International Journal of Nursing Studies 98 (2019) 57–66

Contents lists available at ScienceDirect

International Journal of Nursing Studies

journal homepage: www.elsevier.com/ijns

The influence of anxiety on student nurse performance in a simulated clinical setting: A mixed methods design

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ARTICLE INFO

Article history:
Received 4 July 2018
Received in revised form 2 June 2019
Accepted 14 June 2019

Keywords:
Anxiety
Clinical performance
Emergency
High-fidelity
Novice nurses
Nursing
Simulation
Performance
Patient scenario

ABSTRACT

Background: Anxiety has a powerful impact on learning due to activation of anxiety hormones, which target related receptors in the working memory. Experiential learning requires some degree of challenge and anxiety. Patient simulation, as a form of experiential learning, has been an integrated component of health professional education internationally over the last two decades, especially in undergraduate nursing education. Little information is available to determine if and how anxiety impacts nursing students' clinical performance during simulation.
Objectives: To investigate physiological and psychological anxiety during emergency scenarios in high-fidelity simulation and understand the effect of anxiety on clinical performance.
Design: First^{2}Act was the model for the simulation intervention. Second and third year undergraduate nursing students attended a two-hour simulation session and completed a demographic questionnaire plus pre-simulation self-reported psychological anxiety scale. A heart rate variability monitor was attached to each student's chest to measure heart rate variability (as a sign of anxiety) before engaging in two video-recorded simulated emergency scenarios (cardiac and respiratory) with a professional actor playing the patient. Performance was rated by a clinician followed by video-assisted debriefing. Finally, heart monitors were removed and students repeated self-reports of psychological anxiety.
Results: Students' psychological anxiety was high pre-simulation and remained high post-simulation. With regard to physiological anxiety, students were anxious at the start of the simulation but became more relaxed toward the end as they gained familiarly with the simulation environment ($p < .007$). Clinical performance increased significantly in the second scenario ($p < .001$). Factors found to positively affect clinical performance were length of enrolment in the nursing degree ($p = .001$), current employment in a nursing or allied healthcare field ($p = .030$), and previous emergency experience ($p = .047$). The relationship between physiological anxiety and clinical performance was statistically not significant, although there was an indication that low level anxiety led to optimal performance.
Conclusion: High-fidelity patient simulation has the capacity to arouse novice nurses psychologically and physiologically while managing emergency situations. Indicative outcomes suggest that optimal performance was apparent when anxiety levels were low, indicating that they had received insufficient training to deal with situations that induced moderate to high anxiety levels.

What is already known about the topic?

- Patient simulation as a teaching and learning tool is well integrated in nursing programs
- Simulated setting could be a profound source of anxiety
- Moderate level of anxiety leads to optimal performance

What this paper adds

- High-fidelity simulation has the capacity to evoke novice nurses' anxiety physiologically and psychologically
- Low level of anxiety leads to optimal clinical performance in simulated setting

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https://doi.org/10.1016/j.ijnurstu.2019.06.006
0020-7489/

1. Background

Anxiety has been found to be influential on learning in aviation (Lindseth, 1994), the military (Clemons, 1996), competitive sport (Craft et al., 2003), medical practice (Smith and Kleinman, 1989), and clinical nursing settings (Meisenhelder, 1987). This is due to activation of the hypothalamus-pituitary adrenal (HPA) axis which results in release of glucocorticoids from the adrenal cortex and across receptors in the brain, more precisely receptors in the working memory (Selye, 1950). Hence, the working memory is the key component directly affected by anxiety hormones. Evidence indicates that anxiety leads to poor performance through deficits in the cognition process (Ansari and Derakshan, 2010; Schwabe et al., 2009), reducing storage (Hayes et al., 2008) and processing capacity of total working memory (Ansari and Derakshan, 2011). However, anxiety is an idiosyncratic phenomenon (Tallis, 1990), and each person's response varies.

From a psychological perspective, the influence of anxiety on cognitive performance is explained in a number of theories. The Information Processing Theory (IPT) was the first attempt in explaining the negative relationship between anxiety and performance. It asserts that worrying interferes with performance and results in fewer resources being allocated to manage a given task (Humphreys and Revelle, 1984). Cognitive Interference Theory (CIT) further explained that worrying about performance reduced the working memory's capacity and attention, and therefore impaired performance (Sarason, 1984). However, these theories have been critiqued as not being specific enough to explain which cognitive functions are impaired under anxiety (Eysenck and Clavo, 1992).

This led to evolution of Processing Efficiency Theory (PET) and Attentional Control Theory (ACT) (Eysenck et al., 2007) that address fundamental understandings of how anxiety affects performance. To clarify, during anxiety when a goal is being threatened, an individual tries to allocate attention, whether internal (thoughts) or external (distractors) to identify the source of the threat to the goal, which in turn deteriorates performance.

Preparing nursing students for the ever-changing healthcare setting is a fundamental element of transformative nursing education. Quality and safety concerns in nursing education emphasise the need to incorporate new approaches to meet health professional standards (Benner et al., 2010). However, experiential learning requires some degree of challenge and anxiety. Practising nursing skills and undertaking preparatory nursing education can create a significant amount of anxiety for individuals, that might be considered as an obstacle to learning in a clinical setting (Najjar et al., 2015). Anxiety has the potential to reduce the ability of nursing students to retain knowledge, which in turn can reduce their success in a nursing education program (Shearer, 2016).

