



# Decision-making in Sport under Mental and Physical Stress

Teri J. Hepler (Corresponding author)

Department of Exercise and Sport Science, University of Wisconsin-La Crosse

1725 State St. La Crosse, WI, USA

E-mail: thepler@uwlax.edu

Received: 07-16- 2015

Accepted: 29-10- 2015

Published: 31-10- 2015

doi:10.7575/aiac.ijkss.v.3n.4p.79

URL: <http://dx.doi.org/10.7575/aiac.ijkss.v.3n.4p.79>

*The research was funded by a Faculty Research Grant awarded by the University of Wisconsin-La Crosse.*

## Abstract

**Background:** Successful decision-making in sport requires good decisions to be made quickly, but little is understood about the decision process under stress. **Objective:** The purpose of this study was to compare decision outcomes and the Take the First (TTF) heuristic under conditions of mental, physical, and no stress. **Method:** Participants ( $N=112$ ) were divided into 3 stress groups: mental stress (mental serial subtraction), physical stress (running on treadmill at 60-70% of maximum effort), and no stress (counting backwards by 1). Participants were exposed to 30 seconds of stress and then watched a video depicting an offensive situation in basketball requiring them to decide what the player with the ball should do next. Each participant performed 10 trials of the video decision-making task. **Results:** No differences were found between the 3 stress groups on decision quality, TTF frequency, number of options generated, or quality of first generated option. However, participants in the no stress and physical stress conditions were faster in generating their first option and making their final decision as compared to the mental stress group. **Conclusion:** Overall, results suggest that mental stress impairs decision speed and that TTF is an ecologically rationale heuristic in dynamic, time-pressured situations.

**Keywords:** Take the first, Heuristic, Pressure, Cognitive performance

## 1. Introduction

One of the key ingredients to success in sport is making good decisions. Top athletes seem to have a knack for knowing what to do and when to do it. As decision-making is such a critical component of sport performance, it is important to fully understand the process that athletes use to make decisions and the factors that might influence this process. One framework that has helped to shed light on the complex process on decision-making in sport is heuristics. A heuristic is a rule of thumb, or a simple mental device, used to make decisions in situations with limited knowledge and time (Raab & Gigerenzer, 2005). In regards to sport, fast and frugal heuristics may be especially useful because they rely on limited information to make quick decisions (Gigerenzer, Todd, & ABC Research Group, 1999). One fast and frugal heuristic which has been shown to be related to decision-making in dynamic, time pressured situations in sport is the Take the First (TTF) heuristic (Johnson & Raab, 2003; Raab & Johnson, 2007). According to TTF, a person who is performing a familiar, ill-defined task should do the first thing that comes to mind. In essence, TTF represents intuitive or gut decision-making. The TTF heuristic suggests that options are generated in a sequential fashion with earlier options representing better options. As a result, the heuristic proposes that “less-is-more” when it comes to generating different options, as the best option is likely to be one of the first ones that spring to mind. Previous research in sport has provided support for many of the key tenets of TTF. For example, several studies have shown that people choose the first option (i.e., TTF) a majority of the time (e.g., 60-85%) when making decisions in open, interdependent team such as handball and basketball. Moreover, people tend to generate only 2-3 options per trial and the first option is typically the best one (Hepler & Feltz, 2012; Johnson & Raab, 2003; Laborde & Raab, 2013; Raab & Johnson, 2007).

One important aspect that has often been overlooked in previous research on decision-making in sport is that athletes routinely make decisions while performing under various mental and physical stressors. Some commonly cited stressors include poor calls by officials, crowd noise, pain and injury, performance errors, criticism from coach, and poor weather or playing conditions (Anshel & Si, 2008; Qiwei, Anshel, & Kim, 2009). Previous research on sport decision-making has provided somewhat inconclusive evidence regarding the effect of stress on decisions. One recent study examined decision-making on a video decision task in basketball. Results indicated that for highly complex situations, pressure had a negative impact on decision quality (Kinrade, Jackson, & Ashford, 2015). Similarly, another study reported that basketball players made worse decisions in situations categorized as high-criticality possessions (i.e., high stress) as compared to low-criticality possessions (Bar-Eli & Tractinsky, 2000). Conversely, research involving junior elite male water polo players found that high physical stress improved tactical decision-making as compared to lower levels of physical stress (Royal, Farrow, Mujika, Halson, Pyne, & Abernethy, 2006).

