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Communications

Psychological Pressure Distorts High Jumpers' Perception of the Height of the Bar

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Abstract: The effects of psychological pressure on perceiving the height of a jump bar just before starting a high jump run was investigated. University students (N = 14) training for a high jump event performed 15 trials (3 practice, 6 pressure, and 6 non-pressure) in counterbalanced order in their daily practice environment. The height of the bar was judged as significantly higher on pressure trials compared to non-pressure trials. A regression analysis indicated that participants who reported increased subjective perceived pressure tended to judge the bar to be higher. There was no significant difference between pressure and non-pressure trials for the performance index, defined as the success rate. This study provides the first evidence that environmental perceptions prior to executing a motor task under pressure may make performance of the task appear to be more difficult.

Keywords: Action-specific perception; dynamic perception; high jump; psychological stress

1. Introduction

In competitive sport, the influence of psychological pressure on the performance of motor skills cannot be ignored. Pressure is defined as "any factor or combination of factors that increases the importance of performing well on a particular occasion [1]", and it affects performance of several motor skills. While positive effect is so called clutch [2,3], and choking means performance decrement under pressure [1,4]. Choking is a particularly acute problem for athletes, and there is a need to understand how pressure influences performance decrement.

It would be effective to focus on subjective reports of athletes and link those reports with empirical data to gain a full understanding of this issue. This approach could enable us to focus on significant problems having a large impact on sports performance under pressure. One of these problems is subjective changes in perception of the environment reported by athletes during sports

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competitions. These changes include alterations in spatial, temporal, and kinematic information about the opponent. For example, a badminton player recollected that she felt her own court to be larger, the net higher, and her opponent's body bigger when she experienced choking during a game [5]. This evidence suggests that environmental perceptions *prior to* executing motor skills under pressure negatively distort task performance, making it more difficult. However, there is no direct evidence of this in sports contexts. Further, a few previous studies have observed no pressure-induced changes in perception of distance, for example, distance to the hole in a golf-putting task [6] and distance to a knife-wielding opponent in a shooting situation [7].

The purpose of the present study was to investigate experimentally the effects of psychological pressure on judging the height of a jump bar immediately before starting a high jump run. It was predicted that most participants would perceive the bar as higher when under pressure, and especially individuals who felt greater subjective pressure would particularly perceive the bar to be higher. The relationship between changes in height perception and performance outcome of the high jump task under pressure was also examined.

2. Materials and Methods

2.1. Participants

Participants were 14 healthy university students (seven women and seven men) in training for a high jump event. Eight participants (three women and five men) specialized in the high jump, and six participants (four women and two men) specialized in combined events. Written informed consent was obtained from all participants. The university ethics committee approved the experiment.

2.2. Procedure

The experiment was conducted in the participants' daily practice environment. Two participants participated as partners in each session. After they warmed up for approximately 30 minutes at their own pace, they performed three practice trials that familiarized them with the task. The height of the bar on practice trials was set to -28, -24, -20 cm of each participant's personal best height. Following the practice trials, they performed 6 non-pressure and 6 pressure trials, with three trials in each of four test sessions. Eight participants (four pairs) performed four sessions in the following fixed order: non-pressure 1, pressure 1, non-pressure 2, and pressure 2 (i.e., A-B-A-B design). To prevent order effects, the other six participants (three pairs) performed the trials in this fixed order: pressure 1, non-pressure 1, pressure 2, and non-pressure 2 (i.e., B-A-B-A design). Two participants performed in an alternating sequence on all trials.

The height of the bar in pressure and non-pressure conditions was set to -25, -22, -19, -16, -13, -10 cm of each participant's personal best height. The height of six trials in both conditions was randomized for each participant. Before each trial, participants were blindfolded so that they were unable to observe the two experimenters who adjusted the height of the bar. After adjustments of the bar were completed, participants removed the blindfold. They were requested to verbally state the height of the bar in centimeters before they started their run with own timing. Participants received feedback regarding the height of the bar after each practice trial. However, they did not receive any feedback after non-pressure, or pressure trials.