Patient simulation, as a form of experiential learning, has become widespread in healthcare education during the last two decades (Al-Ghareeb and Cooper, 2016). It is a powerful educational approach and contemporary evidence suggests that it could be used to substitute up to 50% of clinical nursing practice (Hayden et al., 2014). However, anxiety produced in simulated settings can be high. Factors that might increase anxiety include being under the "microscope" (Cato, 2013; Cordeau, 2010), expectation "deficiency" (Paige and Morin, 2015), experiencing the "experience" (Paskins and Peile, 2010) and level of fidelity (Dzioba et al., 2014). To date, little evidence is available to determine if and how anxiety impacts on nursing students' clinical performance in simulated settings (Al-Ghareeb et al., 2017). Our aim was therefore to investigate undergraduate nursing students' physiological and psychological anxiety during emergency simulated scenarios, and to identify the effect of anxiety on clinical performance.

2. Methods

The larger study, of which this research was a part, employed mixed methods, in particular an embedded design that involved measuring psychological and physiological anxiety, and clinical performance. This paper focuses on findings of students' performance and anxiety levels arising from heart rate variability monitoring. Human ethical approval was obtained from XXXX Human Research Ethics Committee (MUHREC) (Project number CF14/2171). To reduce extrinsic influences on anxiety, the study was based on 'limited disclosure' and the main aim of the study was concealed. During the recruitment stage, the phrase 'measuring anxiety' was not mentioned. During data collection the Pre-stressors Scale (SAS) was incorporated with other measures to 'dilute' any emphasis on anxiety. To incentivise students, names were entered into a draw to win one of six activity monitoring bracelets. Students were informed of the main study aim after completion of data collection. A pilot study was performed to test feasibility and utility of the study design and to estimate time required for undertaking the data collection. Consent forms were signed by all participants before commencing the data collection.

2.1. Sample and recruitment

Using purposive sampling, we invited two groups of undergraduate nursing students at one multi-campus university, those at the end of their second year and the start of third year to engage in a high-fidelity simulation intervention. To deliver the scenarios, we implemented the face-to-face version of the Feedback Incorporating Review and Simulation Technique to Act on Clinical Trends (FIRST^{2}ACT^{TM}) simulation package (https://first2act.com/, 2019). This is a high-fidelity clinical simulation program that requires participants to recognise deterioration cues and apply appropriate nursing interventions (Cooper et al., 2015). We utilised two scenarios: acute myocardial infarction and chronic, obstructive pulmonary disease (COPD). Each scenario ran for eight minutes with the patient acutely deteriorating at the four-minute mark (Bogossian et al., 2014). A trained actor played the role of applicable patient in both scenarios. Students worked in groups of two or three, rotating roles, such as leadership, between each scenario. Clinical (OSCE) performance ratings were analysed based on group performance i.e. not on an individual basis. More details of participants' journey are illustrated in Table 1.

Students were asked not to consume caffeine, nicotine or alcohol before their simulation session, due to potential effect on heart rate variability (HRV) which was the key physiological measure of anxiety in this study (details below) (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

2.2. Exclusion criteria

Due to influence on HRV, smokers (Cagirci et al., 2009; Kroczek et al., 2016), pregnant women (Niwa et al., 2007; Reyes-Lagos et al., 2015), those with cardiac disease and/or pacemakers (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996), respiratory disease (Reis et al., 2010), diabetes mellitus (Sacre et al., 2012), and high blood pressure (Bourassa et al., 2017) were excluded.

2.3. Tools and instruments

2.3.1. Demographic questionnaire

General information about participants requested included their age, gender, professional history, and general health, including medications, such as inhaled medication for respiratory

Table 1
Participant's journey.

Stage	Activity
Stage 1: Pre-intervention	Students completed: • Consent form • Demographic questionnaire • Pre-stressors appraisal scale (SAS)
Heart Rate Variability monitor placed on students' chests and switched 'ON'	
Stage 2: Simulation intervention	First briefing: • Students listened to the handover delivered by the junior doctor First scenario: • Filming began • Students' performance evaluated by OSCE checklist for the cardiac scenario
Break between scenarios	
	Second briefing: • Students listened to the handover delivered by the junior doctor Second scenario: • Students' performance evaluated by OSCE checklist for the respiratory scenario
Stage 3: Debriefing	• Students reviewed their performance (photo-elicitation) • Student were asked about their anxiety during both scenario
Stage 4: Post-intervention	Students completed: • Post-SAS
Heart Rate Variability monitor switched 'OFF'	

disease. Checks were also made related to recent exercise (Bailo'na et al., 2010), smoking, alcohol, caffeine and/or nicotine consumption and history of heart/respiratory disease, diabetes and high blood pressure.

2.3.2. Objective Structured Clinical Examination (OSCE) checklist

An OSCE checklist was utilised to evaluate students' clinical skill performance in each scenario. Clinical performance was rated at group level; each group was rated using one checklist (e.g. if one student assessed the respiratory rate, the whole group received the point). The OSCE instrument was developed in line with performance measures from FIRST^{2}ACT^{TM} (Bogossian et al., 2014). The cardiac scenario checklist contained 28 items and the respiratory 24. The OSCE incorporated a feasible nominal (yes/no) checklist of key actions participants were expected to accomplished as the patient actually deteriorated in the latter four minutes of each eight-minute scenario. For example, in the first scenario, in the first four minutes, students had to obtain immediate history, undertake a pain assessment, record vital signs and perform ECG. In the second four minutes, students had to assess pain, provide nitrates, repeat vital signs and call for assistance.

