Psychology. Journal of the Higher School of Economics.
2017. Vol. 14. N 1. P. 178–188. DOI: 10.17323/1813-8918.2017.1.178.188.

THE "I AM LOSING" EFFECT IN A SIMPLE SENSORIMOTOR TASK

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Abstract

The article looks into specifics of a sensorimotor skill execution in a competitive pressure situation. It is proposed that the observed deterioration of a learned skill cannot be deemed as a discrete failure: it is better explained as a specific reaction to an erroneous action already committed which in turn leads to further de-automatization and errors. Our participants learned to putt a ball in a hole (playing "Virtual Golf") by pressing and holding a computer key in order to control the putting distance. Then an online competition in pairs was conducted with the rival's scores demonstrated to the participant. We measured the aspiration level (AL) of the participants. Groups with low and high AL did not differ significantly at the stage of training, but during competition the group with a high AL was significantly worse than the group with a low AL. We revealed a general frame effect that we called "losing": when participants with high AL see a negative score on the scoreboard, they make more errors. We did not see increased performance after hits. We also found errors related to a reactive effect: competition shows an increased share of errors caused by one's own miss in a previous trial. Not only does the number of errors after misses increase, but also the quality of those errors changes as their magnitude size also increases. There is also a shift in time estimation trend: we may interpret this as an indicator of a change in control.

Keywords: sensorimotor learning, choking under pressure, cognitive control, time perception, stress, aspiration level, "loosing" effect.

It has now been known for a while that sometimes the desire to excel has a negative effect on performance. High-pressure situations may lead to a poor execution of a well-practiced and mastered motor skill; pressure can serve as a critical factor in many areas of life and in sport (an unexpected failure at competitions has been

The reported study was funded by the RFBR according to the research project №16-06-00376 A and SPbSU grant № 8.38.287.2014.

known as "choking under pressure" (Baumeister, 1984)).

So far there is no single view on mechanisms that lead to a failure in skill execution during high-pressure situations. Despite a large body of experimental studies, the internal trigger that initiates ineffective control strategies under pressure remains unknown; the heightened importance of a task is thought to be an important factor, though how exactly such heightened importance leads to reinvestment (Masters & Maxwell, 2008) or distraction (Beilock & Carr, 2001), and subsequent choke, is still unclear.

We propose that a fault in cognitive control of action within the situation of emotional tension can result from a non-equal value assigned to correct and erroneous actions (for instance, some sports more often impose penalties for errors – such as penalty loops for misses etc.). Our proposition is based on the theory of perspectives suggested by Kahneman et al. (Kahneman & Frederick, 2007; McGraw, Larsen, Kahneman, & Schkade, 2010), that was developed for decision-making conditions; in particular, the theory states that the value of a loss is not equal to that of a gain. A number of studies have shown that the theory of bounded rationality can be extended to simple motor tasks as well (see Sozinov et al., 2012; Trommershäuser, Maloney, & Landy, 2003; Wu, Dal Martello, & Maloney, 2009 and others).

For example, a study by Trommershäuser et al. (Trommershäuser et al., 2003) demonstrated that becoming aware of possible losses associated with outcomes of one's own actions affects action planning. The experiment involved tapping a certain location on the screen, which led to a certain bonus, while some of the zones, on the contrary, were penalized. The results show that the subjects' strategy in this task is far from optimal and the most attention is given to possible errors.

Other research (Wu et al., 2009) revealed rather ambiguous results, but demonstrated that the way the participants used time given for a specific task is also suboptimal. The participants had to sequentially hit two targets that appeared on the screen within a limited period of time with no specific limitations on time distribution within the task itself. The experimenters varied the bonus value of the targets as well as the distance between the first and the second targets. It was shown that no matter what the bonus for hitting the second target was, the participants always spent significantly longer on aiming for the first target even when the cost of hitting the second target was 5 times more than that of the first one. But there was no significant effect of success in hitting the first target on one's result in the second one, thus this strategy cannot be deemed optimal. When comparing the participants' behavior to an optimal model the researchers were faced with a paradoxical result: the more time the subjects had to devote to the second target based on predictions of the optimal model, the less time they actually spent on it. The authors of the paper assume that such limitations in planning a sequence of simple actions correspond to limitations characteristic of intellectual tasks as seen by the theory of bounded rationality (Kahneman, 2003).

