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LEARNING BY ANALOGIES: IMPLICATIONS FOR PERFORMANCE AND ATTENTIONAL PROCESSES UNDER PRESSURE

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LINDA SCHÜCKER [1] *, LISA EBBING [1], NORBERT HAGEMANN [2]
[1] Institute of Sports Science, University of Münster, Germany
[2] Institute of Sports and Sports Science, University of Kassel, Germany

ABSTRACT
Purpose. According to the self-focus theory of choking under pressure, conscious control of automated processes leads to a disruption of movement execution and deterioration in performance. In this study we examined whether analogy learning is a method to prevent choking under pressure. **Basic procedures.** Novice golfers learned the full swing over a period of six weeks either in a traditional way with technical instructions or with analogy instructions. Their performances were assessed in an indoor golf simulator. Attentional processes were measured using a dual task paradigm. Different kinds of learning instructions are linked to measures of skill-focused attention under low and high pressure conditions. **Main findings.** Performance scores in the dual task show that pressure leads to an increase in skill-focused attention of the technical learning group, compared to a decrease in skill-focused attention of the analogy learning group. **Conclusions.** Attentional processes under pressure are related to the method (analogy vs. technical instructions) implemented in the learning phase.

Key words: motor learning, implicit learning, attentional processes

Introduction

Scott Hoch, an American professional golfer was an excellent player for a long time but he had never won a major championship. In 1989 he should have won the Masters in Augusta (Georgia) but he did not. Hoch led Nick Faldo by one on Number 17 but missed a relatively short par putt and fell back. This missed putt, which every professional golf player, including Hoch, would have executed successfully in other circumstances led to a tie on Number 18 and to a sudden death play-off. On the first hole of the play-off Hoch had the possibility to two-putt and win the Masters. The first putt rolled about two feet past the cup so he could have quite easily putted the second to win. He took a long time to decide how to play and finally shot the ball five feet past the hole. For the second time in this tournament, a high level of performance pressure led to a breakdown of performance. In the end Hoch lost the Masters.[1]

Choking under pressure is defined as performing more poorly than expected given one's skill level in situations with increased performance pressure [1]. Pressure results from the individual desire to perform as well as possible in situations which demand high level performance [2]. Despite optimal motivation and individual striving to do one's best, performance drops to a suboptimal level. It is important to note that this less than optimal performance is not just a random fluctuation in performance, in contrast it results in response to a high pressure situation [3].

Two contrasting attentional theories have been proposed to account for skill failure in high pressure situations [e.g. 4]. Distraction theories suppose that pressure creates a distracting environment that shifts attention away from skill execution to task irrelevant cues, for example, worries about the situation [e.g. 5, 6–8]. On the contrary, self-focus theories (also termed explicit monitoring theories) suggest that performance pressure raises self-consciousness and causes the expert performer to pay attention to the process of performing and its step by step control [e.g. 1, 2, 8]. These contrasting predictions about the underlying processes of choking under pressure have been addressed in many studies. There is support for the distraction hypothesis in tasks that load heavily on working memory, for example, mathematical problem solving [e.g. 5]. However, for sensorimotor skills, the self-focus theories have received strong support in explaining performance decrements under pressure.

* Corresponding author.
[1] Top 10 Worst Golf Chokes and Collapses by Brent Kelley (http://golf.about.com/od/historyofgolf/a/worst_chokes_2.htm).

