The effect of changing ball rate on decision making performance in experienced men table tennis players

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Abstract

The aim of this study was to investigate decision making at low and high levels of complexity by experienced table tennis players when balls were thrown at them with varying interval rates (slow, normal and fast). Fifteen players were randomly selected from the experienced table tennis player’s at Bushehr city. Players who earned at least 90% score in the mental exam, proceeded to participate in practical test. The test comprised of two levels of simple and complex decision makings in response to 20 balls that were fired by the bowler machine. The levels of complexities were created by color of balls and alternating target zones. The analysis of variance with repeated measure was used to calculate the dependent variable (α=0.05). The results of a 3×2 ANOVA with repeated measure and Bonferroni post hoc test for main effects showed that simple decision was better in all rates (α=0.05) and one way ANOVA with repeated measure and also the paired samples t-test were used to investigate the partial effects (Adjusted α=0.01). Result showed that normal rate was higher in both decision (α=0.01). Therefore the best decisions are not necessarily occur on more time and athletes can also disrupt the decisions of competitor with reduction the speed of the game.

Keywords: Decision making, ball rate rhythm, complexity of decision, table tennis.

Introduction

In order to obtain a successful execution in sports, it is essential that athletes have high levels of perceptual abilities and be able to demonstrate motor skills in an efficient manner (Cagri Cetinet al., 2011). One of perceptual abilities is decision making that takes place pre-operation based on information processing model. Decision making is defined as the ability to use information from the current situation and the knowledge possessed about it so as to plan, select and execute an appropriate goal-directed action or set of actions (Williams and Ford, 2013).Regardless of definitions, it is clear that deciding about what to do and how to execute it are important components of elite performance in sports (Raab et al., 2005). On the other side, the existence of such items in sports as, decision making factors (coaches, players, etc.), decision making tasks (game calling, ball allocation, etc.), and decision making contexts (during play, during timeout, etc.) provides excellent opportunity to study the process of decision making. (Joseph J., 2006). By putting the aforementioned factors together it can be said that decision making in sports possesses certain number of characteristics. Sport decisions are natural in essence, dynamic, and often made instantaneously or under conditions of moderate to high pressures. There for the variability factor must be realized when studying sports situations. With emphasis on the “available time” two types of decision-makings are discussed when considering various types. First, the analytic decision making, where the player has enough time to assess the situation, reviewing different options
and acts. Second, is the instinctive decision-making which is made when a quick response is required and there is no time for reasoning (Benjamin, et al., 2004).

Table tennis is a typical sport in which players have to decide what movement to perform and how to carry out the movement within a very short time. Roth (1989) showed, in laboratory based pre-cueing experiments, that to make corrections to stroke parameters in table tennis (‘how’ decisions) participants require a response window of at least 399 MS prior to execution. ‘What’ decisions, however, require 556 MS, based on movement durations of about 370 MS (from start of swing to bat-ball contact). These time windows indicate that the selection and execution of sequential table tennis movements are performed, to some degree, in parallel.

A number of factors, such as movement efficiency, task complexity, uncertainty, and speed, influence the effectiveness of movements. To improve movement efficiency, a number of different acquisition techniques have been devised. For instance, Liao et al., (2001) reported that analogy learning, in which a performer is provided with a biomechanical metaphor of how a movement should be executed, rather than traditional explicit instruction methods, results in performance that is both robust under psychological stress and secondary task loading. The complexity of tasks can have an acute effect on both execution and selection of responses (e.g., Fits and Posner, 1967). Reducing or increasing the amount of time between ‘what’ and ‘how’ decisions by manipulating ball speed or altering the size or weight of the ball (Xiaopeng, 1998) can have a major impact on performance. Increasing the number of possible stimuli and responses can also affect shot quality by introducing uncertainty. Ripoll (1989), for example, found that for ‘uncertain’ situations (e.g. match conditions) the movement preparation phase was increased, whereas the movement’s execution phase remained constant. Sorensen, et al., (2001) showed that ball location serves as a parameter for the selection of the stroke, either forehand or backhand, in conditions with known (forehand/backhand) and unknown alternation (random sequence). Masters, Masters, et al., (2008) argue in their paper as implicit motor learning and complex decision making in time-constrained environments concluded that if novices learn the motor component of performance implicitly rather than explicitly, then they will also be efficient when they make a decision and execute an action in close temporal proximity. Finally, variability agents should be considered in study of sports situations. In other research, Poolton, et al., (2006) concluded that low-complexity decisions had no effect on motor performance in either condition. However, high-complexity decisions caused relative performance deterioration in the explicit condition, but not in the analogy condition.

