Essay

Neuroeducational basis of stress and its relationship to academic performance

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ABSTRACT

The essay is an analysis of the relationship between stress and academic performance as a current educational problem. The reflections on this subject aim to support the neuroeducational bases that empower the teacher with resources to prevent and intervene in practice. The fundamental method used is the analysis of documents. The critical and prospective development of the topic is approached in three content cores: a) the historical background, b) the conceptual analysis of stress in its relationship with stressors and academic performance, and c) the neuroeducational conceptions about stress and the exemplification of strategies.

Keywords: Education; Stress; Neurobiology; Academic performance.

Introduction

Nowadays the media and scientific publications circulate a large volume of information that enhances the action of preventing, mastering and even eliminating stress from people's lives. The study of stress is the subject of discussion in multiple sciences and has been interpreted in terms of a wide range of neurophysiological and psychological experiences such as tension, overwhelm, fatigue, feelings of pressure, anguish or fear.

With the aim of approaching the state of the art on the subject, a search was conducted in the Web of Science (WoS) and Sorce Education databases between October and November 2021. The tracing of the descriptor "stress", between the years 2009 to 2019 reported 64 documents (scientific articles) of which 49 are open access and 88% were

published in English language. In relation to the research fields 31 correspond to Clinical Psychology, 24 from Psychiatry, six from Food Science Technologies, two Biomedical Social Sciences and one publication from Molecular Biology, Biophysics and Biochemistry. The highest number of publications is concentrated in 2018 (16 publications). With the aim of establishing an educational perspective on the topic, we proceeded to search for the term "academic stress", regarding which three articles were found comprised between the years 2015, 2017 and 2018 from the area of Psychology. No metadata record was found for the term "school stress".

In view of the scarce information found in the WoS database, the search was extended to the Education Source database in the same period, from which 14 studies related to stress in university students and one related to stress in the infant stage were rescued. This showed that research on the behavior of stress in children between six and 11 years of age is scarce, most of it in Higher Education, those found refer to post-traumatic stress situations, particularly after events such as wars, natural disasters, violation of rights or life-threatening accidents.

The evidence found shows that difficulties in adapting to the school environment during the early years are associated with the appearance of mental health problems in the short, medium and long term. In addition, when children obtain low academic performance and present behavioral problems at school they are more likely to have negative outcomes in adolescence, which in turn is another critical time where social and emotional challenges will be experienced in different ways, depending on the accumulated stock in previous stages (Ministry of Health [MINSAL], 2017). Hence, the idea that school-age children, being in a period of constant change and maturation, constitute a group susceptible to stress due to increasing social demands that require the deployment of their coping skills (Palacio, Tabón, & Toro, 2018).

In Chile the Global School Health Survey showed alarming results around mental health reflecting that, around 30% of the sampled students, had possibly depressive symptoms and between 20 and 22% considered attempting suicide in the last 12 months (Ministry of Health [MINSAL], 2017). In this context the school can affect a student's stability understanding that stressful events occur in everyday spaces. Schools are described as one of the optimal spaces to intervene in the socioemotional and mental health area, given that it is where they spend most of their time (Ministry of Health [MINSAL], 2017).

Consequently with the above, education has the challenge of increasing the cognitive, emotional and executive resources of the child that condition stress and limit the ability to act due to blockages or mental overload, particularly in cases of acute and chronic continuous levels. This implies the improvement of school programs in the balance between the internalization of knowledge, cognitive and emotional skills.

Hence the relevance at the level of educational institutions to master the conditioning elements of stress in their students paying attention to the multiplicity of factors that condition it, in the understanding that an adequate management of stress levels that affect comprehensive training tends to contribute to the prevention of diseases and school failure (Caqueo-Urízar et al., 2020; Cortés, 2020; Palomera-Chávez, 2021). For their part, Chilean research corroborates the tendency to increase anxiety in children, and it is necessary to monitor emotional states as a form of prevention.

The results of research related to stress and academic performance reflect results that do not always agree, on the one hand, those that point out that there is a significant negative relationship between school performance and stress variables (Broc, 2019; Fernández and Luévano, 2018); on the other hand, other studies conclude that those who have an intermediate or higher level of stress (of moderate character) obtain better academic results (Lagos, González, San Martín and García, 2018). By virtue of the limitations found, it is perceived that the analysis of stress is not recurrently addressed in Basic Education, with the exception of works on stress in children and its relationship with academic performance in fifth grade of Primary Education (Valiente, Martínez, Cabal, & Alvarado, 2020) and the levels of executive functionality and perceived child stress. From the above, the inference is that most of the sources, as already noted, are focused on the effects of stress on the academic performance of university students.

