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ANALOGY VS. TECHNICAL LEARNING IN A GOLF PUTTING TASK: AN ANALYSIS OF PERFORMANCE OUTCOMES AND ATTENTIONAL PROCESSES UNDER PRESSURE

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ABSTRACT
Purpose. It is assumed that analogy learning helps prevent individuals from choking under pressure by limiting the conscious control of movements when performing in high-pressure situations. The aim of the study was to extend the application of analogy learning to golf putting and include an assessment on the proposed mechanisms of analogy learning and performance under pressure. **Methods.** Golf novices learned a putting task either by technical instructions or with analogy. After the learning phase, the participants were tested under low- and high-pressure conditions. Attentional focus was measured using a dual-task paradigm based on a skill and an externally focused task. **Results.** Both groups showed an increase in putting accuracy under pressure while performance in both dual-tasks decreased under pressure. Despite a difference in verbal knowledge, no group differences were found in putting or dual-task performance. **Conclusions.** The results suggest that it does not matter if the skill is learned technically or by analogy with regard to performance under pressure.

Key words: motor learning, implicit learning, attentional mechanisms

Introduction

The phenomenon of choking under pressure has been frequently studied over the past several decades. Besides its underlying mechanisms, strategies to prevent choking under pressure are of considerable interest to researchers. Choking under pressure has been defined as performing more poorly than expected given one's skill level in situations with high performance pressure [1, 2]. Cases of choking have occurred across a wide range of sports and even those performed by highly skilled athletes. Missing a seemingly easy putt in an important golf tournament is just one famous example where choking can be observed among professional athletes. However, it is important to keep in mind that not every performance failure can be equated with choking. Random fluctuations in skill level are common; only significantly less than optimal performance as a response to a high pressure situation can be considered as choking [2, 3]. Furthermore, according to Baumeister [1], an additional definition of choking under pressure is where the individual desire to perform in an optimal way is the highest, yet, despite this optimal motivation and the athletes' strive to perform at their best, their performance drops to a suboptimal level.

Researchers attempting to study this phenomenon are required to induce pressure experimentally, which poses one of the challenges in this field of research. Pressure is defined as the presence of a situation in which the incentive for optimal performance is highest and subjectively perceived as such [4]. Furthermore, pressure relies on the contingency of rewards or punishment on performance outcome, it can include the presence of an evaluative audience and other competitors, is dependent on how personally important a performance outcome really is, and in situations when the event is thought to be unrepeatable [4].

Besides individual differences in susceptibility to choking, such as dispositional reinvestment, two different attentional theories have been proposed to explain the paradoxical performance effects in high pressure situations. Distraction theories assume that pressure creates a distracting environment that impairs attentional resources necessary to successfully execute the task [e.g., 2, 5, 6]. Distractions can include concentrating on task-irrelevant stimuli or being apprehensive about a given situation [4, 6–8]. A specific distraction theory currently being discussed is attentional control theory (ACT), which has been proposed by Eysenck et al. [6]. It assumes that under pressure processing resources are disturbed by task-irrelevant stimuli culminating in poorer processing efficiency. Eysenck et al. further assumed that efficiency is disturbed more than effectiveness (performance outcome). Therefore, while performance quality might be stable, more resources are needed to attain a given performance level, or, in other words, one has to invest more effort for the same performance outcome while under pressure. Studies on distraction theories have confirmed it in tasks that require high demands on working memory [9, 10].

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On the other hand, self-focus theories (also termed explicit monitoring theories) have gained support when accounting for the phenomenon of choking during sensorimotor tasks [1, 11]. In this case, it is assumed that pressure causes a redirection of attention to the actual execution of movement, leading to conscious control of usually automated processes and consequently to a breakdown in performance [e.g., 1, 11, 12].

Explicit monitoring theories

Many studies have been designed using explicit monitoring theories as a theoretical guideline. There is ample evidence showing that directing attention to the execution of well-learned motor tasks leads to performance decrements. The detrimental effect of internally focused attention has been studied in a number of different sports. In many of these studies, attentional focus was treated as the independent variable whereas pressure was taken out of the equation. Beilock, Carr, MacMahon, and Starkes [13] conducted two experiments manipulating attentional focus by including an internal skill-focus condition and an external dual-task condition during movement execution. In two different sports, golf putting and soccer dribbling, they found better performance in the external rather than the internal focus of attention in a group of experienced players. However, novice performers as well as experts performing a less familiar task (dribbling with the non-dominant foot in soccer) profited from monitoring the step-by-step execution of the movement, which indicated the importance of skill level for the attentional focus effect. These results were replicated in field hockey, with the slowest performance found when participants monitored the position of their hand while the fastest under dual-task conditions [14]. Similar effects were also found in baseball [15], again in soccer [16], and in golf pitching performance [17]. In running, as a cyclic endurance task, an external focus was superior to two internal focus conditions in terms of movement economy [18]. Wulf et al. conducted a series of experiments on the effects of attentional focus [see 19 for a review]. They explained the detrimental effects of an internal focus of attention by constraining the motor system and interfering with automatic control processes. EMG studies lend support to this constrained action hypothesis [20, 21]. According to the reinvestment theory [22], an inward focus of attention implies conscious control over the movement with explicit knowledge. This, in turn, leads to a deterioration in performance as the skill no longer functions automatically [23]. Reinvestment of declarative knowledge of how a skill works [22] as well as explicitly monitoring a skill [11] and constrained action [19] all consistently conclude that focusing on the execution of well-learned motor tasks has a negative effect on performance by interfering with automatic movement control.

