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What do you hear? The effect of stadium noise on football players' passing performances

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Abstract

Stadium noise - created by spectators and fans - plays a critical part in the reality of professional sports. Due to a lack of research on the impact of these auditory cues and multimodal environments on motor performance, it is currently unclear how professional athletes experience and perceive stadium noise and how this potentially affects performance in practice. In order to explore the effect of stadium noise on athletes' performance, this paper presents an experimental design using the unique and standardised football training tool known as the 'Footbonaut'. Specifically, fifteen skilled German football players engaged in a standardised football-specific technical training program while subjected to four different auditory training conditions; these included both 'positive' and 'negative' stadium noise conditions, a 'baseline' condition providing auditory guidance, and a 'no (auditory) cue' condition. Performance data for passing accuracy and passing time were measured for training in each auditory condition. A repeated measures MANOVA revealed a significant main effect for passing time. Specifically, participants showed faster passing times in the baseline compared to the negative and no auditory cue conditions. Findings are presented and discussed from a constraints-led perspective, allied to principles of ecological dynamics and nonlinear pedagogy. Particularly, the use of representative training experiences (including multimodal sensory and emotional information) appears to underline training to refine expert athletes' adaptive coordination of complex motor actions.

Keywords: association football; multimodal perception; movement adaptability; representative learning

[word count: 4497]

What do you hear? The effect of stadium noise on football players' passing performances

Introduction

"The atmosphere was just totally unique. […] I've never witnessed fans making that much noise in 90 minutes." (McDonald, 2017). This statement, recorded following a professional football (soccer) match, illustrates just how much stadium noise (often in the form of external noise created by fans) plays a part in the reality of professional sports (Bhimani, 2015). This considered, it may be assumed that such constant auditory stadium noise would be replicated in training, in order to familiarise football players with the multimodal perceptual challenges of professional football environments. However, anecdotal evidence from the observation of numerous professional football training environments shows the contrary. Similarly, with regards to academic research, previous means for measuring the impact of auditory cues, in the forms of environmental distractions and stadium noise, on perception and motor action have been insufficient (Herrebrøden et al., 2017; see also Stanton & Spence, 2020, for a review of the effect of auditory cues on perception-action couplings). While some work has investigated general team and referee decision-making performance, such as referees' yellow cards decisions (e.g., Unkelbach & Memmert, 2010; also see Nevill & Holder, 1999, for an overview), very little work has considered how stadium noise, specifically under varying levels of emotional value, impacts individual and specific skill production, such as passing accuracy and passing time in football. With performance data in elite-level football having established more high-speed sprinting actions and improved technical-tactical expertise, players experience decreasing ball contact times in professional competition (e.g., Fransson et al., 2017; Jankowski, 2015). For example, performance analysis of average ball contact times in German national team football games shows a decrease from 2.8 seconds in 2005 to only 0.9 seconds in 2014 (e.g., BDFL, 2018). Thus, passing time may be considered a key

performance indicator for elite-level football-specific skill production and performance. In order to explore the effect of stadium noise (with distinctive emotional valence) on football players' skill performance, this paper presents an experimental design using the standardised football training tool known as the 'Footbonaut' (i.e., see method section). Here, the researchers investigated the effects of bimodal stimulation (i.e., combining visual and auditory information) on players' motor performance (i.e., passing accuracy and time). This unique research approach aimed to better understand skilful coordination of a representative football-specific task under limited multisensory information.

Research and theory on the impact of external (auditory) cues in sports

From a sports science perspective, it is acknowledged that external auditory cues impact performance, including motor or psychological performance (Galanis et al., 2018; Jeon, Kim, Ali, & Choi, 2014). For the purpose of this study, distraction will be operationally defined as the "occurrence of competing stimuli that may interfere with task-related stimuli and divert attention from its original focus" (Nelson et al., 1993; in Galanis et al., 2017, p. 27). Across the limited research that has investigated external distractions on individual performance in sports, many studies have explored performance under cognitively engaging distraction conditions during the execution of primary motor tasks, such as golf putting, basketball free-throwing or football dribbling (e.g., Beilock et al., 2002; Galanis et al., 2017). In a football context, for example, Beilock and colleagues (2002) asked participants of dissimilar skill levels (i.e., novices versus experts) to dribble through a slalom course. Here, participants were confronted with two conditions: a 'skill-focused' condition (using a dribbling task), and a distraction condition (which subjected participants to a secondary auditory word-monitoring task). Findings indicated that especially novices displayed performance decrements (i.e., indicated by decreased dribbling speed) under the cognitive secondary task condition. Interestingly, experts showed contrasting results, displaying enhanced dribbling performances under the dual-task condition. Thus, expert performers with higher skill levels may be less susceptible to cognitive distractions than novices or sub-elite level athletes (Beilock, 2010; Herrebrøden et al., 2017).

