

Factors Related to Choking under Pressure in Sports and the Relationships among Them*

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Factors related to choking under pressure during sports were investigated through a questionnaire survey and the relationship among the factors was examined. A questionnaire survey of choking was conducted among university students in sports-oriented school clubs (n = 535). Exploratory factor analysis extracted 11 factors: changes in motor control and vicious circles, abnormal physical sensations, perceptual and cognitive confusion, introversion, self-consciousness, feelings of physical heaviness and weakness, conscious processing (attention to movements), passivity, feelings of physical fatigue, safety-oriented strategies, and heat sensations. An analytical model with nine factors, (excluding feelings of physical fatigue and heat sensations) as latent variables was constructed, and covariance structure analysis was performed. The results indicated the validity of the mechanistic model of choking, consisting of nine latent variables. According to the model, when self-consciousness, or abnormal physical sensations, had a high profile, conscious processing increased. Furthermore, it was confirmed that conscious processing affected changes in motor control and vicious circles, which led directly to a decline in motor performance. It was also indicated that abnormal physical sensations determined perceptual and cognitive confusion, or feelings of physical heaviness and weakness. On the other hand, when perceptual and cognitive confusion and feelings of physical heaviness and weakness had a high profile, passivity increased. High passivity caused changes in motor control and vicious circles. Moreover, increased passivity led to the adoption of a safety-oriented strategy that often caused changes in motor control and vicious circles. While previous studies have tried to explain choking only from the perspective of changes in attention, the above results suggest the following mechanistic model of choking, indicative of another perspective: Changes in psychological, physiological, and behavioral variables cause a decline in performance. Especially interactions between emotions and cognitions and the adoption of a strategy with a low risk of failure determine changes in motor control.

Keywords: pressure, performance, attention, safety-oriented strategy, changes in motor control

1. Introduction

For many athletes, it is not easy to perform to the best of one's ability during competition. During competition, an athlete may not be able to perform as he/she normally could because of anxiety from spectators or the pressure to perform well. Baumeister (1984) defines "pressure" as a factor or combination of factors that increase the importance of performing well under certain situations. He refers to "choking under pressure"*¹ as the phe-

nomenon in which an athlete's performance declines under pressure. Typical sources of pressure include spectators, evaluation, reward, and time constraints. These types of pressure are common for many competitions. Therefore, the ability to remain unnerved under pressure situations to perform to the best of one's ability can have a great impact on the outcome of a match. Recently, a considerable number of athletes consult specialists for sport mental training or psychological support to control "choking under pressure."

When dealing with “choking under pressure” during competition, pressure is not the only factor that must be dealt with. During “choking under pressure” situations, many factors other than pressure may be involved. “Choking under pressure” is likely to be a result of the interaction between these many factors. However, due to its complexity, the process in which pressure negatively affects performance is still mostly unknown. In order to more effectively prevent and treat “choking under pressure,” the factors that are involved must be identified, and the process that leads to declined performance must be made clear.

“Choking under pressure” has been a frequent topic of research in the field of sport psychology. Experimental studies have been conducted on the psychological, physiological, and behavioral changes that occur when an athlete is under pressure. Psychological aspects that have been studied include an increase in anxiety state (Tanaka and Sekiya, 2006), decrease in self-efficacy (Williams et al., 2002), changes in perception (Pijpers et al., 2006) and changes in attention (Beilock and Carr, 2001; Lewis and Linder, 1997; Mullen et al., 2005). Physiological aspects include increase in heart-rate (Landers et al., 1985) and increase in systolic blood-pressure (Noteboom et al., 2001). These findings indicate physiological stimulation resulting from changes in the autonomic nervous system as well as the endocrine system. In regards to the endocrine system, there is a report that demonstrated increases in cortisol secretion (Salvador et al., 2003). Moreover, behavioral changes include decrease in movement displacement (Beuter et al., 1989; Higuchi et al., 2002; Tanaka and Sekiya, 2010a, 2011), increase in variability of movement displacement (Tanaka and Sekiya, 2006), decrease in variability of movement displacement (Higuchi, 2000), increase in variability of timing (Gray, 2004) and increase in the length of time for movement execution (Beuter and Duda, 1985).

In some cases, studies have utilized questionnaire surveys to study “choking under pressure.” For example, Ichimura (1965) conducted a questionnaire survey regarding experiences of “choking under pressure.” Factor analysis identified the following factors: activation of the sympathetic nervous system, decrease in psychological tension, confusion of motor skills, and anxiety. Arimitsu and Imada (1999) identified a factor characterized by increased

awareness of one’s situation. This factor is composed of feelings of self-imperfection, sense of responsibility, and awareness of others. In addition, questionnaire surveys revealed that anxiety increases before a competitive match (Cerin, 2003; de Mojà and de Mojà, 1986; Hanton et al., 2004).

Recently, some studies have focused on the causes of “choking under pressure” and propose a hypothesis that “choking under pressure” results from a change in attention. Several similar hypotheses explain the phenomenon from a cognitive point of view. These hypotheses can be divided into two groups: The conscious processing hypothesis which attributes the decrease in performance to extra attention to one’s own physical movements (e.g., Hardy et al., 1996; Masters, 1992) and the processing efficiency hypothesis which attributes the decrease in performance to a lack of attention to one’s own physical movements (e.g., Eysenck and Calvo, 1992; Wine, 1971). These two hypotheses explain “choking under pressure” with opposite cognitive changes.

Therefore, studies on “choking under pressure” have clarified many psychological, physiological and behavioral changes and symptoms as well as changes in attention that occur under pressure. However, there are still many issues that remain unresolved regarding the process that leads to “choking under pressure.”

One issue is the reproducibility of “choking under pressure.” Most of the previous studies that attributed “choking under pressure” to changes in attention had aimed to test whether the conscious processing hypothesis or the processing efficiency hypothesis was correct. These studies experimentally created situations of relatively low levels of pressure in the laboratory. However, “choking under pressure” during competition generally involves high levels of pressure and various factors which form complex interactions. Therefore, it is difficult to reproduce the phenomenon of “choking under pressure” in the laboratory. The difficulty in reproducing high levels of pressure in the laboratory has been reported (e.g., Williams et al., 2002). To address this issue, the conscious processing hypothesis and processing efficiency hypothesis need to be tested in real “choking under pressure” situations.

The second issue is to determine the relations between factors that are involved in “choking under pressure.” In addition to changes in attention, vari-

ous psychological, physiological and behavioral changes occur when people “choke” under pressure. The changes that occur in each aspect may be directly induced by pressure, or could be indirectly induced via changes in a different aspect. Therefore it is unlikely that changes in attention singly control the decrease in performance. In order to fully understand the process of “choking under pressure,” we must study the relations between the factors that are involved.

