

Using EEG to measure resilience in postgraduate business students and its importance for future leaders.

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ABSTRACT:

PURPOSE: *This paper aims to examine the time individuals take to recover from adverse effects presented to them. This is important because leadership, particularly transformational leadership, primarily focuses on an individual's social interactions and their ability to exhibit resilience within their workplace. Zehir & Narcikara (2016) identify the need for resilience of individuals as this culminates in increased levels of organisational resilience, which is a necessity for ensuring the ability to cope with a changing geo-political landscape.*

Keywords: Competency, Higher education, Skills, Resilience, EEG, Emotional Stroop, MBA, Leadership.

INTRODUCTION

DESIGN/METHODOLOGY/APPROACH: - We examined the extent to which those who work in jobs with a significant element of leadership are able to recover positively from adverse induced stress (Alonso JF, 2015). To study this, 99 part-time postgraduate executive Master of Business Administration (MBA) students took part in an emotional Stroop test. All participants were presented with a series of colour words, printed in incongruent ink colours, and named the colour of the ink instead of reading the word, as quickly as possible (Anyan F, 2020). The electrical activity in the brain resulting from these visual stimuli was recorded using an Electroencephalogram (EEG).

FINDINGS: This study demonstrated that the EEG techniques can accurately record the time taken to recover from the invoked stress of the Stroop test. The findings from this study provide academic departments with evidence that more work needs to be done with students to develop their

resilience. Particularly for those students who are or will go onto occupy leadership roles (Atchley R, 2017).

ORIGINALITY/VALUE: The use of neuroscientific approaches has long been used in clinical settings. However, few studies have applied these approaches to develop understanding of their use in social sciences. Therefore, this paper provides an original and unique insight into the use of these techniques in higher education (Cleary M, 2018).

Resilience is a concept that is frequently discussed in various social and occupational contexts. Often phrases such as 'they need to become more resilient' are used. This idea is not new; indeed, notions of resilience have been around for decades, they have simply been articulated in different ways (see Tusaie and Dyer, 2004; APA, 2014; Anyan et al., 2020). Existing literature focuses on measuring intrapersonal and interpersonal protective factors presumed to facilitate how resilient an individual is (Connelly EB, 2017). This premise has led to the development of a variety of tools to measure resilience in various groups of individuals, such as adults (Resilience Scale for Adults), adolescents (Resilience Scale for Adolescents) and with various communities, such as Asian and Latin-American.

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With literature on resilience focusing on different domains and receiving an increasing amount of attention. Resilience can be considered through the lens of individual resilience, or system or organisational resilience (Coutu DL, 2002). This is often conceptualised as risk management, for example in relation to natural and man-made threats, also infrastructures, communities, and regions and the resilience of various subsystems (e.g., a community's or region's economy, governmental units, emergency services sector, the civilian population). However, the focus of this paper is on individual resilience (Dabas H, 2018).

There is a general consensus on the definition of resilience. Tusaie and Dyer (2004), American Psychological Association (APA) (2014) and Anyan et al., (2020) suggest that resilience is one's ability to recover from adverse effects (Dressler O, 2004). However, there is a gap in the literature surrounding the time taken to recover from adverse situations. This paper adds to the literature on resilience by exploring recovery time in a group of participants (Eliot JL, 2020). It is important to recognise that this paper is looking at non-critical recovery to temporary stress in a workplace setting. These findings will be different for those experiencing loss, such as bereavement or life-changing situations, for example, unemployment, acute or chronic illness (Erdodi LA, 2018).

Provide one of the few papers that mention the importance of resilience recovery time. Highlighting the need to understand one's threshold of resilience, and the need for space and time for an individual to recover from a stressful event (Fahimi F, 2018). However, they argue that the aspect of space is flawed, but do not offer a reason why, but time is not and needs to be better understood. In order to explore Resilience Recovery Time (RRT), this paper will initially look at the concept of resilience before looking at its importance through the lens of leadership (Gardner H, 1997). This is important due to the demands placed on leaders often result in stress being experienced, and the need to recover from these stressful events quickly in order to move on is key (Lynch, Grummell, & Devine, 2012). After which, we discuss on how we went about trying to measure RRT (Heidlmayr K, 2020).

