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Validation of a One-Item Acute Stress Scale for Driving Tasks

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ABSTRACT

Emergency personnel, such as ambulance crews and firefighters, must perform well both mentally and physically during emergency responses around the clock. Driving under high pressure is expected to be related to high acute stress, but still no validated subjective scale for acute stress is existing. The focus of this study is to validate a new stress scale called VTI Acute Stress Scale (VSS), a scale built on similar approach as the Karolinska sleepiness scale. In total, 49 participants (33 men and 16 women) were recruited among ambulance personnel and emergency response personnel in western Sweden. They drove a passenger car simulator with three scenarios designed to induce varying levels of perceived stress. The results showed that VSS could discriminate between the three driving tasks. The stress ratings were moderate throughout the trials, with no ratings above 7 on the 9-point scale. In conclusion, the VSS can be used to measure acute driver stress in moderately stressful driving conditions. Future studies need to be done during real road conditions.

Keywords: Stress, Driving simulator, Ambulance, First responder

INTRODUCTION

Emergency personnel, such as ambulance crews and firefighters, must perform well both mentally and physically to provide effective emergency responses around the clock. The opportunity for recovery and rest between missions is often limited during work shifts. This can lead to an increased risk of fatigue and perceived stress during emergency responses, which also increases the risk of a crash. During emergency responses, personnel are exposed to acute stress physiological reactions, which are more pronounced in more urgent situations, such as priority 1 alarms in the case of traffic accidents (Karlsson, Niemelä et al., 2020). Stress has been identified as a contributing factor to road crashes due to its negative impact on driving performance (Beanland, Fitzharris et al., 2013; Mou, Zhou et al., 2021; Rastgoo, Nakisa et al., 2018). Stress increases the crash risk by affecting cognitive abilities, resulting in inadequate information processing and imperfect perception

that may in turn lead to deterioration of driver performance (Wiberg, Nilsson et al., 2015). Maintaining sufficient driving ability in all traffic situations is fundamental to prevent road crashes.

Physiological measurements, most often based on Heart Rate (HR) measures, can be used to detect driver stress but there is also a need for subjective rating scales that are easy to use in a driving setting. For driver sleepiness, a scale often used is the 9-point one-item Karolinska Sleepiness Scale (Åkerstedt and Gillberg, 1990). This is a scale that has been proven sensitive and valid as an indicator of sleepiness, and particularly suitable for field studies (Åkerstedt, Anund et al., 2014). However, there is no equivalent measure of acute driver stress. There are several validated instruments available for measuring perceived stress, such as Cohen's Perceived Stress Scale (Cohen, Kamarck et al., 1983). Stress scales typically require the participant to answer several questions about their experiences to enable the calculation of a stress score. Validated one-item scales suitable for quick measurements of perceived acute stress are, however, lacking. In this study we investigated if a new one-item stress scale, named the VTI acute stress scale (VSS), could be used to measure acute driver stress in an ambulance simulator.

METHODS

A simulator trial was conducted with ambulance driving scenarios designed to induce various stress levels in emergency response personnel. Each participant performed three simulator tasks: Task A was a low-stress routine drive with a wildlife encounter towards the end, Task B was a medium-stress urgent callout, Task C was a high-stress emergency response (Table 1). The tasks were counterbalanced between participants. All participants had previous experience using the ambulance simulator, but they were naïve to the specific driving tasks used in the study.

After each driving task, participants completed a questionnaire with questions about perceived stress (9-point VSS scale), task load (NASA-TLX), and sleepiness (9-point KSS scale).

Table 1. Characteristics of the driving tasks.