It is assumed that the consistently reported negative effect of an internal focus of attention mirrors the attentional processes induced by pressure [2]. Indirect evidence was found in training studies, which showed that practice with dealing with an internal focus of attention reduced choking under pressure by letting participants adapt to the attentional focus they experience under pressure [see 7, 11]. More direct evidence about the attentional mechanisms involved in choking was presented by Gray [12]. Using a simulated baseball batting task, he assessed attentional focus by using a dual-task paradigm. A short tone was presented during movement execution. Skill-focused attention was measured by judging the direction of bat movement upon hearing the tone while externally-focused attention was measured by judging the pitch of the tone. When placed under pressure, participants demonstrated a higher level of skill-focused attention (better performance in the skill-focused dual task, meaning higher accuracy in judging bat movement) compared with a control group without pressure. The tone-judgment task was found not to be affected by pressure. Also important was the fact that an increase in skill-focused attention was related to a deterioration in batting performance and changes in batting kinematics. This frequently cited study was the first to directly demonstrate that pressure does induce an inward shift of attentional focus as Baumeister [1] had proposed 20 years earlier. Results from an experimental study that included measurement of the "quiet eye" go in line with strengthening the importance of attentional focus under pressure [24]. This study showed that individuals who did not choke under pressure were able to direct visual attention externally, as was indicated by a longer quiet eye period. Further support for the explicit monitoring theory was demonstrated in an experiment by Gucciardi and Dimmock [25], where they directly compared self-focus to distraction theories on a group of experienced golfers. They showed degraded performance under pressure when they relied on explicit knowledge, while focusing on task-irrelevant cues as well as the swing thought condition did not cause choking.

Attempts to prevent choking under pressure

Different kinds of strategies to prevent choking have been reported in the literature on the subject. One approach is to let participants adapt to the kind of focus they experience under pressure. Studies have found that training under self-focus conditions reduces a deterioration of performance when under pressure [7, 11]. In a recent study, Oudejans and Pijpers [26] demonstrated that training under mild levels of anxiety reduced performance decrements under subsequently higher levels of anxiety. It has to be noted, however, that anxiety (induced in this case by different heights on a climbing wall) is not the same as pressure. Pre-performance routines have also been discussed as a way to alleviate choking. It was assumed that they enable the motor response to run automatically without conscious control [27, 28]. Another approach involved participants thinking of a global cue rather than detailed explicit instructions when performing under pressure [29]. Choking was reduced in this swing thought condition, and similar results were shown by Gucciardi and Dimmock [25].

Opposed to the aforementioned strategies is the approach promoted by Masters [23]. He assumes that explicit knowledge about movement execution is reinvested under pressure and causes detrimental performance effects. It follows that the avoidance of the build-up of explicit knowledge is a way to prevent choking. So, rather than implementing a strategy to help athletes deal with the pressure situation, Masters [23] favors an intervention during the skill acquisition phase. In his experiment, he showed that participants who had only acquired a small amount of explicit knowledge (through implicit learning) were less susceptible to choking under pressure [23]. However, implicit motor learning incorporates several problems (such as it being a lengthy process) that makes it difficult to implement in sports training contexts outside a laboratory setting. As an alternative, Masters [30] suggested analogy learning as it operates with biomechanical metaphors instead of declarative knowledge and technical know-how. Here, he proposed that only one rule which consists of a general analogy ought to be provided and should include all the technical aspects necessary to execute the skill successfully [30]. Liao and Masters [31] designed an experiment to test whether analogy learning shows similar characteristics as implicit learning. Table tennis novices were instructed to learn the topspin forehand either implicitly, explicitly, or by analogy (drawing a right-angled triangle with a table tennis paddle). The results confirmed the implicit characteristics of analogy learning with less explicit knowledge and its robustness when performing under dual-task conditions. In a second experiment, Liao and Masters [31] showed that analogy learners' performance was not negatively affected by pressure as opposed to that of the explicit learning group. Using the same analogy learning paradigm, Law et al. [32] showed that supportive audiences (under the notion that supportive audiences induce stress) brought about performance decrements only in the explicit learning group. It was believed that analogy learners acquire less explicit knowledge about a movement, which leads to less consciously controlled movement execution under stress. Contrasting results were shown in another study using analogy learning in the table tennis forehand [33]. In this study, a large number of repetitions (10,000) were implemented during the learning phase in an analogy and explicit learning group. Performance was assessed after 1,400 and 10,000 repetitions under pressure conditions. Despite the fact that the explicit learning group accumulated more explicit rules, neither of the groups showed performance decrements when under pressure. These findings did not confirm the fact that the amount of explicit knowledge is related to performance decrements under pressure. As table tennis had been predominantly used in analogy learning, Lam, Masters and Maxwell [34, 35] conducted two studies using a new motor task that involved taking basketball shots from a seated position. In one study, it was shown that performance did not degrade for the analogy condition in a dual-task transfer test but did for both explicit and control conditions [35]. The other study involved a pressure manipulation to test Masters' [23] theory of explicit knowledge reinvestment under pressure [34]. After two days of learning with a total of 480 trials, the third day consisted of a test phase in an A–B–A (low-pressure, high-pressure, low-pressure) design. Probe reaction times (PRT) to assess allocation of attention and shooting performance were treated as the dependent variables. No difference in performance was found for the analogy group, while the explicit learning group displayed a significant drop in performance in the high-pressure condition. PRT did not show any differences, suggesting an equal attentional load in both groups. As the analogy learners reported less explicit rules about their movement, the results were interpreted as evidence for the presence of conscious processing. However, as the authors noted in their discussion, this evidence was rather incidental, where a direct measure of cognitive processes under different pressure conditions would be more helpful in finding better evidence on how level analogy learning actually operates. Schücker, Ebbing, and Hagemann [36] conducted a study incorporating two kinds of learning instructions (analogy vs. technical) and linked them to a measure of skill-focused attention under low- and high-pressure. The results revealed higher amounts of skill-focused attention for the technical learning group compared with the analogy learning group during the high-pressure condition. However, these differences were not related to differences in performance and a manipulation check for pressure was missing. Furthermore, the method of analogy learning differed considerably from that of Masters [30], as it worked with a whole set of analogies instead of using a single metaphor encompassing all technical aspects of the movement.