As athletes constantly make decisions under stress, and stress may impact decision-making, it is important to better

understand this relationship in sport. Accordingly, the general purpose of this study was to examine the influence of mental and physical stress on decision-making in sport. The first aim was to explore how mental and physical stress impact decision outcomes, such as the quality and speed of decisions. As previous research has yielded equivocal results regarding the influence of stress on decision outcomes, it is important to continue to investigate the parameters of this relationship. Meanwhile, the second objective examined the influence of stress on various aspects of the TTF heuristic, including TTF frequency, number of options generated, first option quality, and first option speed. This objective is important because it has been suggested that stress can alter a person's use of heuristics (Johnson, Payne, & Bettman, 1993; Payne, Bettman, & Luce, 1996). As seen by the studies cited above, it is possible that mental and physical stress may influence decision-making differently. Therefore, the effects of mental and physical stress were compared for all research questions.

## 2. Methods

### 2.1 Participants

Participants in the study included 112 undergraduate students (57 males, 45 females) enrolled in classes in the exercise and sport science department. Participants were mainly upper level students (33 seniors, 61 juniors, 18 sophomores). Each participant was randomly assigned to a stress condition: mental stress ( $n = 40$ ), physical stress ( $n = 41$ ), and no stress ( $n = 31$ ). Most of the participants had at least 1 year of competitive basketball playing experience ( $n = 85$ ).

### 2.2 Instrumentation

#### 2.2.1 Video situations.

Ten video clips of various offensive situations in basketball (e.g., half-court offense, fast breaks, etc.) were used in the study (see Hepler & Feltz, 2012 for a full description of videos). Each video showed a portion of the play and was suddenly occluded with one player in possession of the ball needing to make a decision regarding the next move. Of the 10 video situations used in the study, 6 were used in a previous study (Hepler & Feltz, 2012) with the basketball experts unanimously agreeing upon a best possible decision. Since there was a clear best option for these videos, they could be construed as easy decision-making scenarios. Therefore, in order to test decision-making under more uncertain situations, 4 additional scenarios were used in the current study. For these 4 videos, only 2 of the basketball coaches agreed upon a best course of action with the third coach selecting a different option.

#### 2.2.2 Scoring of videos.

Likely options for each video situation were scored by three collegiate basketball coaches using the following 5-point Likert scale: 0 = *inappropriate*, 1 = *somewhat appropriate*, 2 = *appropriate*, 3 = *very appropriate*, 4 = *best possible*. The average of all coaches' ratings was used to determine the score of each option. Accordingly, scores could range from 0 (*inappropriate*) to 4 (*best possible*).

#### 2.2.3 Stress conditions.

In the mental stress task, participants were asked to mentally subtract 7 from a four-digit number, respond verbally, and repeat the process with each subsequent answer (e.g., 2028, 2021, 2014, etc.). Participants were instructed to perform as many correct calculations as possible and informed that any mistakes would require them to start over from the beginning. Previous research has used similar mental arithmetic tasks to create mental stress (Diller, Patros, & Prentice, 2011; Whited, Wheat, & Larkin, 2010). Physical stress involved running on a treadmill. Prior to each trial, participants ran on the treadmill for 30 s at a moderate, self-selected pace estimated to be 60-70% of their maximum effort (i.e., an "all out sprint"). Each participant's pace was determined prior to the decision-making task and the same pace was used through all trials. Participants in the no stress, or control, condition simply counted backwards from a 2-digit number (e.g., 73, 72, 71). All stress tasks were performed for 30 s and immediately followed by a decision-making trial.

