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Preventing motor skill failure through left hand contractions:

An intervention study

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Abstract

When athletes fail to execute automatic or well-learned motor tasks, it is assumed that their focus of attention lies on task irrelevant stimuli and they are considered to choke under pressure. Left-hand contractions have been shown to alleviate choking under pressure in different sports. The present study aimed to replicate these findings and tested whether left-hand contractions (clenching a soft ball) can be used as an intervention method against choking in soccer. The effect of left-hand contractions was investigated in a within-subjects design testing right-handed players from the youth academy of SK Rapid Wien, a professional soccer club in the Austrian Bundesliga. 30 semi-professional soccer players performed penalty shootouts on a goal wall. The study examined whether participants who squeezed their left hand contrasted from a control condition in shot accuracy in a high-pressure phase when compared with a low-pressure phase. The participants' heart rates and shot accuracy were measured during both phases. Results revealed significantly higher heart rate levels for both groups during the high-pressure phase compared to the low-pressure phase. While left-hand contractions showed an alleviating effect on performance decrease after pressure induction when compared with the control condition, the obtained effects on task performance were not significant. The results only showed a tendency towards the hypothesis that left-hand contractions may prevent motor skill failure and alleviate choking under pressure.

Keywords: left-hand contractions, performance under pressure, choking under pressure, attention, motor skill failure

Introduction

Choking under pressure (referred to hereafter simply as choking) is something probably everyone has heard of or experienced at some point in life. It is a more common state in sports, especially in professional sports.

Christiano Ronaldo and Lionel Messi for example, the two most famous and arguably best soccer players of their generation, usually take all the important penalty shots for their clubs (Juventus F.C. and F.C. Barcelona) and countries (Portugal and Argentina). They are considered top performers under pressure and just recently had to prove themselves in front of thousands of fans at the World Cup 2018 in Russia and millions in front of the TV. But both Ronaldo (53rd Minute vs. Iran) and Messi (64th Minute vs. Iceland) failed to score a penalty against a rather average goalkeeper, at least for international standards, in their final group stage game of the World Cup 2018. A converted penalty kick would have given their respective teams the late game lead and consequently a better position meaning probably weaker opponents, moving on to the knock out stages. But why does this happen even to the best players of the world? There are two types of theories trying to explain why choking occurs.

The distraction and the self-focus theory both presume that performance alterations under pressure are caused by a false shift of attention (Ehrlenspiel, 2006). The distraction theories on the one hand suggest that actors under pressure centre their attention on task-irrelevant stimuli. The self-focus theories on the other hand assume that actors under pressure turn their focus of attention inward, which also leads to them focusing on irrelevant stimuli (Mesagno & Mullane-Grant, 2010).

Addressing the topic of choking, Beckmann, Gröpel and Ehrlenspiel (2013) performed a study which included participants from various sports (soccer, tae kwon do, and badminton).

They tested left-hand contractions as a potential intervention method against choking. In a series of three experiments, they investigated whether enhancing right-hemispheric activation through hemisphere-specific priming (left-hand ball squeezing) could alleviate motor skill failure. In Experiment 1 of their study they compared the performances of experienced soccer players in a pressure-free situation with that completed under pressure. The participants' task was to take six penalty shots on a goal wall, three into the lower right followed by three into the upper left hole. The players' shot accuracy was measured using a 6-point scale while their anxiety levels were documented via a self-report survey (WAI-S; Ehrlenspiel, Brand, & Graf, 2009). A large crowd was used for pressure induction purposes. During the pressure phase half of the players were instructed to squeeze a soft foam ball with their left hand for 30 seconds right before their first shot on the goal wall. The other half which represented the control condition squeezed the ball with their right hand. As the authors expected, the left hand contractions alleviated a performance decrease after pressure was induced when compared to the control condition (Beckmann et al., 2013). Their results propose that hemisphere-specific priming may prevent motor skill failure.

The aim of the present study was to replicate these findings and test left-hand contractions as an intervention method against choking in soccer, using a similar experimental procedure as Beckmann et al. (2013) with slight modifications in the way pressure was induced, perceived pressure was measured and hand-contraction time was used. These adjustments were made to create a more ecologically valid setting.

A better understanding of why people tend to choke under pressure and which interventions can prevent it from happening could be very helpful for not only professional athletes but also for aspiring youth athletes working with sports psychologists. Coping mechanisms to intervene with the "choke" could already be learned and trained at an early

age, which should be an enormous advantage for those athletes using them because performing excellently at the right moment is the key to become a professional.

But being in high pressure situations is not just common in sports but also very relevant for various other professional fields such as heart surgery for example, in which way more than the end result of a competition is at stake. Testing different routines and intervention methods in order to prevent choking and hence being able to perform at an optimum in a specific moment should therefore receive closer scientific attention.

Theory

Definitions of choking under pressure

The original definition of choking comes from Baumeister (1984), who defined choking as a sub-standard performance in pressure situations despite the presence of outstanding skills and the determination for an excellent performance. Simply said, choking displays a negative change in an actor's performance.

As Baumeister and Showers (1986) claim, a given performance can only be labelled choking if it is obvious that the athlete could have done better and additionally had the ambition to do so. But choking is not just a sub-standard performance. According to Beilock and Gray (2012) choking is executing a task worse than expected, in situations where performance pressure is at its peak, given the athlete's level of skill and her/his earlier achievements. This sub-standard performance is not to be equated with a random fluctuation in an actor's skill level but rather is owed to great pressure during a task (Beilock & Gray, 2012).

Baumeister and Showers (1986) defined *pressure* as the presence of situational incentives for optimal, maximal, or superior performance. It includes the occurrence of an audience, reward or punishment contingency, ego relevance and most essentially competitions

in which performance is compared between performers in pressure situations (Baumeister & Showers, 1986). Whereas *performance pressure* is defined as an aspect of the situation, containing the importance of doing well on a specific occasion (Baumeister, 1984).

