# Assembling a Synthetic Emotion Mediator for quick decision making during acute stress

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## ABSTRACT

**Motivation** – Previous research suggests that emotions and stressors influence the decision making processes in different ways. Decisions made by emergency workers in a stressful situation could be negatively influenced by emotions and stressors. This project aims to train police officers and military personnel to make high quality decisions in a stressful situation, by training them in a virtual reality environment and providing feedback on their valence and arousal levels.

**Research approach** – Literature research has been used to establish a model that can predict an individual's reaction to a stressful situation, and the way this will influence their decisions. This model will be implemented in a Synthetic Emotion Mediator. This mediator will be used in a virtual reality training, in which participants train on making good decisions, even when strong emotions inflicted by an acute stress response take hold of them.

**Keywords**
Stress, emotions, decision making, modelling, police officers, military personnel.

## INTRODUCTION

The 'Accommodating of emotions during quick decisions' project focuses on emergency personnel, who for their profession, enter unclear and stressful situations and are forced to make quick decisions to steer the situation into a positive ending. In such situations, acute stress changes the arousal and valence level of the personnel. Insight in their current emotional state is beneficial for high quality decision making (Seo & Feldman Barrett 2007). This project aims to model the quality of decisions made by individuals in a stressful situation that experience a change in their valence and arousal. This model will be used in a technological device that provides feedback on emotions. This device will be used as a tool in virtual reality trainings for emergency personnel, to improve the quality of decisions made while working under acute stress.

### Decision making under stressful situations

Several reports in the literature show a relationship between stressful situations and the cognitive decision making process. One theory on how stress influences decision making, is that stress impairs the scanning-process and reduces the consideration of alternative outcomes (Keinan, 1987). Keinan (1987) put participants in a stressful situation. Despite the assurance that good performance would help them avoid getting electrical shocks (physical danger) and the absence of time limits, the participants showed disorganized and incomplete scanning patterns. Furthermore, Mendl's (1999) review on performance under pressure, points out that stress causes shifting and narrowing of attention, which may lead to decisions based on inadequate information, in turn affecting decision quality.

Another way to understand the relationship between stressful situations and the decision making process is to look at different cognitive strategies that lead to a decision. Starcke, Pawlikowski, Wolf, Altstotter-Gleich & Brand (2010) for example, describe the intuitive-experiential strategy and the rational-analytical strategy. The first is a natural, heuristic strategy that leads to decisions based on emotions. The rational-analytical strategy is slower, neutral and controlled. These strategies are both influenced by different stressors. The analytical strategies will be more disrupted, for example, by time pressure and noise, while heuristic strategies will not be affected by these stressors (Klein, 1996).

For the military setting, Thunholm (2004) identified three extra strategies that are being used for decision making. These are the avoidant, the dependent and the spontaneous strategies. Thunholm (2008) investigated the relationship between different decision making styles and negative stress experienced by military officers when making a decision. Participants had to make tactical decisions in a battle scenario. As expected, cortisol levels measured in participants that applied avoidant decision making strategies increased

when the participants were forced to make a decision on their own. An unexpected finding, however, was that participants who applied the avoidant style also had higher cortisol baselines. This shows that the decision making process by itself can also be stress evoking for certain individuals. It also shows that individuals who apply different coping strategies will be affected differently by stressful events.

### Decision making and the valence and arousal levels

In addition to stress, emotions can also influence decision making. Negative valence demands cognitive resources that otherwise could be used for decision making processes. Heightened anxiety, for example, is said to deplete working memory capacity and therefore reduces performance on cognitive tasks (Kleider et al. 2010). Khan, Brinkman and Hierons (2010) on the other hand, show that high arousal in programmers increases their debugging performance. Clore and Huntsinger (2007) found that people's judgments are influenced by their current mood or emotion. When a person enters a stressful situation in which he or she needs to make a decision, the first step is primary appraisal to assess the severity of the (potential) danger (Delahaij 2009). It seems therefore that if mood influences the appraisal in a negative way, this may lead to a negative decision.