Task	Urgency	Traffic density	Road type	Events	Speed limit	Time of day
A	Non-urgent	Low	Rural	Wildlife encounter	50/70 kph	Day
B	Urgent	Medium	Urban	None	50 kph	Night
C	Life-threatening	High	Rural and Urban	Reversing car, traffic congestion, deteriorating patient	50/70 kph	Day

Participants

Forty-nine participants (33 men and 16 women) were recruited among ambulance personnel and emergency response personnel in western Sweden. Everyone employed as ambulance paramedics, ambulance nurses or fire-fighters were eligible to participate. Exclusion criterium was self-reported previously diagnosed medical conditions that could affect physiological outcome measures that were included in the study but not reported in this paper, including cardiovascular disease, diabetes, and neurological diseases. Data collections took place at two different ambulance stations on five different occasions in year 2022. The study protocol was approved by the Swedish Ethical Review Authority (ref 2021-04352).

Measures

The VTI acute stress scale (VSS) was developed for the present study to quantify perceived stress. It is a modified version of the Stockholm University Stress scale (SUS; Dahlgren, Kecklund et al., 2005). The 9 verbal anchors of the VSS are designed to match the verbal anchors of the Karolinska Sleepiness Scale (KSS)(Åkerstedt and Gillberg, 1990). The VSS anchors are: 1 completely relaxed (feeling entirely calm and relaxed), 2 very relaxed, 3 relaxed, 4 rather relaxed, 5 neither relaxed nor stressed, 6 slightly stressed, 7 stressed (feeling some tension and pressure), 8 very stressed, 9 extremely stressed (feeling very tense and under high pressure, on the verge of what I can handle).

The NASA Task Load Index (NASA-TLX) is a multi-dimensional rating scale that provides workload ratings across six subscales: mental demand, physical demand, temporal demand, performance, effort, and frustration (Hart and Staveland, 1988).

Karolinska Sleepiness Scale (KSS) is a subjective rating scale where participants can rate their own sleepiness level (Åkerstedt and Gillberg, 1990). The drivers indicated on a nine-point scale how sleepy they had felt (1 = extremely alert to 9 = very sleepy, great effort to keep awake, fighting sleep) on average during the driving task.

Before the study started the drivers were instructed on how to use the rating scales.

Statistical Analysis

Results are generally presented as means with standard deviations (SD). Differences in questionnaire scores between the three driving tasks were analyzed using mixed model ANOVA. Separate regression models were created with each of the outcome measures as the dependent variable. Task (A, B, C) was included as a within-subjects factor and participant was included as a random factor. If the task effect was significant, pairwise comparisons were made between tasks with Tukey post-hoc tests. The significance level was set to 0.05. Statistical analyses were performed in IBM SPSS statistics version 29 (IBM Corp., Armonk, NY, USA).

RESULTS

Forty-eight drivers had VSS ratings from all three drives and were thus included in data analyses. The mean VSS ratings were A = 3.17 (SD 1.58, range 1–7), B = 3.77 (SD 1.59, range 1–6), and C = 4.65 (SD 1.77, range 1–7). The ANOVA with task (A, B, C) as a fixed factor and participant as a random factor showed that there was a significant difference in VSS ratings between tasks (Table 2). Post-hoc tests (Tukey) showed that task A had significantly lower rating than task B and task C, and task B had significantly lower ratings than task C (Table 2).

All NASA-TLX workload subscale scores were significantly higher for task C compared with task A and B (Table 2). Task B had significantly higher scores than task A regarding mental, physical, and temporal demand, effort, and frustration (Table 2). There was no significant difference in sleepiness between tasks (Table 2). KSS scores were generally low with mean ratings of A = 3.16 (SD 1.39), B = 3.31 (SD 1.23), and C = 2.78 (SD 1.12).

The VSS was significantly correlated with NASA-TLX subscales mental demand (r = 0.606), physical demand (r = 0.419), temporal demand (r = 0.605), performance (r = 0.313), effort (r = 0.541), and frustration (r = 0.553). The VSS was also moderately correlated with KSS (r = 0.304).

Table 2. ANOVA of differences in questionnaire scores between driving tasks.