Generally, significant effects of distractions on performance, mediated by variables such as skill level, have been supported in various contexts and may be explained using different theoretical accounts. For this study, it is the methodological perspective of the Constraints-Led Approach (CLA), underpinned by principles of Ecological Dynamics and a Nonlinear Pedagogy (Button et al., 2020; Renshaw et al., 2016), which offers a fruitful approach to investigate the overarching research question:

How is a sub-elite level football player's ability to pass influenced by different stadium noise environments?

In detail, the CLA may be described as an "ecological model centred on the mutual relationship that emerges from interactions of each individual and a performance environment." (Renshaw et al., 2016, p. 466). Here, constraints provide boundaries that can guide players' search for and perception of relevant information, such as passing targets, and directly couple perception with actions, such as an inside-foot pass (e.g., see Fajen et al., 2008). From a constraints-based view, the use of constraint manipulations to design *representative learning environments* (i.e., interchangeably termed 'representative training designs'; Correia et al., 2018) is considered paramount. Specifically, representative training designs aim to sample relevant contextual information that athletes interact with in competition (see Pinder et al., 2011). These notions of constraints and representative learning relate to the present study design in that it has a particular focus on background football crowd noise, which represents an environmental constraint manipulation to the practice design. This constraint may not directly engage players' cognitive processes and hence, the presented research design stands in contrast to experiments that have deliberately engaged individuals in cognitive secondary tasks. Constant noise as a constraint, in particular, may only be subconsciously perceived by players (i.e., it is nonmeaningful) and yet, these auditory cues may still have profound impact on players' skill performance (Stanton & Spence, 2020). While the perception of relevant information is generally considered an indicator of expertise in sport (Klatt & Smeeton, 2019), previous research has demonstrated the mediating role of expertise levels on the effect of auditory distraction on performance. For example, studies by Hassmen and Koivula (2001) and Herrebrøden and colleagues (2017) found expert golfers' performance under 'noisy' conditions (e.g., confronting golfers during performance with sound clips such as dog barking or audience cheering) to either not significantly differ or be slightly enhanced, compared to 'quiet' conditions. Thus, while a limited number of research studies highlight that auditory noise may not be detrimental to expert performance (see Herrebrøden et al., 2017), research on whether non-expert, sub-elite level athletes experience performance impairment warrants further investigation. Notably, there are numerous definitions of expertise in the research literature (see Swann et al., 2015). In the current study, the player sample was defined by the players' experience level and league in which they played at the time of the data collection.

From a constraints-based view, for sub-elite football players training under (stadium) noise conditions, critical auditory information supporting actions and judgments of approaching objects could be cancelled out (Davids et al., 2008). In other words, relevant sounds from the environment or players' own movements could all act as critical information to support accurate perception of the incoming ball and the self-regulation of successive passing execution. Thus, missing this multimodal type of perceptual information, due to (distracting) auditory cues created by a football crowd for instance, may impede perceptual search strategies and self-regulated performance for sub-elite level players (Davids et al., 2008; Williams et al., 1999). In turn, this assumption would lead to the notion that it is the (sub)conscious integration of multiple sensory modalities and the online modulation of auditory-motor interactions that may be affected by constant stadium noise (see Gray, 2008, and Stanton & Spence, 2020, for reviews on the impact of multisensory information on motor actions).