RESILIENCE: Resilience theory is a multifaceted field of study that has been addressed by social workers, psychologists, sociologists, educators and many others over the past few decades. Resilience theory addresses the strengths that people and systems demonstrate that enable them to rise above adversity (Howard CS, 2013). The emergence of resilience theory is associated with a reduction in emphasis on pathology and an increase in emphasis on strengths (Rak & Patterson, 1996). Signalling a move away from a deficit approach of conceptualising responses to a phenomenon that individuals experience to one which focuses on developing an individual's strengths and behaviours in order to be able to deal with the challenges presented to them (Janic M, 2022).

Yet resilience can be categorised as cognitive resilience (Jha, Morrison, Parker, and Stanley, 2017), social resilience (Maclean, Cuthill, & Ross, 2014). Resilience is often seen as the ability to bend but not break, bounce back, and perhaps even grow in the face of adverse life experiences (Jha AP, 2017). However, the American Psychological Association (2014) states that resilience is focused on developing and maintaining a healthy mental state with Anyan et al., (2020) going on to say that this is crucial for positive development and adaptations throughout life. It is important to note that being resilient does not mean that individuals will not experience difficulty or distress and that some stress, notably work-related stress is unavoidable (Jun G, 2016).

Pietrzak and Southwick suggest that resilience is often viewed incorrectly, suggesting that it should not be viewed in a binary manner, you either have it or not. Instead, they argue that resilience is more akin to a continuum, with an individual having differing degrees of resilience depending on the domain in which it is viewed (Killgore WD, 2020). For example, an individual who adapts well in the workplace, thus demonstrating higher levels of resilience, may fail to adapt to the same level in their personal life. Likewise, Kim-Cohen and Turkewitz (2012) state that levels of resilience can change over time. Reinforcing the notion that resilience is a learned behaviour (King GA, 2010).

CONCEPTUAL MODELS OF RESILIENCE : Suggests the principal models of individual resilience are the compensatory model and the challenge model (Ledesma J, 2014).

Werner and Smith (2001) define compensatory resilience as neutralising the exposure that one might experience to risk, in essence working in opposition to the risk. They argue that the risk factors and the compensatory factors independently contribute to predicting the outcome; ideally, the compensatory factors mitigate or neutralise the risks altogether. However, there is a lack of consensus on what the compensatory factors might be (Lee J, 2019).

The challenge model of resilience states that assuming that the risk factors are not too extreme they can actually prepare an individual for their next challenge. However, Fleming and Ledogar (2008) note that exposure to both low and high levels of risk result in negative outcomes but do not define any thresholds, possibly due to levels of exposure being individual, similar to what is seen with stress. Richardson (2002) suggests that the challenge model of resilience is not linear as previously proposed by Flach (1997). Instead, Richardson (2002) suggests that while resilience is attained through a process of disruption and reintegration, as per Flach (1997) it is not as straightforward as literature might suggest (Lim CK, 2015).

It is this model of resilience which underpins this study. This is because we are not looking at the stressors and how to mitigate them, which is more akin to the compensatory form

of resilience, instead we accept that individuals will face a range of stressors and it is the response to stressors that is the focus of this study (Lowe SR, 2021).

If, as a result of this study we are able to identify any trends in the data, then it is hoped that our research will be a platform for further development of ideas (Lynch K, 2012). The authors believe that the focus of this study is particularly important as there has been a lesser emphasis on the challenge model of resilience through literature than the compensatory model (Maclean K, 2014).

In addition, and importantly for this study, resilience is often measured through the use of self-reporting questionnaires, yet there is not standardised test for measuring resilience recovering time. However, Lambert, et al., (2020) have found that self-reporting questionnaire to be less accurate than neuroscientific techniques. Therefore, the authors are seeking to determine whether neuroscientific approaches can be used to determine whether resilience recovery time can be measured (Matthews G, 1993).

