The impact of Stress and the role of Hemispheric Preference on Decision Making

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Abstract

The purpose of this research was to investigate how stress can affect the decision making process, and the role hemispheric preference plays on the decisions mechanism. The paper briefly explores the psychophysiology of stress, considering the impact it has on cognitive functions, and discussing individual differences in stress reactivity, particularly in terms of gender. Thirty participants (18 males, 12 females) answered The Zenhausern Preference Test, a well validated questionnaire used to measure the person's preference of brain hemisphere. The participants were also exposed to the Cold Pressor Test (CPT), where they were asked to insert their hands into ice water for a maximum of 2 minutes. Resting heart rate and blood pressure measures were recorded at initial baseline and after the stressor task as an indicator of Sympathetic Nervous System activation. The effects of stress on decision making were measured by scores of speed and accuracy recorded in two Trail Making Tasks, the first before the CPT (control), and the second after the CPT. A one way ANOVA revealed a significant difference in number of errors before stress. A Tukey HSD *Post hoc* analysis showed that the significance exists between left and right hemispheric preferences (p= .013). The ANOVA also found a significant difference in the scores of speed after stressor. A Tukey *Post hoc* showed that the difference lies between left and right hemispheric preferences (p= .050). The numbers of errors after stress, as well as scores for validation of stress, were not significant. Additionally, there was no significant difference in decision making of men and women.

Keywords: stress, hemispheric preference, brain hemispheres, gender, decision making, cognition, cold pressor test, trail making task.

The impact of stress and the role of hemispheric preference on decision making

General Overview of Stress

It is becoming increasingly difficult to ignore the consistent use of the term stress nowadays, and while it might be an agent of information, with the development of many definitions and different approaches, it could also diminish its real significance to personal and professional life. Stress can be conceptualized as the feeling of anticipation or finding of obstacle to reach one's goal. It could also be defined as the idea of incongruence between the skills available and the real demand (Carver & Connor-Smith, 2010; Lazarus, 2005; Verma, Balhara, & Gupta, 2011). The foundations of stress can be dated to 1932 with the work of Cannon, who first introduced the idea of body's homeostasis, a term that referred to a state of interior balance of substances such as sodium, glucose and temperature. He also developed the Fight-or-flight response theory in which bio-physiological processes of stress have been linked to. Basically, to defend itself of a situation of threat, the body presents stress responses that prepare cardiovascular, neuroendocrine and musculoskeletal systems, as well as immune functions for a battle (Dhabhar, 2008; Dhabhar & McEwen, 2007). Following Cannon's ideas, the studies of Selye (1956) got developed, proposing the existence of a generalised syndrome with a variety of symptoms, called later General Adaptation Syndrome (Selye, 1976). The symptoms are body's responses to stress, with the purpose of keeping the physical and emotional balance of an individual during a tense situation, in other words, it aims to adapt the body to the threat until a solution for the problem is found, increasing this way its chance of survival (Sapolsky, Romero, & Munck, 2000), or even increasing arousal so the body performs in optimum level, with the function of improvement of abilities, a type of stress known as Eustress (Gibbons, Martin, & Moutray, 2008; Lazarus, 1974; Nelson & Simmons, 2004).