The pressure condition included a combination of pressures, including reward, punishment, and social stress involving the partner. After the practice trials, participants were instructed that they would receive 2000 JPY (about 20 USD) as a reward for participation. In addition, the following instruction was given prior to the pressure condition: "I will give you an extra 500 JPY per trial if you succeed in the high jump task. However, if you fail, both you and your partner will lose 500 JPY of the 2000 JPY participation reward." Before the non-pressure condition, participants were instructed that they would 200 JPY per trial if they succeeded in the task, but there would be no penalty for either the participant or the partner for failing to perform the task.

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2.3. Dependent Variables and Data Analysis

To examine psychological effects of the pressure manipulation, perceived pressure and mental effort required to succeed in the task were measured using Visual Analog Scales (VAS) immediately prior to judgment of the bar height on each non-pressure and pressure trial. As an index of height perception, the ratio (%) of the verbal statement of the height of the bar to the actual height was calculated. The bar was perceived as being higher than its actual height if this score was greater than zero, and height perception was lower if this score was less than zero. The performance index was the success rate on the six trials in the two conditions.

For all dependent variables, Wilcoxon signed-rank tests were used to analyze differences between non-pressure and pressure conditions. Variations from the non-pressure to pressure conditions were calculated for all dependent variables, in the form of the average of the six trials in the pressure condition minus that in the non-pressure condition. In order to test the relationships among these variations, Spearman rank-order correlation coefficients (N = 14) were calculated for all relationships. After taking the sample size into consideration, it was decided to use non-parametric tests. The significance level for all analyses was 5 % (two-tailed).

3. Results

Table 1 shows the means and standard errors for all dependent variables in the non-pressure and pressure conditions. There were significant increases in perceived pressure (7.42 mm; Wilcoxon Z = -2.17, p = .030), mental effort (6.77 mm; Z = -2.29, p = .022), and height perception of the bar (0.59 %; Z = -2.17, p = .030) from the non-pressure to pressure conditions. There was no significant difference between conditions for success rates on the task (4.76 %; Z = -1.26, p = .209).

Table 1. Means and standard errors of all dependent variables in the non-pressure and the pressure conditions.

	Non-pressure	Pressure
Perceived pressure (mm)	49.31±5.36	56.73±5.05*
Mental effort (mm)	61.92±3.69	68.69±4.45*
Height perception of the bar (%)	.77±1.23	1.36±1.26*
Success rate of the task (%)	69.05±6.50	73.81±7.76

Note: * $p < .05$

The correlation between changes in perceived pressure and height perception from the non-pressure to pressure conditions was marginal significant (r = .468, p = .091), indicating that participants who reported greater perceived pressure in the pressure condition tended to judge the bar to be higher. For height perception, the correlation with mental effort was not significant (r = .424, p = .131). For success rate, there were no significant correlations (perceived pressure, r = -.348, p = .223; mental effort, r = -.229, p = .430; and height perception, r = -.352, p = .217).

4. Discussion

In the present study, the psychological effects of pressure were reflected in ratings of subjective pressure and mental effort on the VAS. Both scores increased from non-pressure to pressure conditions by approximately 7 mm. Therefore, the psychological effects of pressure manipulations used in this study were effective. The mean perceived height of the bar for all participants under pressure was significantly higher than in the non-pressure conditions, as we expected. In addition, participants who reported greater subjective pressure tended to judge the bar to be higher. Therefore, this study provides the first evidence that psychological pressure could distort environmental perceptions prior to executing a motor task, such that the task would appear to be more difficult.

There are several possible reasons for the perceptual changes found in this study. First, attentional changes under pressure may have distorted environmental perception. Choking under pressure is caused by conscious processing [4] and distraction [8] during task execution. Gray and Cañal-Bruland [9] found that choking in a golf-putting task led to changes in size perception of the hole (i.e., it appeared smaller), and participants who choked showed enhanced conscious processing of putting movements. Participants in this study may also have engaged in conscious processing or experienced distraction prior to the run under pressure, and such attentional changes may have affected their height perception.

However, attentional changes may not be the sole reason that perception changed prior to task performance. Increased anxiety and fear and decreased confidence in task performance may also have been related to the perceptual changes. In previous studies, increases in slant estimation [10] and in distance estimation [11] have been observed for participants in an elevated location. Similarly, psychological aspects under pressure may have caused greater height perception before task performance.