The present study

To this day, explanations for the positive effect of analogy learning in preventing choking under pressure have mostly been deduced rather indirectly. Differences in the amount of explicit knowledge between learning groups are taken as evidence for the conscious processing hypothesis [34]. This study aims to relate different learning methods to an assessment of attentional processes under pressure by means of a dual-task paradigm. Several studies proved that analogy learning is helpful in avoiding performance decrements when under pressure compared with classic learning paradigms based on technical instructions [e.g., 31, 32, 34]. Gray [12] successfully used a dual-task paradigm and showed an increase in skill-focused attention under pressure.

The aim of this study was to combine these two approaches to show the efficacy of analogy learning in alleviating choking under pressure, on the one hand, and to assess its functioning by implementing a skill-focused dual task on the other hand. As analogy learning has not yet been implemented in studying different movement skills, it was decided to test this method on a golf putting task. As the movement in putting has been commonly represented through a pendulum analogy [e.g., 37], it was decided to use this analogy as it incorporates the essential aspects of the movement. In line with previous research, it was expected that analogy and technical learning groups would improve performance equally in the learning phase, but that only the analogy learning group would retain performance under pressure while the technical learning group would show the choking effect. Performance in a skill-focused dual task was used as an indicator for the amount of skill-focused attention. It was assumed that the technical learning group would show an increase in skill-focused attention under pressure when compared with the analogy learning group.

Material and methods

Participants

Forty-one undergraduate students (23 males, 18 females) volunteered to take part in this study. Their mean age was 21.44 years ($SD = 2.98$). None had any previous golf experience nor had received any kind of formal instruction before. Participants were randomly assigned to either an analogy ($n = 20$, 9 females and 11 males) or a technical ($n = 21$, 9 females and 12 males) learning group. Three participants in each group were left-handed. Written informed consent was obtained before the beginning of the experiment. The study was conducted according to the ethical guidelines of the American Psychological Association (APA).

Apparatus

The putting task was performed on an artificial grass putting mat 4 m in length and 1.5 m in width. Standard golf balls were placed 2 m from the target, which was indicated by a red circle with a diameter of 10 cm. A grid with 5 cm squares was plotted on the mat around the target to allow for quick assessment of putting performance by scoring vertical and horizontal error. All participants used the same standard putter. A Casio EX-F1 digital camera (Casio, Japan) was used to record the putting movement at a rate of 30 frames per second.

To assess focus of attention, a dual-task design similar to the one in Gray's [12] experiments was used. A single 100 ms auditory tone (produced at 800 or 1000 Hz) was presented while the participants performed the putt. After completing the putt the participants were randomly asked to either judge the pitch of the tone or at what movement phase the tone was sounded ("Which tone was it?" or "Which picture was it?"). The movement phase was judged by pictures showing the whole putting movement, the participants were asked to indicate which picture best corresponded to the point in time when the tone was heard during the movement (Fig. 1). The tone was linked to a light signal so the actual point in time when the tone was heard could be identified later during video analysis.

Procedure

Participants were tested individually by performing a series of 300 putts during the learning phase followed by another but shorter series of putts in the test phase. They were instructed to try to place the ball as close as possible to the middle of a red circle from a distance of 2 m. The participants were given an information sheet either with the analogy instructions or a set of six technical instructions according to their group. Both groups also received a picture demonstrating the starting position. The analogy group's instructions included the metaphor of performing the movement like a pendulum, which was visually demonstrated to

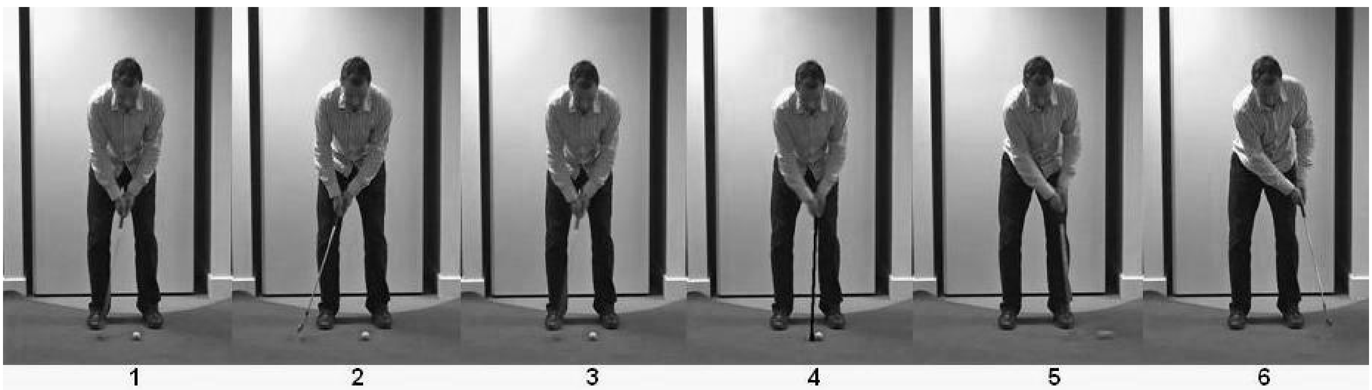

Figure 1. Pictures used for the skill-focused dual task showing the whole putting movement

Table 1. Technical instructions for putting, adapted from Poolton, Maxwell, Masters, and Raab [38]

Technical instructions
1. Move your arms and the club back a short distance
2. Swing your arms and the club forward with a smooth action along a straight line
3. Allow your arms and the club to continue swinging a short distance after contact with the ball
4. Adjust the speed of your arms and the club so that the correct amount of force is applied
5. Adjust the angle of your arms and the club to attain the correct direction
6. Focus on the ground for a few seconds after hitting the ball

them (swinging a weight on a cord). The technical instructions were based on those by Poolton et al. [38]. However, in this study, we did not differentiate between an internal and an external focus of attention as this was not the focus of our experiment (Tab. 1).

After each set of 50 putts the participants rested for a period of 1–2mins. During the break they were reminded of their specific learning instructions. After completing 300 putts both learning groups were asked to write down the rules they had actually used during the learning phase.