Biological Effects of Stress

The reactions to stress are regulated via endocrine systems. These include the activation of the Hypothalamic-Pituitary-Adrenal axis, or HPA, and the activation of the Sympathetic Nervous System, or SNS (Delgado, 2007; O'Doherty et al, 2004; Rangel, Camerer, & Montague, 2008) The SNS, as oppose to the parasympathetic nervous system, is associated with active strategies. It is related to an increase of adrenalin and noradrenalin, the attention gets intensified, respiration, heart rate and blood pressure also increases. Most of the blood flow is used to irrigate the organs that will be necessary for a fight, such as heart, brain and muscles. Activities that stimulate the SNS can be any task that causes excitement or psychological stress, or physical as exercising or moderate changes in temperature (Chrousos & Gold, 1992; Ganong, 2001). Studies made in 2006 found that decreased temperature results in veins more constricted and with less vasomotion, which raises heart rate and blood pressure. These conditions however normalises as soon as the temperature is raised (Kellogg, 2006). When the HPA axis is activated, neuroendocrine hormones such as cortisol are released. If a person has a normal nocturnal sleeping pattern, cortisol levels will tend to be higher during the day, reaching its lowest levels between 10pm and 4am (Nicolson, 2007). However, the high level should be kept under a controlled level. Studies have already related high levels of cortisol to heightened blood pressure, and cortisol level tests are used to predict risks of cardiovascular diseases (Reynolds, Syddall, Walker, Wood, & Philips, 2003). During HPA axis activation, norepinephrine gets converted into epinephrine, and together they get involved in storage of energy, process of insulin, and secretion of glucose as well as its distribution. Basically, they start a broad defence mechanism, protecting the body and storing energy in case it is needed in the future (Habib et al 2000; Porges, 2001). In Summary, HPA axis and SNS, although two distinct mechanisms, work as one, with complementary functions which include the maintenance of blood pressure and heart rate.

Cognitive Effects of Stress

A considerable amount of literature has been published on the effects of stress on cognitive processes. Research showed that early life stress such as famine, bullying and sexual abuse is linked to cognitive impairment in adult life, affecting executive functioning as well as attention and language (Chugani et al. 2001; De Bellis, Hooper, Woolley, & Shenk, 2010). Negative impact on the recovery of long term memory was also found when a single dose of stress hormone was administered one hour before a recall task (de Quervain, Roozendaal, Nitsch, McGaugh, & Hock, 2000). Adding to the general effects of stress, it is suggested that some individual differences causes different outcomes. Studies found a negative correlation between stress and cognition in some people, where the higher the stress reactivity of the person, the lower would be the cognitive performance (Wright, Kunz-Ebrecht, Iliffe, Foese, & Steptoe, 2005).

Contrasting these findings however, researchers argue that stress has a positive impact on brain activity that could be beneficial to cognition since it increases the speed of information processing. Moreover, they believe that with the release of stress hormones there is an enhancement of memory which positively affects performance on cognitive tasks (Cahill, Gorski, & Le, 2003; Hancock & Weaver, 2005).

Stress and Decision Making

A large number of decisions are taken by people on a daily basis, and considering the level of stress linked to many of them it is essential to explore and understand the process to be prepared for the outcomes. Thinking of that, many studies have examined how stress affects and relates to the cognitive process of decision making (Allwood & Salo, 2012; Isen & Labroo, 2003; Pabst, Schoofs, Pawlikowski, Brand, & Wolf, 2013; Shirey, Ebright, & Mcdaniel, 2013).

The impact of stress is not always detrimental to decisions. Studies have shown that stress causes people to think of possible positive results by remembering the previous rewards, which facilitate the decision making (Mather & Lighthall, 2012).

Looking through a different perspective, dual-processes approaches suggest that the decision making is based on two systems. System 1, that is rational and analytical, slower, focused on planning and strategic thought; and System 2, that is intuitive, usually faster, with decisions made effortlessly, but loaded with emotions (Eichenbaum & Cohen, 2001; Frankish, 2010; Kahneman, 2003). Based on that, researchers believe that decisions taken under stress can interfere with the rational thoughts and cause the person to make decisions based more on intuition and processes that are automatic and faster, aggravating problems such as framing effect, a theory that suggests that people tend to avoid risks for gain, but seek risks for losses (Evans, 2003; Kahneman & Klein, 2009; Porcelli & Delgado, 2009; Reyna, 2004). Following the same idea, Janis (1993) proposed the Decision Conflict Theory, which is a mechanism of coping used by people when faced with a stressful situation. According to Janis, their attention increases but they get lost in the search for the solution, failing to consider all the available possibilities since they are not processing information in an organised manner.

Accuracy and Speed of Decisions

The decision making process can be operationalised in many ways, and coming to a conclusion about how to judge the person's decision making capability is a hard task. No consensus exists to date on which measure is the most efficient, therefore, the researcher needs to choose between specific aspects and use as a baseline the theoretical background (Hammond, 2000; Yates, Veinott, & Patalano, 2003).

