The Effect of Simulated Threat on Task Performance During Emotion Recognition

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Abstract. Being able to de-escalate aggressive behavior during face-to-face interactions is an important skill for employees in a variety of domains. To do this effectively, employees should learn to recognize the emotional state of their conversation partner. However, this task can be seriously hindered by the stress triggered by the aggressive encounter. To gain more insight in the impact of threat on task performance during emotion recognition, 30 participants were asked to perform an emotion recognition task using pictures of virtual characters. Each participant performed the task two times, once under normal circumstances, and once in a 'stress' condition in which threatening stimuli were presented whenever a wrong answer was given. Additionally, all 30 participants performed a second, mathematical task, also under a normal and a 'stress' condition. Counterbalancing was used to control for order effects. The results indicate that there was a negative impact of the (simulated) threat on performance in the emotion recognition task, but not in the mathematical task. In follow-up research, these results will be used to develop an adaptive serious game for public service workers, with which they can train their aggression de-escalation skills in a personalized manner.

Keywords: Emotion recognition · Threatening stimuli · Task performance

1 Introduction

Aggressive behavior against employees in the public sector (e.g., police offers, ambulance personnel, and public transport employees) is an ongoing concern world-wide [4, 19]. To prepare employees for aggressive confrontations, by learning them to prevent verbal aggression from escalating into physical violence, dedicated training is required. The current paper is part of a project that aims to develop a simulation-based serious game [18] for public service workers, with which they can train their aggression de-escalation skills [2]. In such a game, a trainee will be engaged in a dialogue with an 'aggressive virtual character' (e.g., a tram driver is confronted with a passenger who starts threatening her because he refuses to pay for his ticket), with the goal to de-escalate the situation by applying the appropriate communication style. During the task, the system will 'monitor' the trainee (in terms of behavior and physiological measurements), in order to provide personalized support [7].

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When it comes to aggression de-escalation, the main skill that needs to be trained is the ability to recognize the emotional state of the conversation partner, and act upon this. An important factor is the distinction between *reactive* and *pro-active* aggression: reactive aggression is characterized as an emotional reaction to a negative event that frustrates a person's desires, whereas pro-active aggression is the instrumental use of aggression to achieve a certain goal [5, 13]. Based on the observed type of aggression, the employee should either apply a more empathic communication style or a more dominant style [1, 2, 9, 14].

However, in realistic situations, this de-escalation task can be seriously hindered by the stress that the aggressive encounter triggers in the employee [10, 12]. To enable our training system to provide effective feedback, it should therefore exploit knowledge on the relation between stress, cognition and task performance. Unfortunately, understanding the interplay between these three concepts is nontrivial, among others because they are somewhat ambiguous. For instance, the literature distinguishes a variety of different *stressors* (e.g., threatening stimuli, workload, time pressure) that influence various *cognitive processes* (e.g., attention, memory, decision making), which may in turn affect performance in a variety of *tasks* (e.g., recognition, recall, calculations). In [20], an extensive literature review is provided on existing studies in this area.

The current paper extends this body of literature by investigating the following question: *is there a negative impact of simulated threat on task performance in an emotion recognition task?* To explore this, 30 participants were asked to perform an emotion recognition task, where they had to categorize pictures of virtual characters. Each participant performed the task two times: once under normal circumstances, and once under 'stress' circumstances, in which threatening stimuli were presented when a wrong answer was given. Additionally, to test the impact of simulated threat on performance in a more intellectual task, all 30 participants also performed a mathematical task, again under a normal and a 'stress' condition.

The remainder of this paper is structured as follows. In Sect. 2, a brief overview is provided about the background of the research, and about the literature on stress and performance. Next, the method used for the experiment is described in Sect. 3, and the results are presented in Sect. 4. Section 5 concludes the paper with a discussion on the results and on directions for follow-up research.

2 Background

In this section, first a summary is provided of the research project that forms the context of this paper. This is followed by a discussion on the relevant literature on stress and performance.