After the learning phase was completed, the participants had to complete four blocks of 20 trials under dual-task conditions. The first series of 20 putts was used for familiarization with the dual-task procedure followed by an A–B–A (low-pressure, high-pressure, low-pressure) design. The second set of 20 putts was used as the first low-pressure baseline and appeared to the participants as just another series of putts. The third series of putts formed the high-pressure condition followed by a second low-pressure baseline. A scenario that has been frequently used before [e.g., 11, 12] was introduced to increase pressure. After completing the first baseline, participants were told that the putting performance of their last 20 putts was to be calculated. They were then told that during the following series of 20 putts they had a chance of winning an additional 10€ (apart from the 5€ participation fee) by improving their putting performance by 20%. They were also given a team scenario where they were paired with another participant of the experiment and both had to improve their performance to win the extra money. They were then told that their partner had successfully completed their portion of the trial. After giving this pressure scenario, the experimenter calculated the actual putting performance (total distance from target) of the last 20 putts and told the participant by how many centimeters they had to improve in the next series to reach the 20% criterion. Participants were reminded that they still had to provide answers for the dual-task condition. At the end of the experiment putting performance in the high pressure condition was calculated and those who actually reached the 20% criterion received the extra reward money. After data collection was completed, all participants were fully debriefed.

To assess whether the introduction of pressure manipulation was successful, a German version of the cognitive and somatic anxiety subscales of the CSAI-2R [39] was administered before each series of 20 putts in the low- and high-pressure situations. A pressure rating scale from 1 (no pressure) to 7 (extreme pressure) was administered after each pressure condition [see 40].

Data Analysis

Putting performance in the learning phase was recorded as the horizontal and vertical distance from target in 5 cm increments. This allowed for a quick assessment during the 300 putts. Total distance from the target was calculated at a later time. In the test phase, the horizontal and vertical distance from target was measured more precisely at 1 cm increments, with total distance also calculated a later time. Video recordings of each participant were analyzed frame by frame with Premiere CS3 Pro (Adobe, USA) to determine the actual point in time at which the tone was sounded during the movement. To assess inter-rater reliability, 10% of the video sample were analyzed by a second independent rater. Intraclass correlation revealed an inter-rater reliability of $r = 0.99$ at $p < 0.001$. As was mentioned previously, the difference between the picture which actually corresponded with the tone signal and the picture the participants selected was used as an indicator for measuring performance of judging the movement phase. Tone pitch judgments were calculated as a percentage of the amount of correct judgments. To analyze the verbal protocol, two independent raters who were blind to the learning conditions of the participants counted the number of explicit rules. Statements were only counted as explicit rules if they referred to the technical or mechanical aspects of the movement (e.g., swing with little acceleration/force). They were excluded if they were irrelevant to movement execution (an example of one is "don't make the concentration phase too short"). Inter-rater reliability was deemed sufficient at $r = 0.84$, $p < 0.001$. Average scores were computed to show the number of rules reported by each participant.

Statistical Analysis

All data analyses were computed with PASW Statistics 18 (SPSS, USA) software. The significance level was set at $p < 0.05$. For effect sizes, η_p^2 or d were calculated. Analysis of variance (ANOVA) was used for the main analysis and violation of the assumption of sphericity was corrected by Greenhouse-Geißer adjustments.

Results

Manipulation check

To assess whether pressure was induced successfully, a two factor ANOVA with the within-subject factor pressure and the between-subject factor group was computed for the somatic and cognitive anxiety subscales of the CSAI-2R [39] and the pressure scale. There was no difference between pressure conditions for the somatic anxiety subscale. However, the cognitive anxiety subscale showed significantly higher values under pressure than under the two low-pressure conditions, F (2, 78) = 25.73, $p < 0.001$, $\eta_p^2 = 0.40$ (first low-pressure M = 16.00, SD = 4.82, high-pressure M = 20.88, SD = 5.73, second low-pressure M = 15.95, SD = 6.30). The pressure scale showed a large effect for pressure as well, F (2, 78) = 91.91, $p < 0.001$, $\eta_p^2 = 0.70$ (first low-pressure M = 2.68, SD = 1.08, high-pressure M = 4.29, SD = 1.23, second low-pressure M = 2.22, SD = 0.99). There was no significant effect of group and no significant interaction effect of group × pressure. The results of the manipulation check lead to the conclusion that pressure was induced successfully by the cover story.

Learning phase

The 300 putts in the learning phase were split into fifteen blocks of 20 putts in order to examine learning progress. For these blocks the mean and within-subject variation (as a measure of putting performance consistency) of total distance (cm) from the target were calculated. To determine whether initial putting performance was equal in the analogy and technical learning group, a one-way ANOVA was computed for the first block of 20 putts. No group differences were found for mean distance from target at F (1, 39) = 1.62, p = 0.69 and within-subject variation in the first block F (1, 39) = 0.00, p = 0.98. Distance from target was found to be far (M = 48.82, SD = 10.15) and within-subject variation high (M = 35.28, SD = 5.67), indicating that the participants were unfamiliar with the task. A 2 × 15 ANOVA (group × block) with repeated measures for the factor block was calculated for the two dependent measures to assess performance throughout the learning phase. For distance-to-target, a significant effect of block was found, F (8.7, 339.25) = 45.65, $p < 0.000$, $\eta_p^2 = 0.54$, but not of group, F (1, 39) = 0.13, p = 0.72, and no interaction effect, F (8.7, 339.25) = 0.76, p = 0.65. The results for within-subject variation revealed the same pattern, a significant effect of block, F (14, 546) = 39.64, $p < 0.000$, $\eta_p^2 = 0.5$, no effect of group, F (1, 39) = 0.02, p = 0.88, and no interaction effect, F (14, 546) = 0.47, p = 0.95. This shows that both groups improved their putting performance equally throughout the learning phase (see Fig. 2 – mean distance, Fig. 3 – within-subject variation).