In the present study, decision making was operationalised in accuracy (number of errors) and speed (seconds) of decisions. Neuropsychological assessments that involves a diverse range of cognitive abilities such as working memory, attention, visual search and scanning for example makes possible to detect the effect of stress on these variables, and consequently on their impact on the number of errors in the task and the time they take to answer the questions (Lezak, Howieson & Loring, 2004; Sánchez-Cubillo et al., 2009; Strauss, Sherman & Spreen, 2006). An example of that is the memory ability that can greatly reflect on accuracy and speed of tasks. Researchers suggest that the release of steroids have an effect on memory, thus it is expected to see an increase in the number of errors in the decisions that are taken under stress when compared to decisions that are taken in a no stress environment, and are therefore, more influenced by rational processes (de Quervain et al. 2000; Jelicic, Geraerts, Merckelbach, & Guerrieri, 2004; Payne, Nadel, Allen, Thomas, & Jacobs, 2002). Contrasting this idea however, studies made with tasks of visual search have shown that stress improved the attentional ability, which would result in higher accuracy and speed of decision (Braunstein-Bercovitz, 2003; Gauchou & Rensink, 2012).

The relationship between speed and accuracy has also been studied in many papers. The also called Speed-accuracy trade-off is a concept that says that the person chooses to focus in one ability in detriment of the other, i.e. focuses in speed and performs badly in accuracy, or focuses in accuracy and slows down the process (Forster, Higgins, & Bianco, 2003; Heitz & Schall, 2012; Lan, Sartori, Neumann, Sourjik, & Tu, 2012). An experiment made with neuroimaging was able to detect the precise brain areas of the trade-off, enabling people to find the balance between speed and accuracy, as well as facilitating the attentional control (van Veen, 2006). Therefore, considering the previous studies in the area, it is suggested that not only will stress affect the speed and accuracy of decision making process, but both variables will also have an impact in each other.

Stress and Gender

As suggested above, stress is associated with manifestations of many physiological and cognitive changes, linked mostly to increased reactivity of HPA and SNS. Stress literature has shown however, that individual characteristics in stress reactivity are also important in determining and predicting specific outcomes. Examples of these are risk factors for health problems that are gender specific (Goldstein et al. 2005; Kelly, Tyrka, Anderson, Price, & Carpenter, 2008; Segerstrom & Miller, 2004; Sinha & Rounsaville, 2002; Zahn-Waxler; 2000).

A study checking sex differences in HPA and autonomic nervous system to acute psychosocial stress found that the differences are consistent with the menstrual cycle, showing that the feminine hormone oestrogen has a great effect on stress responses of women. The study found that exposure to oestrogen lowered the activity of sympathoadrenal responsiveness causing the sex differences on responses to stress (Kajantie & Phillips, 2006). It has also been suggested a general trend of higher stress reactivity in men compared with women for tasks of psychosocial stress such as public speaking, suggesting a higher reactivity of HPA axis for males than females (Kajantie & Phillips, 2006; Kudielka & Kirschbaum, 2005), however, a recent study made also with psychosocial stress found no significant difference between genders (Lennartsson & Jonsdottir, 2011).

Researchers highlight that differences on stress reactivity are usually not found when the focus are on social tasks rather than achievement tasks, and argue that differences between genders found in experiments are very complex to evaluate since they are dependent on many factors such as personal traits, type of measurement used and how people perceive and appraise the stressful event. Many people see stressful situations as challenging, which affects the way they deal with them (Dickerson & Kemeny, 2004; Kassam, Koslov, & Mendes, 2009; Stroud, Salovey, & Epel, 2002). In general, men get more stressed with financial issues, while women suffer with interrelationships, even though they are more satisfied with their social life than men. Men tend to show greater concern to problems in the workplace while women dedicate themselves in general to family issues. And even during married life, there are differences on the way they handle the stress. Men in general benefits more from marriage since women tend to be more socially supportive. Women, when in need of help, lack the support of their husbands and have to rely on friends, while holding the responsibility of house and childcare for themselves (Denton, Margaret, Prus, & Walters, 2004; Fuhrer & Stansfeld, 2002; Lee & Waite, 2005; Ruble, Diane, Greulich, Pomerantz, & Gochberg, 1993).