RESILIENCE AND LEADERSHIP: Silva (2016) stated that leadership is one of those concepts that are very hard to define. According to Bolden (2004) at the heart of the problem of defining leadership lie two fundamental difficulties. Firstly, leadership is a complex construct open to subjective interpretation. Everyone has their own intuitive understanding of what leadership is, based on a mixture of experience and learning, which is difficult to capture in a succinct definition. Secondly, the way in which leadership is defined and understood is strongly influenced by one's theoretical stance. There are those who view leadership as the consequence of a set of traits or characteristics possessed by 'leaders', whilst others view leadership as a social process that emerges from group relationships. Such divergent views will always result in a difference of opinion about the nature of leadership (McArdle S, 2012).

Yet Grint (2004) identifies four problems that make consensus on a common definition of leadership unlikely. Firstly, there is the 'process' problem – a lack of agreement on whether leadership is derived from the personal qualities (i.e. traits) of the leader, or whether a leader induces followership through what they do. Secondly, there is the 'position' problem – is the leader in charge (i.e. with formally allocated authority) or in front (i.e. with informal influence). A third problem is one of 'philosophy' – does the leader exert an intentional, causal influence on the behaviour of followers or are their apparent actions determined by context and situation or even attributed retrospectively? A fourth difficulty is one of 'purity' – is leadership embodied in individuals or groups and is it a purely human phenomenon? While these discussions have and continue to be had as constructs of leadership evolve, to now include leadership within the digital space and leadership during Covid, the issue remains as to the role that resilience plays in leadership (Morote R, 2017).

Howard & Irving (2013) found that leadership development is gained and shaped through the active engagement in hardship or obstacles. They argue that by overcoming obstacles, a person builds a level of resilience to successfully deal with and bounce back from adversity. While argues that by developing resilience organisations build both individual employee's resilience as well as that of the organization (Nawaz R, 2019).

Demonstrated that there is a direct relationship between the stress of the leader's job and their ability to maintain resilience in the face of prolonged contact with adversity. Indeed. King and Rothstein (2010) argue that resilience is critical in leadership. Leaders face rapid changes in the business environment, changes in social, political and economic conditions, all of which make understanding resilience more important than ever. Resiliency is considered important both to continuing success in a career and career recovery. Smith (2015) suggests that coaching can support leaders to become more resilient, even when that was the not defined objective of the coaching intervention. This is due to an overlap between the methods used in coaching and the development of resilience. Williams, Edgerton, & Palme (2010) state that a cognitive behavioural methodology is a common approach in coaching, with Neenan (2017) asserting that individuals can learn to deal with adversity through learning the application of such cognitive behavioural techniques (Norouzinia R, 2020).

However, it is important to note that resilience is developed over a long period of time, and does not just happen overnight (Shaghaei, 2022). While Southwick notes that leaders serve as positive resilient role models by adhering to the core values of the organisation and by using personal narratives of overcoming adversity and achieving success in order to motivate team members (Posner J, 2005). It is at this point we start to get the co-dependency between individual resilience and organisational resilience. While exceptional leaders are considered to be highly resilient (Sonnenfeld and Ward (2008) argue that resilience is not just a characteristic of exceptional people, but can be of everybody (Rak CF, 1996).

METHODOLOGY

This study has adopted a neuroscientific approach in exploring resilience. Specifically, an ElectroEncephaloGram (EEG) was used to measure brain responses indicative of resilience patterns, while participants engaged with a Stroop test.

The Stroop test, in its classic form, requires participants to look at a series of colour words, printed in incongruent ink colours, and name the colour of the ink instead of reading the word, as quickly as possible. For example, if the word "red" is printed in green ink, the examinee is asked to say "green" instead of "red" (Erdori et al, 2018). This incongruency

induces a delay in the respondent's time in processing the information and responding appropriately, since inhibiting the urge to read out the visual colour and not the written word requires additional cognitive effort (Russell JA, 1980). The time delay between reading, processing and responding is traditionally called the Stroop Effect. The Stroop test has been used extensively in neuroscientific studies, in particular with the use of an EEG, to test cognitive functions (Atchley et al, 2017; Fahimi et al, 2018). In particular, it has been used widely, again with the use of an EEG, as a reliable method of inducing stress to participants since it is known to result in irritability and impulsivity (Alonso et al, 2015). Using the Stroop test in this study, helped causing a negative reaction in participants brains since, at the very end of the test, they were presented with a message indicating that they have not performed well, irrespectively of their actual performance during the test (Sonnenfeld J, 2008).