A valid method to address these two issues is to create questionnaire surveys for actual “choking under pressure” situations. An advantage of experimental studies is that measurements can be made objectively, and changes can be measured that the participants are not directly aware of. However, it is difficult to address the issue of the reproducibility of “choking under pressure.” On the other hand, questionnaire surveys can identify participants who have experienced “choking under pressure” and can determine if changes in attention accompany the experience. In contrast to experimental studies, questionnaire surveys utilize subjective data and cannot measure changes that the participant is not aware of. However, whether the participant directed his/her attention toward his/her own physical movements or something aside from his/her own physical movements is a change that is perceived by the participant. It is reasonable to expect participants to be able to recall such changes in attention using a questionnaire. By incorporating question items regarding changes in attention, we aim to examine the validity of the two hypotheses that explain “choking under pressure.”

The previously mentioned questionnaire surveys regarding “choking under pressure” did not investigate the changes in attention that occur when people “choke” under pressure. In addition, there are few studies that have focused on the relations between the factors involved in “choking under pressure.” A study by Tanaka and Sekiya (2011) that employs a golf-putting task demonstrated that increased attention towards a movement causes increases in the variability of the time and speed of the movement. The study also indicates that increased heart rate and negative emotions cause increased acceleration of the movement and decreased grip strength. These findings show that psychological and physiological aspects influence the behavioral aspect. Recent experimental studies have shown that

kinematic and kinetic changes that occur under pressure situations directly cause decreases in performance (e.g., Tanaka and Sekiya, 2006). However, the issue of reproducibility can be raised for experimental studies. Murayama et al. (2009) utilized the grounded theory approach, a qualitative method to determine the process of “choking under pressure.” This inductive reasoning approach was employed to examine the relations between the psychological, physiological and behavioral aspects. The study analyzed interview responses from 13 participants who experienced “choking under pressure.” Results indicated that changes in perception and motor control, risk-averse strategy, and physical fatigue are factors besides changes in attention that are directly correlated to a decline in performance. This study also identified a factor related to changes in motor control as one of the factors involved in declined performance. In addition, psychological changes such as irrational thoughts, negative emotions, and strategy changes as well as physiological changes such as activation of the sympathetic nervous system influence the process of declined performance. It may seem as though this study addresses both of the aforementioned issues, but changes in perception, risk-averse strategy and physical fatigue are factors that were identified from a small number of respondents. It is necessary to examine whether these factors arise for most athletes who experience “choking under pressure.” Furthermore, there are reports that claim personality traits play a role in “choking under pressure.” The personality traits that have been reported to be correlated with “choking under pressure” are neuroticism (Fumoto et al., 1992), sense of self-consciousness (Baumeister, 1984; Wang et al., 2004), trait anxiety (Hashimoto and Tokunaga, 2000). Self-consciousness is a trait that is highly related to introversion (Kimura et al., 2008) and has been demonstrated to be correlated with conscious processing (e.g., Baumeister, 1984). These personality traits are implicated with changes in the three aspects that affect “choking under pressure,” but the possible relations with the factors within the three aspects is unknown.

Although several studies have focused on the relations between the factors that are involved in “choking under pressure,” the two aforementioned issues remain along with methodological constraints such as sample size. In order to obtain a comprehensive understanding of the phenomenon, actual “choking

under pressure” situations must be studied with a large sample size and causes of “choking under pressure” such as perception, strategy, fatigue and personality traits must be investigated in addition to changes in attention. Murayama et al. (2010) conducted one of the few studies to determine the factors involved in “choking under pressure.” A questionnaire survey was conducted for many athletes regarding attention, perception, strategy, fatigue, and personality traits. Factor analysis of the survey results revealed the following seven factors: negative thoughts/feelings, motor control changes, increased physiological arousal, communication failure, nervous personality, pre-competition condition, and abnormal somatic sensation. However, this study did not investigate the relations between the factors which remain an unresolved issue for elucidating the process of “choking under pressure.”

Covariance structure analysis has recently gained attention as a method to investigate the relations between factors. Covariance structure analysis enables the statistical validity testing of relations between latent variables implicated by previous studies. Although, the relations between all latent variables cannot be tested, but the covariance structure analysis provides a method to test theorized models based on hypotheses. Shimamoto and Ishii (2009) conducted a questionnaire survey to determine the effects of sports experiences during physical education classes on the acquisition of life skills. The results of the covariance structure analysis demonstrated that self-disclosure and goal-achievement are factors that affect the acquisition of life skills. Covariance structure analysis is an effective tool for testing the relations between factors involved in a specific phenomenon. For the “choking under pressure” phenomenon, the factors involved in decreased motor performance and the relations between factors can be hypothesized as a model. Testing this model using covariance structure analysis may clarify the process of performance decline. For this phenomenon, we can predict that psychological and physiological aspects influence the behavioral aspect. According to Yamadori (2008), affective physical states precede emotions, thus pointing towards a high likelihood of the physiological aspect affecting the psychological aspect. Besides, according to Murayama et al. (2009), changes in motor control are influenced by psychological factors such as irrational thoughts, negative feelings and risk-averse strategies, and fa-

tigue as well as physiological factors such as activation of the sympathetic nervous system. Particularly, the effects of changes in strategy and fatigue on motor control and decreases in motor performance must be tested using covariance structure analysis. Moreover, Baumeister (1984) and Wang et al. (2004) have indicated that athletes with a high sense of self-consciousness have a stronger sense of internally-directed attention. The effects of personality traits on changes in attention must be tested.

Taking these aspects into account, the process of “choking under pressure” may be clarified by testing the effects of the psychological and physiological aspects on behavioral changes using covariance structure analysis. The purpose of this study is to determine the factors and relations between the factors involved in “choking under pressure” by using covariance structure analysis. Athletes who have experienced “choking under pressure” situations are the respondents of this study. This study aims to conduct a questionnaire study that not only focus on changes in attention but also perception, strategy, fatigue, and personality traits which have been implicated by previous experimental studies, questionnaire surveys and qualitative studies.