### 2.3 Procedure

All procedures and instruments were approved by the institutional review board and informed consent was obtained for all participants. Each participant completed 10 decision-making trials under one of the three stress conditions. Before each trial, participants were exposed to 30 s of the assigned stressor. The decision-making task required participants to name their first, intuitive option, generate any other options they felt were acceptable, select one option as the best decision, and rate their confidence in that decision (0 = not at all confident; 10 = extremely confident). All responses were made verbally and recorded by the experimenter. The computer measured response time for the first option and final decision.

## 3. Results

### 3.1 Descriptive Statistics

On average, participants had over 5 years of competitive basketball playing experience ( $M = 5.80$ ,  $SD = 4.12$ ) and there were no significant differences between the stress groups on number of years of basketball playing experience. Participants used TTF extensively, as they chose the first option on 926 out of 1,120 trials. In terms of average decision outcomes, it took just under 6 s for participants to make *appropriate-to-very appropriate* decisions. See Table 1 for descriptive statistics.

### 3.2 Main Analyses

One-way analysis of variance was used to compare the 3 stress conditions (mental, physical, and no-stress) on the

following decision outcomes and aspects the TTF heuristic: final decision quality, final decision speed, TTF frequency, number of options generated, first option quality, and first option speed. There were no significant group differences on final decision quality ( $F(2,102) = .52, p = .60, \eta^2 = .01$ ), TTF frequency ( $F(2,107) = 1.49, p = .23, \eta^2 = .03$ ), number of options generated ( $F(2,103) = 2.36, p = .10, \eta^2 = .04$ ), or first option quality ( $F(2,107) = .22, p = .80, \eta^2 = .00$ ). However, results indicated that there were group differences on final decision speed ( $F(2,109) = 10.64.383, p = .015, \eta^2 = .07$ ), as well as the speed with which first options were generated ( $F(2,109) = 5.42, p = .006, \eta^2 = .09$ ). According to post hoc tests, participants in the no stress and physical stress conditions made their final decisions significantly faster than participants in the mental stress condition. Similarly, first options were generated significantly faster by participants under no stress and physical stress as compared to mental stress. Table 1 presents the means and standard deviations of each stress group for the variables of interest.

Table 1. Means and Standard Deviations for Decision Outcomes and TTF Variables

	Mental Stress M (SD)	Physical Stress M (SD)	No Stress M (SD)	Total M (SD)
Quality of final decision	2.74 (0.43)	2.64 (0.47)	2.65 (0.48)	2.67 (0.46)
Speed of final decision (s)	6.74 (2.39)*	5.51 (2.16)*	5.42 (1.95)*	5.92 (2.26)
Confidence in final decision	7.07 (1.13)*	7.18 (1.50)*	8.14 (1.34)*	7.41 (1.40)
TTF frequency	8.51 (1.34)	8.63 (1.19)	8.03 (1.86)	8.45 (1.42)
Number of options	1.61 (0.66)	1.44 (0.46)	1.77 (0.74)	1.59 (0.63)
Quality of 1 <sup>st</sup> option	2.70 (0.39)	2.63 (0.46)	2.67 (0.50)	2.67 (0.44)
1 <sup>st</sup> option generation speed (s)	2.85 (1.12)*	2.30 (0.68)*	2.26 (0.69)	2.49 (0.90)