In sports situations it is important, to avoid a deterministic mapping from situation to response. Although the use of “if–then” rules may be a common method for instruction, one can imagine the peril in performing the same action every time one is found in a given situation.

Apart from table tennis, in other research on decision-making and performance, Benjamin, s. et al., (2004) examined the influence of time pressure, attention and decision making during a set of volleyball. According to Fontana (2007) indicated that exercise does not affect accuracy of decision making. Although, the results obtained from researches were not similar and inconsistencies were observed in some, but most researches revealed that accuracy of decision making is not affected by intensity of exercise. Regarding speed of decision making, it was a different story. In general, the speed of decision making showed meaningful increase when exercise intensity went from rest to moderate exercise.

The main point in past studies related to applied tools in research and limitations in methodology. The other problem was that they were far from field conditions. By using more suitable tools and approaching closer to field conditions, this research set out to investigate more closely the effects of changing ball throwing rates (which alter the amount of available decision times) on decision making performance. Therefore, we wanted to examine that what is the effect of time reducing on the decision performance in both simple and complex decisions? In other words, do better decisions take place necessarily with having more time?

**Materials and Methods**

This study was an applied research that carried out in experimental procedure, by using athletes as subjects in repeatable and field conditions to detoxify some of the questions and needs of professional coaches and athletes.

**Statistical Population and Sample**

The statistical Society was the experienced table tennis players of the Bushehr city. Players were asked to fill out a questionnaire regarding personal information, level of experience and level of competitions that individuals had participated. Then according to collected data from the questionnaire, 15 male players with at least 5 years of experience in tennis table who had previously participated in competitions at provincial levels
were randomly selected with a mean age of 26±6.0. After completing an unofficial consent form the players agreed to participate voluntarily in the experiment.

**Apparatus**

The experiment was performed on a standard table tennis table (Nixon NTT2003). On one side of the table was a Newgy Robopong 2040 table tennis ball server that discharged 40-mm balls at desired speeds. 100 balls (50 white and 50 yellow balls) were placed in the ball storage hopper and prior to each experiment the balls were mixed thoroughly to ensure random discharge. The server was adopted to prevent identification of the ball’s color by the participants before discharge. All players used a Butterfly table tennis bat. A Sony video camera was used to record participant’s performances and to determine ball landing points.

**Procedure**

In order to perform the experiment, six large squares (50 cm x 50 cm) were marked in two rows on the same side as the server (see Figure 1). Each square in the row nearest to the robot housed a smaller square (25 cm x 25 cm) to indicate the optimum landing point. During the test, subjects aimed at the right or left squares on the table depending on the type of decision making involved. Between 0 to 3 points were awarded according to the landing point of the ball. For example if a ball had to be directed to the right-hand target and it landed on squares 3 or 6 then it earned 3 points but only 1 point if it landed on squares 2, 5, 8 or 9. Zero score was awarded to balls landing outside the designated areas. Because a test comprised of 20 attempts, the participants were awarded maximum score of 60 points in each test. Players were unaware of the scoring scheme.

![Figure 1: The arrangement of the target squares on the table](image)

**Task and Procedure**

The test used in this study included both simple and complex decision makings which were different in that the color and sequence of balls signified the target area. For the simple decision making round in a 20-trials block, participants were required to direct white balls to the right hand target (square 3) and yellow balls to the left hand target (square 1) while in the complex decision making round the target switched after every two shots. The participants performed shots 1 and 2 similar to simple mode. In shots 3 and 4, the ball color-target representation switched such that, yellow balls were now directed to the target on the right and white balls directed to the targets on the left. Shots 5 and 6 reverted back to white-right and yellow-left. Shots 7 and 8 yellow-right and white-left, and this cycle switching continued until the last ball.