By virtue of the above, the mastery by teachers of the influences of stress on the academic performance of students is a resource for prevention and timely intervention with psycho-pedagogical strategies that do not neglect their focus on the integral formation of their personality. Therefore, this essay ventures into the treatment of a formative bias referred to the insufficient mastery of the neuroeducational bases of stress and its influence on academic performance. Consequently, the objective is: to substantiate the neuroeducational bases of stress and its influence on students' academic performance.

In correspondence with the objective of the essay the critical and prospective development of the topic around three content cores: a) the historical background, b) the

conceptual analysis of stress in its relationship with stressors and academic performance and c) the neuroeducational conceptions about stress and the exemplification of strategies.

Development

The use of stress has among its origins the physical studies on elastic potential energy by Robert Hooke in the 17th century. In the nineteenth century from the Medical Sciences Bernard Claude pointed out the understanding of stress in "the stability of the internal environment is the indispensable condition for free and independent life" (Román and Hernández, 2011, p. 3). The latter refers to internal physiological factors as those responsible for maintaining balance and well-being.

In 1914 the physiologist Walter Cannon was the first to use the term stress, describing it as an adaptive response of the organism to an adverse situation. The physiologist Selye (1936) in his proximity to people with various ailments noticed that specific clinical cases presented similar symptoms, regardless of the morbidity of origin (fever, headache, abdominal pain, weight loss, among others). In his clinical studies, he concluded that the organism responds in a stereotyped manner to noxious stimuli in an effort to adapt to the new condition. He called this picture the General Adaptation Syndrome, which he taxonomized in three stages: alarm reaction, resistance and exhaustion, which he later called stress. Selye presented the stress response in terms of activation of the hypothalamic-pituitary-adrenal-cortico-adrenal axis with increased secretion of corticoids (cortisol) and of the sympathetic-medullary-adrenal axis in reaction to non-specific stimuli (stressors).

The above offers an insight into the ways of understanding stress and its evolution from physics to physiology. Selye's work allowed to expand the study of stress in other sciences with the predominance of a biological and unidimensional approach limiting the consideration of cognitive, socio-affective and contextual factors (Román and Hernández, 2011).

In the 1960s Thomas Holmes created the first questionnaire to measure stress, giving rise to the concept of vulnerability to stress and resilience, generating cognitive therapeutic techniques for its treatment (Zárate, Cárdenas, Acevedo, Sarmientos, & León, 2014). The

main contribution of this researcher was in analyzing the context of the stress sick person and the measurement of the social burden and that, ultimately, negatively affected their health.

At this stage, in order to overcome the limitations of the biological approach, Lazarus' psychological model emphasized the environment as a fundamental variable, together with the subjective perception of the subject, and stated that stress belongs neither to the person nor to the environment, but rather in a dynamic and bidirectional relationship between the two (Zárate et al., 2014). Indeed, this made it possible to broaden the view on the multidimensionality of factors that condition and determine stress, which he called: stimuli, responses, mediators, and finally, modulators (Palacio, Tobón, Toro, & Vicuña, 2018).

In the 1980s, the development of neuroimaging techniques led to the inclusion of neurophysiological variables to determine systemic causes and effects of stress (Zárate et al. 2014), which would begin the search for evidence on brain functions and their impact on adaptation and learning. This made it possible to understand how stress influences cognitive and motivational processes, in the first instance determining what is potentially stressful, and then modulating physiological and behavioral responses (adaptive or detrimental) according to their persistence.

Finally, in the 20th century, the change of paradigms on stress favored the origin of other studies with emphasis on the role of contexts, which gave rise to other denominations regarding stress at school, among them: academic stress, exam stress, among others, without yet achieving consensus in terminology. Although the study of stress has an important volume of physiological and psychological variables in its origin, the current trend is towards interdisciplinary research, contributing to limit the bio-psychological bias of stress. This was evidenced in recent publications given to the study of stress in teaching and learning practices in pandemic conditions by Covid-19 (Andrades-Tobar, García, Concha-Ponce, Valiente, & Lucero, 2021; Caqueo-Urízar et al., 2020; Cortés, 2020; Palomera-Chávez, 2021). The above oriented the analysis of the present essay towards the study of conceptual aspects of stress given the factors that in educational practices condition it and its effect on academic performance.