A recent study (Gershkovich et al., 2013); Moroshkina, Gershkovich, Ivanchej, & Morozov, 2012) tested the hypothesis that the structure of the nature of remuneration emphasizing either possible gains or losses (penalties) would induce a change in one's action control that can in turn affect efficiency.

The experimental task in a virtual shooting environment partially confirmed this view: the subjects had to shoot at moving targets receiving regular scores (+1) with increased value of every fifth target — experimental group one received five more points for a hit while experimental group two was penalized with minus five points for a miss on that particular target. Though no difference in accuracy between bonus/penalty groups was found while shooting at the high-value targets, at the same time preparation for the high-value (5-th) target in the penalty group took significantly longer.

An interesting reactive effect was observed: the penalty group's performance decreased in the trial following a miss at the high-value target while there was no such effect in the bonus group. The authors also showed that such a reactive effect observed is typical of those participants that were oriented towards achievement motivation.

This study allowed us to assume that a fault in skill execution is provoked by one's reaction to his/her's own error. Each error committed increases the value of the precise execution of the action immediately following the error — a participant might word it as "I hope I do not lose any more points". This results in an increased control of action accompanied by an excessive number of checking operations, hence an error is induced. Our theoretical assumption was that the more important it is for a subject to win a competition, the larger is the perceived mismatch (Beilock & Carr, 2001) between target and actual performance, which provokes a change in cognitive control mechanisms.

Based on this theoretical framework, the current study explores further effects of a subjective success/failure experience on performance under competitive pressure. Our experiment models a situation of competition with a rival where a participant can be either weaker (losing) or stronger (winning) than a rival. Our goal was to find errors related to reactive effect in a situation of competitive pressure. Thus we analyzed the accuracy of our participants in relation to the rival's success and the participant's own success in the previous trial and competition overall: according to our empirical hypothesis, performance of the high AL group (measured as a share of errors and error magnitude) after one's own error in the previous trial would decrease in the competition as compared to training. We also hypothesized that performance of the high AL group (measured as share of errors and error magnitude) would decrease within the competitive stage itself a). after the rival's hits as compared to trials after the rival's misses and b). in the "negative score" condition.

Method

The game "Virtual Golf" was devised. The screen showed two objects: a ball and a hole, and the task was "putting", similar to real golf. In order to "putt" the player has to press and hold the spacebar; the longer the player holds the key, the further the ball goes. This task is relatively difficult as there is no visible scale on the screen and the player has to subjectively estimate time intervals. We used three different time intervals (2 seconds, 4 seconds and 5.9 seconds); the intervals were rounded to 100 ms (for instance, every measurement between 100 and 200 ms from trial onset would be recorded as 100 ms). Hits and misses in the game were followed by the sound of applause or a disapproving rumble respectively throughout the entire game. After a miss a message indicating the size of error was shown (e.g. “+0.4 m”) and the subject had to press “OK” to proceed.

The competitive pressure situation was simulated by announcing a competition with an actual rival being present in the same room and demonstrating the rival’s actions and scoreboard throughout the competitive part.

However, the participant’s competitor was in fact not the real person sitting in the same room, but our “virtual rival”: a bot that performed with a certain level of accuracy, specified by the experimenter. Two schemes were used for two random groups of participants: our virtual opponent hit the target in either 50% or 78% of the trials. The average duration of study for one person was an hour.