#### 4. Discussion

This study examined how mental and physical stress influence various aspects of decision-making and the TTF heuristic. In terms of decision outcomes, results suggest that stress impacts the speed of decision-making, but not the quality of the final decision. Specifically, it was found that participants in the mental stress condition were slower to generate their first options and make their final decisions as compared to those under no stress or physical stress. One possible explanation is that mental stress may distract participants' attention from the task at hand thereby slowing down the option-generation and decision process. For example, participants in the mental stress condition may have been distracted by trying to figure out the next number in the sequence or dwelling on an easy arithmetic mistake. These distracting thoughts are similar to what athletes may encounter during competition, such as ruminating over a past mistake or worrying about their performance. Due to these task-unrelated thoughts, the option generation and decision processes may have been delayed. Previous theory and research suggests that performance pressure (i.e., stress) can increase task-irrelevant thoughts (e.g., worries, consequences of actions), which can hurt skill execution (Carver & Scheier, 1981). In particular, rumination has been shown to affect decision-making under pressure (Kinrade, Jackson, & Ashford, 2015). Similarly, stress can tax one's working memory capacity thereby impairing performance on tasks requiring superior executive functioning (Beilock, 2008), such as decision-making. Another possible explanation relates to confidence. Following each decision, participants were asked to rate their confidence in that decision. Results indicated that participants in the no stress condition were more confident in their decisions as compared to participants in the stress conditions ( $F(2,104) = 11.96, p < .001$ ). This finding is similar to previous research citing that stress can decrease decision confidence (Heereman & Wall, 2011). Accordingly, participants in the mental stress condition, who may have been distracted and were not as confident in their decisions, may have second guessed themselves before coming to a final conclusion, resulting in a slower decision time than those performing under no stress. One final possibility that must be considered in any between-subjects design is that the differences were not due to the treatment (i.e., type of stress), but rather were due to preexisting differences among the groups. Accordingly, it is possible that the participants in the mental stress group were simply slower decision-makers than those participants who were assigned to the no stress and physical stress groups. However, as random assignment was used to determine stress condition membership, it is reasonable to assume that the groups were relatively equivalent. To support this notion, it was found that there were no significant differences on basketball playing experience among the three stress groups. Nonetheless, based on the paucity of previous research comparing mental and physical stress and the between-subjects design of the current study, the results should be interpreted with caution.

While results did not find any differences between the stress conditions on quality of final decision, it is important to consider this relationship as it occurs in an authentic athletic context. Many sports involve constantly evolving situations that change from moment to moment. A high quality decision must be made in a timely fashion in order for a decision to be successful. However, the design of the decision task did not take this dynamic, time-pressured element into consideration. In the current study, decision quality was examined separately from decision speed. In this manner, participants could get a high quality decision score even if it took a long time to reach that decision. However, in an actual sporting situation, waiting too long to make a decision often results in a poor outcome (e.g., waiting too long to pass to an open teammate and allowing defender time to recover and intercept the pass). For example, Bar-Eli and Tractinsky (2000) analyzed videos of players' decisions made at the end of close basketball games. Results indicated

that the players made the worst decisions on highly critical (i.e., highly stressful) situations. A key aspect of the study was that it examined decision-making in a live, authentic context whereby successful decision-making required both speed and accuracy. As the current study judged decision quality in a static, non-time-pressured environment, future research should seek to clarify this relationship.

Overall, results of this study supported numerous aspects of TTF and extend its predictions to decision-making under mental and physical stress. First, it was demonstrated that participants rely extensively on TTF, even when performing under conditions of stress. In other words, it seems as if people use the same rules, or heuristics, to make decisions under stress as they do under non-stressful conditions. This provides evidence that TTF is an ecologically rationale heuristic for making decisions in dynamic sporting situations in both stressful and non-stressful conditions. Other facets of TTF that were supported in the current study relate to the option generation process. On average, participants only generated 1.5 options per trial and the first option was in fact the highest quality option. These findings support the “less is more” aspect of TTF stating that few options should be generated because the first option will be among the best. Taken as a whole, it would appear that the tenets and predictions of TTF apply to decision-making under both stressful and non-stressful situations.

Another facet of the study examined if mental stress had a different influence on decision-making as compared to physical stress. Overall, the two types of stress were similar on most dependent variables, except for speed of option-generation and decision-making. Specifically, participants performing under mental stress were slower in generating their first options and making their final decisions as compared to those in the physical stress condition. One possible interpretation of these differences is that mental stress created more cognitive changes (e.g., working memory, attention) than did physical stress. However, it is important to consider other plausible explanations as well. For example, participants in the study were all enrolled in courses offered by the exercise science department. As such, they were likely highly accustomed to physical activity and therefore did not find the physical stressor of running to be sufficiently taxing. Conversely, the mental arithmetic task may have been perceived as highly stressful. It is possible that if the study recruited participants from the math department, then opposite results hailing the benefits of mental stress may have been observed. An alternative explanation is that stressors which are congruent with the type of task influence performance more so than stressors of a different modality. As decision-making and mental serial subtraction are both cognitive tasks, mental stress impaired decision-making performance whereas physical stress (i.e., incongruent stressor) had little-to-no impact. Similarly, it is possible that physical stress may have a bigger impact on the physical execution of a motor skill. As relatively few published studies have compared the effects of mental and physical stress on decision-making, it is important to recognize that this is a fairly unique finding that should be investigated further before making general conclusions.