2.3.3. Stressors Appraisal Scale (SAS)

Cognitive appraisal refers to situation evaluation that is influenced by an individual's goals beliefs and values (Arnold, 1960), and positive and negative outcome perceptions. The appraisal process encompasses two stages: primary appraisal, which is an evaluation of personal relevance, significance and meaning in a given situation (Lazarus, 1966). Secondly, it includes evaluation of the resources available to cope with the situation (Lazarus, 1966). Individuals adapt to any given situation according to whether it is challenging (perceived as task demands met by adequate resources) or as a threat (task demands exceeded resources). The scale consists of ten items: seven items in the primary appraisal, which refers to evaluation of personal relevance, significance and meaning in a given situation (Schneider, 2008) and three items in the secondary appraisal, which involves evaluation of the resources that individuals have to cope with the situation (Schneider, 2008). The ratio between primary and secondary appraisal is the indication as to whether students perceived simulation as a threat or a challenge. In this study, stress appraisal scale was issued pre- and post-test to determine differences in students' psychological anxiety before and after the simulation experience. For example, the pre-SAS rated participants' anticipated anxiety prior to the scenarios of how threatening they expected the task to be; whilst the post-test rated participants' retrospective views of the experience.

Stress Appraisal Scale is reliable and extensively validated for content validity, construct validity, concurrent validity and internal consistency (Schneider, 2008). The primary appraisal items (threat, demand, stressfulness, exertion, effort, importance and uncertainty) were reliable (alpha = .78). The secondary appraisal items (manageability, ability, performance) were also reliable (alpha = .89). Overall reliability score was = 0.79.

2.3.4. Heart rate variability (HRV)

HRV is described as the variation over time of the interval between consecutive heartbeats, as well as oscillation between consecutive, instantaneous heart rate (Constantino et al., 2014). HRV has been used as an indicator of physiological anxiety specifically when the R-R interval is reduced (i.e. a heart rate increase). HRV measurement is noninvasive and measures the variation in heart rhythm through QRS intervals. HRV is a biomarker tool that has been used to capture individuals' psychological status (Shinba, 2017; Zahn et al., 2017) and anxiety is one of the psychological status assessed by HRV (Ramírez et al., 2015a). We decided to use HRV in our study as: 1) this tool had not been used previously in undergraduate nursing education and 2) cardiac output (HRV - mean RR interval) has been evidentially linked to anxiety, attention and emotional control (Ramírez et al., 2015b; Tarvainen et al., 2014). In this study, we used HRV eMotion® monitors, manufactured in Finland (Mega Electronics Ltd, 2016) with monitoring via two electrodes. Mean RR interval/millisecond (ms) was the central measure of anxiety.

2.4. Data analysis

Data from HRV records were entered into Kubios^{TM} software. Raw data was inspected for any artifacts (Tarvainen et al., 2014). Heart rate variability segments for each student were divided into ten segments: first briefing, first four minutes of the first scenario, second four minutes of the first scenario, break, second briefing, first four minutes of the second scenario, second four minutes of the second scenario, debriefing and last four minutes of the whole session. Due to variation in length of debriefing sessions for each case, debriefing segments were divided into first 10 min and second 10 min. Mean RR interval$^{(ms)}$ was extracted for all 10 segments. Differences between baseline (last four minutes of the simulation session) and other segments were a key measure of anxiety (Keitel et al., 2011). By taking this strategy, nine new variables were generated: first briefingdiff, first four minutes of the first scenariodiff, second four minutes of the first scenariodiff and so on. HRV new variables, the demographic questionnaire, clinical performance (OSCE) and Stress Appraisal Scale were entered into SPSS version 32 (IBM Corp. Released, 2015. IBM SPSS Statistics for Windows, 2015). Data were abnormally distributed. Inferential analyses therefore included Friedman test, which was used to assess changes in variables measured on three or more occasions, such as mean RR interval$^{(ms)}$. The Mann-Whitney U test was used to compare scores on continuous variables for two unpaired groups; for example, exploring difference in mean RR intervals$^{(ms)}$ between second and third year nursing students. Further, the Wilcoxon Signed Rank test for assessing changes in continuous variables was measured at two points for paired data, such as investigating changes in mean RR interval$^{(ms)}$ at two points (e.g. in the first and second scenarios for the same group(s)). Finally, Spearman test was adopted for assessing correlation between two continuous variables, such as performance score and psychological anxiety. In order to test different levels of anxiety in relation to performance, students were divided into three group according to their physiological anxiety levels: low, moderate, and high anxiety and the relationship between performance and anxiety levels was tested with Kruskal-Wallis. The accepted level of significance was 0.05 (a = .05).

3. Results

Thirty-three healthy students participated in the study. On the simulation day, none reported consuming any products containing alcohol, nicotine or caffeine or reported physical exercise before the simulation exercise. Students' ages ranged between 20 and 56 years old, with a mean of 32.4 years (SD 10.4). The majority were female (93.9%) with only two males (6.1%). Of the 33 students, 11 (33.3%) were in the second year of the Bachelor of Nursing degree, whereas 22 (66.7%) were in third year. Twenty-two participants were employed in nursing or allied healthcare field at the time. Eleven (33.3%) had previously experienced critical situations, while 22 had not.