With the notion of potential performance decrements for some (sub-elite) players caused by external auditory cues in mind, sports coaches may purposely choose to include perceptual-cognitive distractions into training designs. Particularly, skill training stages focusing on the adaptability of (movement) skills stress the merit of destabilising the training environment by manipulating constraints and information available to players. For example, in a recently introduced 'Periodization of Skill Training' framework (i.e., 'PoST framework'), Otte, Millar, and Klatt (2019) advocate the use of perceptual (and distracting) cues in order to "support or challenge athletes' exploration for functional perception-action couplings and movement solutions" (p. 5). Considering the 'PoST' framework's central training stage of 'Skill Adaptability Training', a group of skilled sub-elite level players working on skill adaptation was chosen for this study (see Otte et al., 2019). Despite players' potential performance impairment through limited hearing (i.e., caused by the addition of loud stadium noise as experienced in professional football games), this more representative training environment may drive players' focus towards relevant visual information, challenge passing action and enhance skill learning (Davids et al., 2008).

Interestingly, findings on affected skill performance due to missing environmental information were further observed for non-acoustic conditions (e.g., participants wearing headphones emitting white noise). For example, an early study by Cobner and Cardiff (1980) found that table tennis players displayed significant performance decrements through decreased stroke accuracy and timing perception during forehand-stroke trials without receiving acoustic information (i.e., under the condition of wearing headphones; see Davids et al., 2008, for detailed descriptions of different studies in this field). This finding may be further underlined by the notion of top performances in table tennis requiring auditory information about the ball bouncing on the racket and table (Hermann et al., 2006). Furthermore, studies by Takeuchi (1993) as well as Mead and Drowatzki (1997) stated experienced tennis players wearing ear protectors to show performance decrements when judging and receiving a service.

Altogether, aforementioned assumptions on the potential effects of 1) external auditory cues (e.g., stadium noise), and 2) non-acoustic training environments on impaired motor performance appear to be underexplored for sub-elite players in the football context. Consequently, the present research study aims to test the following hypotheses:

H1: Highly skilled sub-elite level football players' passing performance scores and times (i.e., passing accuracy and passing time) will significantly decrease under stadium noise conditions compared to playing under a 'baseline' condition.

H2: Highly skilled sub-elite level football players' passing performance scores and times (i.e., passing accuracy and passing time) will significantly decrease under a 'no auditory cue' condition compared to playing under a 'baseline' condition.

Method

Participants.

The participant sample consisted of fifteen male football players (n=15) that played for the U23s age group team of a professional German football club during the 2019/20 season. Participants were between 18 and 33 years old (M= 21.3 years, SD= 4.4) and included players covering various playing positions (e.g., central defenders and attacking midfielders). This specialised target group of young U23s players was chosen for two reasons: first, from a skill training perspective, the U23s football context displays a unique transition training phase, in which players move from elite-level youth football to professional senior men's football (i.e., highly skilled players with limited exposure to loud auditory stadium noise; see Otte et al., 2020). The chosen player target group presented a selection of sub-elite players with robust technical skills that, on average, have been developed in training and competition for over 15 years (*SD*= 4.4 years). While few single players have already gained limited playing experience in front of (distracting) football crowds of up to 10,000 or more spectators, the selection of these highly skilled sub-elite level players allowed for adequate control against the variable of learned performance under stadium-like noise conditions. In other words, the chosen player group aspires to play at the highest senior football level but has not yet been acquainted with the noise that expert players at the (inter)national top-level are normally confronted with in a stadium. Second, chosen players have been nearly equally acquainted with the specialised training environment (i.e., the Footbonaut) for several months as part of regular individual talent development sessions.

Study Design and Setting.

The study design used the setting of a football-specific assessment and training tool, termed Footbonaut (CGoal GmbH, Berlin, Germany; see Figure 1 for an exemplary image of one participant in the Footbonaut).

[Figure1]

Described as a "robotic cage which footballers can use to improve passing, spatial awareness and control", the Footbonaut presents a high-tech training machine, currently only accessible to two German football clubs (McGowan, 2012). Particularly, its standardised technical training programs permit the 'Footbonaut' to become a validated and reliable study instrument for players' passing performance (see, Beavan et al., 2018, for a validation of the

Footbonaut as a training and research instrument). Especially in terms of measuring football passing accuracy and passing time, the Footbonaut allows for “serial coupling between perception and action with the addition of unpredictability” (Beavan et al., 2018, p. 2). Notably, this coupling between player and machine (despite not replicating a ‘true’ performance setting) is investigated in regard to whether and how search and coordination of functional movement solutions can be broken by stadium crowd noise.