Beilock and Gray (2012) describe choking as a relatively discrete performance state, meaning that choking has a clear beginning and end to it which represents the performer's interpretation of a high-pressure situation. This definition sets choking apart from other states such as regular performance slumps, in which athletes have extended periods of below average performances while the cause of their poor execution usually is not to be located (Beilock & Gray, 2012; Grove & Stoll, 1999).

A more recent definition for choking comes from Mesagno and Hill (2013) who define choking as “an acute and considerable decrease in skill execution and performance when self-expected standards are normally achievable, which is the result of increased anxiety under perceived pressure” (Mesagno & Hill, 2013, p. 273).

Collectively this leaves us with three important requirements for choking: Available skilled performance, anxiety increase under pressure, and performance decrease below expectations.

Theoretical views on choking

In sports, an optimal or clutch performance only occurs when the attentional focus lies on task-relevant information and processes, while task-irrelevant cues are being concurrently ignored (Moran, 2016). As mentioned in the introduction, choking has been explained by two main theoretical, attention based views, the distraction model and self-focus model. These two theories assume that performance changes under pressure are due to altered cognitive processes which lead to a false focus of attention being either internal, meaning movement-related or external, meaning environmental (Ehrlenspiel, 2006). The distraction theories on

the one hand propose that actors under pressure focus their attention on task-irrelevant stimuli as a result of heightened anxiety (Mullen, Hardy, & Tattersall, 2005; Oudejans, Kuijpers, Kooijman, & Bakker, 2011). There are two main mechanisms explaining this model. Either the selective function of attention is reduced, possibly due to capacity limitations, and an greater amount of information has to be dealt with leading to the abandonment of relevant information, or the attentional focus is shifted towards task-irrelevant stimuli which then leads to the missing out of critical features of the task (Baumeister & Showers, 1986). Support for the distraction theories comes from qualitative research in which athletes described feelings such as worries and negative thoughts under high-pressure situations and attributed their reduced performance to such distracting factors (Oudejans et al., 2011).

The self-focused theories on the other hand propose that actors under pressure turn their attentional focus inward. Carver and Scheier (1981) showed that an increase of pressure raises a higher level of self-awareness which then leads the athlete to become more aware of discrepancies between his ideal goal and his actual present behaviour. The knowledge of this discrepancy leads to a greater endeavour but also to a repeated comparison between the standard and possible options for the action. This comparison takes up more time and therefore leads to poor performance resulting either because speed of action is reduced or because a poor option is chosen (Carver & Scheier, 1981). Beilock and Carr (2001) later on proposed that performance decreases under pressure are due to higher attention paid to step-by-step execution of well-learned motor tasks which disrupt the normally automatic behaviour. Additionally Jackson, Ashford, and Norsworthy (2006) showed that poor performances also occur when athletes try to monitor and control movements deliberately, rather than monitoring movements alone.

Therefore the self-focus theories, similar to the distraction theories, also state that choking is due to concentrating on task-irrelevant (internal/external) stimuli. Regarding motor

skill failure, the self-focus theories are more widely supported than the distraction theories (Mesagno & Mullane-Grant, 2010). Nevertheless Mesagno, Marchant and Morris (2009) provided qualitative evidence that the two models are able to coexist, even overlap to some point and that both of the explanations are applicable.

An additional model for choking, which has gained more attention in recent literature, is the self-presentation theory. It focuses on why state anxiety increases under pressure and is based on personality-inspired research trying to explain the origins of why some athletes are more predisposed to anxiety increases than others and hence more likely to choke than others too (Mesagno, Harvey, & Janelle, 2011). Self-presentation refers to behaviours aimed at promoting an image of self to others and resembles the process by which people try to regulate how they are perceived and judged by others (Schlenker, 1980). While social anxiety decreases presenting oneself in a sociably desirable way to others it increases when people are motivated to make this desired impression but doubt they will manage to do so (Schlenker & Leary, 1982).

Leary (1992) theorized that competitive anxiety is a sport-specific form of social anxiety that is related to self-presentation during competition. He later argued that social anxiety increases if there is a possibility for relational devaluation to occur. He explained that relational devaluation would increase an athlete's social anxiety when the impression he made led others to devalue, reject or even avoid him. Athletes that fail to perform fear for their public image (Leary & Jongman-Sereno, 2014). Mesagno (2009) labelled this state as athletic identity, which is the amount to which individuals identify with the role of an athlete. If this identity is jeopardised, when an athlete fails to perform for instance, anxiety increases because of the possibility of relational devaluation. Simply speaking, being known as a "choker" in the public eye can quickly lead to self- and relational devaluation in athletes. Athletes, who

experience such negative emotions, may be more likely to experience choking as long as they are not equipped with the appropriate skills to cope with them (Mesagno, 2009).

Anxiety in sports

During competition athletes can react both physically and mentally in a way which can negatively affect their performance. Anxiety is one term used to describe this condition and is defined as the emotional or cognitive aspect of physiological arousal (Wiese-Bjornstal & Weiss, 1999). In Psychology two types of anxiety are generally differentiated: trait and state anxiety. Trait anxiety on the one side is known as a characteristic of personality in which nervousness is a steady personality trait in an individual. State anxiety on the other side relates to momentary feelings of anxiety in a particular situation such as a competition (McCanny, 2014). There are two components of anxiety that have been defined in the literature. First we have the mental component normally labelled as cognitive anxiety or simply as worry and then there is a physiological component normally labelled as somatic anxiety (Morris, Davis, & Hutchings, 1981; Martens, Vealey & Burton, 1990).

An athlete who is cognitively anxious has “negative expectations and cognitive concerns about [him- or herself], the situation at hand, and potential consequences” (Martens et al., 1990, p. 541). Athletes who experience high levels of cognitive anxiety are worried about their ability to perform and fear the consequences of not performing as well as they can. Somatic anxiety refers to the perception of one’s physiological arousal symptoms, such as a rapid heart rate, shortness of breath, sweaty palms and muscle tension (Morris et al., 1981). The Multi-Dimensional Anxiety Theory states that somatic anxiety should drop once the performance begins but cognitive anxiety may remain high if confidence levels are small (Martens et al., 1990).

