. The control group carried out a placebo task of completing concentration grids, each with a short rest between, which took the same amount of time as the driving task.

Participants carried out their assigned intervention immediately after the pre-test. They completed the intervention for forty-five minutes in the appropriate conditions, with short breaks in between each circuit completed/imaged. They then performed the post-test, which was again calculated using the mean score of five circuits of the driving task.

Brief interviews were conducted after the experiment by the experimenter to ensure that the instructions were carried out as requested and to assess any difficulties that may have occurred during the interventions. Three weeks after the post-tests, the participants completed a retention test. This retention test consisted of three practice circuits and five recorded circuits of the track. The mean score of these five attempts was taken as the retention test score. This test was completed to indicate whether the interventions delivered over a short timescale could produce a lasting performance effect.

Results

Self-report data

One-way ANOVAs were performed on the MIQ-R data. These revealed no significant between-group differences in MIQ-R visual, $F = .09$, $p > .05$, and kinesthetic subscale scores, $F = .01$, $p > .05$. Therefore, participants assigned to the groups did not differ in visual and kinaesthetic imagery ability.

Manipulation checks were completed by conducting brief interviews recorded in note form. Participants were asked specifically about their imagery experiences, whether they had any problems with the imagery, and whether they completed the imagery as per the instructions given at the beginning of the study. All participants reported performing their imagery as instructed and did not report any major problems; hence all data were included in the study. Participants in the physical practice group and control group did not report using any spontaneous imagery during the course of the study.

Performance data

As can be seen in Figure 1, the mean time taken to complete the course (in seconds) was lower in the post-test than in the pre-test, indicating a performance improvement. The mean percentage time improvements (in seconds) were 6.37% in the PETTLEP imagery group, 8.17% in the physical practice group and 3.08% in the traditional imagery group. The control group improved by 0.40%. Effect sizes (*d*) for the change over time were .23 for the traditional imagery group, .44 for the PETTLEP imagery group, .55 for the physical practice group and .03 for the control group. These are classified as small, moderate, moderate and small respectively (Thomas et al., 2005).

After checking for pre-test differences using a one-way ANOVA, no significant between-group differences in the pre-test were revealed, $F\ (3,76) = 0.90$, $p > .05$. Therefore, a repeated measures ANOVA was conducted and revealed a significant interaction effect, $F\ (3,76) = 6.61$, $p < .001$. Tukeys HSD post-hoc tests showed that the PETTLEP imagery and physical practice groups improved significantly from pre-test to post-test ($p < 0.01$), whereas the traditional imagery and control groups did not ($p > 0.05$). Additionally, there was no significant difference between the magnitude of the improvement shown by the physical practice and PETTLEP imagery groups ($p > 0.05$).

The participants were required to complete a retention test three weeks subsequent to the post-test. During this time, the participants were asked not to complete any imagery or physical practice of the task. The adherence rate for returning to complete these tests was 57 out of 80 participants (71.25%).

Compared to the post-test scores, the scores for the PETTLEP group improved by 2.48%, followed by the control group (1.01%). The physical practice group and traditional imagery group performed worse (-.95% and -.11% respectively). However, an ANCOVA, with post-test scores entered as the covariate to assess continued improvement, revealed no significant effect for group, ($F(3,52) = 2.65$, $p<.05$). See Figure 1 for a visual representation of these findings.