Self-focus explanations for choking in sensorimotor skills

Explicit monitoring theories have received support from studies directly manipulating the focus of attention as well as from training studies which provide indirect support for a self-focus explanation of choking. Results in various sensorimotor skill domains show that directing attention to the execution of well learned motor tasks leads to deterioration in performance. For example, Beilock et al. [9] studied this effect in golf putting and dribbling with a soccer ball. In both sports, they found that an internal focus of attention led to performance decrements for experienced players on behavioral measures (higher number of strokes per holes in golf and slower completion of a dribbling course in soccer). Similar effects were found in baseball [10], in soccer [11] and in field hockey [12]. These studies typically manipulate attention focus by the use of dual task paradigms. The secondary task either directs attention to external stimuli (subjects, for example, have to perform an auditory monitoring task) or to skill execution (subjects, for example, monitor the side of the foot that most recently contacted the ball in a dribbling task) [9]. For skilled performers, attention to the step-by-step control of proceduralized skills leads to poorer performance, whereas a focus on external stimuli does not harm performance. Beilock et al. [13] used a different kind of manipulation to investigate attentional focus effects. Novice and expert golfers were instructed to either emphasise accuracy or speed while executing a series of putts. Experts putted more accurately under speed instructions, whereas novices were more accurate under accuracy instructions. Speed instructions intended to reduce the time to explicitly monitored movement execution. Hence, the automated skill of an expert benefits from instructions that limit attention to performance execution. According to Masters and colleagues [14, 15] an inward focusing of attention leads to conscious processing of explicit knowledge with the result of an isolated concentration on specific components of the movement. As a consequence, the overall sequence of the movement is disturbed and not executed smoothly. Masters [14] terms this explanation the "reinvestment hypothesis". Beilock and Carr [1] talk about deterioration in performance through explicit monitoring or execution focus theories. Attention on the step-by-step control of an automated movement leads to its breakdown. Wulf and colleagues [e.g. 16–18] have conducted a series of studies on the attentional focus effect. Their explanation is the "constraint action hypothesis" which is less cognitive in nature than Master's [14] reinvestment hypothesis. The constraint action hypothesis assumes that the conscious control of a movement leads to a constraint of the motor system by interfering with automatic "processes that would 'normally' regulate" movement coordination [17, p. 6]. Support for this explanation comes from studies using electromyographic (EMG) outcome measures [e.g. 16, 19]. Although these explanations (reinvestment, explicit monitoring or constraint action) propose different specific processes, they all have in common that an inward focus on movement execution disrupts automated processes, which leads to deterioration in performance.

The question is whether the previously described attentional focus effect applies to skilled performance when executed under high amounts of pressure. Training studies provide indirect evidence for an inward shift of attention on movement execution in pressure situations. Beilock and Carr [1, Experiment 4] examined whether practice in dealing with self-focused attention or training in a dual task environment would reduce choking under pressure. Participants practiced the golf putt under three different learning conditions and were then exposed to a pressure situation. The conditions were single task, dual task (auditory monitoring) or self-consciousness (participants were videotaped in order to direct attention to themselves and their performance). Beilock and Carr found that performance decrements in a pressure situation were eliminated by self-consciousness training [1]. They concluded that training under internal focus conditions helps performers to adapt to the type of attentional focus that occurs under pressure. Lewis and Linder [8] had used this study design before and also found that learning a skill in a self-consciousness environment prevents performers from choking.

Important insight into the underlying attentional processes of choking comes from a study conducted by Gray [20]. He directly investigated the effects of performance pressure in a baseball batting task. College baseball players batted under two different dual task conditions (judging tone frequency or direction of bat movement on tone presentation). When placed under pressure the level of skill-focused attention was significantly higher, indicated by better performance in the skill-focused dual task: Participants judged the direction of bat movement significantly more correctly in the pressure condition compared to a control group who performed the dual task without pressure. There was no difference in the tone judgement task. The increase in skill-focused attention was associated with degradation in batting performance as well as changes in batting kinematics. This finding provides the first direct evidence that choking under pressure is caused by an inward shift of attentional focus as proposed by Baumeister [2].

Jackson and Willson [21] proposed a method to prevent the reinvestment of explicit rules under pressure. This method holds thinking of a global cue rather than thinking about detailed technical rules. Experienced golfers had to put under conditions of low and high state anxiety. A set of different attentional strategies was given, including a swing thought condition. Participants' putting performance was assessed. Choking under pressure was significantly reduced when participants verbalised a single global cue word (swing thought). In a recent study it was also shown that a swing thought condition reduced choking under pressure [4].