Stress can be defined as the biological response to intrinsic and extrinsic stimuli that can trigger different pathological conditions, affecting health in general (Yaribeygi Panahi, Sahraei, Johnston, & Sahebkar, 2017). Inquiries substantiate that psychological and psychochemical stress tends to the affectation of the immune system and places the

subject in conditions prone to get sick (Bae, Shin, Bae, & Van Eden, 2019). In general, it is a biological warning system and is a complex term to understand from a reductionist approach. It has neither a single cause nor a single effect since the factors associated with it depend, to a large extent, on the interaction between the subject's experiences, perceptions and competencies in a context versus the multiplicity of stimuli in the environment.

Hence the classification of three types of stress: a) acute stress tends to be stimulating and exciting in small doses, with manifestations associated with emotional imbalances, muscular, digestive problems and transient cardiorespiratory symptoms; b) episodic acute stress exists in individuals who suffer, in general, from acute stress whose life routines are characterized by disorganization, the symptoms of this are similar to the previous one but more extensive and varied: persistent tension headache, migraines, hypertension, chest pain and heart disease; and, c) chronic stress is increasingly destructive that tends to affect health such as myocardial infarction, cerebrovascular stroke and violent behaviors.

Despite this grouping, none of the elements depend exclusively on either the context or the subject, as they are interrelated and depend on subjective issues such as individual perceptions. Therefore, it is necessary that current representations of stress are approached from interactionist and multifactorial approaches, rather than in a linear way between stress and disease as it was at the beginning.

Neurosciences provide information on the structural and functional changes at brain level that tend to generate long-lasting chronic states of stress with propensity to develop psychiatric disorders with focus on early stages. The taxonomy of Zarate et al. (2014) emphasizes the influence of stress on brain activity in three types: acute, chronic and daily:

- Acute stress has a dual effect with a certain degree of dependence on the stimulus, on the one hand it would act in favor of learning and plasticity processes through the induction of glutamatergic synapses, in the case that the stimuli are not perceived as aversive. On the other hand, exposure to some stimuli such as social pressure decreases the survival of new neurons (Zarate et al., 2014).
- Chronic stress can generate neuroanatomical changes, mainly in the hippocampus, amygdala and prefrontal cortex regions; on the one hand, the hippocampus is reduced in size, while the amygdala is increased, which would

explain the appearance of reactions dependent on this area such as fear, anxiety and aggression. The effects on the pre-frontal cortex explain a decrease in executive functions related to emotional self-regulation and decreased attention that alters the ability to cope with stress (Zarate et al., 2014).

- Daily stress is associated with low cortisol levels and symptoms such as anxiety, low self-esteem, depression and feelings of inadequacy (Trianes et al., 2012).

Based on the above, a new way of conceiving stress by its nature emerges: if it is negative, due to insufficient or exaggerated responses in relation to the demand, it is called distress. If it is positive, that is, when responses to stressor stimuli are performed in harmony, respecting the physiological and psychological parameters of the subject it is called eustress (Buñay et al., 2017).

In the gender variable the perceptions and behaviors associated with stress have different implications in the brain, for example in men the predominant activation of the pre-frontal cortex, while in women of the limbic system. This structural difference explains the tendency for men to react by fleeing or attacking, while women's behavior tends to be helping and protective.

In this sense, the relationship between stress and performance according to the Yerkes-Dodson Law indicates that boredom and disengagement activate an excessively small amount of stress hormones secreted by the hypothalamic-pituitary-adrenal axis, so that performance suffers. Motivation favors the so-called good stress and places the subject in the optimal zone of functioning; on the contrary, if the problems are excessive, the subject enters the exhaustion zone in which the levels of cortisol (the main stress hormone) are high and hinder performance. The aforementioned supports that at certain times stress can generate higher levels of performance, depending on the degree of stress, so a balance should be sought so that it does not affect the body and prevent harmonious performance; while acute stress can sometimes be stimulating, this is not the case with chronic stress, which is generated from prolonged acute stress and has continued negative effects (Valdivieso-León, Lucas, Tous-Pallarés, & Espinoza-Díaz, 2020).

The concept of academic achievement is defined as the degree of knowledge demonstrated in an area compared to the student's age and results, with grades being one way of assessing it. Hence, it is considered that school success or failure depends on neurobiological factors, being the cognitive functions essential to face the demand in

learning. The presence of alterations in these processes or a deficient maturation are generally synonymous with learning problems.