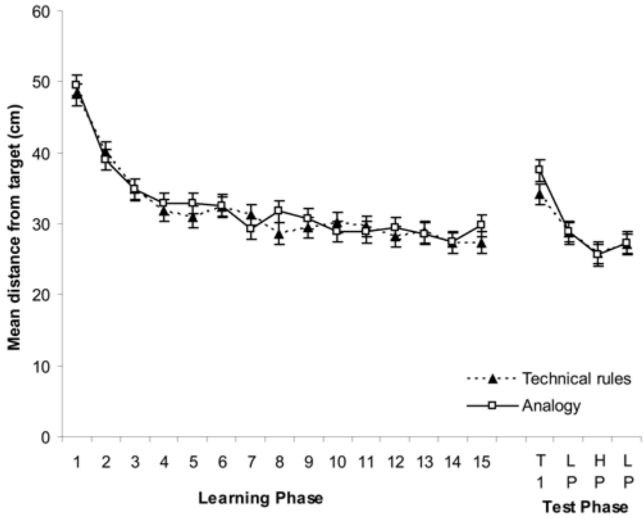

Figure 2. Mean distance from target of technical and analogy learning groups throughout the learning and test phases

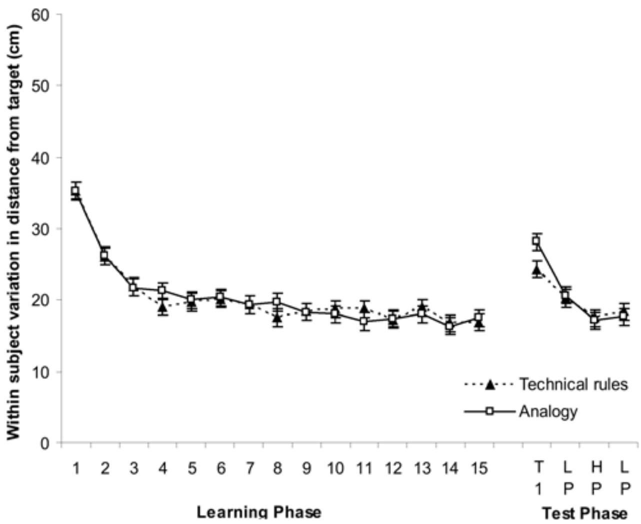

Figure 3. Within-subject variation in distance from target of the technical and analogy learning groups throughout the learning and test phases

Test phase: Putting performance

A 2 × 3 (group × pressure condition) ANOVA with repeated measures on pressure condition was computed to analyze for differences between the three pressure conditions. For mean distance-to-target, the effect of pressure was significant at F (2, 78) = 3.72, p = 0.03, $\eta_p^2 = 0.09$. Post-hoc paired sampled t tests with Bonferroni adjustments revealed that performance was significantly improved from the first low-pressure to high-pressure condition (p = 0.02, see Fig. 2). There was no effect of group, F (1, 39) = 0.00, p = 0.97, and no interaction effect, F (2, 78) = 0.05, p = 0.95. The same pattern was found for within-subject variation. There was a significant effect of pressure, F (2, 78) = 6.56, p = 0.002, $\eta_p^2 = 0.14$. Post-hoc tests showed that performance was significantly improved from the first low-pressure to high-pressure condition (p = 0.005), and also from first low-pressure to second low-pressure (p = 0.03, see Fig. 3). There was no effect of group, F (1, 39) = 0.04, p = 0.84, and no interaction effect, F (2, 78) = 0.19, p = 0.83.

Test phase: secondary task performance

Tone pitch judgments

To analyze performance in the tone pitch judgment task, 2 × 3 (group × pressure condition) ANOVA with repeated measures on pressure condition was computed with the dependent measure of correct tone judgments measured as a percentage. Analysis revealed a significant effect of pressure, F (2, 78) = 4.11, p = 0.02, $\eta_p^2 = 0.1$. Post-hoc paired sampled t tests with Bonferroni adjustments showed that tone recognition under high-pressure was significantly worse than in the first low-pressure condition (p = 0.03, see Fig. 4).

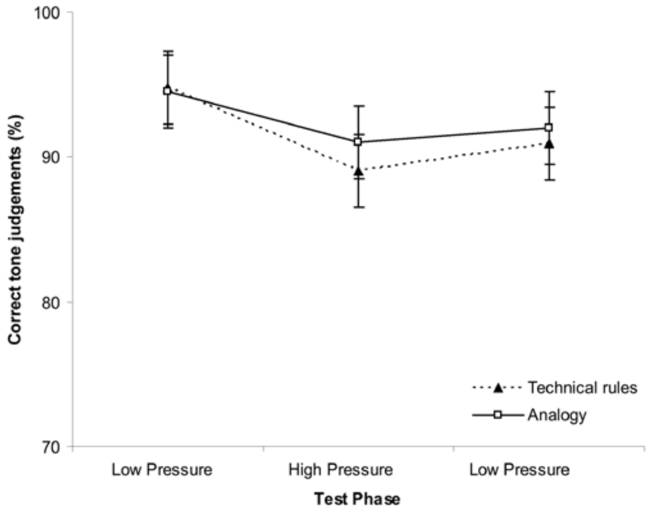

Figure 4. Tone judgments in the externally-focused dual task

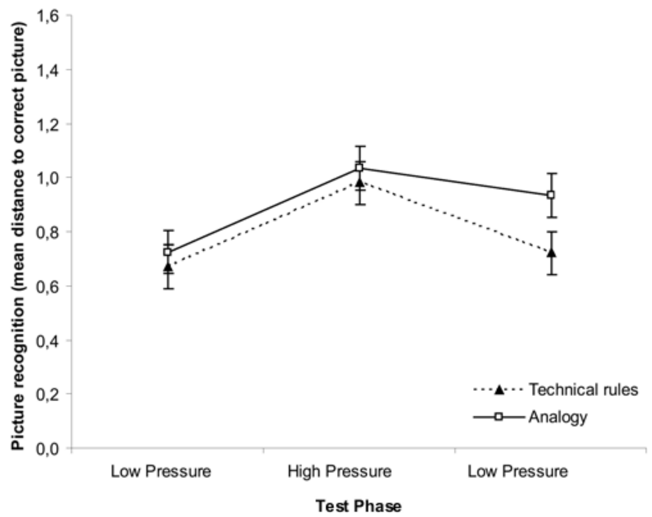

Figure 5. Picture recognition in the internally-focused dual task

There was no effect of group, F (1, 39) = 0.1, p = 0.76, and no interaction effect, F (2, 78) = 0.23, p = 0.80.