Implicit learning to prevent choking under pressure

Masters [14] relates an inward shift of attention to conscious processing of explicit knowledge of how the skill works. More specifically he talks about reinvestment of conscious knowledge under high amounts of stress. Explicit knowledge about movement execution includes technical know-how and rules about the movement processes. Beilock and Carr [1, Experiment 1] were able to demonstrate an effect of level of expertise on the amount and content of generic and episodic knowledge of golf putting. Reduced episodic memories of specific putts in golf among experts indicate that performance is controlled by automated procedural knowledge. According to explicit monitoring theories of choking, this proceduralization makes performance vulnerable to deterioration of performance under pressure.

An approach to prevent choking is the attempt to avoid the build-up of a conscious representation about the movement process during the learning phase. Two types of learning theories that operate without explicit knowledge have been reported in the literature: implicit learning and the related analogy learning. In the former type of learning a skill is acquired without knowledge of explicit rules, but rather learned along the way without necessarily intending to do so. In Masters' [14] experiment subjects learned a golf putting skill either explicitly or implicitly and their performances were assessed under stress in a post-test condition. The hypothesis that performers with a small amount of explicit knowledge were less prone to choking was supported by the results.

However, by implicit learning the learning progress will take a long way as no rules or other aids to acquire the skill are given. An alternative is provided by analogy learning. Analogy learning in sport operates with biomechanical metaphors or metaphors of motion instead of explicit rules and technical know-how. Masters [22] states the following: "The aim is to get the pupil to perform the to-be-learned skill using one general analogical rule which acts as a biomechanical metaphor encompassing many of the technical rules necessary for successful execution of the skill. The learner follows this simple analogy and inadvertently employs these camouflaged rules" [22, p. 538].

Liao and Masters [23] examined the hypothesis that analogy learning is implicit in nature and will therefore show similar characteristics to implicit learning. They instructed table tennis novices to learn the topspin forehand either implicitly (no additional instructions but secondary task in the learning phase), explicitly (set of 12 basic techniques on how to hit topspin) or by analogy (instruction to pretend to draw a right-angled triangle with the bat). Their results confirmed that the implicit characteristics (a small number of explicable explicit rules, robustness under secondary task load and a lack of correlation between confidence and performance) also apply to analogy learning (Experiment 1). In a second experiment they were furthermore able to demonstrate that the performance of an analogy learning group was not affected by stress, suggesting that this method may be a possible means to prevent choking under pressure. Using the same approach as Liao and Masters [23] (learning the table tennis forehand by analogy), Law et al. [24] showed that supportive audiences induced performance decrements in the explicit learning group but not in the analogy learning group. It is assumed that the presence of supportive audiences leads to the same processes as stress, an inward shift of attention and in turn to a deterioration in performance. Analogy versus explicit learning has predominantly been studied in table tennis. Recently Lam et al. [25] investigated this subject in a modified basketball shooting task. In a dual task transfer test performance decrements were shown for explicit and control conditions, but not for the analogy learning group.

Contrasting results are shown in a recent study [26]. The table tennis forehand was performed 10,000 times by an analogy and explicit learning group. After 1,400 and 10,000 repetitions, performance under pressure was assessed but did not show any difference between the groups despite differences in rule formation. This result does not confirm that the amount of explicit knowledge is detrimental for performance under pressure.

The present study

The present experiment was designed to evaluate whether analogy learning can be used as a sound method to prevent choking under pressure. For the full swing in golf a learning paradigm including two different learning conditions (one classic condition with technical instructions and one condition with analogy learning) was implemented. Different learning methods for the golf swing and their effectiveness are also of applied relevance for golf clubs as they teach the golf swing to novices on a daily basis. When put under pressure, it is assumed that the analogy learning group will focus less internally and show better performance than the technical learning group. This experiment combines studies that examine learning conditions with regard to choking under pressure and studies that directly measure attentional processes. We do not only want to show that the analogy group will show better performance under pressure, but we also want to show directly that different attentional processes apply to technical and analogy learning group in the pressure condition. This will be done by using a skill-focused dual task so that performance in the dual task can be used as an indicator of attention focus. Under high pressure we expect that the technical learning group will perform better in the dual task than under low pressure thus showing an increase in internal focus of attention. We assume, furthermore, that the analogy learning group will show similar dual task performance under low and high pressure as they are protected from focusing internally under pressure by learning by analogy.

