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# Autonomic Adaption to Clinical Simulation in Psychology Students: Teaching Applications

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**Abstract**
Simulation is used to facilitate new learning in a variety of situations. One application of simulation could be to help therapists gain therapeutic skills prior to seeing clients. This particular study was interested in measuring changes in stress response by looking at subjective and objective measures of distress (as measured by SUDS, HR, and HRV) over three sessions of simulated therapy. 16 second year psychology students participated in three sessions, and had their HR and HRV measured by Polar watches. Over the three sessions, there was a decrease in perceived distress, as measured by SUDS ratings. During and between sessions, there was inconclusive change in physiological parameters.

**Keywords** Simulation · Therapeutic skills · Autonomic modulation · Heart rate · State of distress

## Introduction

Simulation offers a complex and appropriate framework for the design of new learning experiences. Currently 4 modalities are considered: computer-based simulation; simulated patient; simulated clinical immersion; and procedural simulation (Chiniara et al. 2013). The use of a simulated patient becomes of vital importance in the acquisition of therapeutic skills in psychology for two reasons: first, this practice represents a key element that determines the effectiveness of any psychological treatment; and second, for ethical reasons students may have the opportunity to access a realistic and secure situation outside the clinical environment (Liaw et al. 2014). In this line, the use of simulated professional context is being positioned as the basic pillars of the evaluation of student's professional competences in the field of biomedicine science. Despite the growing interest in simulation, and specifically simulated practice with patients in psychology, there is a lack of empirical studies that analyse the psychophysiological response and performance of students in this new educational context.

Repeated exposure to a realistic situation such as a simulated patient will help students in practical training to reduce the intensity of the physiological distress response associated with this situation in future expositions (Rankin et al. 2009; Beltrán-Velasco et al. 2018). This habituation response of autonomous nervous system as well as cognitive flexibility are basic to archive performance in professional context (Groves and Thompson 1970; Diamond 2013).

Given the limited capacity of cognitive attention and memory resources, training in therapeutic skills would improve executive functions by the improve of cortical resources efficiency. Stress and anxiety constitutes one of the main threats, as it reduces the regional cerebral blood flow in the prefrontal cortex, with a premature and intense effect on the executive functions (Kane and Engle 2002). In fact, the prefrontal region in which the executive functions are located, presented the maturation after the age when psychology students have to face the simulated patient training and OSCE evaluations (Gogtay et al. 2004). The evaluation

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of performance in this training is complex since it constitutes a cognitively complex and demanding situation in which high levels of distress would decrease performance (Burgess and Simons 2005). Then, the evaluation of stress response by biomarkers that can assess the hypothalamic–pituitary–adrenal axis response, would give to the evaluator an objective tool. To analyse this stress response recent studies analyzed the autonomic modulation by the study of heart rate (HR) and heart rate variability (time between R–R waves of the electrocardiogram, HRV), been this methodology portable, non-invasive and applicable in many context (Clemente-Suárez and Arroyo-Toledo 2017; Sánchez-Molina et al. 2017; Clemente-Suárez et al. 2016b; Delgado-Moreno et al. 2017; Clemente-Suárez 2017). Thus, the aim of this research was to analyse the autonomic modulation of psychology students in a clinical simulation training. The initial hypothesis was that a habituation process would be archived decreasing the sympathetic autonomous nervous system activation.

## Materials and Methods

### Participants

We analyzed 16 students of the second year of the Psychology degree. 12.5% men and 87.5% women. They were between 20 and 26 years old. M = 22.68; SD = 6.23. We used a purposive sampling to obtain the participants of the present study. All the participants filled in an informed consent form in accordance with the Helsinki Declaration guidelines. All students have the same experience in coping with simulation scenarios, so the acquisition of competencies is done under the same conditions. The simulation scenario is a simulated hospital located at the university.