Subsequently state anxiety can be a very unpleasant feeling for athletes experiencing certain negative physiological symptoms before and during important competitions. This can increase the probability of choking as long as they are not taught different techniques that can help them control their anxiety.

Heart rate and somatic anxiety

As mentioned in the previous paragraph somatic anxiety represents the physiological arousal symptoms of anxiety and is reflected in such responses as rapid heart rate or shortness of breath for example (Morris et al. 1981). Next to a number of physiological markers of anxiety, including electro dermal activity (EDA), heart rate variability (HRV) and blood pressure (BP), heart rate (HR) can also be considered as a useful indicator for a person's anxiety (Vrijkotte, Van Doornen, & De Geus, 2000).

Since semi-professional soccer players are already used to having their HR monitored during practises and games for sport scientific reasons and the simple style of measurement that is required for it, the present study chose participants' HR levels as the physiological marker of somatic anxiety and measure of perceived pressure.

Motor skills and behaviour

Fitts and Posner (1967) explained, when a motor skill is learned, it goes through three different phases including a cognitive, an associative and an autonomous stage. During the cognitive phase the left hemisphere plays a significant role in developing mental images of the action with verbal representations of the action that help the performer to transfer a more basic and comprehensive understanding of the demanded execution process of the action (Beckmann et al., 2013).

During the associative phase, the execution of the action learned in the cognitive phase is physically performed by the actor and therefore she/he associates the cognitive

representations with behavioural experiences (Fitts & Posner, 1967). In this stage, the performer's skill is also developed with increases in both timing and efficiency of the physical movement and brain activation (Deeny, Hillman, Janelle, & Hatfield, 2003).

During the final and autonomous phase, the performer achieves to perform the action with little to no conscious effort and the initial conscious verbal representation is now no longer necessary. Therefore there is no need to think about what needs to be done (Fitts & Posner, 1967). In the expert stage motor skills are usually considered automatic or autonomous and do not require conscious control to be performed correctly. The verbal-analytical centres in the left hemisphere need only be activated when starting a learned movement while the visual-spatial processes in the right hemisphere are activated for automatic, skilled performance (Beckmann et al., 2013).

Accordingly, after a skill becomes automatic, the performer no longer needs conscious control over the movement execution and left-hemispheric inhibition follows. However, if the execution of the motor skill is trying to be controlled intentionally, the performer may relapse to the previous cognitive learning stage, with motor behaviour consciously systematized through verbal representations (Fitts & Posner, 1967). The attempted control and regression into the earlier cognitive phase may interfere with the automatic skill execution and hence lead to its breakdown (Beilock & Carr, 2001; Gröpel & Mesagno, 2017). Under pressure this “reversal” of phases may occur and the normally automatic processes are consciously controlled again. This “reversal” then leads to a step-by-step control of the action and subsequently to a poor execution of the task (Beilock & Carr, 2001).

This is where the concept of motor behaviour is consistent with the self-focus theory: There is no need to think about the motor skill because it is autonomous, but when athletes under pressure do, they might underperform and choke.

Hemisphere-specific priming

It is known that the two hemispheres of the human brain are not equal. Relative functional differences between the left and right hemispheric asymmetries were found for various cognitive functions (Corballis, 2009). As for the two hemispheres of the brain, Hellige (2001) suggests that inflicting simultaneous activity that selectively activates a hemisphere generates a benefit for the performance of an activity based on the functions of that hemisphere. This is known as hemisphere-specific priming (Hellige, 2001). A series of studies (e.g., Baumann, Kuhl, & Kazén, 2005; Peterson, Shackman & Harmon-Jones, 2008) was able to show that unilateral muscle contractions activate the contralateral brain hemispheres and the associated functions.

Peterson et al. (2008) investigated the effect of left- and right-hand contractions on asymmetrical electroencephalographic (EEG) activity. What they found was a higher relative left hemispheric activation throughout the right-hand contractions and a higher relative right hemispheric activation throughout the left-hand contractions. Furthermore it was shown that increased left hemispheric activity is subject to conscious control, while right hemispheric activity is linked to the execution of automated behaviour (Binkofski et al., 2000; Hellige, 2001; Hugdahl & Davidson, 2003). Right hemispheric activity has also been connected to skilled performance (Hatfield, Landers & Ray, 1984). While an increase of right hemispheric activity through neurofeedback training has led to a substantial enhancement in motor performance midst pre-elite archers, a rise in left-hemispheric activity had the opposite effect (Landers, Petruzzello, Salazar, & Crews, 1991). Consequently, these studies demonstrate that left hemispheric activity should be attenuated and right hemispheric activity increased regarding skilled performance. Yet, poorer performances among trained athletes were related to an increase in left hemispheric activation (Crews, 2004).

Beckmann et al. (2013) presumed that this detrimental hemispheric asymmetry reflects a setback into the cognitive phase of motor learning that occurs under pressure which in turn can cause choking. The perceived pressure is expected to create a conscious control of normally automated behaviour, which disrupts the execution of this automatism and as a result leads to poor performance (Baumeister, 1984; Beilock & Carr, 2001).

Beckmann et al. (2013) used this knowledge on hemispheric-specific priming and theorized that squeezing a ball or clenching the left hand prior to a motor task would reduce the probability of athletes choking. While the ball-squeezing task does not provide a regional specification of hemispheric activation they found that this simple manipulation can indeed optimize a skilled motor performance under pressure. Therefore they suggested that squeezing a soft ball with the left hand prior to performing a skilled motor task should enhance right hemispheric activation and thus help to dominate the visual processes necessary for successful performance. Although performance pressure may stimulate dominant left hemispheric activation (Kuhl, 2001), which increases the possibility of a decrease in skilled performance, Beckmann et al. (2013) argued that activating the right hemisphere would eradicate left hemisphere dominance and hence could alleviate choking.