Material and methods

Participants

Fifty-one participants (33 male, 18 female) aged 21 – 65 years (*M* = 32.7, *SD* = 12.3) volunteered for this study. They were randomly assigned to either an analogy learning group (*n* = 28) or a technical learning group (*n* = 23). 49 of the participants were right handed, two participants were left handed. All participants were inexperienced in golf playing and had no official permission to play golf in Germany (inclusion criteria to participate in this study). After completion of the learning experiment subjects took an assessment to get this official permission. A questionnaire tapped the participants' experience in golf, 34 of them had taken a trial course but never played golf on a regular basis. The study was conducted according to the ethical guidelines of the American Psychological Association (APA).

Figure 1. ProTee Golf Simulator System
(with permission from ProTee United)

Apparatus

To measure swing performance an indoor golf simulator was used (ProTee Golf Simulator System, Zaltbommel, The Netherlands), see Figure 1. The player hits a ball and the system measures the swing characteristics with 94 optic high speed sensors. Two parameters were taken to evaluate the participant's swing performance: carry and off-line. These parameters mainly determine the overall quality of the swing. Carry is measured in meters (m) and is defined as the length of ball flight up to the point of impact on the ground. Off-line is given in degree (°) to assess deviance from straight ball flight. The best performance is given when the shot is preferably long and straight.

To assess attention focus a skill-focused dual task design similar to the one used in Gray's [20] experiments was used. A single auditory tone was presented while participants performed the swing. After completion of the swing they had to judge the swing phase (backswing, downswing and follow through) in which the tone appeared. Pictures of each phase were shown and the

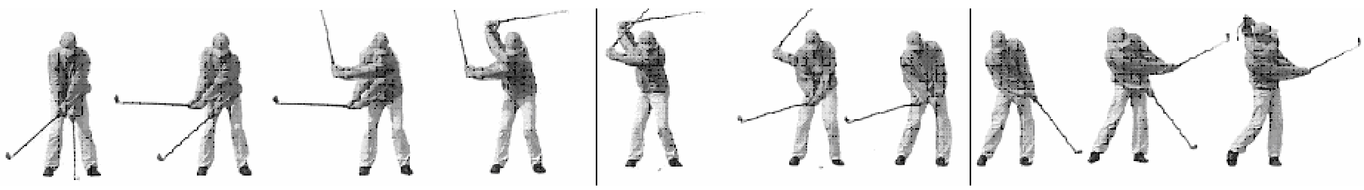

Figure 2. Pictures of the backswing, downswing and follow through phase according to Lehnertz, Heuler and Quirmbach [27] used for the skill-focused dual task (with permission from Deutscher Golf Verband e.V.)

participants were asked to indicate the picture that corresponded to the time interval the tone appeared during the swing, see Figure 2. The tone was linked to a light signal so the actual time interval in which the tone appeared could be identified by video analysis. An independent rater who had not been introduced to the aim of the study analysed the videos frame by frame with the program V1 Home 2.0 to determine in which movement phase the light was visible, meaning the tone was presented to the participants.

Procedure

During a six-week learning phase a golf-professional instructed the participants to learn the full swing in golf. Each participant had a one-hour golf lesson together with 5 – 7 other participants once a week. After this one-hour lesson there was another hour of free practice. The participants were assigned to two different learning conditions. An instructional set for each condition was developed with the golf-professional and experienced coaches before the experiment. The instructional set included rules and metaphors for basic position and swing phases as well as instructions for error corrections as this is an important aspect when learning the golf swing. On the whole, there were nine technical instructions and associated metaphors for basic position, split into grip position (4), pressure on the grip (1) and posture (4). For the different phases of the swing there were 21 technical rules and related metaphors, separated into backswing (12), downswing (5) contact (2) and position of golf club head (2). Individual characteristics of the different learning groups and examples are presented in the following section.