For the current study, players were provided with the identical training program throughout each executed training session. In detail, 1) visual information of the passing source and passing target ‘window’; 2) auditory cues; and 3) ball speed and trajectories at which players received incoming passes all remained the same for each comparable passing repetition per session. Further, players were advised to position themselves in the centre of the training square (i.e., approximately 6-7 metres away from each passing source) and auditory ‘beep’ sound cues on passing source and target were provided one second prior to each ball release. In addition to the standardised training design, the Footbonaut (and the indoor facility in which it is built) endorsed further control of variables, such as ball size, ball pressure, light, and sound conditions (i.e., using stadium-realistic noises at identical volumes), for each participating player; thus, the Footbonaut made the study setting a reliable and standardised research environment in which solely the auditory noise conditions varied between trial sessions. Notably, two stadium recordings of fans either singing and chanting (i.e., positive) or fans ‘booing’ and whistling (i.e., negative) were pre-tested for their validity. Thirty participants between 19 and 26 years (*M*= 21.40 years, *SD*= 1.79) were asked to estimate the valence of the auditory stadium cues in the range of four -2 to +2 Likert-type scales (0 representing a neutral opinion). The first stadium recording was rated as more motivating, $t(29) = 17.517$, $p < .001$, $d = 3.198$, less disturbing, $t(29) = 8.532$, $p < .001$, $d = 1.558$, more supporting, $t(29) = 13.614$, $p < .001$, $d = 2.486$, and more positive, $t(29) =$

14.231, $p < .001$, $d = 2.598$, compared to the second stadium recording. Consequently, the first stadium recording was termed as a 'positive' auditory training condition and the second recording as a 'negative' condition in the current study. Table 1 includes all means and standard deviations for all items included in the survey.

[Table1]

Procedures.

Prior to the study, participants were asked to give consent and fill out an 'expertise questionnaire' (i.e., including information on playing history and the positional profile). Additionally, each player performed a short physical warm-up, followed by a technical warm-up, including ten passing repetitions allowing participants to familiarise themselves in the Footbonaut.

Following the warm-up procedures, each player was instructed to perform four sessions of identical football passing practice rounds (i.e., the execution of 32 low passes per session over the course of approximately 2-3 minutes). The settings of the Footbonaut were standardised for each training session (i.e., both the passing sources and the speed at which balls were played at the participant remained identical throughout each player's session). The training sessions were executed in randomised order under four specific auditory noise conditions:

1. *'Baseline' condition:* the training environment allows for participants to perceive all relevant visual information (i.e., light signals) and auditory cues (i.e., 'beep' sound signals at a volume of approximately 75dB) on passing source and passing target 'window', as provided by the Footbonaut (i.e., participant's hearing was not distracted).

2. *'No auditory' cue condition:* the training environment significantly limits the participant's perception of auditory information (i.e., 'beep' sound signals) on passing source and target 'window' provided by the Footbonaut (i.e., participants were asked to wear ear defenders throughout the training session).
3. *Positive auditory cue condition:* the training environment displays loud stadium noises (i.e., a football crowd singing) played through speakers in the Footbonaut (i.e., with a volume of approximately 85dB); thus, the participant's perception of auditory information (i.e., 'beep' sound signals) on passing source and target 'window' provided by the Footbonaut are impaired.
4. *Negative auditory cue condition:* the training environment displays loud stadium noises (i.e., a football crowd whistling and 'booing') played through speakers in the Footbonaut (i.e., with a volume of approximately 85dB); thus, the participant's perception of auditory information (i.e., 'beep' sound signals) on passing source and target 'window' provided by the Footbonaut are impaired.

Measures.

Quantitative performance of each passing practice session was measured on standardised output data provided by the Footbonaut mobile data app; this output data included: 1) a total passing accuracy/score (in %) for each session; and 2) an average passing time between receiving the ball and passing it through the correct target 'window' (in s) for each repetition and in total for each entire passing practice session. Specifically, players were instructed to receive and pass the ball "as quickly as possible" without any further information provided.

Data analysis.