Measures. The dependent variable was the participant’s error, resulting from over- or underestimation of the required time interval (holding the button too long or not long enough). To analyze the performance dynamics, we measured the number of errors in every 24 trials (the choice of this figure was based on the game design: we used a sequence of 24 trials with our three time intervals balanced across this sequence that was then repeated over the course of the session. For instance, the training session contained 144 trials — that is, 6 identical sequences of 24).

Apart from the share of errors from all trials, we also studied error magnitude size as an indicator of performance deterioration.

Aspiration Level (AL). We measured the aspiration level using Schwarzlander’s motor test (Borozdina, 2011). In this test a participant claims a certain target level he/she wishes to achieve while performing a simple motor task (drawing as much “pluses” as possible using paper-and-pencil), then records his/her actual performance and corrects the target value for the next trial. The test result reflects a “target deviation” typical of the participant, that is his/her trend to correct a personal goal in relation to the actual performance observed (calculated using the following formula: ((TV2 – AR1) + (TV3 – AR2) + (TV4 – AR3))/3, where TV stands for “Target Value” and AR for “Achieved Result”). We defined the high and low AL groups using median split.

Participants. A total of 33 participants aged 20 to 36 years (M=26.9, SD=3.0) voluntarily took part in the study. Participants were divided into pairs and randomly assigned to the groups to compete with a “strong rival” or “weak rival”.

The final data analysis included 31 people; the data of 2 other participants were dropped out as they were unable to master the skill by the end of the training session. 15 participants were competing with a weak rival while 16 participants were assigned to a strong rival group; also 15 participants showed a low aspiration level while 16 participants had a high one. No correlation was found between these two parameters.

Procedure

The experiment was conducted in pairs. Upon arrival to the laboratory participants were told that they would compete with each other, and the winner would receive a prize. First, they were asked to participate in a training session with 144 trials broken down into three sections to shape a certain level of skill mastery. The participant could see his/her progress as he/she was awarded with 1 point for every hit and the current score was demonstrated on the top of the screen (e.g. "Ivan: 40"). Misses were not allocated any points. Upon completion of the training phase there was a short break (approximately 5 minutes) during which both of the participants performed Schwarzlander's motor test to measure their AL. After that the online competition began: it included 120 trials and each shot by the participant was followed by the shot of his "rival". The scoreboard showed current progress (e.g. Ivan: 40, Rival: 35).

After the game a post-experimental interview was conducted, during which we asked participants questions such as whether they felt they had mastered the skill by the end of the training session and whether they had aimed to win in the competition etc.

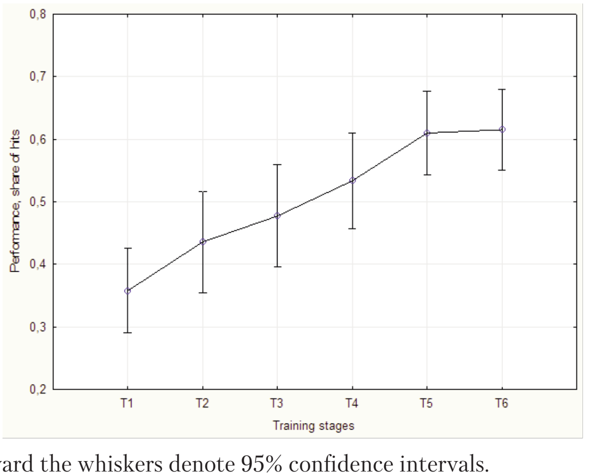
Then both of the participants were informed of the real scheme of the experiment and were given a little prize.

Results

Skill acquisition. First, we were able to show that during our training session all subjects included in analysis learned a sensorimotor skill and their level of mastery passed the cognitive phase of skill acquisition (based on Fitts & Posner, 1967) as sequences 5 and 6 of the training session show a plateau (see Figure 1). This allows us to discuss subsequent skill deterioration during a competitive pressure situation. We used the level of performance during sequences 5–6 as our baseline for further comparison.