It is clear that stress and emotions influence the quality of decisions, and that it is important to identify the factors and their negative effects to aid decision makers in highly stressful situations. This project aims to develop new interventions and tools that can reduce the negative effects and improve the quality of decision making strategies of professionals in crises.

## GOAL OF THE PROJECT

The goal of the 'accommodating emotions during quick decisions' project is to develop new methods to reduce the negative effects of emotions on decisions made when the decision maker is under high pressure or stress. Thus improving the quality of the decision. To accomplish this, the project will address the following research questions:

*Which stress factors and emotional conditions influence the quality of decisions of professionals?*

The identified stress factors will be used in a model that will predict performance of decisions.

*How can emotional conditions that influence decision making be recognized automatically?*

Different physiological measures will be fused into a single emotion parameter that predicts different performance outcomes. The end goal of this project is the creation of a Synthetic Emotion Mediator (SEM). This system will register the user's emotional state (valence and arousal levels) and provide feedback when the user needs to make decisions under high pressure. It will be used in simulated training scenario's, with the use of virtual reality technology. To make both SEM and the training as effective as possible this project focuses also on the third research question:

*In what way can the quality of decisions made under high pressure be improved with the help of virtual reality and SEM?*

Virtual Reality has the potential to elicit stress reactions in individuals (Bouchard, Guitard, Bernier & Robillard, 2011) and is already in use for treatment of phobia's (ter Heijden & Brinkman, 2011). This project will use virtual reality to simulate stressful environments to train emergency workers in decision making. By giving feedback on valence and arousal levels, the users will have more insight in their own state. This has a positive effect on the quality of decisions (Seo & Feldman Barrett, 2007). It is expected that the SEM will especially be an effective support system during trainings. The effectiveness of the SEM will be tested in virtual environments that will reflect realistic stressful situations for police, fire-fighters or military personnel.

## APPROACH

In the first year of this four year project, a domain analysis has been conducted to identify the real problems when a police officer or soldier makes a decision when experiencing acute stress. This led to a model describing this process. The second year will focus on programming this model and validating it with data gathered in research conducted in the first and second year. After validation, the model will be implemented in the first SEM prototype. After that, in the third and fourth year, research will be conducted to improve the SEM and finally to show the effectiveness of the new training aids developed in this project.

### Model

Figure 1 shows a model under development that is based on the literature. The final version of this model will be used for simulation. The external environment consists of any stressful situation and the task demands. After perceiving the environment an appraisal will be established (Delahaij 2009). The appraisal will determine the chosen coping strategy, but also influences the subjective experienced task demands (Bosse, Both, Lambalgen, van & Treur 2008). The amount of effort put into the task will depend on the experienced demands and coping strategy. A high level of effort will increase exhaustion. Mood can change depending on exhaustion and the way one appraises the situation. Mood influences physical responses. Coping strategies reflect the current mood and will steer the decisions. The external environment will then change, depending on what decision is made.

