Behavior under High Arousal Conditions: On the Difference between High Optimists and Low Optimists*

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Abstract

An analysis of individual differences in behavior under high arousal conditions was conducted. Participants completed a measure of optimism (the Explanatory Style questionnaire) and were divided into high and low optimists on the basis of these scores. Then, participants played the “water-pipe game” under conditions of “time pressure” and “severity” designed to increase arousal. (“Emergency” consists of both these factors together.) In this game, they had to click a computer mouse to complete the game using the minimum number of clicks. We found that high optimists' click frequency increased and their thinking time declined under the high-arousal condition. This was not so in the control condition, who tended to act promptly without much active thought. On the other hand, we found that low optimists' click frequency did not increase under any conditions, but their total number of clicks was larger than high optimists'. Namely low optimists seemed to act carefully but in an inefficient fashion. Processing efficiency theory can account for this pattern: anxiety leads to a reduction in the storage capacity of the working memory system. These results suggest that trait optimism can influence behavior patterns such as “choking” under pressure.

Key words: Emergency, High Arousal Level, Time Pressure, High Optimist, Low Optimist, Positive Psychology, Choking under Pressure

1. Introduction

Human errors can occur under both low and high arousal conditions ⁽¹⁾⁽²⁾. Situations that make people panic or otherwise highly upset often lead to impaired task performance, even for tasks that are typically executed fairly easily. Such situations are often referred to as “emergencies”, although most studies do not provide a precise definition of this term. In a previous study ⁽³⁾⁽⁴⁾, we have provided a concrete operational definition of an emergency situation and examined behavioral performance therein: Participants played the “water-pipe game”, in which they had to run water from a source tank to specific targets under the conditions described below using the minimum number of mouse clicks. We designed three experimental conditions. The “high arousal condition (HA) that included time pressure and a “severity” dimension, because previous studies ⁽⁵⁾ have indicated that these are

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characteristic of emergency situations. Severity" was defined as "event related consequences" and "predictability." Severity was also task dependent. For example, if people were in a fire, severity was to run away from it to survive, whereas if people were gambling, severity was to win a fortune. Such a condition was designated an emergency situation in our previous study. The "time pressure condition (TP)" included only this aspect. Finally, a "control condition (CT)" did not feature any alarms, time limits, or severity aspects, and was intended to approximate a "normal" situation.

We assumed that performance in the HA condition would be worst across the three conditions, due to additive effects of time pressure and situation severity. This was the case in our previous study, where participants tended to behaviorally react without much forethought under such conditions.

The present study examined one potential individual difference in this tendency to react in emergency situations. It seems reasonable to assume that people will differ in their capacity to respond effectively in such situations, and such individual differences have important implications in terms of human error during emergencies and minimizing costs to life and well-being.

The present study examined individual differences in optimism, a popular recent focus in the area of positive psychology. Some studies in this area have suggested that optimists enjoy good health, including reduced risk of cardiovascular disease ⁽⁶⁾⁽⁷⁾, stroke ⁽⁸⁾, depression ⁽⁹⁾ and cancer ⁽¹⁰⁾. Additionally, such individuals tend to perform well in the workplace ⁽¹¹⁾⁽¹²⁾. Such robust differences between high and low optimists could conceivably generalize to responding in emergency situations.

2. Method

2.1 Participants

Participants ($n = 30$ men, *Age* 28 years, (age range: 22-32 years) took part in this experiment. All participants reported normal or corrected-to-normal vision and hearing. The experiment lasted for about 3 hours. Participants received a reward of 6,000 yen for their participation. The final number of participants was 26 due either to program problems, technical issues, or unusually low scores, because they stopped playing the game when they were tired out from solving it.

2.2 Apparatus and materials

We used the apparatus and materials described below. Figure 1 shows the layout of the experimental device.

LCD monitor: This monitor (a Nanao 22.0 wide LCD monitor S2243W-HXBK) presented the task visually.

Speakers: Emitted alarm sounds (Onkyo 77monitor GX-77m).

Lamps: Gave off alarm lights (Patlite PHU-3-RYG).

Industrial fan: Gave off a breeze as another form of alarm (Trusco TFZ-45SA).

Reaction keys: Used for participant responding (Mouse: Fujitsu M/N: M-U0019-0, numerical keypad: Sanwa Supply USB numerical keypad NT-USB14SVK).

2.3 Main Task

The experimental task simulated a water-pipe game (in this task, participants had to run water from a source tank to specific targets). This game was a modified version of the task used by Kano ⁽¹³⁾.