### Measures and Instruments

#### Physiological Records

The autonomic modulation of the participants was analyzed using the HRV record. These variables were monitored through an analysis of the R–R interval of the heart beat with a Polar V800 heart rate monitor (Polar, Kempele, Finland) as previous research (Clemente-Suárez et al. 2015). The R–R series was analyzed using the Kubios HRV software (version 2.0, Biosignal Analysis and Medical Imaging Group, University of Kuopio, Finland), developed in accordance with the recommendations of the existing scientific literature (Task Force 1996). This software has demonstrated it is extremely valid, and capable of registering non-linear trends that are often presented in registers of variation in the time interval between beats (R–R) (Moya and Salvador 2002) (Table 1).

**Table 1** Heart rate variability results during the entire clinical simulation training

| | First session | | | | Second session | | | | Third session | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre (M ± SD) | 1° thirth (M ± SD) | 2° thirth (M ± SD) | 3° thirth (M ± SD) | Pre (M ± SD) | 1° thirth (M ± SD) | 2° thirth (M ± SD) | 3° thirth (M ± SD) | Pre (M ± SD) | 1° thirth (M ± SD) | 2° thirth (M ± SD) | 3° thirth (M ± SD) |
| HF nu | 20.8 ± 11.3 | 19.7 ± 9.6 | 20.2 ± 8.3 | 22.1 ± 7.5 | 22.1 ± 11.3 | 25.8 ± 11.5 | 21.7 ± 10.4 | 21.2 ± 9.1 | 22.7 ± 14.9 | 26.0 ± 11.6 | 27.8 ± 9.2 | 24.7 ± 9.6 |
| LF nu | 79.1 ± 11.3 | 80.3 ± 9.6 | 79.7 ± 8.1 | 77.9 ± 7.5 | 71.4 ± 22.5 | 74.2 ± 11.4 | 783 ± 10.4 | 78.7 ± 9.1 | 77.3 ± 14.9 | 73.9 ± 11.6 | 72.2 ± 9.2 | 75.3 ± 9.6 |
| RMSSD | 28.2 ± 13.4 | 24.9 ± 13.6 | 27.0 ± 14.5 | 30.0 ± 13.8 | 27.4 ± 24.4 | 26.3 ± 16.5 | 28.9 ± 18.3 | 30.0 ± 17.5 | 35.2 ± 18.9 | 37.2 ± 20.0 | 37.2 ± 20.7 | 40.7 ± 20.4 |
| PNN50 | 6.2 ± 4.7 | 7.4 ± 8.1 | 8.9 ± 8.7 | 10.8 ± 9.6 | 6.9 ± 9.3 | 8.2 ± 12.4 | 8.9 ± 11.6 | 10.2 ± 13.5 | 14.0 ± 14.9 | 14.6 ± 12.9 | 15.6 ± 13.4 | 17.3 ± 13.9 |
| SD1 | 20.0 ± 9.5 | 17.6 ± 9.6 | 19.1 ± 10.3 | 26.6 ± 17.8 | 19.5 ± 17.3 | 18.6 ± 1.7 | 20.5 ± 13.0 | 21.3 ± 12.4 | 24.5 ± 12.5 | 26.3 ± 14.2 | 26.4 ± 14.7 | 28.8 ± 14.4 |
| SD2 | 106.1 ± 66.1 | 88.7 ± 26.4 | 80.0 ± 27.3 | 86.7 ± 30.6 | 84.9 ± 38.2 | 85.2 ± 35.4 | 87.3 ± 32.2 | 90.2 ± 22.5 | 112.4 ± 47.9 | 109.3 ± 34.9 | 88.6 ± 21.1 | 93.8 ± 26.4 |

*HF* High frequency, *LF* low frequency, *RMSSD* square root of the mean of the sum of the squared differences between adjacent normal R–R intervals, *nu* normalized unit, *SD1* standard deviations of the scattergram 1, *SD2* standard deviations of the scattergram 2, *PNN50* the proportion of NN50 divided by total number of NNs, *HR* heart rate, *HRV* heart rate variability

The following physiological measurements were evaluated:

- Heart rate

Corresponding to the time domain of the HRV:

- Percentage of differences between normal adjacent R–R intervals greater than 50 ms. (PNN50)
- The square root of the average of the sum of the differences squared between normal adjacent R–R intervals (RMSSD)

Corresponding to the frequency domain of the HRV:

- The low-frequency band in normalised units (low-frequency LF (un));
- The high-frequency band in normalised units (high-frequency, HF (un));

Corresponding to the non linear domain of the HRV:

- The sensitivity of the short-term variability (SD1)
- The long-term variability (SD2).