2. Methods

2.1. Respondents

A questionnaire survey was conducted for 786 university students involved in athletic teams or athletic clubs to investigate “choking under pressure” during athletic competition. Incomplete, misconstrued or biased responses were omitted for a total of 696 valid responses (511 male; 185 female). The valid response rate was 88.5 %. The present study required respondents to be able to respond regarding a “choking under pressure” situation. Therefore, only respondents who had experienced a “choking under pressure” situation were subjected to analysis. Results of the survey indicated 161 out of the 696 valid respondents had not experienced a “choking under pressure” situation within the past year. This study subjected data from 535 respondents (393 male; 142 female) for further analysis. The average age of respondents was 20.2 ± 1.3 years.

2.2. Data collection

1) Survey period

Data collection was conducted for one year and seven months between October, 2009 and May, 2011.

2) Questionnaire items and procedure

The questionnaire was distributed to members of athletic teams and athletic clubs. The questionnaire asked respondents to provide basic personal information and respond to 17 question items regarding personal characteristics during their daily lives. These question items intended to measure personality and thus were abbreviated P1-P17. According to Arimitsu (1999), public self-consciousness, emotional instability and shyness are raised as personality traits that are deeply correlated with “choking under pressure.” This study created 17 question items based on previous questionnaires to measure public self-consciousness (Sugawara, 1984), emotional instability (Wada, 1996) and shyness (Aikawa, 1991). For the purposes of this study, we define “choking under pressure” as “performance decrements under circumstances that increase the importance of good or improved performance (Baumeister, 1984).” This definition was used to determine if respondents experienced “choking under pressure.” The questionnaire asked respondents to specify the sport in which the experience occurred and the respondents’ athletic experience and performance history. The respondents who had experienced a “choking under pressure” situation during a university athletic event were asked to describe the situation and respond to 105 question items. Respondents who had not experienced a “choking under pressure” situation were omitted from analysis.

The question items were created to investigate all factors that had been implicated in “choking under pressure” from previous questionnaire and experimental studies. The question items were based on questionnaire surveys conducted by Ichimura (1965) regarding activation of the sympathetic nervous system, decrease in psychological tension, confusion of motor skills, and anxiety as well as Arimitsu and Imada (1999) regarding feelings of self-imperfection, physical imperfection, shaking, sense of responsibility, physiological response and awareness of others. In addition, question items were created to include Murayama et al.’s (2009) qualitative study

which reported that risk-averse strategy, physical fatigue, pre-competition conditioning status, vicious circle of “choking under pressure” and decrease in motor performance are factors that may be involved. Question items regarding changes in attention were added to address experimental findings regarding “choking under pressure.” Taking these factors into account, a questionnaire of 122 question items was created. Excluding the basic personal information questions and questions regarding athletic history, all questions were created with five Likert-type choices: 1. Does not apply, 2. Somewhat does not apply, 3. Neither applies nor does not apply, 4. Somewhat applies, 5. Very much applies.

2.3. Data analysis

Exploratory factor analysis (Maximum likelihood method, Promax rotation) was conducted on the results from the 122 questions (P1-P17, Q1-Q105) regarding “choking under pressure” to determine common factors of the results. An analysis model was created based on correlations between factors and previous studies on “choking under pressure.” The analysis model was tested using covariance structure analysis whether it could explain the “choking under pressure” phenomenon. The goodness of fit of the data were measured using GFI (Goodness of Fit Index), CFI (Comparative Fit Index), AGFI (Adjusted Goodness of Fit Index), and RMSEA (Root Mean Square Error of Approximation) based on indices cited by Oshio (2004). The level of statistical significance was set as 5 %. For exploratory factor analysis, SPSS Statistics Ver. 19 (IBM) was used and for covariance structure analysis, Amos 16.0 (SPSS) was used for statistical analysis.

3. Results

3.1. Identification of factors related to “choking under pressure”

Results from exploratory factor analysis identified 11 factors: F1 “Changes in motor control and vicious circles,” F2 “Abnormal physical sensations,” F3 “Perceptual and cognitive confusion,” F4 “Introversion,” F5 “Self-consciousness,” F6 “Feelings of physical heaviness and weakness,” F7 “Conscious processing (attention to movements),”

F8 “Passivity,” F9 “Feelings of physical fatigue,” F10 “Safety-oriented strategies,” and F11 “Heat sensation.” The names of the factors were based on questionnaire studies conducted by Ichimura (1965) and Arimitsu and Imada (1999) as well as the qualitative study by Murayama et al. (2009). The number of factors was based on eigenvalues and cumulative contribution ratios, as a result, 11 factors and 77 question items were extracted. The cumulative contribution ratio for the 11 factors was 46.8%. The Cronback’s α coefficients for each factor are as follows: F1 = .93, F2 = .87, F3 = .81, F4 = .81, F5 = .76, F6 = .84, F7 = .74, F8 = .83, F9 = .83, F10 = .77, F11 = .78. Table 1 displays the correlation matrix for the 11 factors.

The 22 question items for F1 related to changes in motor control and promoted “choking under pressure” including movement confusion, abnormal plays or increased mistakes, and rushing. The factor was named “Changes in motor control and vicious circles.” The 12 question items for F2 related to abnormal physical sensations involved with “choking under pressure” such as floating sensations or shaking, and abnormal breathing patterns. The factor was named “Abnormal physical sensations.” The 10 question items for F3 related to resignation to perform well or apprehension for performing poorly, and negative perceptions or awareness towards environment. The factor was named “Perceptual and cognitive confusion.” The six question items for F4 related to passive and evasive thoughts as well as irrational thoughts. The items indicated the introverted personality traits of respondents. The factor was named “Introversion.” The five question items for F5 related to awareness of evaluation by others,

worrying and tension. The items indicated the level of self-consciousness of respondents. The factor was named “Self-consciousness.” The four question items for F6 related to feelings of heaviness of hands and feet as well as incomplete control over strength. The factor was named “Feelings of physical heaviness and weakness.” The four question items for F7 related to increased attention towards one’s own movements and form during “choking under pressure” situations as well as increased mental effort to control one’s own movements. The factor was named “Conscious processing.” The five question items for F8 related to increased hesitation or half-hearted plays and passive movements. The factor was named “Passivity.” The three question items for F9 related to physical fatigue. The factor was named “Feelings of physical fatigue.” The four question items for F10 related to risk-averse movements or plays and changes to safe strategies. The factor was named “Safety-oriented strategies.” The two question items for F11 related to a heat sensation that takes over the body. The factor was named “Heat sensation.”