Passing accuracy scores (%) and passing time (in s) as the dependent variables were analysed by conducting a repeated-measures multivariate analysis of variance (MANOVA) with auditory cue condition (i.e., baseline, no auditory cue, positive auditory cue, negative auditory cue) as the within-subject factor. Bonferroni-corrected pairwise comparisons were used to follow up significant main effects.

Results

Footbonaut scores.

Across all conditions (baseline, no auditory cue, positive auditory cue, negative auditory cue), participants had a passing accuracy score of 85.77 % (*SD* = 5.89 %) and a passing time of 2.22 s (*SD* = 0.16 s). The MANOVA revealed no significant main effect of passing accuracy score (H1), $F(3,43) = .322$, $p = .809$, but a significant main effect of passing time (H2), $F(3,42) = 5.794$, $p = .002$, $\eta^2 = .293$. Post-hoc comparisons (Bonferroni corrected adjusted alpha of 0.013) indicated that participants reacted faster in the baseline condition compared to the negative, $t(14) = -3.221$, $p = .006$, $d = .832$, and no auditory cue condition, $t(14) = -3.898$, $p = .002$, $d = .1.006$. There was neither a significant difference between the baseline and positive, $t(14) = -2.563$, $p = .023$, nor between the positive and negative, $t(14) = -.855$, $p = .407$, nor between the positive and no auditory, $t(14) = -.776$, $p = .451$, nor between the negative and no auditory cue condition, $t(14) = .270$, $p = .791$ (see Figure 2). Consequently, results lead to partial acceptance of H1 and H2.

[Figure2]

Discussion

The predominant goal of this research design was to investigate the effect of stadium noise (in the form of external auditory cues) on players' passing performance (i.e., passing accuracy and time). Results indicate no significant effect of audio cues on passing accuracy scores, but some effect on passing time. Findings are discussed and study limitations, implications, and opportunities for future research are presented.

Football passing time as a critical performance indicator.

Significant statistical differences between average passing time in the baseline condition compared to the no auditory cue and the negative stadium noise condition present a remarkable finding. Specifically, it was revealed that players under (no) auditory cues required a longer time to pass the ball to the correct target. Interestingly, this finding on maintained accuracy and diminished speed may be related to research in medicine that found expert surgeons (compared to less experienced surgeons) to slow down movements when confronted with increased cognitive workload during surgical procedure (see Nguyen et al., 2019). While slower movements may be explained by skilled players prioritising movement accuracy over speed when facing complex tasks (e.g., passing accuracy under loud stadium noise), this finding may considerably affect training designs. With players in professional football being under constant time pressure to rapidly and successfully pass the ball, advanced passing time displays a critical performance indicator for young players aspiring to play at the highest (inter)national football level. Consequently, findings show the need for integrating these representative stadium noise conditions into training session designs; this, is in order to get sub-elite-level players acquainted with these performance environments. Thus, the discussion considers critical principles of the CLA, such as the *representativeness of training designs* and the *adjustment of task complexity for skill refinement.*

Stadium noise conditions may work to enhance the representativeness of training designs in response to multimodal performance demands in football games. Particularly, the achievement of goals in competition, as based on actions and constraints that players have previously been exposed to in training (i.e., termed action functionality; Pinder et al., 2011), is targeted by the research. Further, indicated by decreased player performance under environmental constraint manipulations within the training design, this work supports an important notion of representative learning: that is, immediate skill performance may decrease before skill development and control become more adaptable and functional over time (e.g., Button et al., 2020). By confronting players with relevant affordance landscapes (i.e., opportunities for actions), players' perception, cognition, emotions, and (motor) behaviour solutions become more adaptable in response to individual, environment, and task constraint interactions (Seifert, Araújo, Komar, & Davids, 2017). In turn, enabling players to experience training under (negative) stadium noise conditions may be regarded as one valuable way of replicating environmental constraints experienced in football. Specifically, this study makes a case that representative auditory cues may be distracting to movement coordination and performance in sub-elite level players. Here, audio cues can cause disruptions to couplings that force players to search for new ways to adapt to relevant sources of information and to functionally solve movement problems. Notably, non-significant differences between the positive and baseline condition may be explained by the notion that positive stadium noise may lead to more player enjoyment, intrinsic motivation, and less negative self-talk (see De Muynck et al., 2017, for an elaboration based on self-determination theory). Thus, while players in the positive condition may have benefitted from the encouraging, emotion-laden training environment, players in the baseline condition had the advantage of better hearing the auditory cues provided by the Footbonaut. This latter condition, supporting the multisensory integration of visual and auditory information, has been proven to enhance performance in sports (e.g., Klein-Soetebier et al., 2020). In turn, both conditions potentially had their positive effects on skill performance. Yet, due to the presented study design, this argumentation remains open for future research to investigate and confirm.