### Psychological Measurements

**Subjective Perception of Distress Strait** A scale of subjective distress units (SUDS) is used, showing scores of between 0 and 100. Each of them represent a level of distress perceived by the subject at the time of valuation, ranging from zero (0), which implies "Completely indifferent and cold; does not affect me" to one hundred (100), which means "So distressed and tense that I can't deal with it" This scale will be applied in the five minutes before the start of the session and provides information based on the level of stress assessed by the individual and which represents the cognitive relationship between the objective event and the emotional response (Tapia et al. 2007).

## Design and Procedure

A within-subject 3 × 4 × 7 factorial design was used with 2 independent variables. Intra-session period with 4 levels (M0, pre-session interval); M1 (interval corresponding to the first third), M2 (interval corresponding to the second third) and M3 (interval corresponding to the third third); and Session with 3 levels (S1) or the first session, (S2) or the second session, (S3) or the third session.

The measures were: biological variables: CF (ppm), HRF, through the LF (nu) parameters, HF (nu), PNN50 (No.), RMSSD (ms) and SD2 (ms). Finally, the subjective perception of state of distress (SUDS) was evaluated as a psychological variable immediately before starting each of the three sessions (Fig. 1).

*Clinical simulation training* In these scenarios, the students coping the situation with simulated patients with differences pathologies that they have prepared previously.

The evaluation is carried out in three different sessions, in the office of therapeutic intervention of the University. The process begins with the placement of the Polar V800 heart rate monitor (Polar, Kempele, Finland) during the pre-evaluation (M0). The evaluated student waits sitting as a professional therapist until the patient/patients access the office and that is when the simulated evaluation begins. It develops a real consultation in which the patient makes demands that the student must handle. This exposure is repeated over three separate sessions over a period of time (1 week in between) so that HRV records can be compared from the beginning of exposure to the end of the simulation to confirm the existence of therapeutic skills acquisition and the completion of the habituation process.

For a more exhaustive analysis, the sessions which allowed comparing different moments within the same scenario experienced.

## Data Analysis

The statistical analysis was carried out using the SPSS 17.0 statistical program. Descriptive were analyzed for each variable (average and standard deviation) and a multivariate

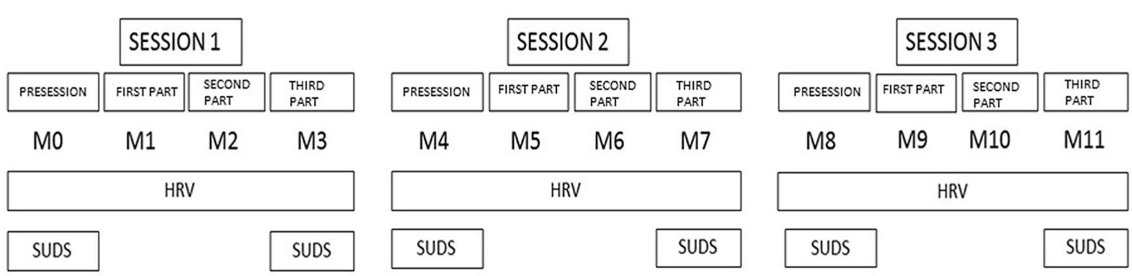


**Fig. 1** Research design. *M* moment, *SUDS* subjective units of distress, *HRV* heart rate variability

analysis was carried out to evaluate the effect of the sessions, of moments during the session and of their possible interaction on the physiological and psychological measurements analyzed. The Tukey test was used for ad-hoc comparisons. The signification level was 0.05.