Figure 1 Experimental Device Layout

As Figure 2 shows, the water from the upper tank ran through both pipes, and the pipe whose flow was switchable arrived eventually at the seven electric bulbs. Four types of switches were used: Cross-shape, T-shape, L-shape, and skew shape, and a total of 23 switches were used in each task. If water was flowing in the pipes, they were blue in color; on the other hand, the pipes were black if water was absent. Participants could change over the water flow when they clicked the switches, with a single 90° click. If they wanted to rotate the switch clockwise, they had to left-click. If they wanted to rotate the switch anticlockwise, they had to right-click (we also used the inverse pattern, with these two patterns being counter-balanced across participants). When the flow of water from the tank to the electric bulbs was backed up (blocked), the bulbs were turned off (and turned from either yellow or red to dark grey).

The goal of this task was to have all red bulbs turned off and all yellow bulbs lit up. Task rules were as follows:

1. When the flow of water from the tank to the bulbs was backed up, the bulbs were turned off.
2. Participants had to try to perform the task using the minimum number of clicks.
3. The goal of this task was to turn all red bulbs off and all yellow bulbs on.
4. The positions of the switches were changed between trials.
5. There were three difficulty levels (low/medium/high), decided by the minimum number of clicks needed to win the game (one, three, and six clicks, respectively).
6. Trial order was counterbalanced between participants.

These main tasks were related to some aspects of operations in the workplace, for example, complex repairs, difficult train driving conditions, and complicated office procedures, among others.

2.3.1 Subtask

In addition to the main task, a visual target consisting of a picture of a gorilla was presented at the center of the monitor every 10 seconds. Participants had to push a key on a numerical keypad in their left hand as quickly and precisely as possible to dispel the visual target. We designed this task to distract the participants from the main task.

Figure 2 Experimental Task
(the gorilla picture at the center is the visual target)

2.3 Experimental Conditions

Participants conducted the experimental task under three conditions, as described below. In this experiment, all participants completed all conditions.

2.3.1 High Arousal Condition (HA)

In addition to the time limit imposed for the task (75 seconds), various alarms were used as described above. “Severity” was also implemented in this condition (as described below). Stimuli for this condition were as follows.

Time limit display: The time limit was displayed at the bottom of the screen. Display color was black at first, but changed gradually to red in increments of 15 seconds. The color was bright red after 61 seconds elapsed. The time limit for the task was 75 seconds, after which the display shut down.

Visual stimuli: Lights flashed from the beginning of the task. Light color and timing were set with reference to ISO11428:1996⁽¹⁴⁾.

1. For the first 15 seconds, two green LEDs flashed at 0.8 Hz.
2. For the next 15 seconds, two yellow LEDs flashed at 1.6 Hz.
3. For the next 15 seconds, two red LEDs flashed at 3.2 Hz.
4. For the next 15 seconds, four red LEDs flashed at 6.4 Hz.
5. For the last 15 seconds, all LEDs (red, yellow, and green) flashed at 10 Hz.

Auditory stimuli: From the beginning of the task, pure-tone alarms went off (of about 300 ms duration; 2 kHz; 85 dB (A)). Auditory stimulus design referenced ISO11429:1996⁽¹⁵⁾.

1. For the first 15 seconds, the tone was repeated twice with a two-second downtime.
2. For the next 15 seconds, the tone was repeated three times with a one-second downtime.

3. For the next 15 seconds, the tone was repeated four times with a 500 ms downtime.
4. For the next 15 seconds, the tone was repeated five times with a 250 ms downtime.
5. For the last fifteen seconds, there was no downtime; the tone was continuous.

Tactile stimulus: The strong breeze of an industrial fan provided a third “alarm”. The breeze was activated when 30 seconds remained. This stimulus was incorporated based on a previous study in which arousal level rose as a function of wind strength ⁽¹⁶⁾.

Severity manipulation: Participants were told that if they failed to successfully complete the task within the allotted time limit, the possibility of a reduction in their rewards would increase. In the post-experimental debriefing, participants were told the purpose of this experiment and assured that they would receive the full amount of money. This procedure was based on an earlier study showing that an unstable reward structure triggers anxiety in participants ⁽¹⁷⁾. This condition served as an analogue to an emergency situation ⁽⁵⁾.

2.3.2 Time pressure condition (TP)

In this condition, only the time limit (75 seconds) was used, with no alarm lights, sounds, breeze, or severity manipulation used.

2.3.3 Control condition (CT)

This condition did not feature alarms, a time limit, or a severity manipulation. Participants were allowed to dwell on the task as they saw fit.