An EEG device, Enobio 20 by Neuroelectrics, was used to measure brain responses to the Stroop test. Results were calculated based on the Russell's Circumplex Model of Affect which was originally created to portray the interdependence of affect states such as distress, depression and excitement (Russell, 1980). Russell's model has two axes: the horizontal, representing valence which can range from negative to positive emotions, and the vertical, representing arousal which can range from activated to deactivated emotions. The main premise behind this dimensional model is that every emotion incorporates a combination of these two dimensions, valence and arousal. Evidence, both from psychological self-assessment methods and from biological and neuroscientific methods, seem to validate this approach since they corroborate the constant presence of a pleasant/unpleasant dimension of emotion and of an excitation/sleepiness one EEG devices are often used to provide measurements of the affective dimensions of emotions on the Russell model, even developing the model even further by adding dimensions (Southwick FS 2017).

Valence in this study was measured by recording alpha brainwave frontal asymmetry, left vs. right hemisphere, as this is standard method for examining positive vs. negative emotional brain states. Arousal was measured by utilizing the EEG power spectra approach, which is a well-established method for analysing brainwave data for signal potency over wave frequency, in studying states of anaesthesia vs. alertness for example (e.g. Matthews & Amelang, 1993; Dressler et al. 2004). (Tusaie K, 2004).

As explained above, to measure resilience, respondents were shown the Stroop test with a sequence of words of colours, such as "red", "blue", "green", while the words themselves were coloured differently than the colour word. Participants' task was to press keys on the keyboard whenever they would see that the colour word and the colour in which the word is written do not match. In the process, two feedback messages appeared, both meant to induce unpleasant

arousal, or stress, in the respondents' brains. These feedback messages prompted participants to do better, insinuating that they were not performing optimally. At the very end, a negative message indicating that they did poorly in the test overall was shown, regardless of their actual performance. Resilience in this study is defined as the time that it took participants' brains to return to their previous brain state after the negative effect of the non-performing message at the end of the Stroop test (Van Noordt S, 2020).

Using EEG technology and methods to measure resilience is aimed at adding a new perspective to the available approaches, which in organisational settings are predominantly, if not exclusively, of the self-reporting type. Even in non-organisational settings, like the recent Covid-19 lockdowns, studying resilience relied heavily on self-reporting tools, like the CD-RISC, the Beck Depression Inventory-II (BDI-II), the Zung Self-Rated Anxiety Scale (SAS), and the Multidimensional Scale of Perceived Social Support (MSPSS) (Kilgore et al, 2022). Although there is already strong evidence of the advantages and contribution of utilizing EEGs in studying resilience, especially in the health/medical field such an approach is still underutilised in organisational, managerial, learning and leadership settings (Williams H, 2010).

The sampling unit was part-time postgraduate executive MBA (master's in business administration) students. A total of 99 individuals (n=99), 59 were male (m=59) and 40 were female (f=40), participated in an emotional recognition test. This sampling unit was selected due to participants being employed as leaders or managers within their organization.

Therefore, individuals would already have experience in leading others within their workplace. This will ensure a level of validity to the results due to their real-world application. Participants were self-selecting through presentations to their class cohort based on a convenience sample (Plowright, 2011) and all had at least five years of leadership experience; hence, the executive MBA rather than the standard MBA programme. In total, 94% of participants were in the age range 30–49 years.

This initial study would provide details of whether a larger scale study should be conducted. It is also worth noting that the results of this study at this stage may not be generalizable due to the limitations of sample size (Zehir C, 2016).

FINDINGS AND DISCUSSION: This section of the paper presents and discusses the results from the EEG measurements. These are going to be discussed based on overall results, gender and then age.

The measurements collected using EEG, were based on the theta and beta ratios. The higher the theta relative to beta, the higher stress levels, and thus, lower resilience.