Technical learning group. Technical instructions typically contain movement descriptions and include biomechanical and physiological processes. The movement of single body parts and their relative position are described in detail. Added to this are descriptions of how the muscles should be activated and where tension on muscles is necessary. Thus, these instructions include a high number of explicit rules of how the skill works. On the basis of a textbook on learning the golf swing [27] and with experience of the golf-professional and coaches, the specific technical instructions were developed. For example, the instruction for the right grip was as follows: "The pressure of both hands on the grip is equal. The wrists should move freely, hands should stay on the grip while swinging." The technical instruction for the correct posture was the following: "From an upright position the core is bended slightly to the front. The knees are also bended so that the club touches the ground. Body weight should be evenly distributed between heel and ball."

Analogy learning group. In the learning process some teachers draw analogies to give the learner a better understanding of how the skill works. According to Liao and Masters [23] "the function of the analogy is to integrate the complex rule structure of the to-be-learned skill in a simple biomechanical metaphor that can be reproduced by the learner" [p. 308]. Thus, in one single analogical rule many of the technical rules that are necessary for successful execution of the skill are encompassed [22]. In contrast to Masters' conception of analogy learning, we do not operate with a single analogy but with a whole set of analogies to learn the full swing in golf. We believe that for the new learning of a complex motor movement as the golf swing (unlike the usually studied table tennis forehand) a single metaphor cannot encompass all the necessary aspects of this movement. A textbook for learning golf operating with many analogies [28] helped to develop the instructional set for the analogy group. The golf professional and coaches provided further information for creating several analogies. The instruction for the correct grip was the following: "Imagine you have an open tube of toothpaste between your hands and the contents must not be pushed out." The correct posture was taught with the following instruction: "The posture is comparable to a light lowering of the bottom on the rim of a bar stool."

Test intervals. The first performance test was done after the first training session and used as a baseline measure. After the fifth session there was a second performance test to measure training progress. Each performance test included 10 full swings in the ProTee Golf Simulator System. After the sixth session a test under conditions of low pressure and a test under conditions of high pressure were performed. Subjects were told they had to perform two sets of 12 full swings in the ProTee Golf Simulator.

Pressure conditions. The second set of swings was introduced as a part of the test to get the official permission to play golf in Germany, whereas the first set was introduced as a preparation set. Without this official permission you are not allowed to play on a golf course in Germany, so the test for this permission is very important for everyone who wants to play golf in Germany. Subjects were told that the indoor learning conditions differ from the outdoor environment on the actual golf course. For this reason they would be able to show their indoor learned performance in an indoor test. For a good result (long and straight ball flight) bonus hits would be given for the outdoor permission test. The highest reward was a bonus of 2 hits on 3 holes of 9 to be played in the test round. In this way a realistic pressure manipulation was obtained, showing the high relevance of the indoor test on the later official permission outdoor test. In each of the two sets the skill-focused dual task was conducted. As a comprehensible explanation for the tone judgement task, participants were told that correct judgement of the tone was used to determine the stability of the swing. After completion of the two tests subjects were debriefed and participants finally finished the experiment with the full test to get the official permission to play golf in Germany.

Statistical analysis

All data analyses were computed with SPSS 15. Repeated measure ANOVAs with between subject factors of learning condition and within subject factors for first and second test intervals and low and high pressure conditions were computed for the different parameters. For effect sizes η_p^2 was calculated.

Results

Learning progress

As not all the participants were present in the baseline test after session one and the learning progress test after session five the performance of only 46 participants (25 in the analogy learning group and 21 in the technical learning group) was analysed. Both groups showed a significant improvement from the first to the fifth training session on the parameter carry, $F(1, 44) = 14.28$, $p < 0.05$, $\eta_p^2 = 0.25$. The interaction effect of test interval and learning condition was not significant, $F(1, 44) = 0.07$, $p = 0.79$. For off-line there was neither a significant main effect, $F(1, 44) = 0.01$, $p = 0.92$, nor a significant interaction effect, $F(1, 44) = 0.43$, $p = 0.51$. The main effect for learning condition was neither significant for carry, $F(1, 44) = 1.38$, $p = 0.25$, nor for off-line $F(1, 44) = 0.00$, $p = 0.98$. Technical and analogy learning groups did not differ significantly with regard to learning progress. Descriptive values of the baseline test and the test after fifth session are presented in Table 1.