Their research included three experiments in which athletes of different sports had to perform motor skill tasks under pressure. They showed that right-handed athletes who squeezed a ball in their left hand before competing were less likely to choke under pressure than right-handed players who squeezed a ball in their right hand. These results show that hemisphere-specific priming using left-hand contractions can prevent motor skill failure (Beckmann et al., 2013).

The present study

Based on Beckmann et al.'s (2013) results, the aim of this research was to replicate the findings of their Experiment 1. In this experiment Beckmann et al. (2013) let experienced soccer players compete in penalty shootouts and measured the accuracy of the players' shots which was used as a dependent variable. The participants performed six penalty shots in a pressure-free situation and another six after a pressure induction. Half the players squeezed a soft ball in their left hand before the second six shots under pressure were taken while the other half squeezed the ball with their right hand.

The present study tested whether hemisphere-specific priming (left-hand contractions) can prevent motor skill failure and therefore can be used as an intervention strategy against choking in soccer. In particular it was hypothesised that right-handed soccer players contracting their left hand just prior to performing a soccer-based motor skill task would be less likely to choke under pressure than right-handed players who contracted their right hand.

Experiment

In this Experiment we wanted to address the influence of hemisphere-specific priming on shooting performance in soccer under pressure conditions and try to replicate and extend the findings from Beckmann et al.'s (2013) Experiment 1 in soccer. In order to do so, a similar experimental procedure was chosen with slight differences in inducing pressure, measuring perceived pressure and hand-squeezing time. First, instead of having a large crowd watching during the task, important figures of the team such as the head coach, the assistant coach and the sports psychologist were present. Additionally participants were told that they were being filmed, while not actually being recorded during the task. Further an objective measure of somatic anxiety was chosen by evaluating the participants' heart rate (HR) instead of using a self-report scale for state anxiety. Lastly the hand-squeezing time was reduced to 10 seconds compared to Beckmann et al.'s (2013) 30 seconds, being a more realistic time

frame for players available during pressure situations in soccer. These modifications were made in order to adopt more ecologically valid settings and an easier applicability of the intervention strategy.

Experienced youth soccer players competed in penalty shootouts. The players' shot accuracy was measured and was used as the dependent variable. Participants took six penalty shots in a pressure-free situation (i.e., low-pressure phase) and another six shots after a pressure induction (i.e., high-pressure phase). Half the players squeezed a soft foam ball in their left hand before each shot of the high-pressure phase was performed (i.e., left-hand squeezing condition); the other half took each shot of the high-pressure phase after squeezing the foam ball with their right hand (i.e., right-hand squeezing condition). Beckmann et al. (2013) chose right-hand squeezing as the control condition as earlier research indicated that performing simple behavioural steps prior to executing a motor task under pressure decreases choking due to an enhancement of concentration (Mesagno & Mullane-Grant, 2010).

We examined whether participants who squeezed their left hand contrasted from those who squeezed their right hand in shot accuracy in the high-pressure phase when compared with the low-pressure phase. Participants were under the impression that the effect of concentration on their shot accuracy is tested.

Method

Participants

An a priori sample-size calculation with G*Power 3 (G*Power version 3.1.9.2; Faul, Erdfelder, Buchner, & Lang, 2009) for two groups and two repeated measurements, based on middle-to-large effect size ($f = 0.30$), power = 0.80, and $\alpha = 0.05$, resulted in a sample size of 34 participants. The anticipation of a middle-to-large effect size was based on previous research investigating the effect of hemisphere-specific priming on choking (Beckmann et al.,

2013). The study sample consisted of 34 male soccer players from SK Rapid Wien's youth academic program (14 - 21 years). Academic players are experienced and active players who participate in competitions on a weekly basis and train between four and five times a week under professional circumstances. The youth and semi-professional soccer players partook voluntarily in the experiment. Since the predicted effects have only been shown for right-handed athletes so far (Beckmann et al., 2013) our data analyses only included right-handed players and neglected left-handed players as indicated by the Edinburgh Handedness Inventory – Short Form (Veale, 2014).

We tested the baseline (e.g. low-pressure phase) of 34 experienced soccer players with a mean age of 17.4 (range = 16 - 20 years) and a mean laterality quotient of +90.1 (range = +63 - +100). Due to injuries that occurred outside of our experiment, only 32 players were able to take part in the high-pressure phase. Due to a loss of data caused by low watch-battery and hence no storage option in two cases of the high-pressure phase, the final sample consisted of 30 right-handed male soccer players with a mean age of 17.4 (range = 16 - 20 years). Their mean laterality quotient was +90.8 (range = +63 - +100).

Task and apparatus

The participants' task was to shoot a soccer ball from the official indoor penalty spot, which standard distance is 6 meters, into either of two holes of a goal wall (Fédération Internationale de Football Association, 2010). The goal wall (213 X 152 cm) is commercially available training equipment that consists of a tubular frame and a 5-fibre polyester net element strapped into it containing two goal shot holes, each 50 cm in diameter (displayed in Appendix). Beckman et al. (2013) used a slightly bigger goal wall (270 X 188 cm) made out of wood but had the same diameter in the goal shot holes (50 cm) in their experiment. In order to have the same measuring templates as Beckmann et al. (2013) we created similar but smaller wall elements (106.5 X 76 cm each) by dividing our goal wall in four squares using

white tape. This division of the goal wall helped to judge the individual shots of each player more accurately.

Athletes were assigned to take two practise shots, one shot into the lower right and one into the upper left hole. Directly thereafter they were told to take six penalty shots, three shots into the lower right hole, followed by three shots into the upper left hole. Their performance was measured by recording each shot on a 6-point scale:

6 points for a clean shot in, 5 points for rim-and-in, 4 points for rim-and-out, 3 points for a shot in the surrounding wall element, 2 points for a shot in the goal wall (other than in the surrounding wall element), and 1 point for a complete miss.