Beta waves are typically activated during cognitive tasks, while intensive theta waves relate to increased attention

and information uptake. This shows a stronger activation in brains amygdala region; classically associated with brain's emotional processing centre. The amygdala area registers all emotions, but in particular fear. However, fear limits the brains' cognitive processing ability. This limitation in cognitive processing adversely impacts on an individual's performance in a task [Table 1].

Provides details of the results of participants' ability to respond to induced stress as measured through the EEG system. The pre-feedback is the participants resting state before they received the results of the Stroop test. The feedback score is the point when individuals received news that they did not achieve well on the Stroop test, regardless of their actual score. This has invoked a level of stress which is evidence in the reduction in score. For males this was a 0.4 drop whereas in females it was a 0.9 drop, suggesting that female participants were more greatly affected by this result [Figure 1].

In male participants table 1 (visualised in chart 1) that measurements of beta waves returned to their pre-feedback level just after 6 seconds, whereas in female participants after an initial spike, it was over 10 seconds before the beta waves returned to close to their pre-feedback levels.

This data suggests that in this particular experiment male participants 'recovered' from the negative feedback more quickly than female participants. This supports Lowe et al

(2022) claim that women are less resilient than men. They found that resilience differences by gender were explained by the presence of reported "background stressors" for women (most notably burnout, caring for children/dependents). These findings add to a limited body of predominantly theoretical literature calling for attention to contextual influences on gender differences in measuring stress and concepts of resilience. It is important to note that while all participants were in leadership roles, the experimental methodology does not mimic real life scenarios. The use of the Stroop test cannot be attributed to either workplace or personal circumstances. Therefore, it is feasible that individuals will respond with different levels of resilience based on the differing situations encountered. For example, and possible an extreme one, is resilience resulting from the bereavement of a close family member. If an individual's resilience returned to pre-bereavement levels within the timespan identified in table 1, then subsequent concerns might be identified around the psychological processing of external events.

While the intention is not to diminish the findings presented in this paper, they do have implications for leaders who may not possess sufficient resilience. Studies have shown that leaders with low levels of resilience are less able to respond in positive way to crises they may encounter. Thus, negatively impacting on the levels of resilience of those around them. For example, leaders with high levels of resilience focus

Table 1.
Data Summary from EEG for Male and Female Participants.

| | Tack go/no | Negative Feed Back | (Black screen time in second) | | | | | | | | | |
|------------|-------------|--------------------|-------------------------------|------|------|------|------|------|------|------|------|------|
| Male | Prefeedback | Feedback | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Average | 0.73 | 0.69 | 0.68 | 0.66 | 0.70 | 0.68 | 0.69 | 0.7 | 0.71 | 0.77 | 0.75 | 0.74 |
| Variance | 0.18 | 0.19 | 0.24 | 0.27 | 0.24 | 0.35 | 0.29 | 0.2 | 0.18 | 0.28 | 0.46 | 0.23 |
| Devstand | 0.43 | 0.44 | 0.49 | 0.52 | 0.49 | 0.59 | 0.54 | 0.45 | 0.42 | 0.53 | 0.68 | 0.47 |
| Stat Error | 0.07 | 0.07 | 0.07 | 0.08 | 0.07 | 0.09 | 0.08 | 0.07 | 0.06 | 0.08 | 0.1 | 0.07 |
| Female | Prefeedback | Feedback | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Average | 0.74 | 0.65 | 0.68 | 0.73 | 0.65 | 0.64 | 0.67 | 0.69 | 0.66 | 0.7 | 0.72 | 0.72 |
| Variance | 0.23 | 0.26 | 0.32 | 0.27 | 0.34 | 0.39 | 0.33 | 0.43 | 0.36 | 0.23 | 0.31 | 0.39 |
| Dev stand | 0.48 | 0.51 | 0.56 | 0.52 | 0.58 | 0.62 | 0.58 | 0.67 | 0.61 | 0.49 | 0.56 | 0.63 |
| Stat Error | 0.07 | 0.07 | 0.08 | 0.07 | 0.08 | 0.09 | 0.08 | 0.1 | 0.09 | 0.07 | 0.08 | 0.09 |

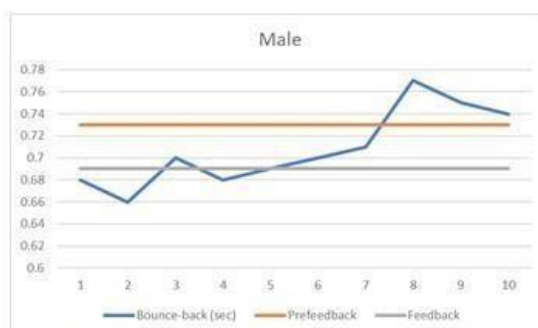


Chart 1: Results of male participants.

