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Does individual experience affect performance during cardiopulmonary resuscitation with additional external distractors?

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Cardiopulmonary resuscitation is perceived as a stressful task. Additional external distractors, such as noise and bystanders, may interfere with crucial tasks and might adversely influence patient outcome. We investigated the effects of external distractors on resuscitation performance of anaesthesia residents and consultants with different levels of experience. Thirty physicians performed two simulated resuscitation scenarios in random order, one scenario without additional distractors (control) and one scenario with additional distractors (noise, scripted family member). Resuscitation performance was assessed by a score based on European Resuscitation Council guidelines, presented as median (IQR [range]). We found that performance scores were lower under experimental conditions (11.8 (9.0–19.5 [−9.0 to 28.5]) than under control conditions 19.5 (14.0–25.5 [5.0–29.5]), p = 0.0002). No interaction was observed between additional distractors and experience level (p = 0.4480). External distractors markedly reduce the quality of cardiopulmonary resuscitation. This suggests that all team members, including senior healthcare providers, require training to improve performance under stressful conditions.

INTRODUCTION

Cardiopulmonary resuscitation (CPR) is perceived as a stressful task by medical teams [1, 2]. Stress is defined as a non-specific response of the body to an event or stimulus (stressor), and it has been suggested that stress can interfere with the performance of technical skills in critical situations [2, 3]. Stressors vary in form and include factors regularly encountered during CPR, such as high workload and time

pressure. Additional external distractors, such as noise and presence of family members or bystanders during resuscitation, may also distract from crucial tasks and may have a negative impact on teamwork, and hence might adversely influence overall patient outcome.

Previous data on the effect of external distractors on human performance during CPR are conflicting [1, 2]. Moreover, to our knowledge, there are no data on whether the experience of a healthcare provider has an influence on performance during CPR when affected by additional distractors. Although it seems plausible that more experienced providers – who may often serve as the leader of a resuscitation team – can better focus on their tasks and may get distracted less easily than inexperienced providers, this might not necessarily be true. Therefore, we investigated whether external distractors influence performance during a standardised simulated CPR scenario in general, and specifically tested the hypothesis that performance during CPR with external distractors depends on the level of experience of healthcare providers.

METHODS

The study was conducted at the ADAM simulation centre of the VU university medical centre in Amsterdam, the Netherlands. The institutional ethical review board approved the study. Every participant gave written informed consent to take part in this study. Thirty physicians with different levels of clinical experience (group 1: 1st and 2nd year anaesthesia residents; group 2: 4th and 5th year anaesthesia residents; group 3: consultant anaesthetists; n = 10 per group) participated on a voluntary basis. All participants were part of our hospital resuscitation team and were trained in advanced life support (ALS). Volunteers were informed that their CPR performance during two simulated scenarios would be evaluated in the context of a scientific investigation, but they were not aware that we were specifically interested in the effects of external distractors.

Before commencing the study, each participant received a 15-min structured familiarisation with both the simulator and the environment (available equipment and drugs, logistics and communication pathways to get further assistance). A full-scale patient simulator (SimMan™; Laerdal Medical Corporation, Stavanger, Norway) was used to simulate CPR scenarios as described below. Features of this simulator include palpable pulses and spontaneous breathing with visible thoracic excursions. The simulator was placed on an emergency room stretcher in our simulation centre, and was connected to a monitor that displayed all common vital signs such as ECG, non-invasive blood pressure, capnography and temperature. A peripheral intravenous cannula was in place to allow for intravenous administration of drugs. All drugs and equipment necessary to perform CPR according to current guideline recommendations, including a manual defibrillator, were available in the simulating room.

In this randomised crossover study, each volunteer participated in two simulated CPR scenarios. One ‘standard’ resuscitation scenario without external distractors served as the control condition, and one scenario with additional distractors as

described below served as the experimental condition. Participants were assigned the role of leader of the resuscitation team, and were provided with three additional team members, who were part of the research group: a first-year anaesthesia resident; a medical student; and an emergency room nurse. The team was instructed to act with helpful attitude, but to be active on commands of the participant only. All scenarios were recorded on video to allow for accurate rating of CPR performance.