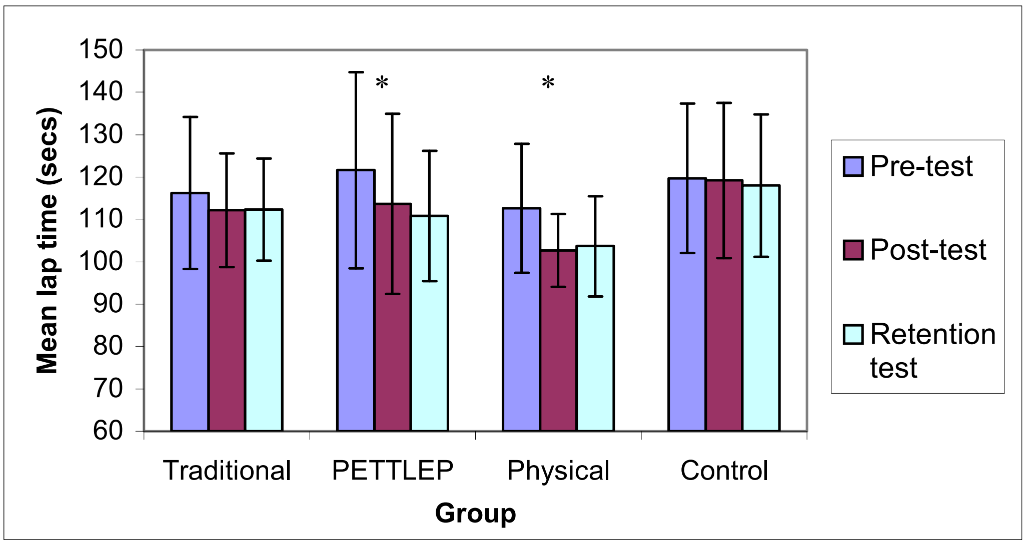

Figure 1: Mean and SD pre-test, post-test and retention test times across the groups.

Discussion

The results of the study partially support the first hypothesis, as the PETTLEP imagery and physical practice groups showed an improvement in performance from pre-test to post-test. However, the traditional imagery group and control group did not improve significantly from pre-test to post-test. This is surprising, as many former studies that have employed a more traditional imagery technique have shown it to be effective. However, other studies focusing on this type of approach, including the stimulus-only imagery used by Smith and Collins (2004), support the findings of the present study. The studies that have found traditional imagery to be effective with cognitive tasks have employed the method over a number of weeks, rather than the short-term approach adopted in this study. It may be, therefore, that interventions require a higher level of functional equivalence when being employed over such a short duration. This type of intervention would require the participants to focus on the posture, environment and emotions required for the immediate subsequent performance. It may also be that previous studies, which have found a significant performance effect for traditional imagery, have engaged differing levels of functional equivalence. These differences may give an explanation for the variation in findings. However, due to a lack of information regarding the specific intervention within the methods of such studies, this remains speculative. For example, although traditional imagery typically involves visualization in a relaxed position, other factors of the PETTLEP approach, such as involving emotions and imaging from an internal perspective, may have been used. The inclusion of these elements would have been equivalent to the traditional imagery group in the present study, as these factors were incorporated into their imagery, but over a much shorter time period.

The second hypothesis was supported as the PETTLEP imagery group improved significantly from pre-test to post-test, whereas the traditional imagery group did not. This finding may be because of the level of functional equivalence used in the PETTLEP imagery intervention. This functional equivalence was achieved in the present study by the participants completing their imagery whilst sat at the computer, touching the relevant keys. They were also instructed to image from an internal perspective and including any emotions that they associated with performance. Many other studies have shown that by increasing the functional equivalence, the positive effect on performance is also increased. Smith and Collins (2004) found that on a computerized barrier knock-down task, the group receiving stimulus and response imagery improved significantly more than the stimulus-only imagery group. Additionally the late CNV wave was apparent with the stimulus and response imagery group, and not with the stimulus-only group. This finding shows that neurological processes are much more similar to physical action when the imagery contains response propositions: a technique employed for the PETTLEP imagery group in the present study. As the results were achieved by the employment of a short-term imagery intervention, there are strong implications for athletes. Although it is not practical to complete this intervention as part of a pre-performance routine, as they typically only last for a few minutes, athletes should try to complete more functionally equivalent or PETTLEP imagery as part of their daily routine or a few hours prior to competition. This intervention may then have a positive effect on the subsequent performance. The effect of PETTLEP imagery over a shorter time period, which could feasibly be completed as part of a pre-performance routine, is an area that warrants future research.

The effect sizes apparent from the present study are lower than those shown in the meta-analyses (e.g., Feltz & Landers, 1983). However, this finding may be due to the short period over which the intervention was carried out.

Completing PETTLEP imagery over a longer period of time may have produced effect sizes more comparable or larger than those apparent in the meta-analyses and would be an interesting issue for imagery researchers to examine.