3.2. Correlations between latent variables

1) Hypothesized analysis model

The identified factors from exploratory factor analysis were set as latent variables to create an analysis model to hypothesize the relations between the latent variables. When creating the analysis model, the relations between factors that demonstrated correlation coefficients greater than .40 were focused on. The cause and effect relations were predicted from findings of previous studies on “choking under pressure.” The correlation coefficients for “Feelings of physical fatigue” and “Heat sensation” with “Changes in motor control and vicious circles” were .30 and .19, respectively. These values were relatively low, and the two factors only weakly correlated with other factors. These two factors were therefore omitted from further analysis. The remaining nine factors were used as latent variables to create an analysis model assuming correlations between the variables (Figure 1).

“Introversion” and “Self-consciousness” are factors related to the respondents’ personality traits. Introversion and public self-consciousness are reported to be closely related personality traits (Kimura et al., 2008). “Self-consciousness” can

Table 1 Factor correlation matrix for 11 factors.

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| F1 | | | | | | | | | | | |
| F2 | .48 | | | | | | | | | | |
| F3 | .52 | .52 | | | | | | | | | |
| F4 | .27 | .31 | .31 | | | | | | | | |
| F5 | .46 | .21 | .37 | .43 | | | | | | | |
| F6 | .52 | .48 | .37 | .28 | .23 | | | | | | |
| F7 | .48 | .29 | .25 | .09 | .28 | .32 | | | | | |
| F8 | .53 | .20 | .20 | .14 | .22 | .51 | .36 | | | | |
| F9 | .30 | .32 | .22 | .12 | .11 | .30 | .33 | .27 | | | |
| F10 | .46 | .21 | .27 | .16 | .17 | .28 | .20 | .35 | .17 | | |
| F11 | .19 | .34 | .29 | .12 | .17 | .27 | .31 | .09 | .29 | .22 | |

Rounded off to two decimal places

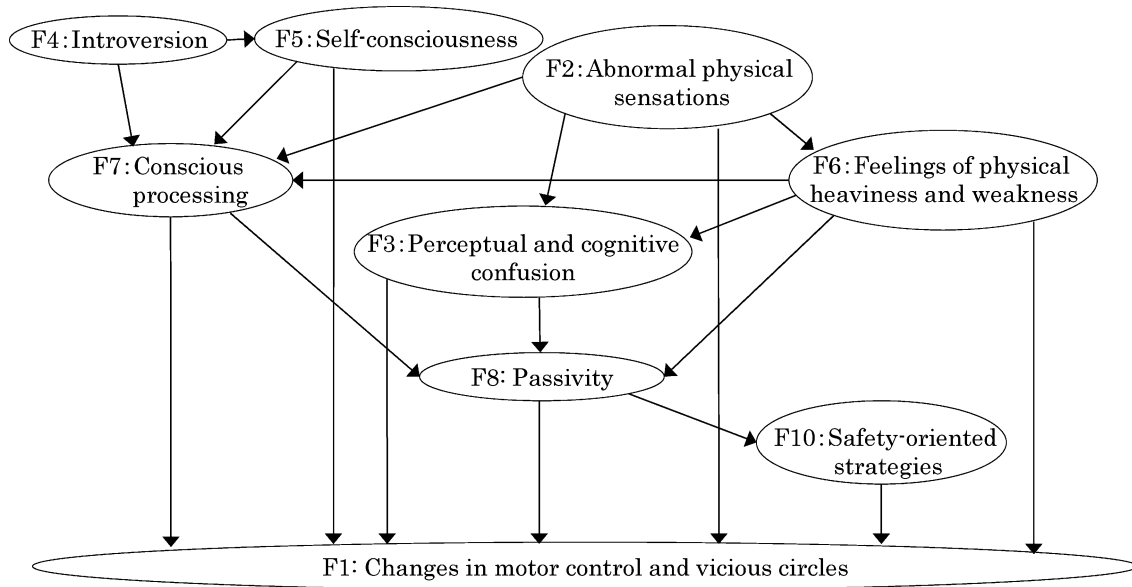


Figure 1 Model for analyzing “choking under pressure” assuming a relationship between latent variables

possibly lead to internally-directed attention to one’s movement or form and we predicted that “Self-consciousness” is affected by “Introversion.” Baumeister (1984) and Wang et al. (2004) have demonstrated that athletes with a greater sense of self-consciousness tend to exert more internally-directed attention. Taking these findings into account, we predicted “Introversion” and “Self-consciousness” to affect “Conscious processing.” We further hypothesized “Conscious processing” to affect “Changes in motor control and vicious circles” and “Passivity.” As previously mentioned, affective physical states precede emotions (e.g., Yamadori, 2008). Therefore we predicted “Abnormal physical sensations” to affect “Conscious processing,” “Perceptual and cognitive confusion” and “Feelings of physical heaviness and weakness.” We assumed that “Perceptual and cognitive confusion” arises from the abnormal “Feelings of physical heaviness and weakness.” Furthermore, changes in motor control that involves “Feelings of physical heaviness and weakness” may bring about “Safety-oriented strategies.” “Safety-oriented strategies” may be promoted by “Passivity.” Thus, we predict that “Feelings of physical heaviness and weakness” affect “Passivity,” and “Passivity” and “Safety-oriented strategies” lead to “Changes in motor control and vicious circles.”

2) Evaluation and reconstruction of analysis model

This study utilized the rating methods mentioned by Oshio (2004). The standard to adopt the model

was set at .90 for the CFI, GFI and AGFI. The covariance structure analysis of the analysis model provided goodness of fit values as follows: RMSEA = .05, GFI = .74, AGFI = .72, CFI = .77. The observable variable was 77 for this study. Toyoda (2002) suggests the use of RMSEA to measure the degree of dissociation for each degree of freedom for situations in which the observable variable is greater than 30. We therefore mainly used the RMSEA to measure the goodness of fit of our model with the data. Using Browne and Cudeck’s (1993) study as a reference, we set the standard value for the acceptance of the model at below .08. Our model did not achieve the minimum standard for model acceptance above .90 for the GFI, AGFI, or CFI indices, but it passed the minimum standard of below .08 for the RMSEA index. The following path coefficients between latent variables did not demonstrate a significant relation: “Feelings of physical heaviness and weakness” to “Perceptual and cognitive confusion” (path coefficient = .07), “Feelings of physical heaviness and weakness” to “Conscious processing” (path coefficient = .17), “Introversion” to “Conscious processing” (path coefficient = −.11), “Self-consciousness” to “Changes in motor control and vicious circles” (path coefficient = .11), “Abnormal physical sensations” to “Changes in motor control and vicious circles” (path coefficient = .16), and “Feelings of physical heaviness and weakness” to “Changes in motor control and vicious circles” (path coefficient = −.07). For