Movement phase judgments

Performance in movement phase recognition was calculated by the difference between the picture which actually corresponded to when the tone was sounded and the picture the participants selected. The mean spread to the correct picture was analyzed by 2 × 3 ANOVA to look at differences in the pressure conditions and the learning groups. The effect of pressure was found to be significant, F (2, 78) = 11.54, $p < 0.001$, $\eta_p^2 = 0.23$. As Figure 5 shows, the post-hoc test revealed that performance in picture recognition degraded from the first low-pressure to high-pressure condition ($p < 0.01$). There was a trend for improvement in picture recognition from high-pressure to second low-pressure (p = 0.06). As for the tone judgment task, there was no effect of group, F (1, 39) = 1.32, p = 0.26, and no interaction effect, F (2, 78) = 0.98, p = 0.38.

Verbal knowledge

An independent samples t test revealed that the number of explicit rules was significantly higher for the technical learning group (M = 3.38, SD = 1.23) than for the analogy learning group (M = 2.0, SD = 1.01), t (39) = 3.9, $p < 0.001$, d = 1.6.

Discussion

In this study, we examined two methods of learning a golf putting task (analogy vs. technical) with regard to the stability of performance under pressure and the attentional processes that were involved. In line with our expectations, both learning groups improved performance equally throughout the learning phase, indicating that the pendulum analogy for golf putting is as effective in learning as receiving traditional technical instructions. As shown in other studies, the analogy learning group reported fewer technical instructions than the technical learning group. However, our assumptions about performance under pressure were not supported by the results. Firstly, despite a significant increase in pressure as evidenced in both manipulation checks (CSAI-2R and pressure scale), there were no performance decrements for either of the two learning groups. On the contrary, both groups showed an increase in performance from the low-pressure to high-pressure conditions. This finding goes in line with a recent study conducted by Ehrlenspiel, Wei, and Sternad [41], where participants in the stressed group did not choke either but instead improved task performance in a rhythmic ball bouncing task. In Koedijker et al.'s longitudinal study [33] on analogy learning in table tennis, both learning groups did not show any decrements in performance, however, there were no increases in performance either. Our study did not show an advantage of analogy compared to technical learning, and therefore is not consistent with studies that did find a positive effect of analogy learning in preventing choking under pressure when compared with traditional learning [e.g. 31, 34]. However, it is important to keep in mind that choking under pressure did not occur in either group.

The results of the two dual-tasks are not consistent with the previously-stated assumptions either. Firstly, contrary to Schücker et al.'s findings [36], the dual-task designed to measure the amount of skill-focused attention did not reveal any differences between the two learning groups. In all pressure conditions, both groups showed an equal response to the two dual tasks despite a different amount of technical verbal knowledge. We would have expected a higher amount of skill-focused attention in the explicit learning group when under pressure. In the dual task, both groups showed similar results in the external focus of attention as well. Secondly, the skilled focus as well as the external focus of the dual task showed decreased accuracy under pressure, which could signify that the amount of attention devoted to the secondary task decreased in general under pressure. Lam et al.'s [34] findings of probe reaction time results under pressure for analogy and explicit learning groups did not reveal any differences between them either, despite a difference in performance under pressure. Allocation of attentional resources during movement execution was equal in all conditions in Lam et al.'s study [34]. In our study, both groups increased putting performance and decreased accuracy in both dual tasks.

The participants in our study did not show any form of performance decrement under high pressure, thus no evidence of choking under pressure was found. It seems that the significant increases in CSAI-2R scores were not powerful enough to produce performance deficits. The scores of the cognitive anxiety subscale and pressure scale were similar to those reported previously by other researchers [e.g., 40]. However, despite the expected decrease in performance, both groups showed increases in performance under pressure, which was not expected at all. One theory that has been discussed with regard to increases in performance is the social facilitation theory originally postulated by Zajonc [42]. Performance in simple motor tasks might actually improve under pressure as induced by social evaluative audiences [5]. The question then stands: is golf putting a simple motor task? Golf putting is a complex movement which needs to be performed very accurately in order to lead to good performance outcomes. It is doubtful that it had been so well learned by the groups that social facilitation effects could explain for their increase in performance. This is also intersecting considering the fact that researchers looking at the choking phenomenon have previously used the golf putting task [e.g., 11, 23]. There were no evident differences between the analogy and technical learning group under pressure, where even though the skill had been instructed differently in the learning phase, both groups showed the same putting and dual-task performance under pressure. This means that the same mechanisms are applied when the skill is executed under stress. However, as participants knew they had a fifty percent chance of being asked about their movement execution in the secondary task, the participants of both groups might have directed their attention to movement execution because of the nature of the dual-task.

An explanation of the results (increase in putting performance and decrease in dual-task performance under pressure) can also be considered from the perspective of the attentional control theory [6]. It is possible that the participants invested extra effort so as to improve their performance in the golf-putting task (primary task) and neglected the dual-task portion to some degree as it was not part of the pressure manipulation.