2.1 The STRESS Project

Aggressive behavior against public service workers is an ongoing concern in many countries [4, 19]. Most incidents of aggression are of a verbal nature (e.g., insulting, swearing, intimidating), but in about 10 % of the cases the conflicts escalate into physical aggression (e.g., threatening, abusing, robbing). To prepare employees to deal with such aggressive confrontations in an effective manner, dedicated training is required.

An important goal of such training is to help trainees develop their *emotional intelligence*: they should be able to recognize the emotional state of the conversation partner, and act upon this. In the first place, they need to decide whether they are dealing with *reactive* or *pro-active* aggression. Reactive aggression is an emotional reaction to a negative event that frustrates a person's desires (e.g., a passenger becomes angry because the tram is late), whereas pro-active aggression is the instrumental use of aggression to achieve a certain goal (e.g., a passenger intimidates the driver in an attempt to ride for free) [5, 13].

Next, based on the type of aggressive behavior (s)he observes, the employee should select the most appropriate communication style. In particular, when dealing with a reactive aggressor, empathic, *supportive* behavior from the de-escalator is required, for example by ignoring the conflict-seeking behavior, making contact with the aggressor and listening actively to what he has to say. Instead, when dealing with a pro-active aggressor, a more dominant, *directive* type of intervention is assumed to be most effective. In this case it is necessary to show the aggressor that there is a limit to how far he can pursue his aggressive behavior, and making him aware of the consequences of this behavior [1, 2, 9, 14].

The STRESS project[1] aims to develop a simulation-based serious game for aggression de-escalation training, enabling public service workers to develop the type of skills presented above. Users of the system will be placed in front of a 3D Virtual Reality (VR) environment that is either projected on a computer screen or on a head-mounted display. During the training, users will be placed in a virtual scenario in a particular domain (e.g., issuing parking tickets, or selling tram tickets), which involves one or more virtual characters that at some point in time start behaving aggressively. The user's task is to de-escalate the aggressive behavior of the virtual characters by applying the appropriate communication techniques. Meanwhile, they will be monitored by intelligent software that observes (1) the behavior of the trainee (e.g., the responses given to the aggressive virtual character) and (2) the physiological state of the trainee (e.g., heart rate, skin conductance, brain activity). Based on these observations, the system will make an analysis of the trainee's performance, and provide tailored feedback (e.g., as in [7]). To this end, it should ideally combine the two sources of information that it receives as input. Based on the observed behavior, the system should determine whether the trainee is making any cognitive errors (e.g., (s)he may perceive the character as a pro-active aggressor whereas in reality it was showing reactive aggression). And based on the observed physiological measurements, it should determine to what extent the trainee is experiencing any stress. Next, these two analyses can be combined to assess whether the experienced stress may actually be one of the factors causing the impaired performance. Based on such as assessment, the system will be able to provide more adequate, personalized, feedback (such as the instruction to take a deep breath and focus on the facial expression of the character).

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[1] http://stress.few.vu.nl.

2.2 Stress and Performance

Developing a training system that is able to draw conclusions about a person's performance in related to experienced stress, and provide useful feedback upon this, is easier said than done. A general requirement for such a system is that it somehow exploits knowledge about the intricate relation between stress, cognition and task performance. Unfortunately, understanding the interplay between these three concepts is very difficult. According to Staal [20], 'There seem to be as many definitions of stress as there are stress researchers'. Therefore, in the current section we do not attempt to provide a complete overview, but rather take a pragmatic perspective, focusing on those aspects of stress and performance that are relevant for our training system.