Finally, physiological states under pressure, including arousal [9] and muscular activities [12], may have affected perception. Psychological and physiological effort required for motor tasks have been shown to distort perception in the direction of wasted energy costs. For example, distance and slant estimates increase when a heavy backpack is carried and in the absence of optic flow [13,14]. Given that mental effort increased under pressure in the present study, physiological arousal and muscular activities may have also been enhanced under pressure. These physiological changes under pressure may have led to a change in height perception in the direction of greater behavioral energy demand for the task (i.e., a higher bar).

Although height perception was distorted under pressure, success rates of the high jump task did not change from non-pressure to pressure conditions. In addition, variations of height perception and success rate from non-pressure to pressure conditions were not significantly correlated. It has been existed a contradictory explanation that perceptual distortion is considered misperceptions related to performance decrements, or perceptual distortion plays as functional roles to maintain performance [15]. Although the perceptual distortion observed in this study would be therefore regarded as playing a functional role in task performance, it is difficult to eliminate the possibility that the distortion might lead to a performance decrement if a stronger level of stress response, similar to an actual athletic competition, was induced under pressure. Moreover, the performance index measured in this study was crude, recording only task success or failure; more precise performance and kinematic indices could be achieved using motion analysis.

The results of this study suggested that the perception of the environment is distorted before performing a motor skill, depending on the degree of psychological stress caused by pressure. According to Witt [16], action-specific perception is when "people perceive the surrounding environment in terms of their ability to act in it." A series of studies on this topic has reported that the skill level [17], dairy performance [18,19], and task difficulty [20,21] influence the perception of the environment. It would, therefore, be interesting to clarify perceptual distortions under pressure by taking interactions among psychological stress and variables related to action-specific perception into consideration.

Conclusions

Athletes need to maintain optimal perception and action even when they are under pressure during sports competitions. A key finding of this study is that prior to executing motor skills in competitive situations, perceptions about the environment, such as spatial information, could be biased in the direction of increasing the difficulty of motor skills. This tendency would increase for athletes that experience increased state anxiety under pressure. It is suggested that the underlying mechanisms of this phenomenon should be examined from the perspective of cognition, emotion, and physiological states in future research. Moreover, detailed studies on the effects of perceptual biases on motor behavior that include kinematics and performance outcomes would be useful. Stern, Cole, Gollwitzer, Oettingen, and Balcetis [22] indicated that reducing anxiety under pressure by using an implementation intention strategy led to performance improvements along with compensation for the distance perception bias in golf-putting and dart-throwing tasks. This suggests that psychological skills for reducing state anxiety might play a key role in developing optimal perception and action under high pressure.