Using exactly the same scenario twice for each participant (except for the fact that one scenario contains additional distractors) might lead to carry-over effects in the way that participants could instantaneously recognise that they are confronted with the same situation, and that they would basically have to perform the same actions as in the first scenario. We therefore developed two ‘standard’ simulation scenarios that could be presented either with or without additional distractors (i.e. both scenarios could serve as ‘control’ or ‘experimental’ condition, depending on whether distractors were added or not). One scenario featured ventricular tachycardia (VT) without cardiac output and the other ventricular fibrillation (VF). To create a different mind-set for the study participants when entering the simulator room, the case briefing described different medical histories (patient with chest pain vs patient who collapsed). Note that although two different scenarios and medical histories were chosen to create a different mind-set and to minimise carry-over effects, both scenarios required exactly the same treatment during CPR, allowing direct comparison of performance.

For each participant, additional external distractors were randomly added to either the first or second scenario. The external distractors consisted of a scripted family member of the patient (role-play) who was talking to the physician during the procedure at predefined crucial moments (such as the start of resuscitation, defibrillation, re-assessment) and a constant static radio noise at approximately 70 decibels.

Randomisation of the sequence in which the scenarios (VT vs VF) and the distractors (external distractors vs no external distractors) were presented was performed using a sealed envelope technique.

We developed a scoring protocol based on recommendations in the European Resuscitation Council (ERC) guidelines to assess and summarise individual CPR performance in a single score. The score ranges from −12 to +34 (negative scores were assigned for omission of defibrillation, chest compressions and drug administration) and represents a weighted sum of a number of elements that are considered crucial for efficient resuscitation. This includes recognition of cardiac arrest, calling for assistance, recognition of a shockable heart rhythm, time to defibrillation, start of chest compressions, checking quality of chest compressions and time to administration of adrenalin. The score was developed in an audit process within the study group in close collaboration with the hospital's resuscitation board and experienced non-investigator physicians. After data collection, two reviewers watched the recorded videos and independently rated the technical performance.

Since timely defibrillation in shockable rhythms and initiation of chest compressions are considered crucial events during CPR with a proven impact on outcome [4], we specifically considered time to first defibrillation and time to starting of chest compressions as secondary outcome parameters. These times were dichotomised depending on whether participants started chest compressions and performed defibrillation within clinically acceptable limits (60 and 90 s, respectively).

Results were analysed by the STATA 13.0 statistical package (StataCorp, College Station, TX, USA). Performance scores showed a marked skewed distribution. To allow for parametric analysis, the score was transformed to a normal probability distribution using a Box-Cox transformation with a transformation parameter of 1.7 after re-centring of the original score to non-negative values [5]. Normal distribution of the transformed variable was confirmed by the Shapiro–Wilk test and normality plots. Differences between experimental and control conditions (additional distractors vs no additional distractors) were assessed by multifactorial ANOVA. Additional factors included in the ANOVA model were the sequence in which scenarios were presented (potential carry-over effect), time period (potential learning effect), participant identification number (to account for repeated measurements), scenario type and experience group, as well as the interaction between experienced group and distractors (to assess whether the effects of distractors depend on the level of experience).

Dichotomous parameters were compared with Pearson's chi-squared tests. A p value < 0.05 was considered statistically significant.

The intraclass correlation (ICC) was calculated to assess the inter-rater agreement between the two reviewers who individually assigned CPR performance scores.

Power calculations were performed with SAS 9.2 (SAS Institute Inc, Cary, NC, USA). Since the performance score was exclusively developed for this study, no literature was available for a priori estimations of mean differences, standard deviations and correlations between repeated measurements. Calculations using different plausible estimates suggested that a sample size of around 20–30 pairs would be necessary to detect a mean difference of 5 in the performance score between stress and no-stress conditions at a two-sided alpha level of 0.05 and with a power of 0.8. We therefore empirically chose a sample size of 30 pairs.

RESULTS

All participants completed the study. Their characteristics and experience are shown in Table 1.