The no auditory cue condition (by wearing ear defenders) may work to increase information/task complexity for players (i.e., players' subjectively perceived complexity of a given task; see Otte et al., 2019, 2020, for elaborations on this concept). By reducing multimodal sensory input, players' search processes may be limited and directed towards alternative perceptual information (Davids et al., 2008; Stanton & Spence, 2020). Underlined by research advocating the use of multisensory information for coordination of complex motor actions, a combination of various senses may lead to "more accurate estimates of perceptual quantities (e.g., depth, motion)" to support effective performance (Gray, 2008, p. 247). This general statement transfers to the current study in that the intentional reduction of sensory input may increase perceived task complexity. Particularly, with increased task complexity, it is aimed to challenge players' search for specific environmental information to directly support functional movement solutions (Otte et al., 2019). Consequently, for this study, limited hearing in training would be regarded as a constraint manipulation aiming to challenge players' visual and kinaesthetic (touch-based) perception in order to support skill adaptability (Davids et al., 2008; Renshaw & Chow, 2019).

Skilled sub-elite level players' movement adaptability supports skill functionality and robustness.

When comparing passing accuracy scores for sub-elite level players under various auditory cue conditions, results revealed no significant differences. While these findings do not highlight any auditory training condition to be superior (or inferior) for direct passing scores, results prove that sub-elite players are demonstrably skilled at self-regulating movement solutions. In response to perturbing constraint interactions within the training environment, highly-skilled players' perception-action couplings remained largely robust (see

Seifert, Button, & Davids, 2013, for an overview on key properties of advanced athletes' movement systems); hence, these skilled players seemingly used available multimodal information (dependent on the training condition) in an adaptive manner (Williams et al., 1999). This notion corresponds with previous research in sports, such as basketball, climbing, and swimming, which states experts to be able to exploit movement variability in order to functionally adapt sport-specific movement patterns (e.g., Seifert & Davids, 2012). Considering this idea, it is not surprising that players at this advanced skill level maintained passing accuracy; this, however, was at the cost of aforementioned passing time, a critical performance indicator in elite-level football, that may underline the overall sub-elite status of chosen participants.

Limitations and future research.

A few study limitations that drive future research recommendations have to be highlighted. First, the sample size of fifteen highly skilled players represents a study limitation and hinders a generalisation of findings. Future research could access larger samples to test skill performance under auditory cue conditions. Second, although the Footbonaut provided a highly reliable tool for this unique experimental design, full representativeness in terms of auditory condition and football-specific task was only given to some extent. Specifically, the football passing tasks in the Footbonaut are taken out of their game-specific context, including complex and dynamic system interactions between relevant team constraints (Serra-Olivares, Clemente, & González-Víllora, 2016). Particularly, this limitation of decreased representativeness of information extends to both visual information (i.e., the ball is not passed by a teammate) and auditory information (i.e., the 'beep' sound signal is important for player performance in this research design, but not relevant in a football game). Consequently, the investigation of the coupling between machine (Footbonaut) and player, leading to skill performance, restricts the generalisation of findings to the real football game. Hence, future research should further investigate players' passing performance in real-world training environments and whether stadium noise is powerful enough to overcome relevant couplings in diverse and context-dependent sporting situations.

Conclusion

The presented study aims to assess football players' passing performances under auditory cue conditions in the forms of added stadium noise and under limited auditory information. Using the unique football training tool of the Footbonaut, results show that auditory cues, or likewise the absence of them, can disrupt movement coordination. Despite sub-elite players seemingly having acquired robust movement skills in terms of passing accuracy, this study shows that players' passing time was negatively affected by environmental constraint manipulations. This finding, in turn, underlines benefits of representative training designs for skill learning. Underpinned by critical principles of an Ecological Dynamics rationale and the Constraints-Led Approach, it is arguably variable and representative training environments, demanding individual players to constantly adapt to changing constraints, that lead to the development of functional performance solutions over time. In other words, designing and manipulating constraints within football training environments with appropriate levels of task complexity and representativeness supports skill refinement and performance preparation.