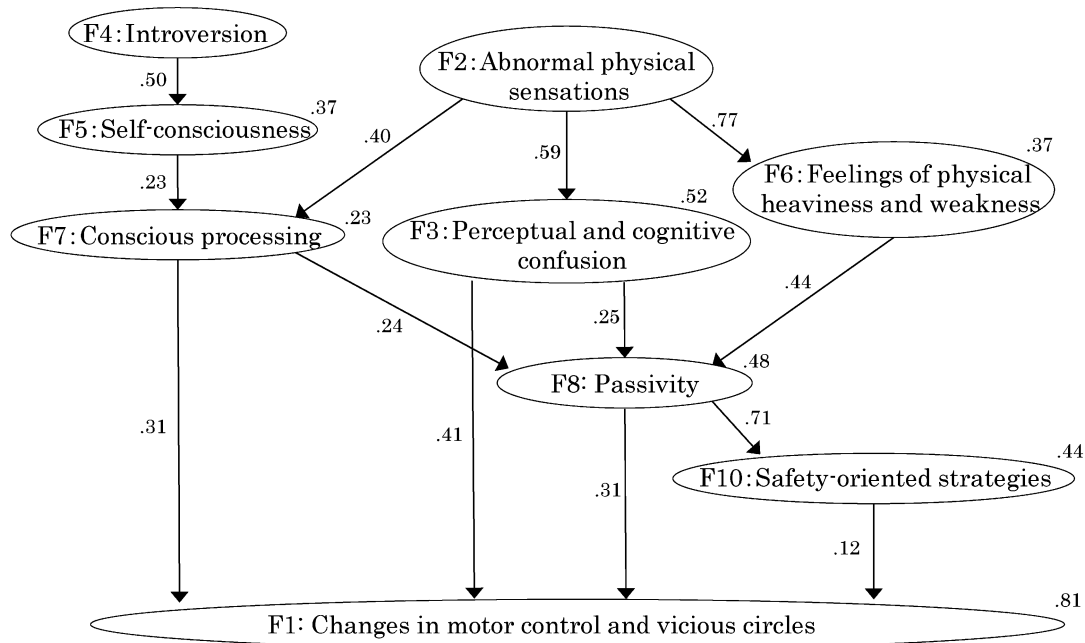


Figure 2 Mechanism model of “choking under pressure” in sports adopted in this study

covariance structure analysis, the deletion of statistically insignificant paths or the addition of new paths can improve the goodness of fit of the model. We deleted the following paths and subjected the model for covariance structure analysis: “Feelings of physical heaviness and weakness” to “Perceptual and cognitive confusion,” “Feelings of physical heaviness and weakness” to “Conscious processing,” “Introversion” to “Conscious processing,” “Self-consciousness” to “Changes in motor control and vicious circles,” “Abnormal physical sensations” to “Changes in motor control and vicious circles,” and “Feelings of physical heaviness and weakness” to “Changes in motor control and vicious circles.” Results indicated that all path coefficients between latent variables were statistically significant ($p < .001$). The goodness of fit values were as follows: RMSEA = .05, GFI = .74, AGFI = .72, and CFI = .77. Confirmatory factor analysis indicated that the influence index for “Changes in motor control and vicious circles” on Q90 and Q85 were .29, relatively low values. These two question items were omitted and covariance structure analysis was conducted. The goodness of fit values were as follows: RMSEA = .05, GFI = .75, AGFI = .73, and CFI = .79. Our model did not achieve the minimum standard for model acceptance above .90 for the GFI, AGFI, or CFI indices, but it passed the minimum standard of below .08 for the RMSEA index. For

the purposes of this study, we judged the analysis model as valid due to its goodness of fit value falling within the acceptance range for the RMSEA index. Confirmatory factor analysis indicated that each latent variable had a significant effect on the observable variable with influence index scores above .40 ($p < .001$). Taking these results into account, the statistical analyses suggest that the relations between the latent variables and the observable variables are appropriate. We present the model which describes the process of “choking under pressure” in Figure 2. We have noted the path coefficients for each path between latent variables. We have also indicated specific effects from a latent variable to another latent variable by presenting the multiple coefficient of determination on the upper right of the latent variable. In Table 2, we list the 11 factors identified by exploratory factor analysis along with factor loading, communality and influence index values for nine latent variables on observable variables from covariance structure analysis. The question items omitted during the process of covariance structure analysis are indicated with a “-.” The observable variables are only listed in Table 2 to simplify Figure 2 to show only latent variables.

4. Discussion

The purpose of this study is to identify the factors

Table 2 Factor loading and communality of 11 factors based on exploratory factor analysis; 9 latent variables, observable variables and influence index based on covariance structure analysis