Overall clinical performance scores ranged from 49.50% to 77.50% (mean = 60.09%, SD = 8.73). In the first scenario (cardiac), groups scores ranged from 41.3% to 72.4% (mean = 54.96%, SD = 10.4%). In the first four minutes of the scenario when the patient's condition was stable, the mean percentage score was 72.4% (SD = 12.73), while in the second four minutes (deterioration) the mean performance score was 30.8% (SD = 8.44), i.e. a notable reduction in performance. In the second scenario (respiratory), group scores ranged from 50.0% to 83.4% (mean = 65.0%; SD = 11.4%). During the first four minutes of the scenario, mean performance score was 65.3% (SD = 15.93), while in the second four minutes, it was 63.5% (SD = 11.88), i.e. performance was maintained. Furthermore, clinical performance increased significantly between the first and second scenarios ($P < .001$), whilst third-year students performed significantly better than second-years ($P = .001$), and students working in healthcare performed significantly better than those who were not ($P = .030$). Students who had previous experience in managing deteriorating patients performed significantly better than those who had not ($p = .047$).

Before students engaged in the simulation scenario they anticipated that the level of demand of the simulation task ranged from 4 to 7 with a mean of 5.87 (SD + .65) and the ability to cope ranged from 2 to 6 with a mean of 4.4 (SD = .917). The relationship between level of demand and the ability to cope is negative (rho = −.440, P = .010). The more the simulation task demanded of the students, the more students did not have sufficient resources to manage the task. Post-simulation, students indicated the task was very demanding, ranging from 4 to 7 (mean = 5.77, SD = .70). Overall, psychological anxiety had increased by the end of the program, but not significantly ($p = .715$). However, more than half (n = 15) were more psychologically anxious at the end of the session than when they commenced.

Tracking RR intervals throughout the simulation indicated that students' mean RR interval was 614.50$^{(ms)}$ during the first briefing, when they were listening to the handover (delivered by an educator playing the role of a junior doctor). This decreased (i.e. more anxious – faster heart rate) to a mean of 610.26$^{(ms)}$ during the first four minutes of the first scenario when the patient's condition was stable. In the second four minutes of the scenario, when the patient started to deteriorate, mean RR interval was 633.47$^{(ms)}$ (i.e. less anxious, reduced heart rate variability). In the second scenario, mean RR interval was 643.27$^{(ms)}$ in the first four minutes and increased slightly to 654.50$^{(ms)}$ in the second four minutes of the scenario. During the debriefing session, students' mean RR interval was 755.22$^{(ms)}$ in the first 10 min and 762.08$^{(ms)}$ in the second 10 min of the debriefing session. At the end of the whole simulation session (baseline – last 4 min), mean RR was 764$^{(ms)}$. Mean RR interval throughout the simulation session is visualised in Fig. 1.

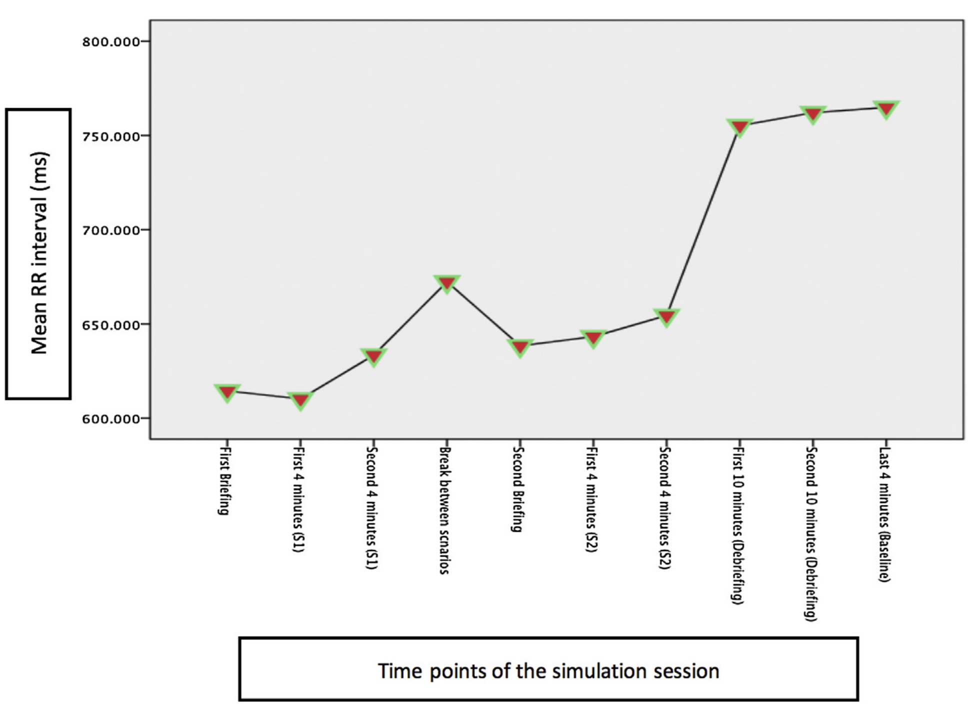

Fig. 1. Mean RR interval $^{(ms)}$ throughout the simulation experience.