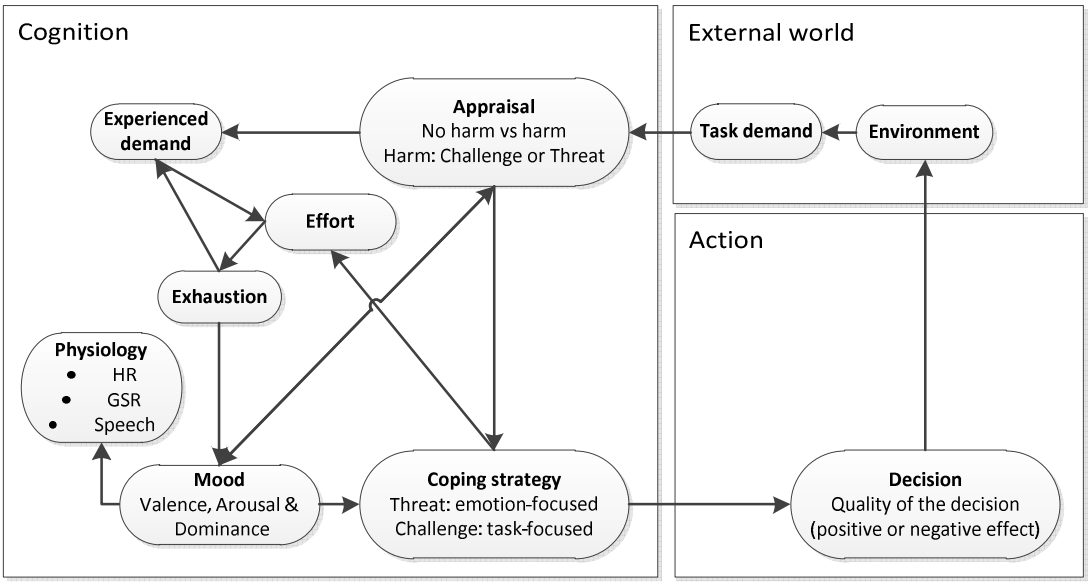


Figure 1. Simulation model of decision making process during stressful events.

#### Determining the variables

To simulate a crisis situation in an experiment or training, it is important to understand what the external environment looks like at that moment, and what kind of decisions need to be made. It is also important to know how police officers or military personnel are trained to handle crises, and to establish what kind of errors occur and at what stage of the decision process they occur. With interviews and contextual inquiries, information about training scenario's and police instructions will be gathered.

#### Creating a computational model

After the model is prepared and an expert review of the crisis situations and the appropriate actions are established, the model will be implemented in a computational modelling environment. Data mining will be used with previously gathered data, to determine the connections and parameters that can be used in an agent language that will create the simulation model.

#### Data input for the model

Some data has already been gathered that can be used validate the simulation model. One experiment looked at subjective stress measures from military personnel before they performed a 10 session biofeedback training and after the training. The participating military personnel had been deployed, but had not been in combat scenario's.

Another available data set consists of an experiment using groups of 5 participants playing a first person shooter in the role of soldier, and one participant playing the commander role. The commander could keep track of the position of the soldiers while checking their stress levels. For this stress level, the Root Mean Square Successive Difference (RMSSD) of the heart rate variability was calculated. The commander could decide when and where to allocate soldiers if their stress levels were too high or low.

One more experiment that will be used to validate the model is the mars500 (Smets, Neerincx, Cohen & van Diggelen, 2012). Six men were on a simulated journey to mars, in which they were locked in a space shuttle for 520 days. Data of this experiment consists of subjective stress levels and performance rates on several tasks.

This data set shows that stress reactions still occur even after a long period of time and stress. The second experiment described here was looking at acute stress and how to measure it. The data already showed that the stress levels reduced during the course of the experiment. This could imply that the stress inflicting properties of the game reduce if participants play too long, or that RMSSD alone shows an overall stress level and not an acute stress level. Merging heart rate variability with other physiological reactions might be a more appropriate stress measure.

#### Using the model for training

Currently, some virtual trainings are available that help emergency personnel develop skills or to prepare them for stressful situations. The application of virtual trainings is based on the assumption that the more a training reflects a realistic scenario, the more effective the training will be. Research has demonstrated that stressful events simulated in virtual environment can elicit physiological stress responses in individuals (Busscher, de Vlieger, Ling & Brinkman, 2011). The military and police departments also use virtual reality

trainings more and more. Virtra system, for example, is being used for military and law enforcement trainings (http://virtra.com/training-content) and the Los Angeles Police Department recently opened a state-of-the-art incident training system called HYDRA.

Since stress evoking virtual reality simulation trainings already exist, this project will add a new dimension to these trainings. Physical reactions to stress will be measured and feedback will be provided to users. In this way, police officers and military personnel can be trained to handle their emotional state when a decision needs to be made in a stressful situation. As described in this paper, decision making will improve when participants can distinguish and identify their emotions. When the model described in this paper is completed and implemented into the SEM, it is expected that a prediction about the quality of the decisions can be made. Using the SEM, professionals will be able to train their decision making skills in a simulated stressful environment while keeping track of their valance and arousal levels and the quality of their decisions, while being in a safe environment.


## ACKNOWLEDGMENTS

This research project (056-22-010) is supported by the Dutch FES programme "Brain and Cognition: Societal Innovation"


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