Figure 1

Performance during training, ANOVA RM for 6 segments



Note. Henceforward the whiskers denote 95% confidence intervals.

We found no significant effect from AL in our baseline condition (Univariate ANOVA, $F(1, 29) = 3.25, p = 0.08, \eta^2 = 0.10$).

Induced pressure. As an indicator of perceived pressure error variability during sessions was compared (De J. Manoel & Connolly, 1995; Zotov, 2011). Individual error SD was calculated for each subject for each segment; no significant differences between the groups with different AL were found but all subjects showed a trend to a greater error variability during competition as compared to training (RM ANOVA, 7 segments, 2 of which are the training plateau and 5 — competition: $F(1, 6) = 2.05$, $p = 0.05$). We can interpret these findings as evidence for successful competitive pressure induction during our online competition.

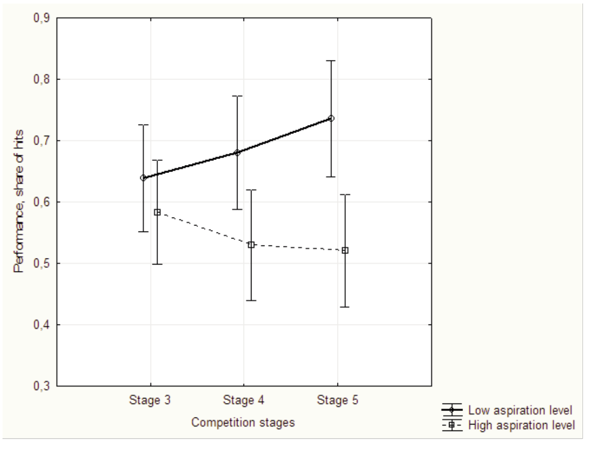
Also all 31 participants reported a desire to win in the competition.

Performance and competitive pressure. Significant effects of pressure on performance were found in an interaction of two factors: stage of the game and AL of the participant. As mentioned earlier, the groups with different AL do not significantly differ at our baseline condition (training plateau). Competition stage reveals a significant effect of the AL (Univariate ANOVA, $F(1, 29) = 6.62$, $p = 0.01$, $\eta^2 = 0.18$), with the high AL group performing worse than the low AL group. To reveal the nature of this effect we looked into competition dynamics using ANOVA RM, breaking the competitive stage into 5 sequences of 24 trials (as described above), and no differences were found in the first part of the competition. However, there is a significant effect during competition segments 3–5: the high AL group performs significantly worse than the low AL group (ANOVA RM, 3 segments (comp. 3; 4; 5), $F(2, 58) = 4.52, p = 0.01, \eta^2 = 0.13$). The low AL group continues to improve performance while on the contrary the high AL group shows a noticeable decrease (see Figure 2). We assume this trend can be related to an increase in task importance and heightened pressure when the participants are anticipating the final results.

One of the possible trends within the framework of our hypothesis would

Figure 2

Performance and AL during the second part of the competition



be increased control after the participant's own miss and their rival's hit in a competitive situation (as both of these situations reflect perceived failure). Our data shows the impact of one's own results in the previous trial on his/her performance in the next one: all participants, regardless of their AL, got worse after missing during the competition as compared to the training session (ANOVA RM, $F(1, 29) = 6.55$, $p = 0.01$, $\eta^2 = 0.18$), while there is no such effect after one's own hits (see Figure 3).

No significant effects of opponent's hit or miss on the next subject's trial were revealed in the competitive session ($F(1, 29) = 0.30$, $p = 0.58$, $\eta^2 = 0.01$).