Demographic data were tested regarding the contribution to heart rate variability during both scenarios. No demographic variables significantly contributed to physiological anxiety (reduction in RR interval). However, there was a tendency in some groups to be more anxious than in others. For example, second-year students (145^{ms}) were more anxious than third-year students (121^{ms}). Students who were not employed in a nursing or healthcare field (149^{ms}) were more anxious than those who were (115^{ms}). Students who had not been in an emergency situation previously (149^{ms}) were more anxious than those who had been (118^{ms}).

Table 2 shows the mean RR interval in each segment, differences between mean baseline RR interval value and the rest of the segments and standard deviation of the difference.

Compared with baseline (as seen in Table 2), greatest reduction in RR interval that students experienced during the simulation session was during the first four minutes of the first scenario as the mean difference was $154.60^{(ms)}$. In other words, students were physiologically anxious at the start but they were more relaxed at the end, as indicated by widening in RR interval. The mean RR interval varied significantly across the nine-time points ($p < .001$). Students were physiologically anxious at the start but they were more relaxed during the second scenario ($p < .000$) and even more relaxed during the debriefing session ($p < .000$). Fig. 2 indicates the difference between segments (time points) of the simulation session, which we refer to it as the level of anxiety throughout the simulation session.

In order to test correlation between physiological anxiety and clinical performance, students were divided into three groups according to their physiological anxiety: low, moderate, and high levels of anxiety. There were no statistically significant differences in performance levels across the three groups (Gp. 1, n = 11: low anxiety, Gp.2, n = 11: moderate anxiety, Gp.3, n=; high anxiety), X^2 (2, n = 33) = .215, p = .643. Despite the lack of statistical differences between groups we were able to amplify the trend in performance in the following way (refer to Fig. 3).

Fig. 3 illustrates the relationship between group performance and anxiety level. In this figure, we divided students according to their physiological anxiety level (mean RR interval) to low, moderate and high levels of anxiety. The blue line in the chart indicates a low level of physiological anxiety. The line shows a positive correlation with performance. Hence, low anxiety might lead to high performance. The green line refers to a moderate level of physiological anxiety. Interestingly, the line indicates a negative relationship with performance. Therefore, a moderate level of anxiety may reduce performance. The red line in the chart indicates a high level of physiological anxiety. The line indicates a negative relationship with performance. Accordingly, high anxiety may reduce performance.

4. Discussion

The purpose of this study was to investigate the effect of anxiety, both physiologically and psychologically, on clinical performance in a simulated setting in undergraduate nursing education. The study sought to capture psychological anxiety before and after an emergency simulation intervention, and to track mean RR interval as a measure of physiological responses to anxiety.

4.1. Anxiety and performance: 'Groups' inverted-U'

Our results indicated that nursing students, on average, obtained half of the required performance (60%). This finding concurs with Cooper et al. (2012) who found that OSCE performance was generally low when managing a deteriorating patient - a mean performance of 54%. This is not surprising given the evidence that undergraduate nursing students have difficulty recognising deterioration cues and therefore fail to respond appropriately to patient deterioration (Bogossian et al., 2014), due to lack of knowledge and clinical skills, poor teamwork and situation awareness (Endacott et al., 2015; McKenna et al., 2014).

We found that nursing students performed significantly better in the second scenario (respiratory) than in the first (cardiac). This finding aligns with Willhaus (2013) regarding improvement of performance in the second scenario, although a different simulation package was used by Willhaus (2013). In terms of clinical performance in the first and second half of the scenarios, our findings are similar to Endacott et al. (2015) and Cooper et al. (2015) who reported that novice nurses' performance declined during episodes of acute deterioration.

The findings also indicate that third-year nursing students performed better than second year nursing students, as did those working in nursing or allied healthcare fields compared to those who did not, and those with had experience of caring for deteriorating patients. These findings are to be expected; it is understood that managing a deteriorating patient can be influenced by education and experience (Endacott et al., 2015).

We discovered that students experiencing low levels of anxiety performed optimally; but performance declined with moderate to high anxiety levels. Based on the inverted-U relationship between anxiety and performance developed by Yerkes and Dodson (1908), a moderate level of anxiety is deemed essential for effective learning, and excessive anxiety may diminish learning. A

Table 2
Differences between mean baseline R-R interval value and other segments.

Segments-Time points of the simulation session	Mean RR interval$^{(ms)}$	The difference in mean RR interval$^{(ms)}$ compared with the last four minutes 'Baseline' (mean = 764.86*)	Std. Deviation of the differences	Confidence Interval (95%) of the differences in means
First scenario				
First briefing	614.50	150.36	62.39	(128.24–172.48)
First four minutes	610.26	154.60	64.59	(131.66–177.54)
Second four minutes	633.47	131.39	68.07	(107.25–155.53)
Break between scenarios				
Break	672.36	92.5	50.67	(74.53–110.47)
Second Scenario				
Second briefing	638.43	126.43	67.14	(102.62–150.24)
First four minutes	643.27	121.59	117.68	(79.86 – 163.32)
Second four minutes	654.50	110.37	51.74	(92.02–128.72)
Debriefing				
First 10 min	755.22	9.64	34.50	(−2.59 to 21.87)
Second 10 min	762.08	2.79	51.74	(15.56–21.14)