A first aspect that should be further defined is the type of stressor that we are interested in. The literature mentions a wide variety of stressors, which include threatening stimuli, workload, thermals, noise, fatigue, and time pressure. For our purposes, it seems reasonable to state that we focus on threatening stimuli as the determinants of experienced stress. After all, we are interested in the type of stress triggered by encounters with aggressive individuals. In other words, the focus lies on a specific state of arousal underlying the fight-or-flight reaction or acute stress response, which is specifically caused by a threatening stimulus [3]. As such, this interpretation of stress comes close to the notion of fear or anxiety [16]. The specific type of threatening stimuli will be a combination of negatively-valenced images (cf. [11]) and disturbing sounds. By doing this, we will create a situation of 'simulated threat', which is comparable to the threat provided by the aggressive virtual characters in our training system.

Next, when examining the effect of stress on task performance, it is important to identify the type of cognitive processes that are involved. Hence, a next challenge is to define the cognitive processes that play a role within our envisioned training system. Like for stressors, the literature also contains a long list of cognitive processes that may be influenced by stress, such as attention, memory, perceptual-motor functions, judgment and decision making [20]. Among this list, the emphasis of the current research is on attentional processes, as these play an important role during face-to-face communication and aggression de-escalation. Nevertheless, these processes cannot be seen entirely separate from, for instance, perceptual-motor functions and decision making.

A third question is to define the type of task that is of interest for our research. As mentioned in [20], the impact of stress on performance is studied for a large diversity of tasks. These tasks include recognition, recall, arithmetic, Stroop tasks, logical reasoning, learning, perceptual-motor tasks, and many more. Obviously, the choice for the type of task that is studied relates to the cognitive process that plays a role. For the current research, we focus on emotion recognition, which is one of the main capabilities that we intend to teach people using our training system. More specifically, we will use a task where participants have to categorize pictures of virtual characters based on the emotions observed in their facial expression.

To conclude, in this paper we are interested in the impact of threatening virtual stimuli (in particular repulsive images and sounds) on performance during emotion recognition tasks. Although we are not aware of any studies that investigated exactly this relationship, the work by Eysenck and colleagues [6] seems relevant. They put forward the Attentional Control Theory (ACT), which states that anxiety can elicit a shift in attention from goal-directed to stimulus-driven, thereby increasing the distribution of attentional resources towards threat-related stimuli at the expense of attention allocated to the task. Although most studies based on ACT originally focused on tasks involving working memory, recently the theory has also been tested for other tasks, such as perceptual-motor tasks and combinations of several tasks (e.g., [15]). Below, we will test to what extent this theory also applies to an emotion recognition task.

3 Method

This section describes the experiment that was conducted to study the impact of threatening virtual stimuli on performance during an emotion recognition task. The expectation was that this influence would be negative, i.e., that people would perform worse at the emotion recognition task in conditions where they were confronted with threatening virtual stimuli.

3.1 Participants

Thirty people participated in this experiment. The age of the participants ranged between 15 and 63, with an average age of 20,8 ($\sigma = 10,6$). Seven of the participants were female and twenty-three were male. All participants were either students (75 %) or teachers (25 %) at a high school, where the experiments were conducted.

3.2 Experimental Setup

The experiment took place at a secondary school in the Netherlands, in a quiet room with the door closed. Participants had to perform a number of tasks on a computer, while wearing a headphone of which the sound was set to its maximum level. The software used for the experiment was implemented using OpenSesame, a graphical, open-source experiment builder designed for the social sciences.[2]

For the experiment, a repeated measures design was used, in which all 30 participants had to perform 2 tasks: an emotion recognition task and an arithmetic task (involving mathematical calculations). This second task was added to investigate the impact of simulated threat on performance in a more intellectual task (requiring working memory) as well. Moreover, participants had to perform each task under two conditions: an experimental ('stress') condition and a control ('neutral') condition. Hence, all participants performed four trials in total (normal emotion recognition, emotion recognition under stress, normal calculations, calculations under stress). Counterbalancing was used to control for order effects. Furthermore, all participants were asked to sign an informed consent form before the start of the experiment. After finishing the experiment, they had to fill in a short questionnaire, asking the participants about their subjective experience. The content of the tasks is explained in detail in

[2] http://osdoc.cogsci.nl/about/.