## Results

A significant effect was found in both the session ($F2.14 = 5.171$, $p < 0.01$) and the "session moment" ($F2.14 = 4.929$, $p < 0.01$) on the heart rate frequency. Differences in intra-session (ppm) and inter-session. The expected changes as a result of the habituation process can be seen starting in the second scenario and the last third of each of them. Significant effect in the session and inter-session differences were found in RMSSD ($F2.14 = 4.660$, $p < 0.01$), PNN50 ($F2.14 = 5.874$, $p < 0.01$) and SD1 ($F2.14 = 3.259$, $p < 0.01$). However, no effect in the session moments or intra-session differences were found.

Inter-session differences in the three physiological parameters: PNN50 (No.); RMSSD (ms); and SD1 (ms). Although differences were found in the average inter-session values, no significant changes were found between the different moments of the sessions. No significant inter-session differences were found, or intra-session differences in LF (nu), HF (nu) or SD2. Finally, a significant effect was found in the sessions on the subjective estimate of distress at the start of the session ($F2.14 = 4.813$, $p < 0.01$). Specifically, the distress perceived at the start of the first session ($M = 62.857$; $SD = 20.91$) was significantly higher than that reported at the start of the second session ($M = 38.33$; $DT = 20.81$).

## Discussion

The aim of this research was to analyse the autonomic modulation of psychology students in a clinical simulation training. The initial hypothesis was that a habituation process would be archived decreasing the sympathetic autonomous nervous system activation. The initial hypothesis was confirmed since a habituation process was evaluated.

The analysis of autonomic modulation in the first session showed an intense anticipatory stress response as the low values of RMSSD, pNN50 and HF showed. This result is related with an increased sympathetic nervous system activation (Clemente-Suárez et al. 2015). The anticipatory stress response has been also studied in different areas by previous researchers, especially in military population, where a higher anticipatory response than in the present research participants was found. These differences may be due to the different exposition context and the different exposure training (Suárez and Pérez 2013; Clemente-Suárez et al. 2016a, b; Clemente-Suárez et al. 2017). In studies with university students who face final test, a high anxiety level was observed, that negatively affected cognitive and physiological functions (Hewig et al. 2008; Lacey et al. 2000). Other authors showed how novel and professional drivers differ quantitatively their levels of pre-driving stress, presenting lower values professionals than non-experienced participants (Sáiz et al. 1997). During the evaluation of the second and third sessions, significant changes are observed as a result of the habituation process. In this line, in the second session a decrease in sympathetic modulation and perceived stress was assessed, showing how just one session is enough to decrease the anticipatory stress response. This decrease in anxiety perception was in consonance with previous studies conducted with experimented military parachute jumpers, that are exposed to a highly danger context that also elicits an intense psychophysiological response (Yonelinas et al. 2011). In the third session, students also presented a lower initial sympathetic modulation and subjective anxiety perception. These results are consistent with previous studies that analyzed the stress response during the execution of dangerous activities like pilots, where experience has a direct impact on their psychophysiological response. This response was consistent with the acquisition of the habituation process through repeated exposure (Clemente-Suárez et al. 2016a).

Traditionally, the differences in performance in cognitively complex areas, such as clinical interventions, have been fundamentally attributed to the student's intelligence involved. However, today we know that some of the executive functions are intimately associated with fluid intelligence (Friedman et al. 2006) and even predict not only academic success but also success in other areas of life, such as employment, marital and even better health (Bailey 2007). Therefore, a learning design that includes training in therapeutic skills to reduce stress response presents beneficial for these population. Some executive functions are very sensitive to distress and learning strategies of them facilitates the habituation process. Further, it is known that chronic exposure, weeks or months, to stressful situations may damage communication between neurons in brain regions such as the hippocampus, affecting learning and memory capabilities (Dickerson and Kemeny 2002; Medina 2011). However, it is increasingly accepted that for the complete expression of stress effects in hippocampus, coactivation of amygdala and hippocampus is required. The local effects of neuromodulators act together with the influences from the amygdala to alter hippocampus memory areas and synaptic plasticity (McEwen 2000; Hebb 2005). These facts are basic to design a type of simulation that provides the correct stimulus for the student. Thus, the choice of stressor to provoke a minimum response that stimulates the amygdala but does not produce a chronic state of fatigue would be the key factor for the correct simulation practices. The data obtained in the present research shown how the duration of the session (45 min), and the total density of sessions (1 session per week for 3 weeks) have led to a reduction in the students' stress response. These findings should be taken into account to design efficient simulation environments for university students.