2.3 Measurement of individual differences

Participants completed a questionnaire to measure optimism before starting the experimental tasks. Seligman designed this questionnaire ⁽¹⁸⁾, and we used a Japanese translation by Yamamura ⁽¹⁹⁾ in the present study.

In a study by Seligman, optimists tended to attribute negative events to external (e.g., to a person other than oneself), unstable (temporary) and specific causes (they attribute such events to specific reasons rather than more pervasive causes). On the other hand, pessimists tend to attribute negative events to internal (themselves), stable (persistent) and global (pervasive) causes ⁽²⁰⁾.

3. Results

Participants were classified into three groups on the basis of questionnaire scores, high, average, and low optimists. The seven highest-scoring participants were deemed "high optimists" while the lowest seven were deemed "low optimists". Data from these fourteen individuals were used in subsequent analyses.

The dependent variables in this experiment were analyzed using a two-factor within-subjects ANOVA. The first factor was task difficulty level (low/medium/high); the second factor was experimental condition (high arousal (HA) / time pressure (TP) / control (CT)). The dependent variables were time to complete (the time necessary to finish the game), the total number of clicks (the total number of clicks used to finish the game), and the mean number of clicks in 15 seconds. These data was analyzed separately for high and low optimist groups.

3.1 Total number of clicks

There were significant main effects of both difficulty level ($F(2, 12) = 5.546, p < .05$) and experimental condition ($F(2, 12) = 7.059, p < .01$) for high optimists. However, no significant interaction between difficulty level and experimental conditions was demonstrated. Post hoc pairwise comparisons for difficulty level showed significant differences between low and high levels, while those for experimental condition showed significant differences between both HA and CT and HA and TP (all $ps < .05$). Total number of clicks increased with task difficulty level, and total number of clicks in HA exceeded those in both CT and TP (Figure 3).

On the other hand, the same analysis of total clicks in low optimists revealed a marginally significant interaction between difficulty level and experimental condition, $F(4, 24) = 2.225, p < .10$. This was not the case for high optimists. Simple main effect tests of experimental condition for each difficulty level revealed a main effect at the high difficulty level, $F(2, 36) = 6.832, p < .005$. The same tests of difficulty level for experimental condition revealed a main effect for the HA condition, $F(2, 36) = 12.123, p < .001$. First, post hoc pairwise comparisons for difficulty level revealed significant differences between both high and low and high and medium difficulties, but only in the HA condition ($p < .05$). Total number of clicks increased drastically as a function of task difficulty in the emergency analogue HA condition. Second, post hoc pairwise comparisons for experimental condition showed significant differences between both HA and CT and HA and TP, but only at the high difficulty level ($p < .05$). Total number of clicks increased with increasing arousal (that is, experimental condition) when the difficulty level was extremely high (Figure 4).

All told, these analyses demonstrate that low optimists increased the total number of clicks only when both arousal level and difficulty level were extremely high.

Figure 3 Number of Total Clicks
(High Optimists)

Figure 4 Number of Total Clicks
(Low Optimists)

3.2 Times to Complete

There were significant main effects of difficulty level for both groups (high optimists: $F(2,12) = 5.202, p < .05$, low optimists: $F(2,12) = 8.442, p < .01$), such that times to complete increased as a function of difficulty level. We repeated this analysis with optimism group as a third factor, finding a marginally significant main effect of optimism group, $F(1,12) = 4.403, p < .10$. Low optimists had somewhat longer times to complete than high optimists. (Figure 5, Figure 6).

Figure 5 Times to Complete
(High Optimists)

Figure 6 Times to Complete
(Low Optimists)

3.3 Mean number of clicks in 15 seconds

Finally, we analyzed mean number of clicks in 15 seconds for high and low optimist groups. This analysis revealed a significant main effect of experimental condition for high optimists ($F(2,12) = 4.410, p < .05$). On the other hand, there was no main effect of difficulty level. Post hoc comparisons highlighted a significant difference between HA and CT conditions ($p < .05$), such that high optimists increased mean number of clicks as arousal level increased (Figure 7).

On the other hand, the same analysis of mean number of clicks in 15 seconds for low optimists revealed no significant differences, with no increase in the HA condition (Figure 8).

Figure 7 Mean Number of Clicks in 15
Seconds (High Optimists)

Figure 8 Mean Number of Clicks in 15
Seconds (Low Optimists)

4. Discussion

Task performance under pressure for high optimists mirrored that of all participants more generally ⁽³⁾⁽⁴⁾, with total clicks to complete the task increasing with both task difficulty and arousal levels.