[TABLE 1]

Overall performance scores were significantly lower when additional external distractors were present than under control conditions (Fig. 1). No interaction was observed between additional distractors and experience level ($p = 0.448$), indicating that the effect of distractors does not depend on the experience level. Figure 2 shows

the effects of additional distractors per group of experience. There were no overall significant differences in median (IQR [range]) performance scores between groups of different experience (1st/2nd year residents: 17 (11.8–20.0 [−3.5 to 28.5]), 4th/5th year residents: 19.8 (11.8–21.8 [−9.0 to 29.5]), consultant anaesthetists 14.3 (9.3–20.5 [−2.0 to 29.0]), p = 0.519). This was equally true under control conditions (1st/2nd year residents: 17.8 (16.0–21.0 [13.0–28.5]), 4th/5th year residents: 20.3 (12.0–25.5 [8.0–2.5]), consultant anaesthetists 20.5 (14.0–26.0 [5.0–29.0]), p = 0.968) as under experimental conditions (1st/2nd year residents: 11.8 (9.0–18.5 [−3.5 to 26.5]), 4th/5th year residents: 19.8 (5.0–21.0 [−9.0 to 28.5]), consultant anaesthetists 9.8 (9.0–14.5 [−2.0 to 18.5]), p = 0.242).

[FIGURE 1.][FIGURE 2.]

When external distractors were present, significantly fewer participants defibrillated within predefined acceptable clinical time limits (8 participants (26.7%) vs 18 participants (60.0%), p = 0.009). We also observed a trend that fewer participants started chest compressions within the predefined time limit in the scenarios with additional distractors (16 participants (53.3%) vs 22 participants (73.3%), p = 0.108). The type of scenario (VF or VT) was not associated with performance (p = 0.735), suggesting that the type did not confound the relationship between performance and distractors or experience, respectively. The sequence in which the scenarios were presented (first experimental, then control vs first control, then experimental) was also not associated with performance (p = 0.588), suggesting that there were no carry-over effects. However, participants scored significantly better during the second scenario compared with the first scenario (median (IQR [range]) 19.0 (16.0–21.5 [8.0–29.0]) vs 11.8 (5.0–20.0 [−9.0 to 29.5]), respectively, p = 0.0007), suggesting a learning effect.

A high inter-rater agreement between the two reviewers who individually assigned CPR performance scores was observed (ICC = 0.938).

DISCUSSION

We tested the hypothesis that external distractors influence performance of physicians during CPR, and assessed whether this depends on the physician's level of experience. The addition of external distractors during CPR markedly reduced the overall quality of performance of anaesthesia residents and anaesthesiologists and significantly delayed the first defibrillation. This is particularly critical because early defibrillation is crucial for survival in patients with VF or pulseless VT [5]. The effects of external distractors on CPR performance score were independent of the level of experience.

Healthcare professionals usually experience management of cardiac arrest as a high-stress situation [2, 3]. This is even more prominent when bystanders such as family members are present [2]. However, current literature is conflicting on whether such additional distractors actually impair CPR performance. Consistent with our data, Fernandez et al. observed that the presence of distractive family members during a simulated CPR scenario did have an adverse impact on CPR performance in

emergency medicine residents [1]. In contrast, Bjørshol et al. did not observe effects of external distractors on CPR quality [2]. In that study, experienced paramedics performed simulation-based resuscitation scenarios with and without distractors. Participants did experience a significant increase in the subjective workload and frustration level when external distractors were present, but CPR performance was not affected. There are several possible reasons for the difference between the findings from that study and our data. First, Bjørshol defined 'quality of CPR' as measuring chest compression depth, chest compression rate and no-flow ratio, as well as time to first shock and time to intubation. Our scoring protocol focused more on the adhesion to the ERC CPR guidelines. This could create a different interpretation of the term 'performance'. Second, the participants in that study were paramedics, whereas our participants were anaesthesiologists. Bjørshol et al. argued that paramedics face socio-emotional stress quite frequently. Paramedics are used to working in public places with bystanders and external distractors, and may therefore be more 'resistant' to such factors than anaesthesiologists, who primarily respond to emergency situations in a confined hospital setting.

Another hypothesis of our study was that medical personnel with more work experience would be less affected by external distractors. Based on the results of our study, we cannot confirm this. No association between the level of distraction and the level of experience was observed, and there were no significant differences in performance between the three experience groups under experimental and control conditions. Common belief and older studies suggest that more experience is associated with better performance [6], whereas accumulating evidence suggests that there is only a weak relationship between the two factors [7]. This is particularly important because more experienced personnel often serve as leaders of resuscitation teams, and are expected to maintain oversight and take correct decisions even under stressful conditions. However, our data suggest that experience neither guarantees good performance during CPR nor is associated with decreased susceptibility to distraction. Rather than solely relying on experienced team leaders, all team members, including senior healthcare providers, require training to improve performance under stressful conditions. This is especially important because external distractors cannot always be eliminated during CPR.