Low and high pressure test

Looking at the tone judgement task, there was a significant interaction of learning group and pressure condition, $F(1, 49) = 14.36$, $p < 0.05$, $\eta_p^2 = 0.23$, see Figure 3. The technical and the analogy learning groups showed similar performances in the tone judgement task when pressure level was low. However, at a high level of performance pressure the technical learning group showed better performance in judging the occurrence of the tone in relation to the swing phase ($p < 0.001$) than the analogy learning group. Post hoc paired sampled t-tests showed a decrease in skill-focused performance for the analogy learning group $t(27) = 4.32$, $p < 0.001$ and a trend to increase in dual task performance for the technical learning group, $t(22) = 1.5$, $p = 0.07$.

The analysis of the two performance parameters, carry and off-line, did not yield any significant effects, main effect pressure (carry), $F(1, 49) = 1.13$, $p = 0.29$, interaction effect pressure and learning condition (carry), $F(1, 49) = 0.37$, $p = 0.37$, main effect pressure (off-line) $F(1, 49) = 1.28$, $p = 0.26$, interaction effect pressure and learning condition (off-line) $F(1, 49) = 1.66$, $p = 0.20$. The main effect for learning condition was neither significant for carry, $F(1, 49) = 0.88$, $p = 0.35$, nor for off-line $F(1, 49) = 0.16$, $p = 0.69$. Although statistically not significant, the analogy learning group shot the ball 3 m further in the high pressure compared to the low pressure condition, whereas the technical learning group kept the same length, see Table 2 for descriptive values.

Table 1. Descriptive values for analogy and technical learning groups in baseline test and after fifth learning session

		After first session (baseline)		After fifth session	
		M	SD	M	SD
Carry (m)	Analogy learning	70.35	25.30	81.86	27.37
	Technical learning	80.16	26.59	90.19	32.10
Off-line (°)	Analogy learning	12.90	5.52	12.23	4.99
	Technical learning	12.38	3.58	12.85	5.71

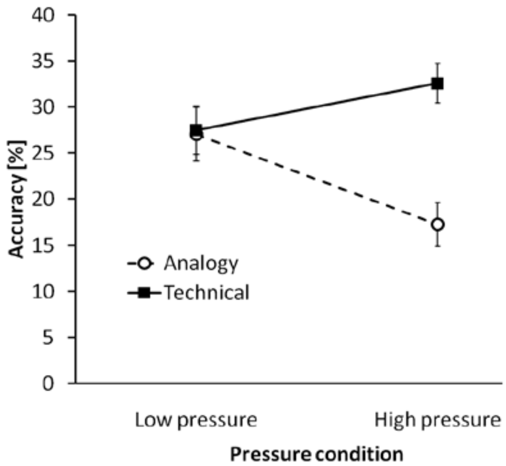

Figure 3. Mean accuracy of tone judgement (%). Performance of analogy and technical learning groups in low pressure and high pressure conditions

Table 2. Descriptive values for analogy and technical learning groups in low and high pressure conditions

		Low pressure		High pressure	
		M	SD	M	SD
Carry (m)	Analogy learning	80.82	23.26	83.80	26.87
	Technical learning	89.69	27.33	89.64	30.00
Off-line (°)	Analogy learning	16.14	7.48	14.33	8.94
	Technical learning	14.52	6.11	14.64	5.46

None of these results was statistically significant

Discussion

In this study we examined whether different learning conditions (analogy learning and technical learning) lead to different performance and attentional processes under conditions of high pressure. Participants learned the full swing in golf in a six-week learning period. We determined performance parameters in an indoor golf simulator and attentional processes with a dual task paradigm.