The participants were given an instruction leaflet explaining both the decision makings processes. After reading the instructions, the participants had oral (mental) exams for each mode of simple and complex. The oral test ensured that subjects are mentally prepared to participate in this study. The participants must have obtained a 90% score to enter the practical stage. After obtaining verbal score in order to minimize the effects of familiarity with the test, the participants were randomly divided into three groups of 5 to play at slow (1 ball every two second), normal (1 ball every one second) and fast playing ball rate (1 ball every half second). Each participant was allowed the first 20 shots as exercise. The video recording of subjects performance were
reviewed in slow motion using a Media Player Classic Software so that an accurate score can be reached for every participant by observing the ball colors and their landing points.

**Statistical Methods**

The mean and standard deviation were used to describe the data, and since we've taken just a group with 15 athletes for test, and all of them did the test in 6 stages (three rates for the simple decision and three rates for the complex decision) so, in order to data analyze, a 3 X 2 way ANOVA with repeated measures (three different ball rates with emphasis on two levels of low and high-complexity decisions) was carried out on performance scores ($\alpha=0.05$). Bonferroni post hoc was used to determine the main effects ($\alpha=0.05$). One way ANOVA with repeated measures and also the paired samples t-test were used to investigate the partial effects (Adjusted $\alpha=0.01$).

**Results**

Table 1 shows the descriptive statistics of the participant’s performance. In this table, the mean of scores are presented for performance of both low and high complexity decisions at three different ball rates. According to the values obtained, the highest scores belong in the low complexity decision performance at normal ball rate (Mean = 45.13) and the lowest scores belong in the high complexity decision at fast rate (Mean=15.80).

<table>
<thead>
<tr>
<th>Decision</th>
<th>Rate</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>simple</td>
<td>slow</td>
<td>43.13</td>
<td>6.66</td>
</tr>
<tr>
<td></td>
<td>normal</td>
<td>45.13</td>
<td>3.50</td>
</tr>
<tr>
<td></td>
<td>fast</td>
<td>28.60</td>
<td>10.83</td>
</tr>
<tr>
<td>complex</td>
<td>slow</td>
<td>22.53</td>
<td>6.57</td>
</tr>
<tr>
<td></td>
<td>normal</td>
<td>26.40</td>
<td>5.35</td>
</tr>
<tr>
<td></td>
<td>fast</td>
<td>15.80</td>
<td>5.08</td>
</tr>
</tbody>
</table>

In order to data analyze, a 3 X 2 way ANOVA with repeated measures (three different ball rates * two levels of low and high-complexity decisions) was carried out on performance scores ($\alpha=0.05$). The results of Bonferroni post hoc test showed that two main effects were significant, meaning that there were significant differences between the means of performances in low complexity decision at three different ball rates($F_{1,14} = 158.29$, $P=0.00$), and also there were significance difference between the mean performances at slow, normal and fast rates in both decisions ($F_{2, 28} = 27.17$, $P=0.00$). It is also clear from the interaction graph in Figure 2. This graph indicates that generally in the execution of decisions with emphasis on the complexity it can be stated that players were better in low complexity than high complexity decision.

One way ANOVA with repeated measures was used to investigate the partial effects separately in low and complex decision and determine the location of differences. This test showed that in two cases i.e. between the mean scores for slow and normal rates with the fast rate were significant differences at adjusted $\alpha=0.01$ level in low complex decisions, while in high complex decision there was only a significant difference between normal and fast rates. There was no significant difference between the slow and normal rates in both decisions at adjusted $\alpha=0.01$ level (Table 2). The paired samples t-test was used to investigate the partial effects between three rates and determine the location of differences. Result showed that there were significant differences at adjusted $\alpha=0.01$ level between all rates (Table 2).
Investigating of interaction effect between rates rhythm with complexity of decisions were showed significant interaction effect (F 2.28=4.51, P=0.02). The Bonferroni post hoc test was used to determine the location of the differences. As is seen, in table 2, significant differences were observed between mean scores of slow and normal (1 & 2) rates of simple decision with all of other rates (3, 4, 5, & 6), while fast rate of simple decision was only significantly different from same rate of complex decision. In complex decision there was only a significant difference between normal and fast rate (α=0.05), and amazingly there was no difference between the slow and fast rates (P=0.061, Table 2).