In general, the findings of our study do not lend credence to the assumptions made in the reinvestment theory and the usefulness of analogy learning in preventing choking under pressure. Despite a difference in verbal knowledge, no differences were found in performance (both groups did not show decreases in performance) nor in attentional processes under pressure. The results do not go in line with explicit monitoring theories, as these would have predicted an increase in skill-focused attention under pressure as per Gray [12]. The results of this study lead to the conclusion that it does not matter how a skill was learned (either by analogy or by technical instructions) when it comes to performance under pressure and limits the conclusions on performance after a short learning interval. However, Koedijker et al. [33] found similar results in a long-term learning interval but different results in table tennis after a short learning interval [43]. Both studies conducted by Koedijker et al. did not include an online measure of attentional focus and included a fast externally paced task in contrast to the slower and self-paced task of golf putting.

Some limitations weaken the conclusion of this study and need to be discussed. First, the issue of pressure manipulation requires further discussion. The results of the manipulation check showed that pressure was induced successfully albeit the observed changes were relatively small. In a laboratory setting, it is very difficult to induce pressure similar to that in real competition. The ecological validity of these types of studies is limited to producing generally smaller levels of stress. However, our results showed that participants did feel more under pressure in the high-pressure condition, allowing comparisons between the pressure conditions to be valid. Nonetheless, it should be considered whether the small changes found in some studies' performance levels should be interpreted as signs of choking.

Apart from the discussed attentional explanation for the observed pattern of performance outcomes, the role of motivation should also be considered. A greater amount of motivation in the high-pressure condition could explain for the participants' better putting performance. According to Baumeister [1] only extremely motivated people choke when under pressure; it may be that the participants were motivated just enough to perform well. Future studies on choking should include an assessment of motivation in addition to measures of anxiety and pressure.

Another issue that is of importance is the length of the learning interval, which was relatively short in this study with only 300 repetitions. In this early stage of skill acquisition, focusing on the skill might not be detrimental to performance as movement execution is far from being completely automated. The inclusion of a dual-task at so early of a stage could have caused performance decrements of the primary task. Our results are limited as they are based on a short learning interval. A similar study but implementing a longer learning interval as in Koedijker et al. [33] should be conducted in the future.

Finally, a critical assessment of the secondary task as a measure of internal and external focus of attention is needed. The aim was to design a task to measure the amount of internal and external focus of attention. The question is whether the dual-task approach is a valid measure for focus of attention. As had been shown before [see 12], designing secondary tasks relating to movement execution and external stimuli is a valid measure. However, it should be questioned whether there are variables that might overlay the results of this measure. Secondary tasks do require at least some allocation of attentional resources. If a secondary task on skill execution is not answered correctly this may not only be due to the fact that attention was not focused on the skill but also that attention was not allocated to the secondary task itself. Therefore, the decrease in secondary task performance under pressure as was observed in this study could also signify that more attention was allocated to do well in the primary task under pressure and that the amount of skill and externally focused attention was not measured precisely by the dual task. In the future, the design of valid measures of attentional focus should be emphasized.

References

1. Baumeister R.F., Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *J Pers Soc Psychol*, 1984, 46 (3), 610–620, doi: 10.1037/0022-3514.46.3.610.
2. Beilock S.L., Gray R., Why do athletes choke under pressure? In: Tenenbaum G., Eklund R.C. (eds.), Handbook of Sport Psychology. John Wiley & Sons, New Jersey 2007, 425–444.
3. Strauss B., Choking under pressure: positive public expectations and decreases in performance [in German]. *Zeitschrift für experimentelle Psychologie*, 1997, 44, 636–655.
4. Baumeister R.F., Showers C.J., A review of paradoxical performance effects: Choking under pressure in sports and mental tests. *Eur J Soc Psychol*, 1986, 16 (4), 361–383, doi: 10.1002/ejsp.2420160405.
5. Strauss B., Social facilitation in motor tasks: a review of research and theory. *Psychol Sport Exerc*, 2002, 3 (3), 237–256, doi: 10.1016/S1469-0292(01)00019-X.
6. Eysenck M.W., Derakshan N., Santos R., Calvo M.G., Anxiety and cognitive performance: Attentional control theory. *Emotion*, 2007, 7 (2), 336–353, doi: 10.1037/1528-3542.7.2.336.
7. Lewis B.P., Linder D.E., Thinking about choking? Attentional processes and paradoxical performance. *Pers Soc Psychol Bull*, 1997, 23 (9), 937–944, doi: 10.1177/0146167297239003.
8. Wine J., Test anxiety and direction of attention. *Psychol Bull*, 1971, 76 (2), 92–104, doi: 10.1037/h0031332.
9. Beilock S.L., Carr T.H., When high-powered people fail: Working memory and "Choking under pressure" in math. Psychol Sci, 2005, 16 (2), 101–105, doi: 10.1111/j.0956-7976.2005.00789.x.
10. Beilock S.L., Kulp C.A., Holt L.E., Carr T.H., More on the fragility of performance: Choking under pressure in mathematical problem solving. *J Exp Psychol: Gen*, 2004, 133 (4), 584–600, doi: 10.1037/0096-3445.133.4.584.
11. Beilock S.L., Carr T.H., On the fragility of skilled performance: What governs choking under pressure? *J Exp Psychol: Gen*, 2001, 130 (4), 701–725, doi: 10.1037/0096-3445.130.4.701.
12. Gray R., Attending to the execution of a complex sensorimotor skill: Expertise differences, choking, and slumps. *J Exp Psychol: Appl*, 2004, 10 (1), 42–54, doi: 10.1037/1076-898X.10.1.42.
13. Beilock S.L., Carr T.H., MacMahon C., Starkes J.L., When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *J Exp Psychol: Appl*, 2002, 8 (1), 6–16, doi: 10.1037/1076-898X.8.1.6.
14. Jackson R.C., Ashford K.J., Norsworthy G., Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *J Sport Exerc Psychol*, 2006, 28 (1), 40–68.
15. Castaneda B., Gray R., Effects of focus of attention on baseball batting performance in players of differing skill levels. *J Sport Exerc Psychol*, 2007, 29 (1), 60–77.
16. Ford P., Hodges N.J., Williams A.M., Online attentional-focus manipulations in a soccer-dribbling task: Implications for the proceduralization of motor skills. *J Mot Behav*, 2005, 37 (5), 386–394, doi: 10.3200/JMBR.37.5.386-394.
17. Bell J.J., Hardy J., Effects of attentional focus on skilled performance in golf. *J Appl Sport Psychol*, 2009, 21 (2), 163–177, doi: 10.1080/10413200902795323.
18. Schücker L., Hagemann N., Strauss B., Völker K., The effect of attentional focus on running economy. *J Sports Sci*, 2009,27(12),1241–1248,doi:10.1080/02640410903150467.
19. Wulf G., Attentional focus and motor learning: A review of 10 years of research. *E-Journal Bewegung und Training*, 2007, 1, 1–64.
20. Vance J., Wulf G., Töllner T., McNevin N., Mercer J., EMG activity as a function of the performer's focus of attention. *J Mot Behav*, 2004, 36 (4), 450–459, doi: 10.3200/JMBR.36.4.450-459.