The low results in standardized tests in Chile emphasize the domain of the factors that intervene in the achievement of learning. Among the findings found, variables such as: socioeconomic level, family-school link, teaching practices, the role of the teacher and the role of motivation to learn are mentioned. Due to the multitude of variables that appear in the results of research on the factors that influence learning and academic achievement, a classification into three areas is presented:

- Student-centered factors, those attributed to the student and his or her personality. Among the most recurrent are motivation (intrinsic, extrinsic and affiliative), expectations, knowledge, emotions, cognitive profile, self-control, among others. In this sense, daily stressors are of greater concern than chronic stress, since they cause a psychological and physiological imbalance that tends to generate anxiety, depression, low self-esteem and feelings of inadequacy (Valiente et al., 2020).
- Context-centered factors, from this model three axes of the student's environment are analyzed, each with specific variables, such as: the family, the educational center, school climate and the social environment, and how these facilitate or weaken the student's academic performance (Barreto and Alvarez, 2017).
- Interrelation factors, from here academic performance is understood as the result and relationship of personal, social and psychosocial variables (Solano, 2015).

Despite advances in research on the complexity of stress and the role played by the environment, a bio-psychological approach still predominates in its study. In the relationship between stress and academic performance, there is a tendency to move from a paradigm centered on the assimilation of knowledge to another based on integral education (Valiente et al., 2020). This argues the need to generate educational public policies focused on the preventive approach, the training of emotional and coexistence skills, and the empowerment of teachers in coping strategies from their initial training.

In the Transactional Model of Stress and Coping by Lazarus and Folkman (1984), coping is analyzed as a dynamic, multidimensional and biopsychosocial process in which subjects try to palliate, resist and/or overcome the consequences of a stressful situation with cognitive and behavioral efforts to reestablish equilibrium and adapt to the situation.

Students need to employ effective psychological skills and coping strategies to meet their expectations and improve their performance (Mohammadi, 2019). To this end, the most appropriate approach to reduce psychological and behavioral stress responses is the use and administration of coping strategies such as thought restructuring, physiological relaxation techniques, visualization or imagery, breathing techniques, and self-dialogues (Briganti, Varriale, & Ferrara, 2018). In general, coping strategies can focus on both the emotion and the problem depending on the emotional and cognitive assessment of each human being. However, problem solving, cognitive restructuring, support seeking social emotional expression and social withdrawal are the most commonly used strategies (Valdivieso-León et al., 2020).

From the above, the need to re-signify in context practices that from neuroeducation are validated to reduce stress, among them: mindfulness, music therapy and the practice of sports. In the case of mindfulness (MF), it refers to specific practices used to focus a person's attention (meditation, yoga, breathing, concentration on a single point, on an object, etc.) and is characterized by intentionality and unprejudiced observation of the experience. MF is an attentional cognitive strategy to train attention regulation, reduce stress and promote mental health (Galante et al., 2018).

Music therapy according to the World Federation of Music Therapy is the use of music and/or its elements (sound, rhythm, melody, and harmony) with a patient or group to promote and facilitate communication, interaction, learning, mobility, expression, organization, and other meaningful therapeutic goals to work on the person's physical, emotional, social, and cognitive needs. Music therapy has the potential to modulate factors involved in cognition and behavior, attract attention, elicit emotional responses, engage cognitive functions and evoke movement patterns.

On the other hand, the practice of sport stands out in Anshel's model (2019) for its contributions in the control of emotions, the organization of information and the planning of responses to stressful situations. In this model, also from the perspective of coping, two dimensions are taxonomized, in approach and avoidance; where the sequence begins with the detection of the stressor and then its cognitive assessment is performed.

Finally, Neuroeducation highlights factors related to the better functioning of the brain in stressful conditions and the use of the referred strategies from its understanding of the body-mind relationship and how it influences the balance of emotions, motivation, social interactions, the use of executive functions and classroom organization.

Conclusions

The historical background on the study of stress provided an overview of the evolution of scientific knowledge. The research on stress initially originated from physiology and psychology, which were later extended to the educational sciences. The interpretation of the concept and the taxonomies on stress clarify that it is indeed necessary to study it with a flexible and contextualized vision. In the consultation of publications in the WoS and Education Source databases, it was found that, in general, research on the subject does not originate in the Educational Sciences, but rather this is a field of transfer and studies in Higher Education predominate.

Critical reflection with a neuroeducational approach highlights among the current challenges the change of paradigms in the study of stress with a focus on the integrative analysis of the set of factors that condition it, the characteristics of the context and the understanding of physiological changes that influence academic performance. The literature review provided information on validated neuroeducational strategies whose use favors stress reduction in practice. The problem investigated has among its future research scenarios the formation of emotional skills and the management of coexistence with a preventive approach that involves the educational communities with a participatory role.