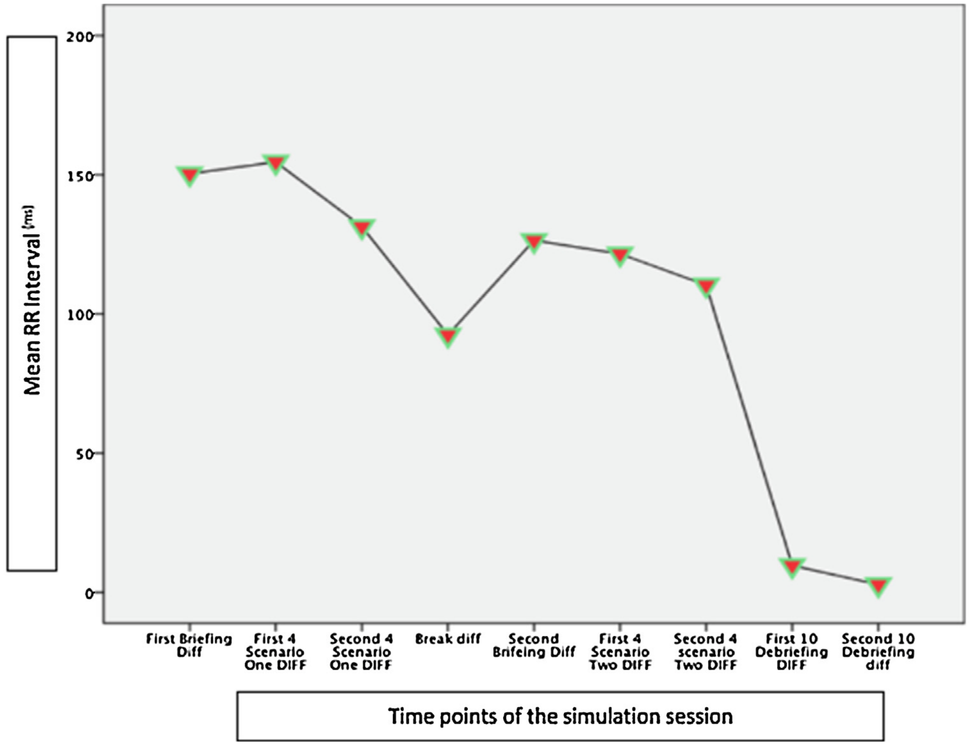

Fig. 2. Difference between segments (time point) of the simulation session.

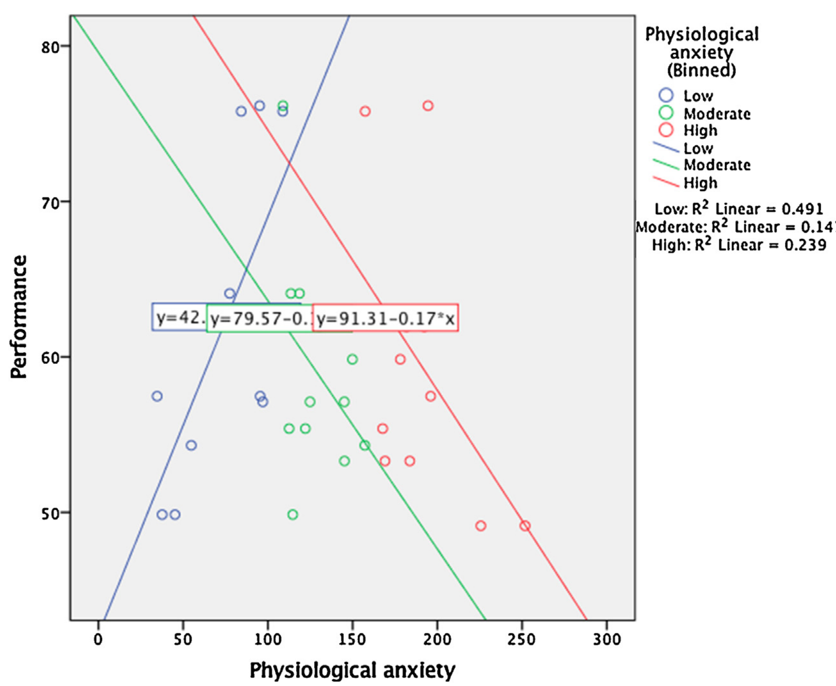

Fig. 3. Clinical performance in relation to level of physiological anxiety.

contemporary model of Yerkes and Dodson (1908), known as ‘learning zones’ explains describes anxiety levels as comfort-stretch-panic zones, with evidence that learners learn most when they are stretched and under moderate levels of anxiety (Palethorpe and Wilson, 2011). Uniquely, we identified that the inverted-U model appeared at the ‘group’ level. In essence, clinical performance declined for the groups who experienced moderate to high levels of anxiety and was optimal for those who experienced low levels of anxiety. Fig. 4 refers to undergraduate nursing students and group performance based on Yerkes and Dodson’s law.

In Fig. 4, the inverted-U curve is skewed to the left. This is in contrast with previous pioneers in this field, who proposed that moderate levels of anxiety are essential in learning and no learning