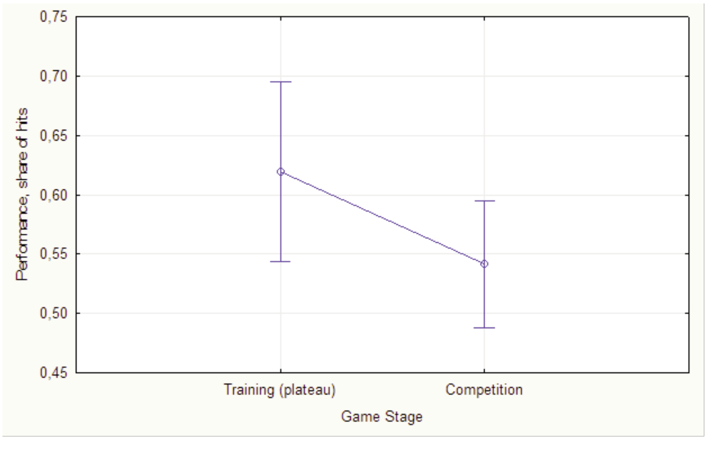
Accuracy. Apart from performance as a share of hits, we also studied differences in error magnitude. First of all, there are already significant differences between error magnitude after one's own hit and miss during the training plateau ($F(1, 577) = 8.30$, $p = 0.004$, $\eta^2 = 0.01$). Moreover, this effect reflects a marked change in trend: after hits the mean error has a positive value, that is, the participant tends to "over-press" the button, holding it for a longer time while after misses the error becomes negative, meaning that our participants tend to hold the button not sufficiently long (see Figure 4). Such a shift may reflect a speed-up in subjective time as participants tend to think a certain interval has already passed while in fact it has not.

Significant difference between error magnitudes after hits and misses is preserved during competition ($F(1, 1520) = 4.77$, $p = 0.03$, $\eta^2 = 0.003$), though in both conditions mean error becomes negative, suggesting not sufficient holding of the button.

Scoreboard effect. Further information about the observed effects was obtained by analyzing the dynamics of performance during the competition in relation to the score balance that was displayed to the participant: all the trials were broken into two groups – the trials with positive or negative score balance demonstrated prior to the trial. The negative score balance was interpreted as "I am losing", while the positive score balance as "I am winning".

Figure 3

Performance after miss



According to our data, individuals with high AL performed significantly worse in the "I am losing" condition (Univariate ANOVA, F(1, 26) = 5.60, $p = 0.02$, $\eta^2 = 0.18$) as compared to participants with low AL in the same situation (see Figure 5). No differences between groups were found in the "I am winning" situation; we did not compare both conditions directly as not all the participants had experience in winning; some of them started losing (or being equal to the rival) from the very start of the competition.

Discussion

The groups with low and high AL did not differ significantly during the training stages, but in the situation of competitive pressure the group with a high LA was significantly worse than

Figure 4

Differences in error magnitude during training (plateau)

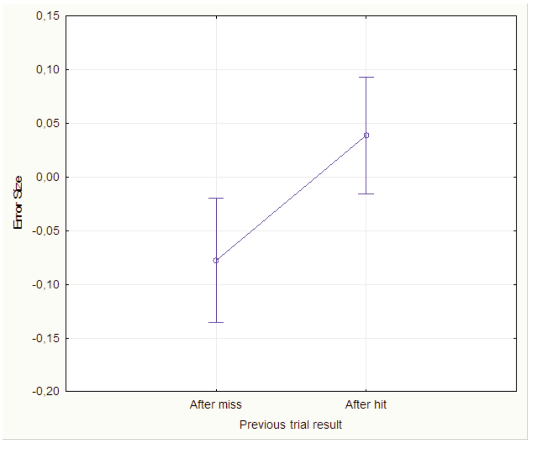
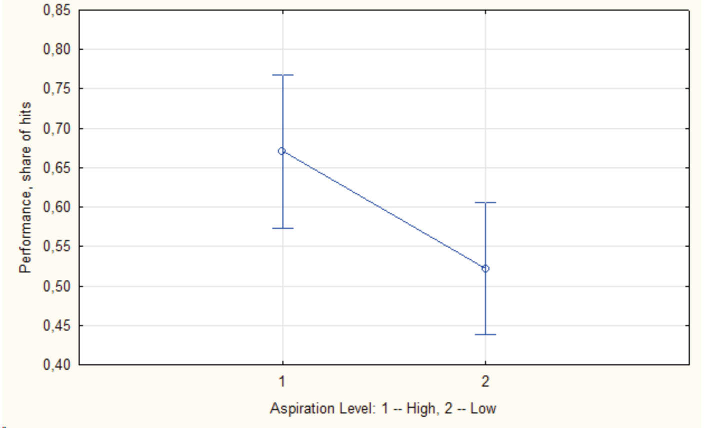