| Question item content (latent variables and observable variables) | Factor loading | Communality | Influence index |
|---|----------------|-------------|-----------------|
| F1: Changes in motor control and vicious circles | | | |
| Q104 I made more movements or plays that did not lead to positive results | .83 | .65 | .70 |
| Q90 I was disappointed in myself | .79 | .64 | — |
| Q80 I was unable to perform the correct movement or play | .78 | .61 | .67 |
| Q103 My reaction time became delayed during play | .71 | .65 | .63 |
| Q81 I felt embarrassed | .67 | .61 | .59 |
| Q68 I could not move as I wanted to, which promoted “choking under pressure” | .64 | .78 | .76 |
| Q59 I became anxious following mistakes, which promoted “choking under pressure” | .62 | .63 | .70 |
| Q93 I had no confidence | .57 | .66 | .56 |
| Q74 My play did not lead to positive results | .56 | .64 | .54 |
| Q65 I put a lot of physical effort into the movement that usually comes natural | .52 | .57 | .59 |
| Q61 I became conscious of my mistakes | .51 | .58 | .59 |
| Q52 I made more mistakes than usual | .50 | .54 | .65 |
| Q87 I rushed while trying to calm down | .50 | .54 | .64 |
| Q79 I felt consumed by an inferiority complex | .46 | .56 | .57 |
| Q71 I strained to make the movement (related to the body or movements) | .42 | .49 | .47 |
| Q82 I became more aware of my surroundings | .41 | .51 | .47 |
| Q69 I could not determine if my plays were good or bad | .39 | .51 | .62 |
| Q28 I was rushing | .39 | .58 | .60 |
| Q85 I was able to play without wavering | .38 | .45 | — |
| Q54 I was consumed by the atmosphere | .38 | .46 | .53 |
| Q41 I could only think of negative images | .36 | .54 | .61 |
| Q18 I tried to control myself, but it ended up promoting “choking under pressure” | .35 | .66 | .65 |
| F2: Abnormal physical sensations | | | |
| Q101 I felt that my feet were not touching the ground | .75 | .73 | .64 |
| Q89 I felt that my body was floating | .70 | .62 | .62 |
| Q75 I could not feel my hands or feet | .61 | .63 | .72 |
| Q92 My breathing was irregular and I felt short of breath | .54 | .53 | .67 |
| Q83 I felt a lump in my throat | .48 | .72 | .61 |
| Q94 I could not move my hands and feet like I wanted | .46 | .66 | .69 |
| Q88 I felt that my head was hot(and sweaty) | .45 | .59 | .58 |
| Q84 I could not see the faces of the people around me | .43 | .50 | .60 |
| Q86 My hands felt cold | .43 | .44 | .45 |
| Q96 I did not want to speak with anyone | .39 | .47 | .51 |
| Q35 My hands and feet were shaking | .35 | .49 | .54 |
| Q76 I felt fear | .31 | .61 | .54 |
| F3: Perceptual and cognitive confusion | | | |
| Q45 I had been feeling stress from things that my teammates on the club (university) team had said | .67 | .57 | .55 |
| Q46 I began to not care about the results | .53 | .46 | .52 |
| Q62 I thought that I would fail every time | .48 | .65 | .70 |
| Q33 My technique was not at its best before the match (approximately one week before) | .47 | .50 | .46 |
| Q55 My physical condition was not at its best before the match (approximately one week before) | .45 | .50 | .41 |
| Q21 I had been losing confidence in the specific event or task before the match (e.g., individual/team, service/receive, PK, batting, etc.) | .45 | .39 | .51 |
| Q22 I felt that other people were all looking at me | .44 | .55 | .52 |
| Q97 I felt irritated | .42 | .48 | .56 |
| Q17 I saw surrounding objects as working against me (e.g., net looked higher, own court felt wider, etc.) | .40 | .43 | .53 |
| Q58 I felt detached from the surrounding environment | .36 | .58 | — |

Table 2 Continuance

| Question item content (latent variables and observable variables) | | Factor loading | Communality | Influence index |
|---|---|----------------|-------------|-----------------|
| F4: Introversion | | | | |
| P8 | I do not have a positive personality | .79 | .70 | .78 |
| P3 | I am passive | .76 | .61 | .76 |
| P4 | I tend to think negatively | .74 | .73 | .76 |
| P16 | I tend to be withdrawn | .54 | .71 | .66 |
| P2 | I am prone to feeling guilty | .40 | .50 | .52 |
| P14 | I cannot make new friends easily | .40 | .44 | .43 |
| F5: Self-consciousness | | | | |
| P12 | I worry about rumors concerning myself | .76 | .66 | .67 |
| P17 | I act thinking about how other people will evaluate me | .75 | .58 | .66 |
| P15 | I am easily hurt | .60 | .55 | .70 |
| P11 | I worry a lot | .47 | .45 | .61 |
| P13 | I frequently become nervous or neurotic | .44 | .45 | .60 |
| F6: Feelings of physical heaviness and weakness | | | | |
| Q7 | My feet felt heavy | .92 | .74 | .80 |
| Q9 | My hand and arms felt heavy | .77 | .71 | .80 |
| Q4 | I felt as if I could not move my feet | .64 | .68 | .78 |
| Q3 | I could not exert strength in my hands or feet | .41 | .63 | .63 |
| F7: Conscious processing (attention to movements) | | | | |
| Q66 | I became worried about my form or movements | .70 | .70 | .66 |
| Q29 | I was more aware of my form or movements | .70 | .61 | .56 |
| Q64 | I put forth effort to get rid of “choking under pressure” | .46 | .56 | .63 |
| Q51 | I put forth effort to manage “choking under pressure” | .42 | .73 | .67 |
| F8: Passivity | | | | |
| Q11 | I hesitated many times | .71 | .62 | .73 |
| Q12 | My decision-making skills were negatively affected | .56 | .57 | .69 |
| Q13 | My movements were stiff and not smooth | .52 | .65 | .71 |
| Q36 | My movements were half-hearted | .52 | .59 | .69 |
| Q8 | I was passive | .43 | .58 | .67 |
| F9: Feelings of physical fatigue | | | | |
| Q42 | I became tired from using more physical strength than usual | .86 | .76 | — |
| Q32 | I felt tired quicker than usual | .71 | .67 | — |
| Q16 | I was tired more than usual | .70 | .65 | — |
| F10: Safety-oriented strategies | | | | |
| Q40 | I was aware of movements or plays with low risk | .66 | .65 | .80 |
| Q72 | I utilized passive methods (tactics/strategies) | .62 | .66 | .77 |
| Q31 | I utilized safe, risk-free methods (tactics/strategies) | .57 | .50 | .60 |
| Q105 | I tried to make plays or movements without making mistakes | .46 | .53 | .54 |
| F11: Heat sensations | | | | |
| Q10 | My earlobe or face flushed with heat | .82 | .53 | — |
| Q24 | I felt my whole body was hot(and sweaty) | .71 | 1.00 | — |

Factor loading, communality and influence index were rounded off to two decimal places

related to “choking under pressure” during sports and to determine the relations between the involved factors. The participants of this study were university athletes. Exploratory factor analysis identified the following 11 factors: “Changes in motor control and vicious circles,” “Abnormal physical sensations,” “Perceptual and cognitive confusion,” “Introversion,” “Self-consciousness,” “Feelings of physical heaviness and weakness,” “Conscious processing (attention to movements),” “Passivity,” “Feelings of physical fatigue,” “Safety-oriented strategies,” and “Heat sensation.” The nine factors excluding “Feelings of physical fatigue” and “Heat sensation” were set as latent variables to create an analysis model. The validity of this analysis model to describe the process of “choking under pressure” was confirmed from statistical analysis.