On the other hand, for low optimists total clicks increased with rising arousal levels only when task difficulty was extremely high, even during the HA condition.

These results suggest that high and low optimists may perform quite differently in emergency situations. The finding that low optimists showed an increase in total clicks only under conditions of both high arousal and high task difficulty may reflect the so-called "hysteresis phenomenon" ⁽²¹⁾⁽²²⁾⁽²³⁾.

The hysteresis phenomenon explains "agari" (this term is a Japanese noun referring to a broad range of experiences including 'stage-fright', 'choking under pressure' and social anxiety ⁽²⁴⁾). Extremely high levels of anxiety can lead to performance decreases that can take some time to return to baseline ⁽²⁵⁾. Figure 9 illustrates a model of the hysteresis

phenomenon that can be applied to the present results for low optimists. Although this explanation remains speculative at this point, as we did not directly evaluate the relationship between anxiety and optimism, our results would seem to fit a pattern of decreased performance after anxiety becomes too debilitating.

Figure 9 Hysteresis Phenomenon
(an excerpt from "Psychology World" Vol.45 ⁽²⁶⁾)

Completion times for the task increased with task difficulty, regardless of optimism level, although low optimists did take rather longer to complete the task. This might be partially due to the positive relationship between number of clicks used to complete the task and high levels of both task difficulty and arousal for low optimists. In fact, a comparison between Figure 3 and Figure 4 for the high difficulty HA condition shows more total clicks for low than high optimists, leading to longer completion times for the former.

However, this explanation does not provide a full account, as completion times were longer for low optimists when collapsing across all the conditions, not just HA. We next examined how completion time results compare with those obtained for mean number of clicks in 15 seconds.

Mean clicks increased with arousal level in high optimists, a result consistent with earlier work with general participant samples ⁽³⁾⁽⁴⁾. Our results for optimists appear to mirror those of our previous study, such that these individuals tend to react in high arousal emergency situations without much conscious deliberation. For low optimists, however, mean number of clicks did not increase as a function of arousal, remaining relatively constant even as task pressure increased. As was the case for total number of clicks and completion times, this result appears to reflect a strategic difference in how high and low optimists respond in emergency situations. Although low optimists took longer to complete the task (Figure 6), they did not do so because they needed to use more clicks (Figure 8), which were not influenced by arousal or task difficulty.

In brief, low optimists seem to take action during emergencies with calm and composure, given that they kept clicking at a constant rate across all conditions. However, it is not clear that this calm response style would translate into more effective action, given that task completion times were longer. These longer completion times coupled with a steady clicking rate imply that these individuals were not efficient in their use of switches, toggling many that had no impact on game progress. Our findings are similar to those of a previous study by Eysenck ⁽²⁷⁾, who found that high anxiety individuals performed as well as low anxiety individuals on a test, but took longer to achieve the same results. Eysenck argued that high anxiety participants do not just perform more slowly; rather, processing efficiency decreases, which led Eysenck to propose "processing efficiency theory".

We cannot argue that low optimists in the present study experienced higher anxiety than

high optimists, as this emotional variable was not assessed. However, it seems feasible that the processing inefficiency phenomenon described by Eysenck might have been operating here.

5. Conclusions

From the comparison of high optimists and low optimists, it was clear that the difference between high and low in optimism affects operation strategies in emergencies. The findings were following.

5.1 High Optimists

We summed up the results about high optimists in this study.
Total number of clicks: They increased with both task difficulty and arousal level.
Time to complete: It prolonged with task difficulty level.
Mean number of clicks: They increased with arousal level.

Their task performance under pressure mirrored that of all participants more generally⁽³⁾⁽⁴⁾. High optimists tended to "act promptly without much active thought" in emergencies.

5.2 Low Optimists

We summed up the results about low optimists in this study.
Total number of clicks: They increased drastically as a function of task difficulty in the emergency analogue HA condition.
Time to complete: It prolonged with task difficulty level. Additionally, low optimists had longer times to complete than high optimists.
Mean number of clicks: They were always stable regardless of both task difficulty and arousal level.

Their task performance under pressure was quite different from that of high optimists. Low optimists seemed to "act carefully but in an inefficient fashion" in emergencies. Their performance might arise from "agari", resulted from extremely high levels of both anxiety and arousal. Furthermore, it was also possible that their processing efficiency decreased in emergencies on the hypothesis of "processing efficiency theory".

In conclusion, this study suggests that individual differences in behavioral responses to emergencies do exist, and such differences should be taken into account by training programs in the workplace.

Notes

This study was conducted in collaboration with the Graduate School of Human Sciences, Osaka University.

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