	Main effects (ANOVA)						Post-hoc tests (Tukey)		
	Task			Participant			Task A vs B	Task A vs C	Task B vs C
	F	p-value	$\eta 2$	F	p-value	$\eta 2$	p-value	p-value	p-value
VSS	22.9	<0.001	0.33	4.8	<0.001	0.71	0.021	<0.001	<0.001
Mental d.	33.0	<0.001	0.41	6.1	<0.001	0.75	<0.001	<0.001	<0.001
Physical d.	18.3	<0.001	0.28	7.5	<0.001	0.79	0.009	<0.001	0.009
Temporal d.	78.7	<0.001	0.62	2.8	<0.001	0.59	<0.001	<0.001	<0.001
Performance	7.2	0.001	0.13	2.5	<0.001	0.55	0.55	0.001	0.026
Effort	34.3	<0.001	0.42	6.4	<0.001	0.76	<0.001	<0.001	<0.001
Frustration	40.1	<0.001	0.46	2.8	<0.001	0.58	<0.001	<0.001	<0.001
KSS	6.7	0.002	0.12	6.6	<0.001	0.77	0.61	0.029	0.002

DISCUSSION

The focus of the study is to validate a new stress scale called VTI Acute Stress Scale (VSS), a scale built on similar approach as the KSS. The VSS could discriminate between the three driving tasks designed to induce varying levels of perceived stress. The medium correlations between VSS scores and NASA-TLX scores show that the VSS acute stress score is related to but not identical to workload.

The stress ratings were moderate throughout the trials, with no ratings above 7 on the 9-point scale. This could be due to simulator scenarios not being perceived as stressful as real-life emergency driving situations. Using simulators enabled a high control of the scenarios and consistency between participants. However, it is challenging to achieve the same feeling of urgency

as in real life emergency situations when driving in a simulator. Further evaluation of the VSS in real-life and in very high stress scenarios is therefore warranted. Moreover, a challenge of studying stress in driving is that it normally only occurs in isolated short events connected to a complex traffic scenario, making it difficult to capture the perceived stress level at the exact moment of high stress.

The main benefit with the VSS is that it matches the KSS in terms of range, increments, and verbal anchors. This allows the concurrent measurement of perceived stress and sleepiness in traffic safety studies. It is well-documented that fatigue is a contributing factor in 10–30% of all road crashes (Hallvig, Anund et al., 2014; Philip and Åkerstedt, 2006; Zwahlen, Jackowski et al., 2016). The link between stress and road crashes has not been studied to the same extent. Stress has been found to negatively affect driver performance and significantly increase the risk of a crash (Rastgoo, Nakisa et al., 2018). Australian national crash reports show that stress is among the ten leading contributors to serious casualty crashes (Beanland, Fitzharris et al., 2013).

Stress during driving depends on a multitude of factors (Gnardellis, Tzamalouka et al., 2008; Mamcarz, Droździel et al., 2019; Wang, Murphey et al., 2019) such as driving workload, quality of sleep, personality, and lifestyle. The literature suggests that professional drivers with long working days suffer significantly more driving stress compared to other drivers, with the corresponding effect on their driving style (Magaña, Pañeda et al., 2021). Ambulance personnel are exposed to several risk factors for future illnesses in their profession, including acute and chronic stress (Hegg-Deloye, Brassard et al., 2014). Work-related stress itself is a risk factor for developing cardiovascular diseases and stroke (Huang, Xu et al., 2015; Steptoe and Kivimäki, 2013). The acute stress responses during an emergency mission is influenced by the current situation (acute stress), events earlier during the shift, and events in everyday life (chronic stress) (Karlsson, Niemelä et al., 2020). Future studies should investigate whether VSS ratings during emergency responses are affected by chronic stress levels.

CONCLUSION

In conclusion, the VSS can be used to measure acute driver stress in moderately stressful driving conditions. Future studies need to validate VSS during high stress scenarios, and in real road conditions with naturalistic driving.

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