4.1. Personality traits and attention in the context of pressure

Our questionnaire survey incorporated questions regarding changes in attention. Survey results demonstrated that a change in attention described as “Conscious processing” occurs during “choking under pressure” situations. In addition, a relation between “Conscious processing” and personality traits was revealed. Our model demonstrates that “Introversion” affects “Self-consciousness” and high levels of “Self-consciousness” promote “Conscious processing” which leads to changes in motor control and the vicious circle of “choking under pressure.” Baumeister (1984) and Wang et al. (2004) have reported that athletes with higher senses of self-consciousness have increased levels of conscious processing. However, we have shown for the first time that “Introversion” affects “Self-consciousness.” Fenigstein et al. (1975) divides self-consciousness into three factors. The first factor is private self-consciousness which directs one’s attention towards the inner unshared part of the self. The second factor is public self-consciousness which directs attention towards how others view the self. The third factor is social anxiety which include anxiety, shyness and embarrassment. “Self-consciousness” in the context of this study deals with tendencies to become more aware of others’ evaluations or rumors concerning oneself as well as increased anxiety from personality traits such as neuroticism or being worrisome. Therefore, “self-consciousness” in this study

indicates public self-consciousness and social anxiety. Public self-consciousness and social anxiety are closely correlated personality traits (Sugawara, 1984) and bring about “choking under pressure” or make a person prone to “choking under pressure” (Arimitsu, 1999; Tsutsumi, 2006).

The levels of public self-consciousness and social anxiety also affect attention and awareness. It has been reported that those with higher levels of public self-consciousness are more sensitive towards others’ critical attitudes (Fenigstein, 1979). We can predict that the “self-consciousness” we refer to in this study is a personality trait that promotes attention and awareness towards others. According to Tsutsumi (2006), “choking under pressure” occurs when one’s consciousness becomes directed towards others and one’s control over the self becomes lost. Tsutsumi (2006) further argues that directing one’s consciousness back to the self and creating one’s own world can reduce “choking under pressure.” “Self-consciousness” is a personality trait that is closely related to “choking under pressure,” particularly the public self-consciousness which directs awareness towards the external environment is the factor that most closely correlates with “choking under pressure.” In our study, “Introversion” is a factor that regulates “Self-consciousness.” Athletes with higher levels of “Introversion” have been reported to be more sensitive towards external stimuli and more prone to be excessively motivated during competition (Sugihara, 1987). Taking these findings into account, we predict that under pressure situations, athletes with high levels of “Introversion” tend to become excessively motivated and develop a heightened sense of “self-consciousness” leading to increased attention and awareness towards external stimuli.

In our study, we identified “Self-consciousness,” a factor known to promote attention towards external stimuli as a factor that controls “Conscious processing,” a factor that represents excessive internally directed attention towards movements. These results may seem contradictory at first glance regarding the relation between self-consciousness and changes in attention. However, Sugawara (1984) demonstrated that public self-consciousness and exhibitionism are correlated and that someone with a high level of exhibitionism tends to either take self-presentation behaviors or defensive, evasive behaviors. Self-presentation behaviors give rise to a strong

sense of awareness of how one is perceived by others and thus may increase a sense of internally directed attention. “Self-consciousness” in this study is a characteristic that promotes awareness and attention directed at others, but increased levels of self-presentation may lead to “Conscious processing,” an internally directed form of attention and thus alter motor control leading to decreased performance.

The effect of public self-consciousness on conscious processing is a new finding that has not been previously reported. Change in attention has been studied by many experimental studies and demonstrated to negatively affect performance. However, it remained unknown whether this phenomenon occurred during “choking under pressure” situations. Questionnaire surveys on “choking under pressure” (e.g., Ichimura, 1965) have studied the symptoms of “choking under pressure” but had not addressed whether changes in attention occurred or if personality traits played a role. Therefore, the significance of this study is that changes in attention occur during actual “choking under pressure” situations and changes in attention is correlated with personality traits.

4.2. Interaction between emotion and cognition

Our model demonstrated that “Abnormal physical sensations” is a factor that controls “Conscious processing.” “Abnormal physical sensations” refers to floating sensations or shaking, and abnormal breathing patterns. The factor also controls “Perceptual and cognitive confusion” and “Feelings of physical heaviness and weakness.” The path coefficient for “Abnormal physical sensations” to “Perceptual and cognitive confusion” is .59 and “Abnormal physical sensations” to “Feelings of physical heaviness and weakness” is .77, both relatively high values. “Feelings of physical heaviness and weakness” is a factor that refers to feelings of heaviness of hands and feet as well as incomplete control over strength. During “choking under pressure” situations, many changes occur including altered attention leading to conscious processing of movement, despair, resignation, negative perceptions and awareness of environment, and feelings of heaviness or loss of strength of hands and feet. These changes are more likely to occur when “Abnormal physical sensations” are at a high level.

“Abnormal physical sensations” is an abnormal sensation based on an affective physical state reflecting the influences of the physiological aspect. According to the catastrophe model which explains “choking under pressure” as an interaction between physiological activation and cognitive anxiety (Hardy, 1990; Hardy and Parfitt, 1991), high levels of physiological activation and increased cognitive anxiety lead to decreased performance. Although it has been demonstrated that affective physical states precede emotions (Yamadori, 2008), the relations between “Abnormal physical sensations,” an affective physical state, and “Conscious processing” or “Feelings of physical heaviness and weakness” have not been reported. Calvo and Miguel-Tobal (1998) point out that clear changes in heart rate or galvanic skin responses promote perceptions of internal feelings and thus make it more likely for respondents to report feelings of anxiety. However they did not mention whether those changes relate to conscious processing.

Our study demonstrates that higher levels of “Abnormal physical sensations” promote “Conscious processing,” “Perceptual and cognitive confusion,” and “Feelings of physical heaviness and weakness.” These results indicate that the interactions between emotions and cognitions underpin “choking under pressure.”

By the way, in this study, we did not identify reduction in processing efficiency as a factor. It is possible that “Abnormal physical sensations” played a role in this result. Cognitive changes such as processing efficiency and conscious processing have been tested experimentally in the context of “choking under pressure.” However, the “choking under pressure” situations created in the lab are likely not as strong as the situations that involve abnormal physical sensations such as floating sensations or shaking. It is likely that “choking under pressure” situations in the lab are clearly different from actual situations in terms of the physical affective response. Strong affective physical responses may cause an athlete to focus on one’s own physical state or movement instead of external spectators or results. However, there are very few studies that have specifically studied changes in attention for high levels of pressure. It remains unclear whether actual “choking under pressure” situations entail decreased processing efficiency. Future studies will need to be conducted to test the changes in attention

that occur for high levels of pressure.

It is difficult to explain “choking under pressure” from only a cognitive perspective. The results from this study incorporate factors other than changes in attention to explain “choking under pressure” and present the importance of clarifying the relations between the involved factors.