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Tables

Table 1

Means and standard deviations for the pre-tested valence of stadium noise cues

Items*		Mean	Standard Deviation
Pair 1	Positive cue – item scale: demotivating/ motivating	1.00	± 0.46
	Negative cue – item scale: demotivating/ motivating	-0.97	± 0.41
Pair 2	Positive cue – item scale: disturbing/ not disturbing	1.13	± 0.90
	Negative cue – item: disturbing/ not disturbing	-0.70	± 0.79
Pair 3	Positive cue – item scale: not supporting/ supporting	0.97	± 0.72
	Negative cue – item scale: not supporting/ supporting	-0.13	± 0.57
Pair 4	Positive cue – item scale: negative/ positive	0.80	± 0.55
	Negative cue – item scale: negative/ positive	-1.37	± 0.49

**Items based on a questionnaire to pre-test the validity of two stadium recordings of: 1) fans singing and chanting (i.e., positive); and 2) fans 'booing' and whistling (i.e., negative). 30 subjects (n=30) were asked to estimate the valence of the auditory stadium cues in the range of four -2 to +2 Likert-type scales (0 representing a neutral opinion).*

Figures

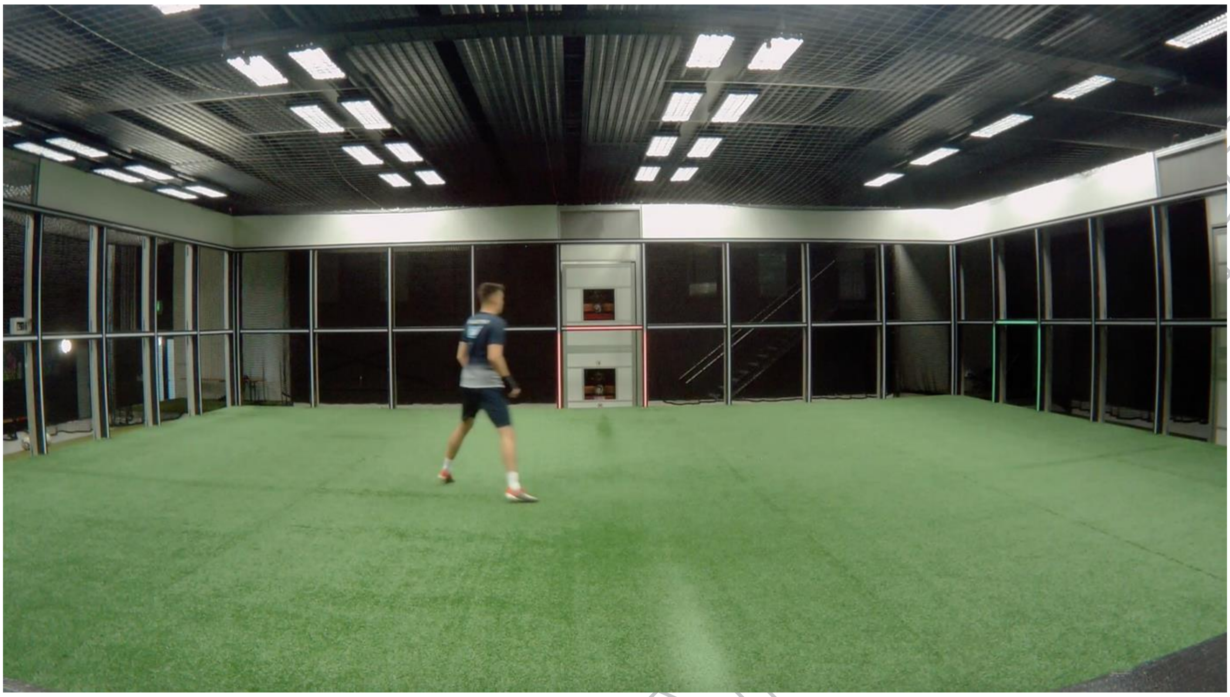

Figure 1. An exemplary image of one participant during the standardised 'baseline' training program in the Footbonaut. While the lighted, red window in the centre displays the passing source (i.e., the ball cannon passing a ball to the player), the lighted, green window on the right presents the target 'window' (i.e., the target to pass the incoming ball into).