In this context, ample evidence shows that multidisciplinary simulation training improves technical and non-technical skills in medical teams [8-21]. Non-technical skills including communication, leadership, workload and task distribution have been shown to play a pivotal role in mastering stressful clinical situations [3, 8, 10, 22-30]. Therefore, training sessions that particularly address non-technical skills and stress management might help individuals and teams to be better prepared for CPR with a high level of external distractors.

We used a full-scale simulator to assess the effects of external distractors on CPR performance. Performing a similar study in real resuscitations raises several logistic, technical and ethical issues. First, cardiac arrests are acute events in a heterogeneous patient population in different settings and handled by varying resuscitation teams, making it impossible to achieve standardised conditions. Second, assessment of human performance during CPR is a logistic challenge, as it is unlikely that trained

observers or a video system arrive at the scene from the very beginning of the arrest. Third, it would be unethical to experimentally introduce distractors with a potentially adverse effect on CPR performance during actual resuscitations. In contrast, use of the simulator allowed for a randomised crossover design under standardised study conditions and in which each participant served as his/her own control. Cardiac arrest scenarios could be run under identical conditions for all participants, distractors could be reproducibly manipulated and CPR performance could reliably be recorded and assessed. Due to these properties, simulator-based studies are broadly accepted as research instruments for CPR performance [12]. Nonetheless, resuscitation on a simulator differs from conditions encountered in actual resuscitation settings. In particular, the level of stress may be higher during an actual resuscitation, but since conditions are alike for all participants, simulation does allow comparisons of experimental vs control conditions.

Our study goal was to assess the impact of distractors on performance. However, to our knowledge no standard scoring protocols are available to assess overall individual human performance of the resuscitation team leader during CPR. Guided by similar scoring protocols used in the aviation industry to score pilot performance, we identified all relevant tasks outlined in the ERC resuscitation algorithm. In an internal audit process, we assigned weights to each task depending on its relevance, and assigned negative scores for omission of tasks that play a pivotal role in the algorithm for shockable rhythms, such as defibrillation, chest compressions and administration of adrenaline. Subsequently, our weighting method was discussed with non-investigator experts in the field from our hospital's resuscitation commission, and was readjusted until consensus was reached. The overall performance score is the sum of the individual weighted scores, and hence reflects how well the algorithm was followed by the resuscitation team leader, while giving more emphasis on aspects deemed to play a more critical role in the algorithm. Our data show an excellent inter-rater agreement, suggesting good reproducibility of the score that we have developed. Beside the performance score, we also used time to chest compressions and time to defibrillation as outcome parameters. Although there is a broad consensus that both events should be commenced as early as possible, maximum acceptable time limits are not defined in the literature. We consider delays > 60 s unacceptable for starting with chest compressions, and delays > 90 s unacceptable for defibrillation (we allowed extra time for defibrillation because defibrillation pads need to be attached first). Hence, we defined 60 and 90 s, respectively, as cut-off-points for dichotomising response times.

We used two different types of scenarios (VT and VF) to minimise carry-over effects, and our data indeed do not provide evidence for carry-over effects. Moreover, the data demonstrate that using two different scenario types did not confound the relationship between performance and distractors or experience, respectively. However, we did observe a learning effect in the way that performance scores were on average higher in the second than in the first scenario. Due to balanced randomisation, an equal number of participants started with either the control or experimental scenario, and hence the learning effect did not systematically bias the relationship between distraction and performance in our study. In fact, the learning effect is a central goal of simulator teaching sessions, and although it was

not a focus of our investigation, this observation does underline the potential of simulation-based training to improve skills that might be beneficial to patient care and safety. We conclude that human performance during CPR is altered when external distractors are added. The effects on performance do not depend on general work experience. It is likely that non-technical skills such as teamwork and leadership skills play an important role. Healthcare should invest more effort into training the non-technical skills of individuals and teams who are working in a high-stress environment.