One of the assumptions was that the analogy learning group and the technical learning group would not differ in learning progress. The results supported this assumption. Both groups showed parallel learning progress on the parameter carry. However, after four training sessions no progress was found on the parameter off-line. It follows that analogy learning as a form of implicit motor learning does not interfere with learning progress as compared to a classic learning situation with technical instructions. These findings support Masters' [22] view on the advantages of analogy learning. However, it has to be taken into account that the analogy learning method in this study differs from Master' view as in the present study we operate with a whole set of analogies.

A major finding of this study was the difference between the two learning groups in dual task performance under pressure. Attention focus was measured with a design similar to Gray [20]. Participants had to indicate in which phase of the golf swing a tone was presented during movement execution. The skill-focused attention measured with this dual task was comparable in the analogy and technical learning groups in a low pressure situation. This means that the presented tone was judged equally by the two groups in relation to the swing phase. This pattern changed when participants were put under performance pressure. Those who learned with explicit technical rules displayed a trend for an increased attention focus on movement execution as shown by better performance in the skill-focused dual task (a higher number of correct tone judgements). Opposed to that, the analogy learning group displayed a decreased attention focus on skill execution which was a surprising result. There was no reason to believe that pressure would actually reduce skill-focused attention of the analogy learning group, we expected that dual task performance of this group would not be affected by pressure.

It seems that analogy learning and technical learning lead to different attentional processes in a high stress situation. Explicitly acquired knowledge is activated in a performance pressure situation [14]. In analogy learning knowledge seems to be processed differently as it is not activated under pressure. Even though using verbal instructions, the motion metaphors might be processed and stored in a visuospatial form rather than in the form of explicable verbal rules. However, we have to ask why the analogy learning group did not display a similar amount of internal focused attention under low and high pressure conditions but actually showed a decrease in internal focus of attention under pressure. At this point we cannot provide a sound explanation for this finding.

Looking at the performance parameters the expected picture is not as clear. We assumed that the analogy learning group would show better performance under pressure than the technical learning group. As reported, we did not find any significant main or interaction effects on the performance parameters (carry and off-line) for different pressure and learning conditions. This means we did not observe performance decrements under pressure for either of the learning groups. We would have expected to observe the phenomenon of choking under pressure for the technical learning group, however, the results did not support our assumption. We assumed that an increased attentional focus on movement execution would be related to worse performance. Despite differences in dual task performance (technical learning group showed an increase in skill focused attention under pressure compared to analogy learning group) we did not observe differences in performance. A reason for the findings not being significant could be the degree of automation of the golf swing. An internal attentional focus on movement execution does lead to performance decrements when the to-be-performed skill is already well automated [e.g. 9, 10]. As subjects in this study learned the skill over a six-week period, the level of proceduralization of the skill might not have been enough for performance decrements with an increased internal attentional focus. It would be interesting to look at the results of pressure after a longer learning interval as it was done in the table tennis study by Koedijker et al. [26].

A limiting factor of this study, which has to be taken into account, is that no objective measure of stress level was implemented. Assessing stress level after the low pressure pre-test might have disturbed participants with respect to the following high pressure post-test, that is why no questionnaire was distributed between the two performance sets. Still, the amount of actually felt performance pressure can only be assumed by the realistic implementation of the stress manipulation. Even though we do not have an objective manipulation check we prefer this lifelike pressure manipulation to the manipulation used in many laboratory settings. The test to get the official permission to play golf in Germany puts participants into a real performance situation. The studies that use monetary rewards or artificial social pressure seem to manipulate pressure successfully – but whether this pressure is comparable to real life pressure situations has to be questioned.

The fact that performance had not significantly improved on both performance parameters might also be explained by the length of the learning interval. Four weeks lay between the baseline and the performance test session for learning progress. However, carry has to be seen as one of the most important parameters and an improvement here shows that participants actually did learn and improve their full swing in golf. Furthermore, it has to be taken into account that the baseline measure took place after the first training. Participants had already acquired main parts of the golf swing during the first session. The considerable increase in learning progress that one has to expect when a new skill is learned might have already taken place during the first learning session before the baseline measurement. This could explain why there were no big differences between baseline and performance tests for learning progress.