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References

1. Baumeister, R.F. Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *J. Pers. Soc. Psychol.* **1984**, 46, 610-620. doi: 10.1037/0022-3514.46.3.610. PMID: 6707866.
2. Otten, M. Choking vs. clutch performance: A study of sport performance under pressure. *J. Sport. Exerc. Psychol.* **2009,** 31, 583-601. doi: 10.1123/jsep.31.5.583. PMID: 20016110.
3. Otten, M.P. Clutch performance in sport: A positive psychology perspective. *Int. J. Sport. Psychol.* **2013**, 44, 285-287. doi: 10.7352/IJSP2013.44.288.
4. Masters, R.S.W. Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of complex motor skill under pressure. *Br. J. Psychol.* **1992**, 83, 343-358. doi: 10.1111/j.2044-8295.1992.tb02446.x.
5. Murayama, T.; Tanaka, Y.; Sekiya, H. Qualitative research on the mechanism of choking under pressure. *Japan. J. Phys. Educ. Hlth. Sport. Sci.* **2009**, 54, 263-277. doi: 10.5432/jjpehss.a540202.
6. Ogasa, K.; Nakamoto, H.; Ikudome, S.; Mori, S. The effects of psychological pressure on perception and motor planning. *Japan. J. Phys. Educ. Hlth. Sport. Sci.* **2016**, 61, 133-147. doi: 10.5432/jjpehss.15080.
7. Nieuwenhuys, A.; Cañal-Bruland, R.; Oudejans, R.R.D. Effects of threat on police officers' shooting behavior: Anxiety, action specificity, and affective influences on perception. *Appl. Cogn. Psychol.* **2012**, 26, 608-615. doi: 10.1002/acp.2838.
8. Mullen, R.; Hardy, L.; Tattersall, A. The effects of anxiety on motor performance: A test of the conscious processing hypothesis. *J. Sport. Exerc. Psychol.* **2005**, 27, 212-225. doi: 10.1123/jsep.27.2.212.
9. Gray, R.; Cañal-Bruland, R. Attentional focus, perceived target size, and movement kinematics under performance pressure. *Psychon. Bull. Rev.* **2015**, *22*, 1692-1700. doi: 10.3758/s13423-015-0838-z. PMID: 25933628.
10. Stefanucci, J.K.; Proffitt, D.R.; Clore, G.L.; Parekh, N. Skating down a steeper slope: Fear influences the perception of geographical slant. *Perception* **2008**, 37, 321-323. doi: 10.1068/p5796. PMID: 18414594. PMCID: PMC2293293.
11. Stefanucci, J.K.; Proffitt, D.R. The roles of altitude and fear in the perception of height. *J. Exp. Psychol. Hum. Percept. Perform.* **2009**, 35, 424-438. doi: 10.1037/a0013894. PMID: 19331498. PMCID: PMC3398806.
12. Tanaka, Y.; Funase, K.; Sekiya, H.; Sasaki, J.; Tanaka, Y.M. Psychological pressure facilitates corticospinal excitability: Motor preparation processes and EMG activity in a choice reaction task. *Int. J. Sport. Exerc. Psychol.* **2014**, 12, 287-301. doi: 10.1080/1612197X.2014.916336.
13. Durgin, F.H.; Baird, J.A.; Greenburg, M.; Russell, R.; Shaughnessy, K.; Waymouth, S. Who is being deceived? The experimental demands of wearing a backpack. *Psychon. Bull. Rev.* **2009**, 16, 964-969. doi: 10.3758/PBR.16.5.964. PMID: 19815806.
14. Proffitt, D.R.; Stefanucci, J.; Banton, T.; Esptein, W. The role of effort in perceiving distance. *Psychol. Sci.* **2003**, 14, 106-112. doi: 10.1111/1467-9280.t01-1-014m27. PMID: 12661670.
15. Gray, R. Embodied perception in sport. *Int. Rev. Sport. Exerc. Psychol.* **2014**, *7*, 72-86. doi: 10.1080/1750984X.2013.871572.
16. Witt, J.K. Action's effect on perception. *Psychol. Sci.* **2011**, 20, 201-206. doi: 10.1177/ 0963721411408770.
17. Witt, J.K.; Schuck, D.M.; Taylor, J.E.T. Action-specific effects underwater. *Perception* **2011**, 40, 530-537. doi: 10.1068/p6910. PMID: 21882717.

18. Witt, J.K.; Linkenauger, S.A.; Bakdash, J.Z.; Proffitt, D.R. Putting to a bigger hole: Golf performance relates to perceived size. *Psychon. Bull. Rev.* **2008**, 15, 581-585. doi: 10.3758/15.3.581. PMID: 18567258. PMCID: PMC3193943.
19. Witt, J.K.; Proffitt, D.R. See the ball, hit the ball: Apparent ball size is correlated with batting average. *Psychol. Sci.* **2005**, 16, 937-938. doi: 10.1111/j.1467-9280.2005.01640.x.
20. Witt, J.K.; Sugovic, M. Performance and ease influence perceived speed. *Perception* **2010**, 39, 1341-1353. doi: 10.1068/p6699. PMID: 21180356.
21. Witt, J.K.; Sugovic, M. Does ease to block a ball affect perceived ball speed? Examination of alternative hypotheses. *J. Exp. Psychol. Hum. Percept. Perform.* **2012**, 38, 1202-1214. doi: 10.1037/a0026512. PMID: 22201463.
22. Stern, C.; Cole, S.; Gollwitzer, P.M.; Oettingen, G.; Balcetis, E. Effects of implementation intentions on anxiety, perceived proximity, and motor performance. *Pers. Soc. Psychol. Bull.* **2013**, 39, 623-635. doi: 10.1177/0146167213479612. PMID: 23436769.