The same scale was used by Beckmann et al. (2013).

Instruments

A self-report scale for handedness and a physiological, objective measure of somatic anxiety (HR) were used. First, we tested the participants' handedness through the Edinburgh Handedness Inventory – Short Form (Veale, 2014). We chose the short form over the extended version of the Edinburgh Handedness Inventory (Oldfield, 1971) because of limited time available with each player. The scale (displayed in Appendix) consists of 4 instead of 10 items related to the use of the hands during different activities including writing, throwing, using a spoon and a toothbrush (Veale, 2014).

Comparing the two forms in his research Veale (2014) found that despite its brevity, the shorter version revealed very good reliability, factor score determinacy, and correlation with scores on the extended 10-item version. Laterality coefficients range from -100 to +100. Positive values imply the tendency to right-handedness, while negative values imply the tendency to left-handedness. A participant is considered to be right-handed when her/his score is higher than 60.

In order to measure the participants' level of somatic anxiety, we monitored the participants' HR before and during the task using the Polar V800 GPS running watch combined with a Polar chest HR monitor in the low-pressure phase and the Polar M430 running watch measuring the heart rate directly over the participants' wrist in the high-pressure phase. Two different types of watches had to be used due to logistical reasons. Compared to Beckmann et al. (2013) we used an objective measure of somatic anxiety instead of a self-report survey (WAI-S; Ehrlenspiel, Brand, & Graf, 2009).

Procedure

The experiment was performed in the training facility of SK Rapid Wien's youth academy at the Ernst-Happel-Stadion in Vienna. The goal wall was set up outside of the Sports Psychology office for practical reasons. This part of the stadium is covered by a roof and is wind still. An artificial turf was laid out on top of the concrete floor in order to let the participants take their shots with their soccer boots on and to have a more realistic feeling imitating the grass on a soccer pitch. Before going outside, the players filled out the Edinburgh Handedness Inventory – Short Form (Veale, 2014) and the informed consent. They then were asked to put on the Polar watch and chest strap and were allowed to warm up. Afterwards, we called the participant to the goal wall and tested his baseline performance (i.e., the low-pressure phase). Each participant completed two practice shots (one for each goal hole), followed by six test shots (three shots into the lower right hole followed by three shots into the upper left hole). The only persons present in this phase were the researcher, his assistant, and the participant taking the penalty shots.

The high-pressure phase was performed three to four weeks later at approximately the same time as the low-pressure phase was tested. After all participants were warmed up, pressure was induced. Participants were randomly selected into two teams and were told to compete against each other in a penalty shootout. We let the participants know that the team

that scored more points would win and be rewarded with small prizes (e.g. protein bars). As in the low-pressure phase, all participants performed six shots plus two practice shots. To enhance the pressure, the teams (5 vs.5 players – 6 vs. 6 players) performed the task on a rotational basis; after a player from one team finished one shot, the task changed to a player from the competing team. In this phase the team's coach, the team's sport psychologist, the researcher, his assistant and all the other participants (the ones involved in the penalty shootout) were present during the task. Adding to the induced pressure we told the players that we would record their performance via camera whereas we only pretended to film them.

After the instructions, the competition started. Immediately prior to each shot, the participant squeezed the soft foam ball for 10 seconds (two times per second) instead of Beckmann et al.'s (2013) 30 seconds which was considered to be too long to simulate an actual in-game situation. Picked randomly, half the players squeezed the ball with their left hand (i.e., left-hand squeezing condition), whereas the other half used their right hand (i.e., right-hand squeezing condition). After all players completed their shots on the goal wall, the competition was evaluated and the winning team rewarded. Participants were then debriefed and thanked for their participation.

Results

Evaluation methods

The statistical evaluation of the data was carried out using SPSS 24.00 for Windows. The significance level was set to $p < 0.05$.

The following statistical methods were used to test the hypothesis:

Two repeated measure ANOVAs were performed. The requirements such as interval scale level of the AV, categorical level of the UV, normal distribution of the AV or a group size $N > 30$ and sphericity were checked before application. A post hoc test was calculated for further investigation. Repeated contrasts were used to compare the following group with the previous group (Field, 2013).

The Simple Analysis of Variance (ANOVA) was used to calculate mean differences between more than two independent groups. The applicable requirements such as interval scale level, normal distribution of data and homogeneity of variances were checked before application. If a significant result is available, post-hoc tests can be used to calculate significant differences between the groups. In the present study, the post-hoc test Scheffé was used due to the different group sizes (Eid, Gollwitzer & Schmitt, 2013).

The Levene test was used to check the homogeneity of the variances.

In order to clarify the results, additional effect strengths were calculated using partial η^2 . According to Eid et al. (2013) the interpretation can be carried out according to the following guidelines: from .14 on large effect; from .06 on medium effect; from .01 on small effect.

Test of position effect

The test of position effect on score was performed in order to see if the positions (goalkeeper, defender, midfielder and forward) significantly differentiated in terms of performance scores during the two phases (low- and high-pressure phase). The distribution of the player positions was as follows: Goalkeeper: 13%, Defender: 30.3%, Midfielder: 33.3%, Forward: 23.3% (see diagram 1).