Gender and Decision Making

A body of research have studied the effects of stress on decision making of men and women and found that there are significant differences on the way they handle stressful decisions and the outcomes (Lighthall, Mather, & Gorlick, 2009; Porcelli & Delgado, 2009; Preston, Buchanan, Stansfield, & Bechara, 2007; Takahashi et al, 2010). In general, comparative studies made with males and females during decision making tasks find that men outperform women in speed. The studies showed that men tend to focus only on long-term gains whereas women balance the short and long-term possibilities which cause them to take longer to decide (Overman, 2004; Seock & Bailey, 2008; van den Bos, Homberg, & de Visser, 2013).

Hemispheric Preference

It is an empirical reality that individuals differ on the way they deal with daily situations, and gender is not the only factor influencing this process. In terms of neurological differences, the hemispheric preference is known to explain much of the diversity on people's personality and different ways to solve an issue (Devlin & Singh, 2010; Kelley, 2011; Langdon & Coltheart, 2004; Morton, & Rafto, 2010; Russo, Persegani, Torlini, Papeschi, &

Trimarchi, 2001; Voglmaier et al, 2000). Recent evidence showed that although the brain hemispheres look symmetric, they are very different in their structure and their functions, and in general, people tend to show dominance in the use of left or right hemispheres for certain activities. This brain dominance means that, although both hemispheres have the information processing ability, one side might outperform the other; moreover, the manner on which the information is processed will also change as a result of the asymmetries present in the brain connections (Gupta, Dubey, Saxena, & Pandey, 2011; Rossion et al, 2000; Stephan, Fink, & Marshal, 2007).

In general, the right hemisphere is specialised in non-verbal and visuospatial thought, holistic and emotional process of information, creative and intuitive thought, and sees the bigger picture. They are typical of people that are spontaneous and adapt to change; On the other hand, the left hemisphere is specialised in language. It functions on an analytical, rational and linear manner, typical of people that like discipline, rules and focus on details (Herve, Zago, Petit, Mazoyer, Tzourio-Mazoyer, 2013; Iaccino, 1993; Nielsen, Zielinski, Fergunson, Lainhart, & Anderson, 2013; Shulman et al, 2010; Springer, 1998; Stephan et al, 2003; Toga & Thompson, 2003).

Questions have been raised about the existence or not of preference between both hemispheres. A recent study used neuroimaging technology with over a thousand brains and found no clear evidence of connectivity that could establish a dominance of left or right hemisphere (Nielsen, Zielinski, Ferguson, Lainhart, & Anderson, 2013). As explained above, it is known that both hemispheres are well capable of performing most tasks. The preference explains a better performance of one hemisphere over the other, which does not mean that the opposite side is not capable of performing the same way, in other words, every individual show characteristics of both hemispheres, the important thing is which predominates in most activities. It is a matter of preference, not dominance (Singh, 2002). A growing body of literature however, have not only found evidences of the existence of hemispheric preference on humans, but have also shown that is exists across vertebrates and also some invertebrates (Aizawa et al., 2005; Concha, Burdine, Russell, Schier, & Wilson, 2000; Concha & Wilson, 2001; Gamse et al., 2005; Halpern, Gunturkun, Hopkins, & Rogers, 2005; Laeng, Zarrinpar, & Kosslyn, 2003; Liang et al., 2000; Lux et al., 2004; Skiba et al., 2002).