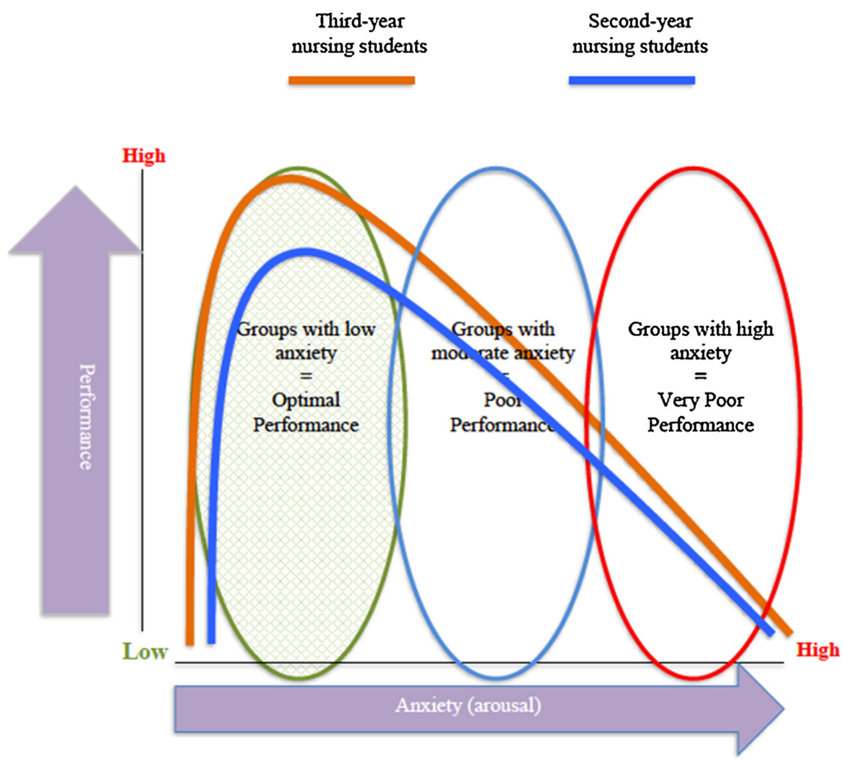

Fig. 4. Undergraduate nursing students' anxiety and performance at 'group' level based on Yerkes and Dodson's law.

happens under low levels of anxiety (Luine et al., 1994; Sanders and Lushington, 2002; Yerkes and Dodson, 1908). However, our investigation was completed with novice nurses in real-life emergency situations managing critical patients, and therefore even moderate anxiety led to poor performance. Notably, however third-year students performed significantly better than second-year students.

4.2. Integrated model of anxiety waves and group performance during emergency simulated simulation

Our intentions were to understand novice nurses' psychological anxiety by assessing their cognitive appraisal before and after simulations, and to examine students' physiological anxiety reaction while managing a simulated scenario. By amalgamating all data, including participants' qualitative descriptions of their anxiety in the debriefing interviews, we were able to build a theoretical model of group performance related to psychological and physical anxiety. The emerging model consists of three phases: input/antecedents, processing and output. More in depth details of anxiety waves throughout the simulation session is illustrated in Fig. 5.

4.3. Phase 1: input/antecedent phase

Psychological anxiety was measured before and after the simulation session. This study to our knowledge is the first attempt in the nursing and simulation literature to apply the Stress Appraisal Scale. Prior to the simulation session, participants perceived the expectations to be too demanding and believed they did not have sufficient coping skills to manage. This was captured from the pre-SAS scale as the majority of the students (n = 26) were threatened (demands exceeded resources) indicating inability to cope (Schneider, 2008). This result indicates that coping is important in managing and reducing psychological distress (Galbraith and Brown, 2011). Coping is about strategy and knowledge used for solving problems. Since the students in the current study believed they did not have the skills to cope with the scenarios, this may negatively influenced their performance.

4.4. Phase 2: processing phase

This phase included the two scenarios: a cardiac and a respiratory case. We found that physiological anxiety was highest during the first briefing (of the first scenario) and was reduced from the second briefing/scenario onward. The novelty of this study is the utilisation of HRV monitoring, specifically, the mean RR interval index, as a measure of physiological anxiety. Results identified from the study signify that students experienced a wave of anxiety during the first scenario that we refer to as 'high tide' anxiety. They were less anxious during the second, and we refer to this as 'low tide anxiety'. When students were listening to the briefing prior to commencement of the first scenario, they were physiologically anxious. We found no research in the nursing and health professional education literature which indicated how learners perceived simulation psychologically or physiologically. When the first scenario commenced, students were the most anxious during the first four minutes when the patient condition was stable. Perhaps, this could be due to fear of not knowing what they were going to encounter.

Students' physiological anxiety reduced marginally when the patient started to deteriorate, which is perhaps counterintuitive. However, their performance declined in the second half of the scenario, when the patient acutely deteriorated. This decline in performance may explained as an unexpected increase in demand with the need for additional resources, which were not available, as