Figure 5

Performance with negative score ("I am losing")



the group with a low LA. We assume that the aspiration level correlates with the subjectively perceived mismatch between the target and the actual performance and therefore may serve as evidence for our initial hypothesis: a decrease in the performance is triggered by a change in control mechanisms initiated by one's reaction to his/her own errors. We revealed a general frame effect that we called "losing": participants with high AL make more errors when they see a negative score on the scoreboard. It is important to note that this effect is not related to a rival's performance directly – it is the general frame of either "winning" or "losing" that the participant experiences. We believe that the observed errors are related to an increase in the specific value of a particular trial within the general context. We did not see increased performance after hits, and this matches the data collected by Wu (Wu et al., 2009). However, we revealed errors related to a reactive effect: competition shows an increased share of errors caused by one's own miss in the previous trial. Not only does the number of errors after misses increase but also the quality of those errors changes as their magnitude size increases as well and there is also a shift in time estimation trend: we may interpret this as an indicator of a change in control.

Our data supports our hypothesis that the problem of deterioration of a learned skill in a competitive pressure situation cannot be deemed as a discrete failure: it is better explained as a specific reaction to an erroneous action already committed which in turn causes further de-automatization and another error. Thus it can be inferred that one's reaction to his/her own error provokes suboptimal control strategies related to the subjective value of thection.

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Эффект «проигрыша» при выполнении простой сенсомоторной задачи в ситуации соревнования

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Резюме

В статье рассматриваются особенности выполнения сенсомоторного навыка в ситуации соревновательного давления. Выдвигается предположение, что разрушение навыка не является отдельным феноменом – эффект лучше объясняется специфической реакцией на уже совершенное ошибочное действие, которое, в свою очередь, приводит к последующей деавтоматизации навыка и дальнейшим ошибкам. Испытуемые тренировались выполнять задачу попадания мячом в лунку (виртуальный гольф), дальность полета регулировалась через время удержания клавиши на клавиатуре компьютера. Затем испытуемые принимали участие в онлайн-соревновании внутри пары, где результаты соперника демонстрировались испытуемому. Фиксировался уровень притязаний (УП). На этапе тренировки не было обнаружено значимых различий между группами с низким и высоким УП, однако на этапе соревнования группа с высоким УП оказалась значимо хуже, чем группа с низким УП. Был обнаружен общий фреймовый эффект, обозначенный как «проигрывание»: при наблюдении негативного счета на табло испытуемые с более высоким уровнем притязаний совершали больше ошибок. Улучшения результативности после попаданий в цель не наблюдалось. Кроме того, удалось обнаружить ошибки, связанные с реактивным эффектом: в соревновании увеличивается доля ошибок, вызванных собственным промахом в предыдущей пробе. Повышается не только количество ошибок после промахов – их характер также претерпевает изменения, поскольку увеличивается величина промаха и меняется тенденция оценки временны́х интервалов. Описанные результаты можно интерпретировать как свидетельство изменений в процессе контроля.

Ключевые слова: сенсомоторное научение, соревновательное давление, соревновательный стресс, когнитивный контроль, восприятие времени, уровень притязаний, эффект «проигрыша».

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