As promising as the analogy learning approach may seem, it is a means against choking under pressure that can only apply to persons who have not yet acquired a skill over a long learning period. Experts who have already learned the skill in the traditional, explicit way will have already stored a large number of explicit rules. Learning by analogies might not be helpful to prevent choking under pressure as they do no longer have to learn the performance pattern of the skill. Nevertheless it would be interesting to let experts train with motion metaphors and assess performance under pressure later on. Yet, Jackson and Willson's [21] approach to prevent choking by using global cue words might better fit performances at an expert level.

Conclusions

The aim of our study was to link two different kinds of learning strategies to performance and an assessment of attentional processes under pressure. Both learning strategies were equally effective in the learning process. We were able to show different attentional processes of analogy and technical learning groups under pressure using a skill-focused dual task. This provides evidence for the involvement of attentional processes in performing under pressure. However, we were not able to show that differences in attentional processes are linked to performance parameters. Showing differences in skill focused attention under pressure dependent on the strategy used during the learning phase is an important finding but we cannot claim that analogy learning is more effective than technical learning in preventing people from choking.

References

1. 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.
2. Baumeister R.F., Choking under pressure: self-consciousness and paradoxical effects of incentives on skillful performance. *J Person Soc Psychol*, 1984, 46 (3), 610–620.
3. 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.
4. 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.
5. 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.
6. Wine J., Test anxiety and direction of attention. *Psychol Bull*, 1971, 76 (2), 92–104.
7. 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.
8. Lewis B.P., Linder D.E., Thinking about choking? Attentional processes and paradoxical performance. *Pers Soc Psychol B*, 1997, 23 (9), 937–944.
9. 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.
10. 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.
11. Ford P., Williams A.M., Hodges N.J., Online attentional-focus manipulations in a soccer-dribbling task: Implications for the proceduralization of motor skills. *J Motor Behav*, 2005, 37 (5), 386–394.
12. 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.

13. Beilock S.L., Bertenthal B.I., McCoy A.M., Carr T.H., Haste does not always make waste: Expertise, direction of attention, and speed versus accuracy in performing sensorimotor skills. *Psychon Bull Rev*, 2004, 11 (2), 373–379.
14. 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, 343–358.
15. Masters R.S.W., Polman R.C.J., Hammond N.V., "Reinvestment": A dimension of personality implicated in skill breakdown under pressure. *Pers Indiv Differ*, 1993, 14 (5), 655–666.
16. 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.
17. Wulf G., Attentional focus and motor learning: A review of 10 years of research. *Bewegung Training*, 2007, 1, 1–64.
18. Wulf G., McNevin N., Shea C.H., The automaticity of complex motor skill learning as a function of attentional focus. *Q J Exp Psychol*, 2001, 54A (4), 1143–1154.
19. 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, 304–309. doi:10.1016/j.brainresbull.2005.06.035.
20. 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.
21. 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.
22. Masters R.S.W., Theoretical aspects of implicit learning in sport. *Int J Sport Psychol*, 2000, 31, 530–541.
23. Liao C., Masters R.S.W., Analogy learning: A means to implicit motor learning. *J Sports Sci*, 2001, 19, 307–319.
24. Law J., Masters R.S.W., Bray S.R., Eves F., Bardswell I., Motor performance as a function of audience affability and metaknowledge. *J Sport Exerc Psychol*, 2003, 25 (4), 484–500.
25. 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.
26. 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, 237–256.
27. Lehnertz K., Heuler O., Quirmbach S., The technique of the golf swing [in German]. Deutscher Golf Verband e.V. Lehrbrief 4, Albrecht Golf Verlag GmbH, Gräfelfing 2002.
28. Spearman M., Aim of golf. Visual-imagery lessons to improve every aspect of your game. Rodale, USA 2004.

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Address for correspondence
Linda Schücker
University of Münster
Institute of Sports Science
Department of Sport Psychology
Horstmarer Landweg 62b
48149 Münster, Germany
e-mail: lindaschuecker@uni-muenster.de