The third hypothesis was not supported by the results of the present study. Whilst the physical practice group did improve from pre-test to post-test, it was not significantly more effective than the PETTLEP imagery group. This result is surprising, as previous studies have shown physical practice interventions to be superior to imagery interventions (*cf.* Driskell, Copper & Moran, 1994). This finding also has large implications for competing athletes. Physical practice immediately prior to performance may be detrimental as it may cause a tiring effect. However, as PETTLEP imagery seems to be as effective as physical practice, this makes an ideal substitute. As the short-term PETTLEP intervention has powerful and lasting effects, it could be used in anything from daily practice to half time reviews and refocusing plans. Completing PETTLEP imagery would allow the athletes to gain the benefits of further practicing without risking the fatigue associated with physical practice.

The findings of previous studies specifically focusing on the PETTLEP model have produced similar results. Smith et al. (2007) found that, in the hockey flick task, the effect on performance significantly improved as more PETTLEP components were added. With the gymnastics beam skill, they found that only the physical practice and PETTLEP groups improved significantly from pre-test to post-test, with no significant difference between them. The effect sizes for their study were large for the physical practice group and PETTLEP imagery group and moderate for the stimulus only group. Although the classifications of the effect sizes in the present study differ from these (being moderate for the physical practice and PETTLEP interventions and small for the traditional imagery intervention), the same variation is apparent in both the present study and that of Smith et al. (2007).

The results of the retention tests indicate that a performance effect can be maintained when using PETTLEP imagery. Although the findings were not statistically significant, the PETTLEP imagery group continued to show a performance improvement, whereas the physical practice and traditional imagery groups did not. The lack of statistical significance may be due to the short term nature of the intervention; significant retention results may have been apparent had this been over a longer time period. The retention of performance effects achieved through PETTLEP imagery is an area that clearly warrants further research. Again, as the PETTLEP imagery intervention had a lasting effect (although this was not statistically significant), athletes could employ PETTLEP imagery as much as three weeks prior to competition and benefit from the same performance effect.

A study completed by Smith and Collins (2004) examined the effect of physical practice, stimulus and response proposition imagery, and stimulus proposition imagery on a computerized barrier knock-down task. They found that the stimulus and response proposition imagery and physical practice interventions improved to a significantly greater degree than the stimulus proposition imagery and control groups. The effect sizes were calculated as large for the stimulus and response proposition imagery and physical practice groups and small for the stimulus proposition group. The effect size finding of the stimulus proposition group was .29, compared to .23 in the present study. However, although the values were higher for the PETTLEP imagery and physical practice groups in the present study, they were not as high as those exhibited by Smith and Collins (2004). This, again, may be due to the short nature of the intervention.

Additionally, Smith and Collins (2004) measured the late CNV waves of the participants. They found that the late CNV was observed prior to real and imagined movements in the stimulus and response proposition imagery group, but not prior to imagined movement in the stimulus proposition group. This result offers a possible explanation of the findings of the present study as, although it was not measured, it may be that as functional equivalence of the intervention increases, the CNV (associated with physical performance) can be observed more consistently.

Therefore, the results of the study support the PETTLEP model when it is used over a short period on a cognitively based task. This finding has many implications for pre-performance routines, as completing PETTLEP imagery prior to performance is as effective as physically practicing, on cognitive tasks. The employment of this model as part of a pre-performance routine is also advantageous, as elements of the PETTLEP model, such as environment, would be easier to include into the imagery, as the performer would already be at the venue. The physical and emotion components would also be partly accounted for, as it is likely that the athlete would already be dressed in the correct clothing and experiencing some of the emotions associated with their immediately subsequent performance.

Developments of the study could include testing the model on a cognitive task over a longer and shorter intervention period. Doing so would allow the findings to be generalized and have practical applications across a number of disciplines. These disciplines include the medical profession, where cognitive tasks, such as performing a blood pressure test, need to be completed regularly and accurately. Also, in future research, manipulation checks could be completed in the form of structured questionnaires to allow frequency counts for participants' responses. Within the sport psychology literature, it may be useful to test the model with alternative cognitive tasks, such as barrier knock-down tasks, as these have already been shown to benefit from traditional imagery interventions. Further tests of the PETTLEP model could also include tasks that vary in their motor vs. cognitive elements such as darts (high cognitive, low motor) and weightlifting (low cognitive, high motor) in addition to those with high requirements of both motor and cognitive components (e.g., slalom). This would allow the model to be tested across a range of sports with a range of athletes (e.g. returning from injury, re-focusing plans) to assess its wide range effectiveness.

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