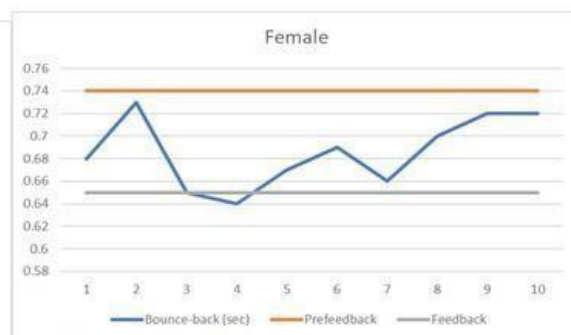


Chart 2: Results of female participants.

Figure 1. Measurements of beta waves in Male and Female Participants.

their efforts on meeting the psychological needs and health of their followers and are therefore well placed to positively impact subordinate resilience. The need for resilience of individuals culminates in increased levels of organisational resilience, which is a necessity for ensuring the ability to cope with a changing geo-political landscape. Cleary et al., (2018) found the benefits of interventions and training to support an individual's resilience. Their study, albeit focused on health professionals, suggests that resilience training may be of benefit. However, not all interventions enhanced resilience. With training over a longer period being more effective, based on scores observed in resilience assessments. The main approach to training for resilience is through mindfulness-based interventions as well as Cognitive Behavioural Therapy (CBT).

While not wishing to advocate the embedding of CBT within a curricular, as this requires specific training, but could some of the underpinning principles of CBT be integrated. For example, mitigating negative beliefs about one's performance in tasks, and adopting a positive (or growth) mindset when approaching tasks, have been proven in the field of elite sports (see McArdle and Moore, 2012) to have a positive impact on resilience.

The challenge for organisations is the extent to which these practices, if they can, as the evidence suggests improves levels of resilience, be integrated into normal working practice. This might lead to a more nuanced approach to coaching or mentoring in order to build in these practices as a small step to help resilience at both an individual and organisational level.

CONCLUSION

There has been considerable literature on resilience and the ability to measure improvements in level of resilience. However, the ability to have high levels of resilience is important for individuals and organisations, but this is negated if it takes individuals a significant period to recover from adverse effects. Having demonstrated through this study the ability to measure resilience through the use of EEG techniques, is a novel approach to considering resilience.

The use of postgraduate students who are also working professionals in this study provides academic departments evidence that more work needs to be done with students to develop their resilience. This is particularly important for those students who are or will go on to occupy leadership roles.

From the perspective of the student, it is important that they recognise their own and others resilience because as Hughes et al. (2005) suggest developing leaders with these skills is key to individual and organisational success. If students understand their levels of resilience, then they are in a position to improve and increase their job-related performance (Erdogan and Boz, 2020).

While not wanting to overstate the impact of this study, the findings could be interpreted more generally in a way to encourage those in academia and leadership positions to reflect on how they are developing resilience in individuals so that they can respond more effectively within the environment that they interact.

The more studies, like this one, that highlight this issue, the more emphasis academic staff will place on this when designing course content. However, work in this area is in its infancy and further work need to be undertaken to develop the use of neuroscientific-based techniques for applied applications such as this study. Taking the findings of this research forward, such as looking at resilience in different cultures or organisational sectors would add to the limited number of studies in this field. Future research needs to replicate this study in order to ascertain whether similar results are achieved. Additionally, work to ascertain whether there are significant differences in the ability to recognise empathy between different occupational sectors. This would potentially provide a granular level of detail that could be used to support individuals more effectively.

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