Hemispheric Preference and Stress

With regard to stress research, it is also possible to see many differences in both hemispheres and their reactivity. Right frontal activity (RFA) has been linked to expression of negative feelings and behaviours, in humans and also rodents (Coan & Allen, 2004; Sullivan, 2004). Deeper neurological assessments have also found higher levels of cortisol on people that demonstrate a higher RFA, and while the right hemisphere seems to be the hemisphere mediating stress, it is also the side of the brain that takes longer to recover (Buss et al., 2003; Cerqueira, Almeida & Sousa, 2008; Davidson, 2004; Rilling et al., 2001; Sullivan, 2004; Tops et al., 2005). The left hemisphere suffers a great drop in activity during stress, becoming less analytic but better on the ability of finding global solutions rather than focusing only on details, suggesting that people tend to make a shift toward the opposite hemisphere in a stressful situation (Cerqueira, Almeida, & Sousa, 2008.; Gidron, Germeys, & Shani, 2010; Lewis, Weekes, & Wang, 2007).

Also related to stress is the ability to handle emotions which has been found to be lateralised in the hemispheres. According to this approach, the valence hypothesis, the right hemisphere tends to externalise their emotions more often although showing higher levels of tension, they also were found to have less control over their impulses and view themselves in a negative light, on the other hand, the left hemisphere tends to internalise the emotions and be more responsive to positive stimuli. They are less prone to tension, have greater control over impulses, and a positive view of themselves (Alfano & Cimino, 2008; Ali & Cimino, 1997; Canli, Desmond, Zhao, Glover, & Gabrieli, 1998; Vingiano, 1989). A study found that an inability to switch from one hemisphere to another during a situation of stress could cause pathologies characteristics from the hemisphere the patient is stuck in, i.e. depression for right hemisphere or mania for left hemisphere (Pettigrew & Miller, 1998).

Hemispheric Preference and Decision Making

The study of individual differences on decision making is vast, and taking a closer look at it, it is possible to relate the personal characteristics to each of the brain hemispheres such as scores of reports of negative life events and types of cognitive ability, if numerical or spatial (Bruine de Bruin, Parker, & Fischhoff, 2007; Mckenzie & Nelson, 2003; Stanovich, 2008).

One of the individual differences that affects decision making is framing effect. According to neurological research, framing involves the amygdala, which is a part of the brain that detects emotionally relevant information and is more likely to take contextual cues into consideration (Adolphs, 2006, McElroy & Seta, 2004). Considering that, it is expected that the right hemisphere show higher levels of framing effect, and consequently, people with a right hemispheric preference. At the same time, it suggests a lower influence of contextual cues on people with left hemispheric preference, and thus, lower framing effects (Hellige, 2001; Snodgrass & Harring, 2004).

Much has been said about brain hemisphere and the influence in our personalities, however far too little attention has been paid to hemispheric preference and its relation to the decision making process, particularly the decisions taken under stress. Although extensive research in the last few years has been carried out on decision making, it focused on financial and risky decision making, neglecting the specific influence of hemispheric preference.

The main purpose of this study is to shed light and explore the role of hemispheric preference during the decision making process after a stressor task. No directional hypotheses are being made due to the low number of research available on the topic. The measures being used are The Cold Pressor Test as the stressor task, the Zenhausern Preference Test (Zenhausern, 1978) to check hemispheric preference, and a modified version of the Trail Making Task (see Appendices C and D) as the decision making test.

The hypotheses driving the present research are the following:

- There will be a significant difference in blood pressure before and after stress;
- There will be a significant difference in heart rate before and after stress;
- There will be a significant difference in speed of decisions before and after stress;
- There will be a significant difference in accuracy of decisions before and after stress;
- There will be a significant difference in decision making of men and women before and after stress;
- There will be a significant difference in decision making across brain hemispheres before and after stress.

Methods

Participants

The sample of thirty participants was comprised of 12 females and 18 males, and although the age range was 19-59 years, the sample as a whole was relatively young, (M= 30.30, SD = 10.81). All participants were above eighteen years of age for ethical purposes. The recruitment was made by convenience sampling, with both students and non students. One participant, recruited by the same criteria as the others, provided pilot rating values. Each participant agreed to take part in the experiment to fulfil partial course requirements of the BA Honours Psychology from Dublin Business School, and for which they signed an informed consent. Additionally, they provided demographic information of age and sex. Each participant completed control and post stressor conditions, and scores were recorded seconds after completion. No data was discarded, and no participants left at any stage.