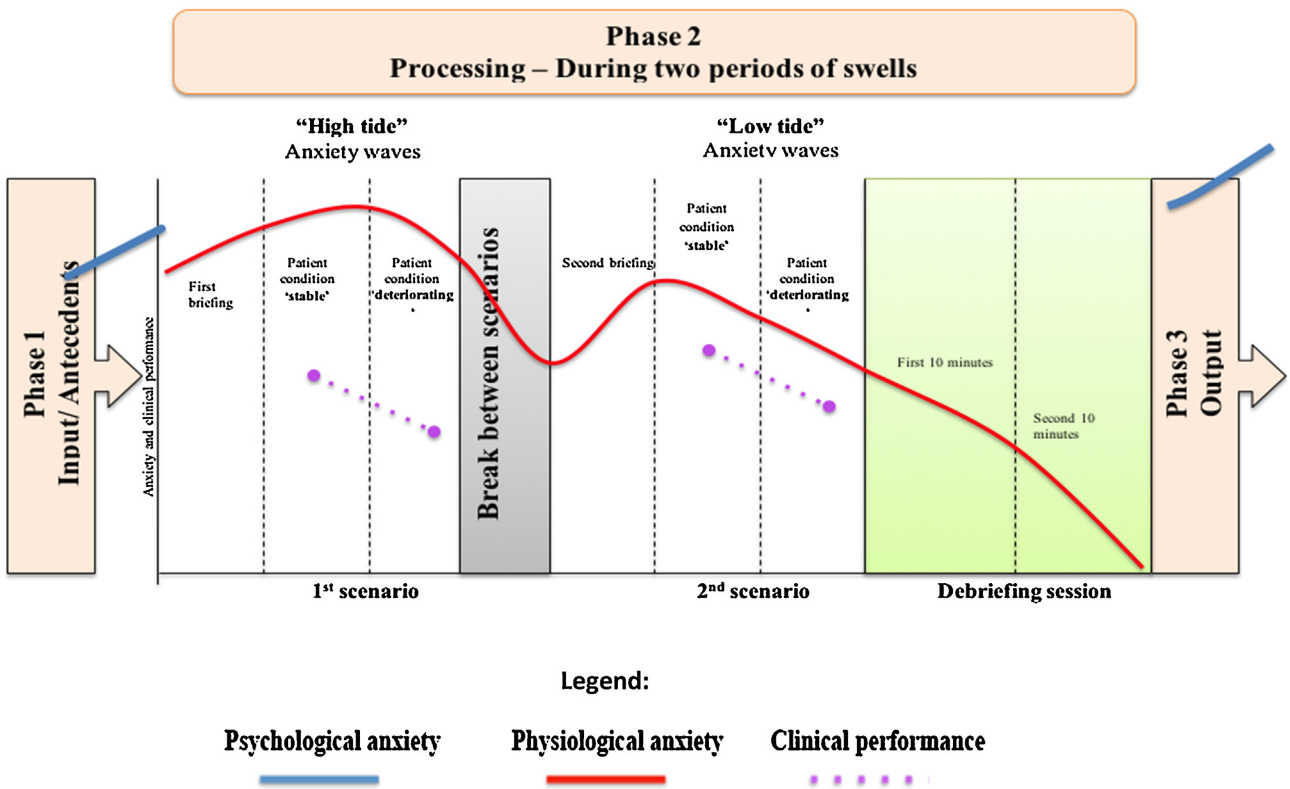

Fig. 5. Integrated model of anxiety waves and group performance during emergency simulations.

indicated during phase 1 of this model. It could be assumed that psychological anxiety is the cause of poor performance.

During the second briefing, students again became anxious after the short break between scenarios. However, their anxiety reduced when the second scenario began. Overall, students were less anxious physiologically than in the first scenario, and experienced 'low tide anxiety'. Our interpretation is that reduction in fear of the unknown occurred as students became familiar with the setting.

The model therefore illustrates how physiological anxiety has a negative impact on clinical performance. This finding has not been encountered previously in the healthcare professional literature and is crucial for the delivery of appropriate care during emergency situations. Our study reveals that novice nurses did not have the ability to adapt to changes when treating a rapidly declining patient.

4.5. Phase 3: output phase

Despite reduction in physiological anxiety over time, nursing students remained psychologically anxious. We had expected that students' psychological anxiety would reduce post-simulation, as they became more familiar with the situation. However, others have identified that a reduction in anxiety is not necessarily evident in the immediate post-simulation phase. For example, in one study emergency medicine residents were asked to self-report on their anxiety levels pre- and post-simulation on a visual analogue scale with reported increases post-simulation (Kharasch et al., 2011). In the same vein, in Canada, 'novice' flight paramedics self-reported anxiety levels after a high-fidelity scenario using a mobile patient simulator. Psychological anxiety was measured using the STAI tool and was high (Leblanc et al., 2005). In a prospective observational cohort study conducted in Canada by Clarke et al. (2014), results indicated that 34 emergency medicine residents' psychological anxiety was equal pre- and post-simulation. The more anxious the residents were pre-simulation, the more likely they were to be anxious at the end of the high-fidelity simulation, which is mirrored in our findings.

In this study, the inverted-U hypothesis was tested for the first time in nursing education using heart rate variability as the physiological marker. Future studies might consider validating the model incorporating larger sample sizes, more experienced nurses, adding control group and using different physiological markers such as salivary alpha-amylase or cortisol levels in other educational settings. However, further studies are also needed to test the model at an individual level

4.6. Limitations of the study

The study is limited by the small sample size and students were recruited from one Australian university. Hence, generalisability of the findings is limited due to sample homogeneity. This is a common feasibility issue with such studies due to the complexity of heart rate variability analyses (Morgan and Mora, 2017), and the demands of the simulation design. Additionally, the Hawthorne effect (Landsberger, 1958) may have influenced outcomes due to observational and monitoring effects. For example, although the study was based on limited disclosure, some students recognised that the heart monitors were placed on their chests to capture their anxiety levels. Further, clinical performance was rated by OSCE checklist at a group level, which did not allow us to examine performance at the individual level.

5. Conclusion

High-fidelity patient simulation has the capacity to arouse novice nurses' psychologically and physiologically while managing an emergency situation. This study suggests that HRV monitoring provides insights into the relationship between students' anxiety and performance in simulations. More research is needed to extend this study and enable greater understanding of the role of anxiety in clinical performance to facilitate optimal learning outcomes.

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