21. Zachry T., Wulf G., Mercer J., Bezodis N., Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. *Brain Res Bull*, 2005, 67 (4), 304–309, doi: 10.1016/j.brainresbull.2005.06.035.
22. Masters R.S.W., Maxwell J.P., The theory of reinvestment. *Int Rev Sport Exerc Psychol*, 2008, 1 (2), 160–183, doi: 10.1080/17509840802287218.
23. Masters R.S.W., Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *Br J Psychol*, 1992, 83 (3), 343–358, doi: 10.1111/j.2044-8295.1992.tb02446.x.
24. Vickers J.N., Williams A.M., Performing under pressure: The effects of physiological arousal, cognitive anxiety, and gaze control in biathlon. *J Mot Behav*, 2007, 39 (5), 381–394, doi: 10.3200/JMBR.39.5.381-394.
25. Gucciardi D.F., Dimmock J.A., Choking under pressure in sensorimotor skills: Conscious processing or depleted attentional resources? *Psychol Sport Exerc*, 2008, 9 (1), 45–59, doi: 10.1016/j.psychsport.2006.10.007.
26. Oudejans R.R.D., Pijpers J.R., Training with mild anxiety may prevent choking under higher levels of anxiety. *Psychol Sport Exerc*, 2010, 11 (1), 44–50, doi: 10.1016/j.psychsport.2009.05.002.
27. Cohn P.J., Preperformance Routines in Sport: Theoretical Support and Practical Applications. Sport Psychol, 1990, 4 (3), 301–312.
28. Lonsdale C., Tam J.T.M., On the temporal and behavioural consistency of pre-performance routines: An intra-individual analysis of elite basketball players' free throw shooting accuracy. *J Sports Sci*, 2008, 26 (3), 259–266, doi: 10.1080/02640410701473962.
29. Jackson R.C., Willson R.J., Using 'swing thoughts' to prevent paradoxical performance effects in golf putting. In: Farrally M.R., Cochran A.J. (eds.), Science and golf III: Proceedings of the 1998 world scientific congress of golf. Human Kinetics, Leeds 1999, 166–173.
30. Masters R.S.W., Theoretical aspects of implicit learning in sport. *Int J Sport Psychol*, 2000, 31 (4), 530–541.
31. Liao C., Masters R.S.W., Analogy learning: A means to implicit motor learning. *J Sports Sci*, 2001, 19 (5), 307–319, doi: 10.1080/02640410152006081.
32. Law J., Masters R., Bray S.R., Eves F.F., Bardswell I., Motor performance as a function of audience affability and metaknowledge. *J Sport Exerc Psychol*, 2003, 25 (4), 484–500.
33. Koedijker J.M., Oudejans R.R.D., Beek P.J., Table tennis performance following explicit and analogy learning over 10.000 repetitions. *Int J Sport Psychol*, 2008, 39 (3), 237–256.
34. Lam W.K., Maxwell J.P., Masters R., Analogy learning and the performance of motor skills under pressure. *J Sport Exerc Psychol*, 2009, 31 (3), 337–357.
35. Lam W.K., Maxwell J.P., Masters R.S.W., Analogy versus explicit learning of a modified basketball shooting task: Performance and kinematic outcomes. *J Sports Sci*, 2009, 27 (2), 179–191, doi: 10.1080/02640410802448764.
36. Schücker L., Ebbing L., Hagemann N., Learning by Analogies: Implications for performance and attentional processes under pressure. *Hum Mov*, 2010, 11 (2), 191–199, doi:10.2478/v10038-010-0025-z.
37. Letzelter H., Letzelter M., Golftechniken: Wieso, weshalb, warum? [in German]. Philippka, Münster 2002.
38. Poolton J.M., Maxwell J.P., Masters R.S.W., Raab M., Benefits of an external focus of attention: Common coding or conscious processing? *J Sports Sci*, 2006, 24 (1), 89–99, doi: 10.1080/02640410500130854.
39. Cox R.H., Martens M.P., Russell W.D., Measuring anxiety in athletics: The Revised Competitive State Anxiety Inventory-2. *J Sport Exerc Psychol*, 2003, 25 (4), 519–533.
40. Kinrade N.P., Jackson R.C., Ashford K.J., Dispositional reinvestment and skill failure in cognitive and motor tasks. *Psychol Sport Exerc*, 2010, 11 (4), 312–319, doi: 10.1016/j.psychsport.2010.02.005.
41. Ehrlenspiel F., Wei K., Sternad D., Open-loop, closed-loop and compensatory control: performance improvement under pressure in a rhythmic task. *Exp Brain Res*, 2010, 201 (4), 729–741, doi: 10.1007/s00221-009-2087-8.
42. Zajonc R.B., Social facilitation. *Science*, 1965, 149 (3681), 269–274, doi: 10.1126/science.149.3681.269 .
43. Koedijker J.M., Oudejans R.R.D., Beek P.J., Explicit rules and direction of attention in learning and performing the table tennis forehand. *Int J Sport Psychol*, 2007, 38 (2), 227–244.

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