Table 2: Pairwise Comparisons
1, 2, & 3= slow, normal & fast rates of simple decision
4, 5, & 6= slow, normal & fast rates of complex decision

<table>
<thead>
<tr>
<th></th>
<th>Rate</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
<th>Lowed bound</th>
<th>upper bound</th>
</tr>
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<tr>
<td>1</td>
<td>2</td>
<td>-2.000</td>
<td>1.852</td>
<td>1.000</td>
<td>-8.536</td>
<td>-4.536</td>
<td>-4.536</td>
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<tr>
<td></td>
<td>4</td>
<td>20.600*</td>
<td>2.140</td>
<td>.000</td>
<td>13.047</td>
<td>28.153</td>
<td>7.153</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>16.733*</td>
<td>2.163</td>
<td>.000</td>
<td>9.097</td>
<td>24.370</td>
<td>-4.370</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>27.333*</td>
<td>2.083</td>
<td>.000</td>
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</tr>
<tr>
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<td>3</td>
<td>16.533*</td>
<td>2.731</td>
<td>.000</td>
<td>6.896</td>
<td>26.171</td>
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<td>1.917</td>
<td>.000</td>
<td>15.834</td>
<td>29.366</td>
<td>3.366</td>
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<td></td>
<td>5</td>
<td>18.733*</td>
<td>1.240</td>
<td>.000</td>
<td>14.356</td>
<td>23.110</td>
<td>-8.110</td>
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<tr>
<td></td>
<td>6</td>
<td>29.333*</td>
<td>1.523</td>
<td>.000</td>
<td>23.956</td>
<td>34.710</td>
<td>-4.710</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>6.067</td>
<td>3.664</td>
<td>1.000</td>
<td>-6.865</td>
<td>18.998</td>
<td>-10.998</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2.200</td>
<td>3.030</td>
<td>1.000</td>
<td>-8.496</td>
<td>12.896</td>
<td>-6.896</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>12.800*</td>
<td>2.637</td>
<td>.004</td>
<td>3.492</td>
<td>22.108</td>
<td>-9.108</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6.733</td>
<td>1.963</td>
<td>.061</td>
<td>-1.194</td>
<td>13.661</td>
<td>-0.661</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>10.600</td>
<td>1.546</td>
<td>.000</td>
<td>5.145</td>
<td>16.055</td>
<td>-0.955</td>
</tr>
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</table>
Discussion and Conclusion

Before discussing the results obtained, for better understanding of the content, several points should be mentioned. Firstly, we were not to seek review of decision making but what we investigated was required in the real domain of sport, the decision making performance that happened. On other hand, in the real sport, the player may adopt an appropriate decision, but it is performance of decisions that is caused to losing or acquiring of score. Hence, the decision making performance was used in procedure and research literature. Secondly, the test that used in this study is one of the most useful tools that Masters, et al. (2008) applied in the table tennis research. One of the limitations of previous studies (Fontana, 2007, Lewis, S.F, 1998) was the weakness of used tools which it had caused limitation in the application of obtained results. Thirdly, however this study was to investigated the effect of the changing rate ball on table tennis in simple and complex decisions, but in fact, On the one hand, we manipulated speed of decision making performance, and we tested it via to changing in playing rate, and one the other hand we have practically investigated different accuracy with using of the varying complexity. Consequently, we can say that we verified two questions. What is the effect of increasing of speed ball on decision performance? And what is the effect of altering required accuracy on its performance?

Fourthly, based on both analytic and naturalistic decision making, what was examined in this research was naturalistic decision making. In this study, the person should be adopted both ‘what’ and ‘how’ decisions in limited time, hence naturalistic decision making of persons what that required in professional sports and distinguished professional person than others.