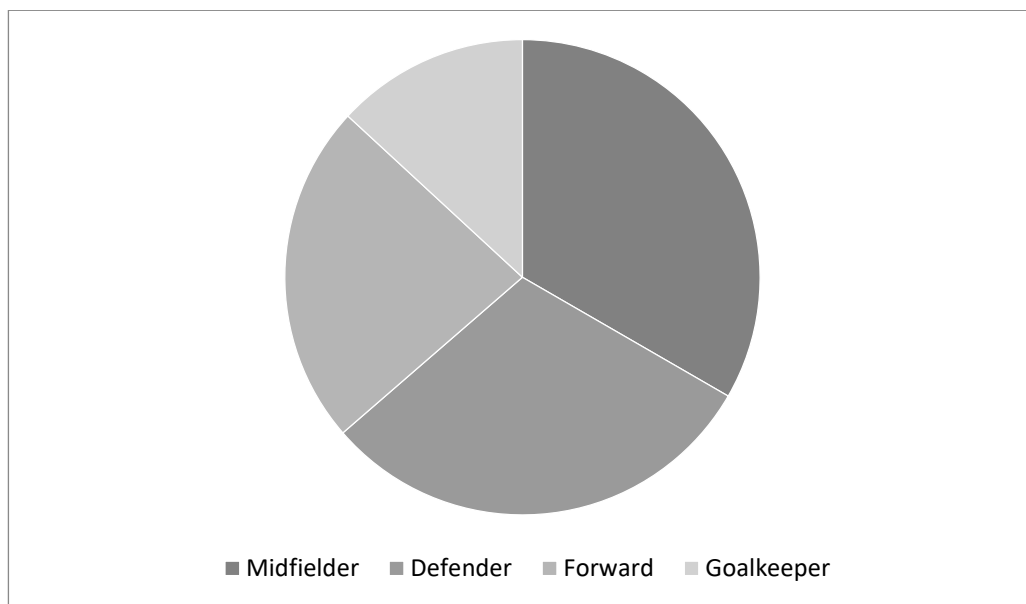


Diagram 1: Percentage distribution of positions

To test the effect of position on score a simple variance analysis (ANOVA) was calculated. The variables Position and Phase were included as factors in the analysis.

The ANOVA revealed that the various positions did not significantly differentiate in terms of performance scores during the two phases (see Table 1). An effect of Position on score was not found.

Table 1

Means and Standard Deviations of Performance Scores of the positions

Position	Low-pressure			High-pressure	
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Forward	7	24.14	1.95	24.86	3.29
Goalkeeper	4	24.00	5.71	24.25	3.95
Midfielder	10	25.40	2.63	25.30	3.06
Defender	9	23.44	2.55	22.44	2.07

Note. Mean scores out of a possible maximum score of 36 with each shoot ranging from 1 – 6 points.

Effectiveness of pressure induction

Before testing the main hypothesis the pressure induction was investigated. In order to see if the induced pressure significantly increased the participants heart rate levels in both groups a repeated measure ANOVA was performed. The variables Group and Phase were included as factors in the analysis.

The ANOVA revealed a significant effect of Phase on HR meaning that the values of the pressure condition (high-pressure phase) were significantly higher than those of the baseline condition (low-pressure phase). Participants exhibited higher HR levels (see Table 2) after pressure induction than they did in the low-pressure phase, $F(1, 29) = 259.56, p < .001, \eta p^2 = .90$ confirming a successful pressure induction in both groups.

Table 2

Means and Standard Deviations of Heart Rate levels of both conditions in both phases

Condition	HR			HR	
	Low-pressure			High-pressure	
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Left- hand squeezing	15	82.23	4.33	90.07	2.59
Right- hand squeezing	15	82.87	3.63	90.07	3.52
Combined values	30	82.55	4.10	90.07	3.15

Test of task performance

The test of task performance was chosen in order to investigate if the left-hand squeezing condition had significantly higher performance scores under pressure than the control condition. To test the main hypothesis a repeated measure ANOVA was performed. The variables Group and Phase were included as factors in the analysis.

The ANOVA revealed that there was no significant effect of Group on score, $F(1, 29) = .01, p = .91, \eta p^2 < .01$. Also, no significant Group X Phase interaction effect was observed. Although participants in the right-hand squeezing group choked and participants in the left-hand squeezing group improved their performance in the high-pressure phase (see Table 3) the interaction effect was not significant, $F(1, 29) = .78, p = .38, \eta p^2 = .03$.

The overall performance did not significantly decrease after the pressure induction ($M = 24.20, SD = 3.07$), when compared with the low-pressure phase ($M = 24.33, SD = 2.96$), $F(1, 29) = .05, p = .83, \eta p^2 < .01$. Therefore no effect of Phase on score was found.

Consequently the main hypothesis was not confirmed.

Table 3

Means and Standard Deviations of Performance Scores and Differences

Condition	Low-pressure			High-pressure		Difference
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Left-hand squeezing	15	24.60	3.42	25.00	3.58	+ .4
Right-hand squeezing	15	24.07	2.26	23.40	2.03	- .67

Note. Positive difference values indicate a performance increase from low-pressure to high-pressure, whereas negative values indicate a performance decrease.

Discussion

The present study was inspired by previous research on choking under pressure performed by Beckmann et al. (2013) and is also based on the model of motor skill failure as imparted by enhanced self-focus and underlying hemispheric asymmetries. It was examined using the choking under pressure paradigm (Baumeister, 1984). It is implicated that pressure stimulates conscious control of normally automated behaviour, which then interrupts the execution of that behaviour, leading to a decrease in performance (Beilock & Carr, 2001). Enhanced left-hemispheric activity was shown to be subject to conscious control, whereas right-hemispheric activity is subject to the execution of automated behaviour (Binkofski et al., 2000; Hellige, 2001; Hugdahl & Davidson, 2003). Trying to replicate Beckmann et al.'s (2013) findings we hypothesized that squeezing the left hand right before a motor skill task in soccer would alleviate choking under pressure.

The results of the present research were not fully consistent with that model and did not support the hypothesis. Compared to Beckmann et al. (2013), who found that left-hand squeezing prevented choking, the present research only trended towards this effect.

Consequently we were not able to provide further evidence for the findings that the increase of right-hemispheric activity through contraction of the left hand may eliminate decreasing performance under pressure and hence alleviate choking. In the presence of situational induced pressure both, participants who contracted their left hand as well as those who contracted their right hand showed relatively stable performances. While the analysis of pressure induction showed significantly higher heart rate values in the pressure phase than in the baseline for both groups, we only found a tendency towards our hypothesis, seeing that left-hand squeezing scores did increase under pressure while right-hand squeezing scores decreased. But none of the effects obtained were significant.