Design

This study is an Experiment which incorporates both, True Experimental and Quasi-Experimental design, with a mix of within and between subjects. Stress is the experimental variable, and along with hemispheric preference and gender, the independent variables, it is presumed to cause an effect on the dependent variables: heart rate, blood pressure (pulse pressure) and Decision Making (speed and accuracy, measured with number of errors). As a True Experiment design it analyses within subject's scores of blood pressure (condensed into Pulse Pressure, with the difference between systolic and diastolic blood pressure), heart rate, speed and number of errors. All participants took part in all within subject's tests, which comprised of a pre stress (control), and post stress test. No participants left at any stage. The between subjects analysis, Quasi-Experiment, checked the scores of gender and hemispheric preference. Participants were allocated to groups according to gender and score on the

Zenhausern Preference Test, i.e. left hemisphere preference, right hemisphere preference, no preference.

Materials

Pen and paper was used to answer demographic questions, informed consent (see Appendix A), Zenhausern Preference Test (Zenhausern, 1978) (See Appendix B), and a partially modified version of the Trail Making Test (See Appendices C and D). To induce a stress response, the Cold Pressor Task was used. The informed consent outlined the purpose of the research to the participant, and highlighted the concern with anonymity of data and how it will be used in the future.

The Zenhausern Preference Test questionnaire (1978) was used to determine the Hemispheric Preference of the participant. It comprised of an introductory explanation, and twenty questions that describes the way the participant is in general, (e.g. Are you artistically or musically creative?; Are you fluent in using words?) that were judged on 10-point scales (1 = never and 10 = always). The questionnaire is scored by rating all responses of odd numbers as left hemispheres scores, and all responses of even numbers as right hemispheres scores; the higher amount of scores determines the hemisphere of preference of the participant. The questionnaire had prior evidence of validity and reliability (Merckel-bach, Muris, Pool, & De Jong, 1997; Merckel-bach, Muris, Pool, De Jong, & Schouten, 1998).

The modified Trail Making Test is a pen and paper test. The original version was first designed as an intelligence test to the Army test battery, and later became one of the most commonly used neuropsychological tests in clinical practice (Rabin, Barr, & Burton, 2005). In this context, the test is used to check the decision making ability of the participants before and after the stressor task, operationalised in scores of speed and errors in Part 1 (see Appendix C) and Part 2 (see Appendix D). The Modified Trail Making Test consists of encircled numbers and letters, which the participants has to connect as quick as possible alternating numbers and letters without taking the pen off the paper. Part 1 consisted of twenty-four circles and Part 2 of twenty-five. When an error is committed, it is recorded and participant had to return to the last correct target and continue with the task until it is completed. Both parts are timed and recorded in seconds.

The Cold Pressor Task (CPT) consists in immersing the participant's hand into ice water for a short period of time. In this experiment the maximum time of hand immersion was 2 minutes. Studies have shown that when applied, the CPT triggers vascular sympathetic activation and raises blood pressure. (Sendowski et al, 2000; Cui, Wilson, & Crandall, 2002) Subtracting diastolic from systolic blood pressure was possible to obtain the arterial Pulse Pressure. Other studies have also tested the validity and reliability of the CPT as an indicator of stress reactivity, showing positive results. (Kelsey, Ornduffm, & Alpert, 2007; Clewett, Schoeke, & Mather, 2013).

Apparatus

A wrist Blood Pressure Monitor SANITAS SBM 09 was used to check variations on blood pressure and heart rate before and after the stressor task. For the Cold Pressor Task, a bucket with ice was used to immerse the participant's hand and a towel to dry it before the pen and paper task. A digital stop watch in an IPhone 4 was used to monitor time. To analyse the data, it was used the software IBM SPSS Statistics Data 21.

Procedure

At first, a verbal explanation about the topic of the thesis was given to the participant. The person was told that it was an experiment to investigate the impact of stress on decision making and the role of hemispheric preference on the decisions mechanism. A brief account of what hemispheric preference means, and how it was presumed to affect our choices and personality was also given. It was also explained the right to withdraw from the study at any given time and the importance given to anonymity. Following that, the informed consent was given to the participant and the person was invited to read, sign and fill up the additional demographic information requested, which consisted of age and gender, apart from the date.