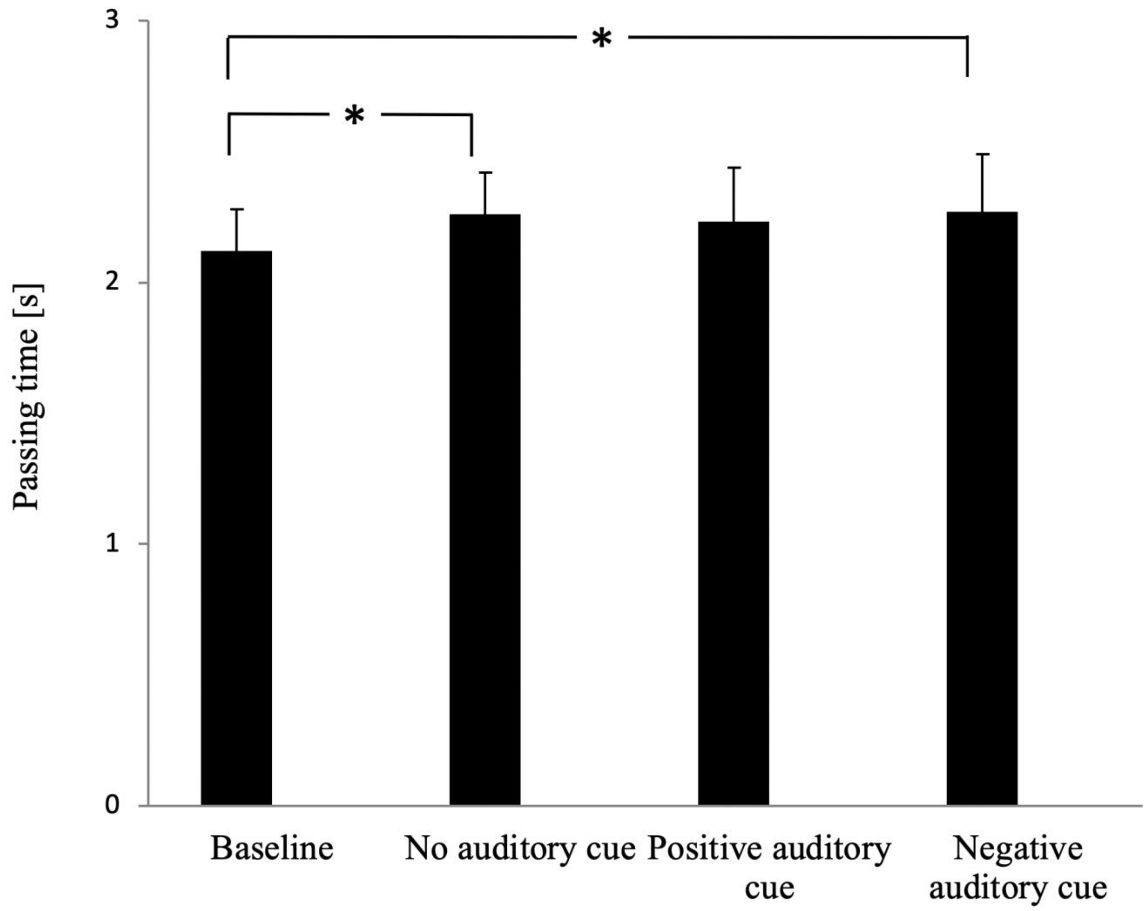

*Figure 2. Passing times in the four auditory cue conditions (baseline, no auditory cue, positive auditory cue, negative auditory cue). Symbols represent across-participant means, and error bars show standard deviations. (Note: *p<.013; Bonferroni corrected post-hoc comparisons had an adjusted alpha of 0.013.)*

Figure Captions

Figure 1. An exemplary image of one participant during the standardised ‘baseline’ training program in the Footbonaut. While the lighted, red window in the centre displays the passing source (i.e., the ball cannon passing a ball to the player), the lighted, green window on the right presents the target ‘window’ (i.e., the target to pass the incoming ball into).

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