In therapeutic intervention, a large distress context, the executive functions of participants could be negatively affected (Decker et al. 2013). Thus, it would be crucial to have practical strategies available that allow students to get used to the scenario and thus reduce their levels of distress. This would make it possible to evaluate their competence in this task without introducing the adverse effects produced by distress. In the same line, the training in therapeutic skills in real scenarios is difficult to practice, mainly for two reasons: first, the low level of opportunity that students have to come in contact with real situations during their training; and second, the high level of complexity that it would represent for them to face a clinical intervention; situation in which they must process a great deal of information, with the added difficulty of having to handle the highly emotional content that may be expressed in these situations (Kaddoura 2010; Kneebone 2005). In the light of the results obtained, the training through simulation allows the reduction of the intra-session and inter-session sympathetic modulation, being these results in consonance with a habituation process (Groves and Thompson 1970). Then, the simulation training analyzed in the present research seems to improve psychophysiological response of students for future real clinical scenarios. This information would help to improve preparation of future psychology students.

## Practical Applications

The measurement of psychophysiological variables in students to be evaluated in a clinical simulation turns out to be a form of practical learning that get over the purely theoretical teaching. This fact indicates that the use of simulation assessments gives students the necessary therapeutic skills. And most importantly, the participants in these simulations, reach the process of habituation, essential for the professional practice of psychology. Therefore, in the field of higher education in the health sciences, students should have the opportunity to perform clinical simulations within their academic hours with the aim of improving their cognitive and psychophysiological capacities once the degree is completed.

## Limitations and Future Lines of Research

The principal limitation of the present research was the small sample size; the difficulty to recruit students in this complex scenario limited a large sample in the present research.

The complex characteristics of simulation scenarios analogous to real situations in clinical practice limit the availability of a broader sample, as their implementation as a technique for the acquisition of therapeutic skills in psychology is more limited and complex than the rest of the normal programmes for acquiring skills, such as for example role-playing, even though it has been demonstrated to be more potentially anxiogenic and realistic. The lack of access to a larger population has also hampered the ability to perform comparisons with control groups.

Although we have an overall measurement of the level of distress perceived by the subject, state of distress, the basal level of distress of the participant or distress risk is not taken into account, and it would be interesting in future studies to carry out a broader description of the topography of the distress response in its physiological, cognitive and motor components to understand better the response given in a situation of simulated practice.

In our study we have focused on understanding the effects of practice in simulation scenarios, limiting ourselves in time to the effects at the time when the practice is carried out. We have not analyzed whether this habituation effect or reduction of activation demonstrated by the participants at the end of the study is maintained in the long term in repeated exposures they may be subject to in the future, or whether the period without practice can represent a return to basal origins of the response. A longitudinal design would have to be established that could provide us with information in future periods on whether the results are maintained or not, and to what extent prior learning in this environment of simulated practice can be generalized to other types of situations.

## Conclusions

Exposure to a simulation scenario produces an increase in sympathetic modulation in students. However, the repeated practice of simulation strategies causes students to complete the habituation process and achieve a decrease in stress levels.

With the results obtained, it is possible to conclude (a) in all degrees of Sciences of the Health the students will realize their future profession trying on a repeated way with stressful events and that directly affect other people;

(b) there is no other form of learning that provides the practical advantages of the simulation; (c) it is important that university students can have a higher education that includes exposure to such events to obtain knowledge that can only be learned from experience.

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