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TABLE AND FIGURES

Table 1. Characteristics of participants performing cardiopulmonary resuscitation with and without external distractors stratified by level of experience. Values are number (proportion), mean (SD) or number.

	Level of experience		
	1st and 2nd year residents (N = 10)	**4th and 5th year residents (N = 10)**	**Consultant anaesthetists (N = 10)**
Male	6 (60%)	6 (60%)	5 (50%)
Age; years	30.1 (2.6)	33.4 (3.8)	39.8 (6.9)
Work experience; years	2.7 (1.1)[a]	5.5 (1.1)[a]	12.3 (7.1)
Number of resuscitations performed (in categories)	< 10 = 2	< 10 = 0	< 10 = 0
	10–50 = 8	10–50 = 5	10–50 = 2
	> 50 = 0	> 50 = 5	> 50 = 8
Number of simulation sessions performed	0 = 2	0 = 0	0 = 0
	1 = 3	1 = 7	1 = 2
	2 = 3	2 = 2	2 = 3
	> 3 = 2	> 3 = 1	> 3 = 3

[a] In the Netherlands residents obtain work experience before their official residency.

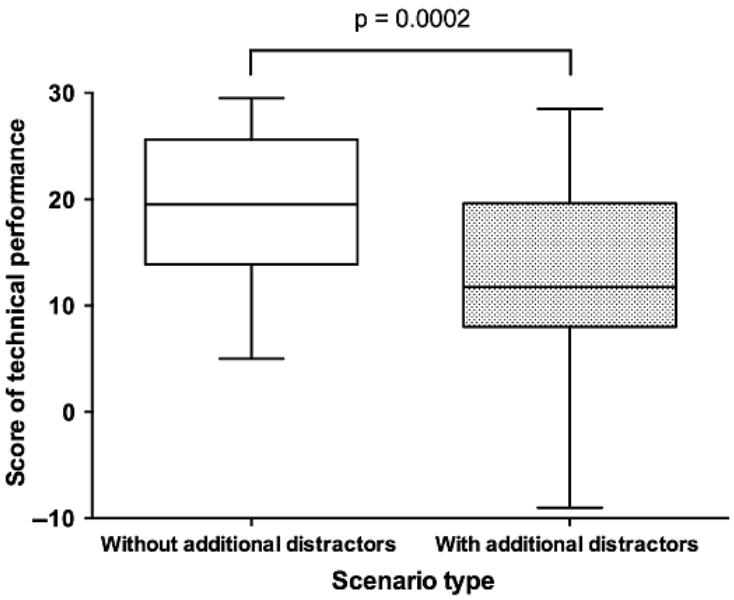

Figure 1 Overall effect of additional distractors on performance during CPR scenarios. The horizontal line inside the box depicts the median, the box itself represents the IQR and the whiskers show the full range of data.

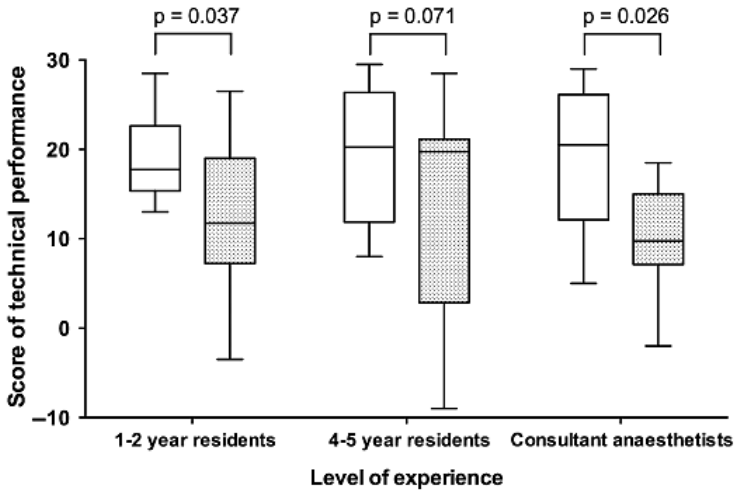

Figure 2 Effects of additional distractors on CPR performance in different groups of experience. White boxes indicate conditions without distractors, grey boxes with distractors.