The experiment started with the participant answering the Zenhausern Preference Test questionnaire. It was explained to the participant that some questions could not be clear, and if any assistance was needed, one was free to request it at any time. Additionally, it was clarified that it was not a questionnaire of right or wrong questions, with no need to generate any anxiety. The participant read the written instructions and completed the questionnaire in his/her own time. When the twenty questions got answered, the blood pressure and heart rate got checked with the wrist monitor in the left wrist, and the participant got explained that control measures were being collected. The data was recorded as soon as collected.

The next task was the first Trail Making Test. The participant was shown a sample of the task and explained that there were numbers and letters encircled, and the task consisted in linking these circles in an orderly manner starting by the number, i.e. 1-A-2-B-3-C and so on. Additionally, the participant could not take the pen off the paper and should try to link all the circles as quick as possible since the time would be recorded. It was clarified that in the case of a mistake, the participant would have to go back to the last circle before the mistake and continue from there, until the task was finished. Additional time was given for questions. When the real task sheet was given to the participant the time started to be recorded and the participant was watched in case of errors.

Following the Trail Making Task, the participant was asked to roll up the sleeves and remove any jewellery, if the case, from the non-dominant arm. Next, the person was shown the bucket of ice, and the Cold Pressor Task explained. The participant was told that there was a maximum of two minutes of immersion of hands in the ice water, but it was also clarified that the participant was free to withdraw the hands whenever the pain felt unbearable, or whenever one felt like doing so. A minimum time of one minute was required to be able to keep the data in the research, however, for ethical purposes this information was not passed on to the participant, whom was free to stop at any time. If it was the case of the person withdrawing the hand before the minimum time, the participation would be thanked and data discarded. All participants however reached the minimum time. The non-dominant hand was immersed and the timer was put on. After the two minutes had passed, the participant's hands got dried and the wrist monitor was used once more to check the blood pressure and heart rate after the stressor. The scores got recorded and the second phase of the Trail Making Test started. The participant got explained that the task was basically the same, and the person would be timed again during the task. The scores for the second task were recorded, and the experiment finished. To counterbalance, preventing order effect, half of the participants were asked to do the Part 1 of the Trail Making Task followed by Part 2, and the other half was asked to do the Part 2 followed by Part 1.

Results

Hypothesis #1:

There will be a significant difference in scores of blood pressure before and after the stressor task.

Table 1

A display of descriptive statistics illustrating the differences between mean scores before and after stressor task.

Variables	Conditions	*N*	*Mean*	*SD*
Blood Pressure	Before Stressor	30	44.47	14.12
	After Stressor	30	44.67	17.45
Heart Rate	Before Stressor	30	76.30	9.25
	After Stressor	30	74.67	9.88
Number of Errors	Before Stressor	30	1.53	2.24
	After Stressor	30	1.50	2.10
Speed	Before Stressor	30	81.57	33.41
	After Stressor	30	78.53	33.52

Descriptive statistics including means and standard deviations for measures of blood pressure (condensed into pulse pressure) are shown in Table 1, and an alpha level of .05 was used for statistical analyses. The mean score for blood pressure before stressor was 44.47

(*SD*=14.12), however the blood pressure after stressor scores mean was slightly higher at 44.67 (*SD*=17.45). The 95% confidence limits show that the population mean difference of the variables lies somewhere between -6.52 and 6.12. These mean scores differed slightly, however, a paired sample t-test showed that there was no significant difference between blood pressure before and blood pressure after stressor (t (29) = -.065, p = .949). Therefore the null cannot be rejected.

Hypothesis #2:

There will be a significant difference in scores of heart rate before and after the stressor task. Descriptive statistics including means and standard deviations for measures of heart rate are shown in Table 1, and an alpha level of .05 was used for statistical analyses. The mean score for Heart Rate before stressor was 76.30 (*SD*=9.25). The Heart Rate scores after the stressor task showed a slight decrease with mean at 74.67 (*SD*=9.88). The 95% confidence limits show that the population mean difference of the variables lies somewhere between -.60 and 3.87. Although there was a slight difference on mean scores, a paired sample t-test showed that there was no significant difference between heart rate before and after the stressor task (t (29) = 1.50, p = .145). Therefore the null cannot be rejected.