The alleviating effect on choking under pressure in Beckmann et al.'s (2013)

experiment may alternatively be explained by an increase in concentration or a decrease in anxiety caused by the hand-squeezing manipulation due to its behavioural components. Mesagno and Mullane-Grant (2010) indeed found that the execution of simple behavioural steps before a motor task helped athletes perform better presumably due to an increase in their concentration levels. They also suggested that such behavioural steps may alter the arousal level substituting a coping strategy to those athletes without a repertoire of such coping mechanisms. While concentration or calming-down effects cannot be ignored here, they are still unlikely to explain the tendency of our results towards the alleviating effect of left-hand contractions on choking, since the hand-squeezing manipulation was also used for the control condition (Beckmann et al., 2013). Half of the participants squeezed their left hand, whereas the other half squeezed their right hand. Various researches on this topic prove that unilateral muscle contractions in the upper limbs activate contralateral brain hemispheres and the functions related to them (e.g., Baumann et al., 2005; Peterson, Shackman & Harmon-Jones, 2008). Furthermore it is known that increased right-hemispheric activity benefits skilled performance (Hatfield et al., 1984). It seems as perceived pressure reverses this optimal arrangement with the left hemisphere becoming dominant. Therefore, the contraction of the left hand could have worked against choking for the left-hand squeezing group because it reinstalled the optimal pattern allowing a more accurate motor skill execution (Beckmann et al., 2013).

A possible explanation for the non-significance of our results regarding left-hand contractions and choking could be connected to the shortened squeezing-time which was reduced from the original 30 seconds (Beckmann et al., 2013) to 10 seconds for application purposes and a more realistic setting. Contracting the left hand twice per second for this time span could simply have been too short to activate the contralateral right hemisphere and its associated functions in order to have a beneficial effect on the participants' performance

under pressure.

It is worth mentioning that pressure is not detrimental to sports performances generally. According to Baumeister (1984) a performance based on strength and stamina for example consists of rather simple motor action, which does not compellingly include complex motor processes that lead to an automated behaviour. Therefore, pressure does not necessarily have to be a disadvantage for such performances. In fact Bond and Titus (1983), who performed a meta-analysis on this topic, found that performance based on strength and stamina did not decrease, but rather increase under pressure. The effect of hemisphere-specific priming therefore applies to performances built on accuracy, as shown in the present research testing the shot accurateness of soccer players during penalty shootouts. Such performances are based on more complex motor sequences (Ehrlenspiel, 2006) and have been proven to be linked to decreasing performances under pressure (Bond & Titus, 1983). Therefore, improving right-hemispheric activity through contraction of the left hand can benefit performances that consist of complex motor tasks. Performance of simple motor action on the other hand need not necessarily be affected detrimentally under pressure (Beckmann et al., 2013).

Some limitations deserve to be mentioned. Due to limited time resources available with each player, the heart rate was only monitored shortly before the participant's first shot on the goal wall in both phases. While having at least 30 seconds of data available before every player's first shot in both phases lead us to a compromisingly solution: In order to see if the induced pressure had an effect on the players we compared their documented heart rate in the two phases during this time span – 30 seconds before their first shot on the goal wall. More time available and a larger amount of heart rate data before the first shot on the goal wall would have provided interesting information such as the players' resting heart rate e.g. In our case the participants had no chance to calm down as they went straight to the goal wall

after putting on the Polar watch and chest strap. An interesting comparison between the resting heart rate and that under pressure was thus withheld from us.

In addition players were monitored with a different model of the Polar watch in each of the two phases due to the necessity of simultaneous measurements and availability reasons. While in the low-pressure phase all of the athletes' heart rate data was measured by the Polar V800 GPS running watch including a Polar chest HR monitor the players used their own watches (Polar M430) in the high-pressure phase measuring the heart rate directly over the watch on their wrist. This could have led to measurement inaccuracies since the chest strap monitor is found to be more precise than the wrist-measured watches. Wang et al. (2017) found variable accuracy among wrist-worn HR monitors. None of the products tested reached the accuracy of a chest strap-based monitor which has the best agreement with an electrocardiogram. Using Lin's concordance correlation coefficient (RC) the Polar H7 for example had a RC of 0,996 (Gillinov et al., 2017; Wang et al., 2017). Still the effect of induced pressure in the present research was strong.

Furthermore the participants' motivation has to be questioned. While performing their baseline score on the one hand, a player's motivation depended solely on his will to score with no distractions or pressure present. During the pressure situation on the other hand present various incentives possibly increased a player's motivation to accomplish higher scores. Incentives such as rewarded gifts for the winning team, performing in front of and against his peers, important people of the club watching on and in believe of being filmed during the task could have had a motivational effect. Ensuing higher motivation levels could be a possible explanation for the relative stable scores in both groups under pressure and even partly increasing performances of the left-hand squeezing condition in the high-pressure phase. Future research could avoid this motivational problem by already including incentives in the baseline phase and not merely in the pressure phase. Handing out small prizes (e.g.

protein bars) for the top three performers in the low-pressure phase or selecting an overall winner throughout both phases could prevent this limiting aspect.

Another problem regarding the two phases is the period of three to four weeks that lied between them for logistical reasons. While an improvement in shooting precision could be ruled out since the players' soccer skills were regarded as stable enough no to change substantially within a few weeks, the difference in the players' daily constitution meaning their mood could not. Researchers trying to replicate or extend Beckmann et al.'s (2013) results should examine the second part of the experiment on the same day as the baseline phase. This way a single performance could less likely be influenced positively or negatively, by the participant's state of mind.