Sect. 3.3 (especially for the neutral condition); the details of the stress condition are provided in Sect. 3.4.

3.3 Task and Procedure

As mentioned above, the experiment involved two tasks: an emotion recognition task and a calculation task.

The emotion recognition task was designed to be representative for the envisioned training system, involving encounters with emotional virtual characters. Within this task, participants were presented a sequence of 50 pictures of virtual characters, showing an emotion expression on their face. The virtual characters were created using the MakeHuman software, an open source environment to create realistic 3D humans for animations, games and illustrations.[3] An example of a virtual character that was used in this task is shown in Fig. 1. Each picture was presented for 100 ms, after which the participant had to indicate which emotion (s)he observed via a multiple-choice menu (with the following possible answers: *happiness*, *sadness*, *anger*, *fear*, and *surprise*). After the participant had provided an answer, the next picture was presented. The task started with three practice questions, followed by the 50 actual questions. The task was finished after the 50th question was answered.

Fig. 1. Screenshot of a virtual character used in the emotion recognition task

The second task was a mathematical task, which was selected as a prototypical example of a more intellectual task, requiring working memory. Participants were presented a sequence of 50 arithmetic equations, and had to judge for each equation whether it was right or wrong. The setup of this task was identical to that of the emotion recognition task, i.e., first three practice questions were given, followed by the 50 actual questions. Only the contents were different: instead of pictures of virtual characters, arithmetic equations were offered. All equations were multiplication

[3] http://www.makehuman.org/.

equations, where the operands at the left-hand side of the equation were numbers of 2 digits (for instance: $11 \times 12 = 132$). Each equation was presented for 1 s, after which participants had to indicate whether it was right or wrong by selecting either *correct* or *incorrect* in a multiple-choice menu. About half of the equations was correct, and the other half was incorrect.

3.4 Stressors

In the previous section, both the emotion recognition and the calculation task were described for the case of the 'neutral' condition. The current section explains how these tasks were adapted to create a 'stress' variant. Recall that, for our purposes, the type of stress experienced by the participants should resemble the anxiety that people experience when confronted with aggressive individuals during face-to-face communication. A crucial aspect of such confrontations is that there is a constant threat that at some point the situation may escalate into actual violence, depending on how one treats the aggressor. For example, saying one minor thing that the aggressor does not appreciate may make him start shouting and perhaps even physically attacking the de-escalator.

To simulate this situation in the experimental environment, the idea was introduced to 'punish' participants for incorrect answers by showing them a highly repulsive picture, combined with a loud, scary noise. The repulsive pictures were taken from the International Affective Picture System (IAPS) [11], and were selected based on their high arousal and low valence scores (according to the standard IAPS ratings). In total, 25 pictures were used, which included spiders, snakes, people with serious wounds to the face, and wounded people in warzones. The scary sounds, 8 in total, were selected based on an Internet search, and included typical sounds from horror movies, like screaming individuals, slamming doors and roaring animals.

The stress condition was identical to the neutral condition, with the exception that whenever a question was answered incorrectly, the participant was 'punished' by presenting him or her an (arbitrary) combination of a repulsive picture and a scary sound. After this combination was offered for 3 s, the experiment would proceed in the normal way.

3.5 Variables

The experiment involved two independent variables, namely the task (either emotion recognition or calculation) and the condition (either 'neutral' or 'stress'). As mentioned earlier, a repeated-measures design was used, in which participants performed both tasks under both conditions. Our dependent variable was the participants' performance, which was measured by the number of correct answers for the task under consideration.