4.3. Factors that affect motor control

This study identified that “Abnormal physical sensations” promote “Feelings of physical heaviness and weakness,” and promoted “Feelings of physical heaviness and weakness” affect “Passivity.” “Passivity” refers to decreased decision-making skills, increased hesitation, and passive movements. It also describes stiff, clumsy movements. We assumed “Passivity” and “Feelings of physical heaviness and weakness” are closely correlated with abnormal motor control during “choking under pressure” situations. “Passivity” was determined to be a factor that controls “Changes in motor control and vicious circles,” the factor directly leading to decreased performance. Recent experimental studies have shown that kinematic and kinetic changes that occur under pressure situations directly cause decreases in performance (e.g., Tanaka and Sekiya, 2006). It has been reported that increased heart rate may lead to behavioral changes (Tanaka and Sekiya, 2010b). The results of this study support the notion that performance is influenced by affective physical states but also demonstrate that there are perceptive and cognitive changes as well physical sensational changes such as heaviness of the hands and feet that are promoted by affective physical states. Furthermore, these changes give rise to passive behaviors and negatively affect performance by altering motor control.

We demonstrate that a greater level of “Passivity” makes it more likely for an athlete to employ a “Safety-oriented strategies” which in turn conducts “Changes in motor control and vicious circles.” “Safety-oriented strategies” refers to passive and safe methods (tactics/strategies) which minimize the risk of failure. These unusual strategies may lead to changes in motor control. The path coefficient from “Passivity” to “Safety-oriented strategies” is .71, a relatively high value. The changes in motor control that arise during “choking under pressure” situations are controlled by changes in strategy which

stress risk-aversion as well as “Passivity” which refers to increased hesitation and half-hearted plays. Previous studies concerning “choking under pressure” have indicated that kinematic changes that occur under pressure are brought about by changes in strategy (Gage et al., 2003; Higuchi et al., 2002; Tanaka and Sekiya, 2006, 2010a). There has not been any study that has utilized questionnaire surveys to examine whether changes in strategy occur during actual “choking under pressure” situations. In the present study, our results indicate that changes in the behavioral aspect make it more likely that an athlete employs a safety-oriented strategies. In order to fully grasp the phenomenon of “choking under pressure,” we must incorporate strategy into the current prevailing hypotheses which only account for changes in attention. One limitation in our study is that the athletes in our study participate in a variety of sports. It will be a topic for future study to determine if the employment of safety-oriented strategies during “choking under pressure” situations occurs for all sports. Studying the specifics of safety-oriented strategies may lead to new methods to prevent changes in motor control.

In this study, we examined the relations between the factors involved in “choking under pressure” and present a model to describe the process of “choking under pressure.” Nine factors were identified to be involved in “choking under pressure,” making it difficult to explain the process using one factor. The model may serve to suggest more effective methods to prevent the changes in attention or physical state that occur under pressure situations.

Assuming that “Passivity” and “Safety-oriented strategies” are factors that control performance, it is still difficult to test how these factors cause kinematic and kinetic changes. Questionnaire surveys in general base their analysis on subjective data, but it is possible that in actual “choking under pressure” situations, kinematic and kinetic changes occur as a result of unconscious events. In order to study the minute kinematic and kinetic changes that occur in the behavioral aspect, experimental studies are more applicable. Objective measurements of these changes under pressure situations can lead to elucidating behavioral changes that directly cause decreased performance or identifying psychological and physiological factors that influence the behavioral changes. It is also impossible to identify all of the relations between latent variables using covari-

ance structure analysis. As mentioned by Murayama et al. (2009), it is likely that relations between factors are not unidirectional. During actual “choking under pressure” situations, a bidirectional interaction may occur. In the present study, we were able to create a valid analysis model based on findings from previous studies, but it remains necessary to test the bidirectional interactions that may occur between factors. The questionnaire survey in the present study provided cross-sectional data, making it impossible to accurately predict the temporal orders between factors. In the future, we must study the cause and effect relations between the factors identified in this study.

5. Conclusion

The purpose of this study is to identify the factors related to “choking under pressure” during sports and to determine the relations between the involved factors. The participants of this study were university athletes. Exploratory factor analysis identified the following 11 factors: “Changes in motor control and vicious circles,” “Abnormal physical sensations,” “Perceptual and cognitive confusion,” “Introversion,” “Self-consciousness,” “Feelings of physical heaviness and weakness,” “Conscious processing,” “Passivity,” “Feelings of physical fatigue,” “Safety-oriented strategies,” and “Heat sensation.” The nine factors excluding “Feelings of physical fatigue” and “Heat sensation” were set as latent variables to create an analysis model. The validity of this analysis model to describe the process of “choking under pressure” was confirmed from statistical analysis. According to our model that describes the process of “choking under pressure,” “Self-consciousness” and “Abnormal physical sensations” promote “Conscious processing” which in turn influences “Changes in motor control and vicious circles,” a factor directly correlated with decreased performance. “Abnormal physical sensations” control “Perceptual and cognitive confusion” as well as “Feelings of physical heaviness and weakness.” Athletes with higher levels of “Perceptual and cognitive confusion” and “Feelings of physical heaviness and weakness” tend to have a greater sense of “Passivity” making an athlete more likely to employ a “Safety-oriented strategies.” The “Safety-oriented strategies” promotes “Changes in motor control and vicious circles.” In summary, the

present study demonstrates that there are changes in the psychological, physiological and behavioral aspects that lead to decreased performance. It is difficult to explain the phenomenon of “choking under pressure” from only changes in attention. We present a model to describe the process of “choking under pressure” in which interactions between emotions and awareness as well as the employment of safety-oriented strategies control changes in motor control.

Note

*1: “Choking under pressure” can be defined as “A state of excessive mental and physical tension experienced during especially important matches or decisive moments (Honma, 2008)” or “Experiences of awareness towards others, feelings of responsibility, self-imperfection, physical imperfection, physiological responses or shaking during situations which could entail negative evaluations of oneself such as elections or social evaluations. Generally, changes in awareness towards others or in sense of responsibility during certain situations (Arimitsu, 2005).” “Choking under pressure” is sometimes referred to as “stage fright (Honma, 2008).” It has been pointed out that there is no fixed definition or terminology when used in the context of psychology research (Arimitsu, 2005; Ichimura, 1965). However, “choking under pressure” is frequently utilized in performance decrements for sports or motor skills (e.g., Beilock and Carr, 2001; Gucciardi et al., 2010). Recent studies frequently use “choking under pressure (Murayama et al., 2009; Tanaka and Sekiya, 2006; Yoshie et al., 2011).” “Especially important matches or decisive moments” and “elections or social evaluations which could entail negative evaluations of oneself” can be construed to refer to “pressure” defined by Baumeister (1984) as a factor that increases the importance of performing well. Taking these factors into account and following recent trends, we utilized “choking under pressure.”

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