One particularly interesting finding of the study was that there were no differences in decision speed between participants in the no stress and physical stress conditions. This is somewhat surprising as several studies have reported that people make faster decisions when performing under physical stress than when performing under little or no stress (Nieuwenhuys, Savelsbergh, & Oudejans, 2012; Rendi, Szabo, Szabó, 2007; Thomson, Watt, & Liukkonen, 2009). For example, one study compared information processing speed while performing a progressive treadmill running task to 50%, 60%, 70%, and 80% of maximum heart rate reserve. Results indicated that decision speed was fastest when participants ran at the highest (80%) intensity. As the current study instructed participants to run at 60-70% of the maximum effort, it is possible that this level of exertion was not intense enough to elicit differences from the no stress condition.

#### *4.1 Limitations and Future Directions*

There are several limitations of the current study. First, the study used a general population, rather than highly experienced basketball players, so it is not known if results would generalize to skilled athletes. Another limitation is that the study used videos to examine decision-making instead of exploring decisions made in a live sporting context. Additionally, the study did not employ any manipulation check of stress (e.g., cortisol, heart rate variability, self-report), so it is not possible to determine how much, if any, stress was created by the mental and physical stress tasks. Likewise, the study utilized a between-subjects design, which despite random assignment may have created unequal groups and allowed individual differences on confounding variables to influence the results. Finally, the study did not incorporate different levels of stress (i.e., high, moderate, low) to determine the effect of different levels of stress on decision-making.

There are several ways in which future research could advance our understanding of decision-making under stress. First, as athletes must make decisions while under the influence of both mental and physical stress, future studies should consider simultaneously combining mental and physical stress. Similarly, future research could manipulate the levels of stress to determine if different amounts have a different influence on decision-making. In other words, it would be valuable to explore if low levels of stress has a different impact on decision-making than does high stress. Future lab studies should consider the authentic target context and, when appropriate, incorporate time pressure for those sports that demand quick, high quality decisions. Using a within subjects design, where participants served as their own controls and experienced various types of stressors, would provide a stronger, more definitive comparison of mental and physical stress. Finally, researchers should investigate how psychosocial variables, such as self-efficacy and trait anxiety, might influence decision-making under stress.

#### 4.2 Conclusions

An athlete's performance is only as good as the decision he or she makes. Making a low quality decision or hesitating for a fraction of a second could mean the difference between success and failure. Accordingly, one way to enhance sport performance is to improve decision-making skills. In order to improve decision capabilities, it is important to better understand how decisions are made and how stress affects the decision-making process. The results of the current study suggest that people make similar quality decisions and use the same decision rule while performing under conditions of mental, physical, and no stress. However, mental stress slows down decision speed. In turn, a slow decision speed will affect the quality of decisions in dynamic, time-pressured situations. Therefore, strategies for coping with mental stress may be useful in helping to improve decision-making.