4 Results

The results of the experiment are presented in Figs. 2 and 3. Figure 2 depicts the average number of correctly answered questions for the emotion recognition task, both for the neutral condition and the stress condition. A paired t-test [$t(58) = -3.02$,

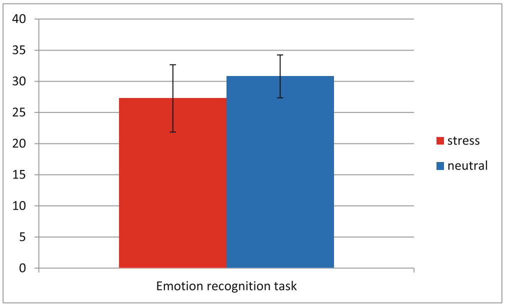

Fig. 2. Number of correctly answered questions in the emotion recognition task

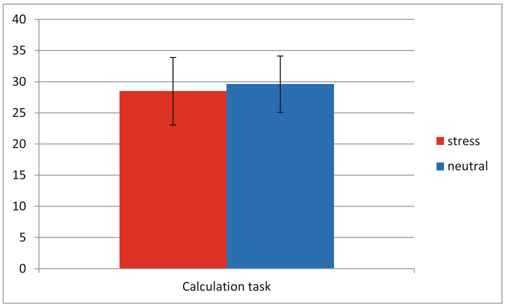

Fig. 3. Number of correctly answered questions in the calculation task

$p < 0.005$] indicated that for this task, the performance in the neutral condition (30.8) was significantly better than in the stress condition (27.3). The average number of correctly answered questions for the calculation task is shown in Fig. 3 (again for both conditions). For this task, a paired t-test [$t(58) = -0.88$, $p = 0.38$] indicated that the performance in the control condition (29.6) was not significantly better than in the experimental condition (28.5).

Hence, it seems that there was indeed a negative impact of simulated threat on performance in the emotion recognition task, whereas such an influence could not be found for the calculation task. These results can be considered in line with existing theories on the relation between anxiety and cognitive performance. In particular, as mentioned earlier, Attentional Control Theory states that anxiety increases the distribution of attentional resources towards threat-related stimuli at the expense of attention allocated to the recognition task [6, 15]. The current experiment provides evidence that this also holds for anxiety that is induced by a combination of repulsive pictures and scary sounds. In contrast, this effect turned out not to hold for a more intellectual task like arithmetic. This is consistent with other studies indicating that anxiety does not impact mathematical performance [8], and may be explained by the fact that for such tasks people provide compensatory effort to maintain the same performance level [6, 17].

5 Discussion

To effectively de-escalate aggressive behavior during face-to-face interactions, employees should learn to recognize the emotional state of their conversation partner without having their performance too much affected by the stress they experience. The current research was performed in the context of a project that aims to develop personalized, simulation-based training for public service workers to improve their aggression de-escalation skills. The results of the experiment provided useful input for the further development of this training system, as they confirmed that there may indeed be a negative impact of threatening stimuli on people's performance during emotion recognition.

Follow-up research will focus on how to incorporate these findings within the training system under development. The main idea here would be to use the gained insights about the relation between threatening stimuli, experienced stress, and performance to generate more appropriate feedback. As a simple example, if during training it turns out that a particular scenario (which includes a lot of threatening stimuli) results in a poor performance of the trainee, the system may use this information to conclude that the trainee is actually very stressed, and may adapt its feedback accordingly (e.g., by suggesting that the trainee should try to regulate his or her stress level). One step further, we intend to develop a computational cognitive model on the relation between threatening stimuli, experienced stress, and performance, and to validate this model against the results of the current study (and similar experiments). Having such a computational model would provide an additional benefit for the training system, as it would allow it to reason about these processes on a quantitative level; for instance, it could be used to determine *how much* the trainee needs to down-regulate his stress level for an acceptable performance. Also such a model could include additional concepts related to mental states, such as a person's attentional resources (cf. Attentional Control Theory [6]), which may offer a basis for even more detailed feedback (e.g., the suggestion to focus attention on particular aspects of the task). Nevertheless, extensive further testing is required before these ideas can be implemented.

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