To review the effect of changing speed on performance by comprehensible statistical analyzes of obtained result is that with the changing speed mean performance of players in both simple and complex decision follows a same pattern. In both types of decisions the highest mean was in normal rate and lowest mean in fast rate. In normal rate than slow, on the contrary to expectations and previous researches (Xiaiopeng, 1998) not only players’ decision making and performance decreased but also was better. Although there was no significant improvement but probable reason in this finding which was observed in both simple and complex decision can be demonstrated important contents. The interesting and important contents is that despite the shorter time of normal rate considers since that this rate was closer to real playing conditions, the experienced players had better performance in such speed. Megan L. et al. (2013) found that the persons exercised in faster time than real time, finally they had better performance. With regard to experience of players in this study and exercising them at high speed, so in higher speed at normal rate, they had better performance than slow rate.

In another study, Megan L. et al.,(2013) concluded that the elite individuals had better decision making about faster video when they were compared with the novice individuals. We didn’t consider novice individuals, but it seems in the event of testing novice the result will be different.

The players can use of ‘‘if→then’’ rules or other analyzes during the fore period and by their prediction practically place in the different situations of decision making. In fast rate this time was reached to zero and the opportunity to use of “if → then” rules was taken from the players. The time of fore period was maximum of 0.5 second in normal rate and 1.5 seconds in slow rate. It was expected that with increasing the time distance between two performance, person must do better analysis and as a result they make a better decision to perform. But on the contrary to our expectation, despite to the longer fore period in slow rate the complex decision making of experienced players, did not lead to better results. Although there was no significance difference between slow and normal rates in the both types of decision, but lower main in slow rate than normal rate indicated that there is an optimum time to understand relevant stimuli (Henin, 1980 &1989).According to the poor results obtained at slow rate, it is recommended to the coaches and players, that it always is not necessary to maximize play speed to confound the opposition’s focus and taken score, but they can make wreck the opposition performance by minimizing usual time and pause before hitting.

Another reason that it can justify the better performance of the players at the normal rate is that the optimal time for experienced player’s decision making was 1 second. Increasing time could lead to the loss of desirable stimuli and attention to irrelevant stimuli. On the other hand, we can say that the optimal range of performance has been placed at normal range (Henin, 1980 and 1989).

More details of the comparing between decision performance in fast rate than slow and normal indicated that significant decrease found in both decisions at fast rate. In this rate, the rhythm rate was more than playing real speed, so that the players were mechanically limited to perform their decisions and they executed techniques as short. On the other hand, although fast rate cognitively wasn’t more than both normal and slow rate but mechanically performance opportunity wasn’t given to the players. Therefore, significant decrease could be due to this limitation. In this section, our finding was as similar as with Xiaiopeng (1998) and Sorensen, et al., (2001) that stated reducing or increasing the amount of time between ‘what’ and ‘how’ decisions by manipulating ball speed or altering the size or weight of the ball can have a major impact on performance.

In the reviewing the influence of accuracy on decision performance, an important point obtained was that with the changing of complexity (attention requirement) of decision task, from simple to complex, in all rates had significant decrease. On the other hand, the simple decision at all rates had more meant than complex
decision, whereas in both decision at three hitting ball rate with equally and same speeds was repeated and only their difference was in complexity. Hence, it can be concluded that there is a significance inverse relationship between accuracy and decisions performance. This result, generally, was observed in previous studies (Fontana, 2007).

Fitts and Posner (1967) found that the complexity of tasks can have an intense effect on both execution and selection of responses. Ripoll (1989) found that for ‘uncertain’ situations (e.g., match conditions) the movement preparation phase was increased compared to ‘certain’ situations (e.g., training drills), whereas the movement’s execution phase remained constant. Masters, et al. (2006) also found that high-complexity decisions caused relative performance deterioration in the explicit condition.

It should be noted that increasing of number ball per second have no effect on reaching time of ball to players (time of exiting the ball from server until reaching end of the table), but the time before of stimuli or foreperiod presentation changed.

So, it is important, in sports situations, to avoid a deterministic mapping from situation to response. Although the use of “if–then” rules may be a common method for instruction (e.g., McPherson and Kernodle, 2003), but it can imagine the peril in performing the same action every time that one is found in a given situation (Johnson,2006). The results of the current experiment suggest that coaches and players should be maximized their practice speeds to understand relevant stimuli during playing conditions at lowest time ,as well as, it is necessary that they exercise at low speeds until with planned and unplanned interruptions, the players don’t make incorrect decision.

References