#### References

- Anshel, M.H. & Si, G. (2008). Coping styles following acute stress in sport among elite Chinese athletes: A test of trait and transactional coping theories. *Journal of Sport Behavior*, 31, 3-21.
- Bar-Eli, M. & Tractinsky, N. (2000). Criticality of game situations and decision-making in basketball: An application of performance crisis perspective. *Psychology of Sport & Exercise*, 1, 27-39.
- Beilock, S.L. (2008). Math performance in stressful situations. *Current Directions in Psychological Science*, 17, 339-343. doi: 10.1111/j.1467-8721.2008.00602.x
- Carver, C.S., & Scheier, M.F. (1981). *Attention and self-regulation: A control-theory approach to human behavior*. New York: Springer-Verlag.
- Diller, J.W., Patros, C.H., & Prentice, P.R. (2011). Temporal discounting and heart rate reactivity to stress. *Behavioural Processes*, 87, 306-309. doi: 10.1016/j.beproc.2011.05.001
- Gigerenzer, G., Todd, P.M., & ABC Research Group (1999). *Simple heuristics that make us smart*. New York: Oxford University Press.
- Heereman, J. & Walla, P. (2011). Stress, uncertainty, and decision confidence. *Applied Psychophysiology and Biofeedback*, 36, 273-279. doi: 10/1007/s10484-011-9167-9
- Hepler, T.J. & Feltz, D.L. (2012). Take the first heuristic, self-efficacy, and decision-making in sport. *Journal of Experimental Psychology: Applied*, 18, 154-161.
- Johnson, E.J., Payne, J.W., & Bettman, J.R. (1993). Adapting to time constraints. In O. Svenson & J. Maule (Eds.) *Time pressure and stress in human judgment and decision making*, (pp. 103-116). New York: Plenum.
- Johnson, J.G. & Raab, M. (2003). Take the first: Option-generation and resulting choices. *Organizational Behavior and Human Decision Processes*, 91, 215-229.
- Kinrade, N.P., Jackson, R.C., & Ashford, K.J. (2015). Reinvestment, task complexity and decision making under pressure in basketball. *Psychology of Sport and Exercise*, 20, 11-19.
- Laborde, S. & Raab, M. (2013). The tale of hearts and reason: The influence of mood on decision making. *Journal of Sport & Exercise Psychology*, 35, 339-357.
- Nieuwenhuys, A., Savelsbergh, G.J.P., & Oudejans, R.R.D. (2012). Shoot or don't shoot? Why police officers are more included to shoot when they are anxious. *Emotion*, 12, 827-833. doi: 10.1037/a0025699.
- Payne, J.W., Bettman, J.R., & Luce, M.F. (1996). When time is money: Decision behavior under opportunity-cost time pressure. *Organizational Behavior and Human Decision Processes*, 66, 131-152.
- Porcelli, A.J., Delgado, M.R. (2009). Acute stress modulates risk taking in financial decision making. *Psychological Science*, 20, 278-283.
- Qiwei, G., Anshel, M.H., & Kim, J.K. (2009). Sources of cognitive appraisals of acute stress and predictors of coping style among male and female Chinese athletes. *International Journal of Sport & Exercise Psychology*, 7, 68-88.
- Raab, M. & Gigerenzer, G. (2005). Intelligence as smart heuristics. In R.J. Sternberg, J. Davidson, & J. Pretz (Eds). *Cognition and intelligence* (pp. 188-207). Cambridge: Cambridge University Press.
- Raab, M. & Johnson, J.G. (2007). Expertise-based differences in search and option-generation strategies. *Journal of Experimental Psychology: Applied*, 13, 158-170.
- Rendi, M., Szabo, A., & Szabó, T. (2007). Relationship between physical exercise workload, information processing speed, and affect. *International Journal of Applied Sports Sciences*, 19, 86-95.
- Royal, K.A., Farrow, D., Mukika, I., Halson, S.L., Pyne, D., & Abernethy, B. (2006). The effects of fatigue on decision making and shooting skill performance in water polo players. *Journal of Sports Sciences*, 24, 807-815.
- Thomson, K., Watt, A., Liukkonen, J. (2009). Differences in ball sports athletes speed discrimination skills before and after exercise induced fatigue. *Journal of Sports Science and Medicine*, 8, 259-264.
- Whited, M. C., Wheat, A., L., & Larkin, K. T. (2010). The influence of forgiveness and apology on cardiovascular reactivity and recovery in response to mental stress. *Journal of Behavioral Medicine*, 33, 293-304.