Finally the number of participants, only 30 players, naturally yields in a limitation of the present study. A larger sample size could have provided more significant effects on this matter. To conclude the analysis, it can be stated that our pressure induction was successful, while not providing further evidence of left-hand contractions having an alleviating effect on choking in soccer and subsequently not replicating the results of Beckmann et al. (2013).

Despite the non-significant results of our study, the present research still suggests practical implications. Different pre-performance routines (e.g. imagination, deep breathing, and visualisation) are often used to enable concentration and optimize arousal levels (Mesagno & Mullane-Grant, 2010). In the course of debriefing the participants were asked if they would consider using the left hand-squeezing manipulation as a pre-performance routine or an actual in game routine (without the use of a soft ball, simply by contracting the left hand). The majority of players stated that its brevity and simplicity makes it a well usable and practical technique which can easily be applied. Hence, contracting the left hand prior to a motor task under pressure may establish itself as a useful element of pre-performance and in game routines besides the already accomplished ones.

Future research should study this additional benefit of hemisphere-specific priming in the field more deeply. A replication of the present study with a distinctively higher number of participants increasing its power may provide more definitive results. Lastly, although we used a game-like situation (especially in the high-pressure phase), we still used a goal wall instead of an actual soccer goal with a goalkeeper in it mirroring Beckmann et al.'s (2013) experimental construct. The main reason for this is that the goalkeeper would have too much influence on the final result, as he cannot show enough consistency and thus creates another variable, which has to be taken into account. Hence future research should focus on investigating sports in which pressure situations are not influenced by a direct opponent. The free throw in Basketball or putting in Golf would be perfectly fitted for this kind of research, since the process of the task is stable.

Away from the field of sports, future research on choking could be further extended to other areas in which the performance of professionals is not just important for their own success, but crucial to the lives of others, such as the performance of heart or emergency surgeons during operations. For example, Wetzel et al. (2006) found that surgeons demonstrate a significant decrease in performance when experiencing high levels of anxiety. Therefore, more pre performance techniques are desirable in order to alleviate crucial effects of choking.

As mentioned in the beginning of this paper, choking is something everybody has to cope with at some point in life. Having the equipped tools in order to handle anxiety and prevent “the choke” is essential for athletes on their way to professionalism but even more vital for other professional fields in which the final outcome determines life or death.

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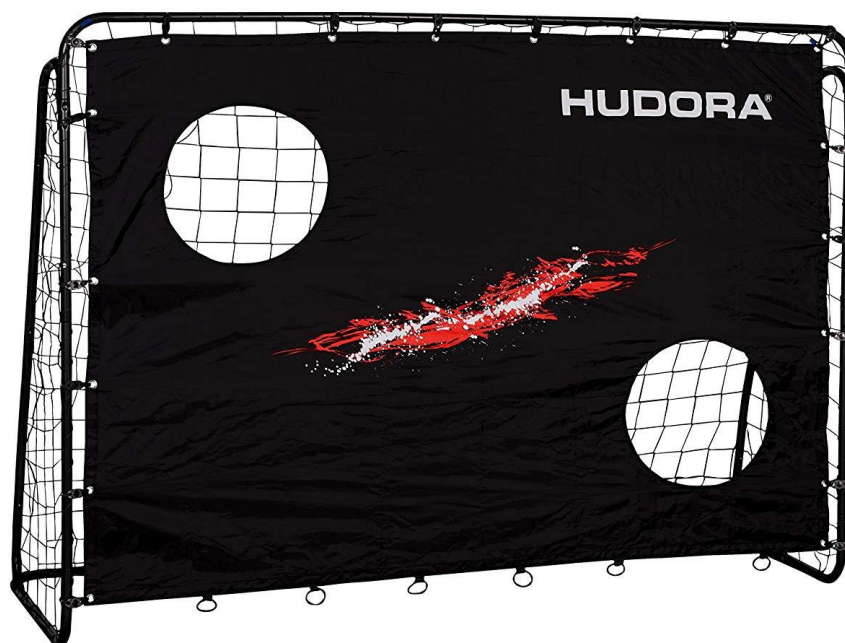
Appendix

Edinburgh Handedness Inventory - Short Form

Please indicate your preferences in the use of hands in the following activities or objects:

	Always right	Usually right	Both equally	Usually left	Always left
Writing	☐	☐	☐	☐	☐
Throwing	☐	☐	☐	☐	☐
Toothbrush	☐	☐	☐	☐	☐
Spoon	☐	☐	☐	☐	☐

Retrieved from: <http://www.jaimieveale.com/wp-content/uploads/2014/04/Edinburgh-Handedness-Inventory-short-form.pdf>

The Goal Wall

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Deutsche Zusammenfassung

Wenn AthletInnen bei der Ausführung automatischer oder gut erlernter motorischer Aufgaben versagen, wird davon ausgegangen, dass ihr Aufmerksamkeitsfokus auf aufgabenrelevante Reize gerichtet ist und sie unter Druck „ersticken“ (*Choking under Pressure*). Es konnte für verschiedene Sportarten gezeigt werden, dass linke Handkontraktionen *Choking* verringern können. Ziel dieser Studie war es, diese Ergebnisse zu replizieren und zu zeigen, dass Kontraktionen der linken Hand (durch zusammenpressen eines weichen Balls) als Interventionsmethode gegen *Choking* im Fußball eingesetzt werden kann. Die Wirkung von linkshändigen Kontraktionen wurden in einem *Within-Subjects Design* an 30 rechtshändigen Fußballspielern der SK Rapid Wien Akademie untersucht, die eine motorische Aufgabe (Schuss auf Torwand) in einer drucklosen und einer druckhohen Phase ausübten, im Vergleich zu einer rechtshändigen Kontrollgruppe, die ihre rechte Hand kontrahierte. Während die Ergebnisse leicht in Richtung der Hypothese tendieren, die besagt, dass hemisphärisch-spezifisches Priming das Versagen motorischer Fähigkeiten unter Druck verhindern und somit *Choking* lindern kann, sind die beobachteten Effekte nicht signifikant.