Hypothesis #3:

There will be a significant difference in scores of speed of decision making before and after the stressor task. Descriptive statistics including means and standard deviations for measures of Speed are shown in Table 1, and an alpha level of .05 was used for statistical analyses. The mean score for Speed before stressor was 81.57 (*SD*=33.41). The Speed score after the stressor task showed a slight decrease with mean at 78.53 (*SD*=33.52). The 95% confidence limits show that the population mean difference of the variables lies somewhere between -

5.61 and 11.67. Although there was a slight difference on mean scores, a paired sample t-test showed that there was no significant difference between Speed scores before stressor task and after (t (29) = .718, p = .478). Therefore the null cannot be rejected.

Hypothesis #4:

There will be a significant difference in scores of number of errors in decision making before and after the stressor task. Descriptive statistics including means and standard deviations for measures of number of errors are shown in Table 1, and an alpha level of .05 was used for all statistical analyses. The mean score for number of errors before stressor was 1.53 (*SD*=2.24). The scores for numbers of errors lowered slightly after the stressor task with the mean at 1.50 (*SD*= 2.10). The 95% confidence limits show that the population mean difference of the variables lies somewhere between -.80 and .87. The analysis of mean scores presented some difference, however a paired sample t-test showed that there was no significant difference between the number of errors before the stressor task and after (t (29) = .082, p = .935). Therefore the null cannot be rejected.

Hypothesis #5:

There will be a significant difference in decision making (speed and number of errors) of men and women before and after the stressor task.

Table 2

A display of descriptive statistics illustrating the differences in decision making between genders before and after the stressor task.

Variables	Gender	*N*	*Mean*	*SD*
Number of errors before stressor	Male	12	1.00	1.03
	Female	18	2.33	3.23
Number of errors after Stressor	Male	12	1.11	1.45
	Female	18	2.08	2.78
Speed before stressor	Male	12	76.83	26.77
	Female	18	88.67	41.80
Speed after stressor	Male	12	71.11	22.10
	Female	18	89.67	44.51

Descriptive statistics, including means and standard deviations, for measures of number of errors are shown in Table 2. The mean of scores for males before stressor was 1.00 (*SD*=1.03) against a mean at 2.33 (SD=3.23) for females on the same conditions. The scores for males increased slightly after the stressor task with the mean at 1.11 (*SD* = 1.45), whereas females presented a decrease with the mean at 2.08 (*SD*=2.78). After comparing the results of both genders, the 95% confidence limits showed that the population mean difference of the variable number of errors before stressor is between -3.42 and .76, and after stressor is somewhere between -2.83 and .89. An independent samples t-test found that there was no significant difference in number of errors between males and females before the stressor task (t (28) = -1.38, p = .190), or after the stressor task (t (28) = -1.12, p = .282). Therefore the null cannot be rejected.

For the variable speed before stressor task, males had the mean at 76.83 (*SD*=26.73), and were found to perform better than females who had their mean at 88.67 (*SD*=41.80). After the stressor task, males showed a decrease in speed with mean 71.11 (*SD*=22.10) against females with a mean at 89.70 (*SD*=44.51). The 95% confidence limits showed that the population mean difference of the variable speed before stressor task is between -37.38 and 13.71, and speed after stressor task is between -48.17 and 11.06. The analysis of mean scores presented some difference, however an independent sample t-test showed that there was no significant difference in the speed of men and women before the stressor task ($t(28) = -.95$, $p = .351$), and after ($t(28) = -1.34$, $p = .201$). Therefore the null cannot be rejected.

Hypothesis #6:

There will be a significant difference in decision making across brain hemisphere preferences before and after the stressor task

Table 3

A table of descriptive statistics showing the scores of decision making across brain hemisphere preferences.

Variables	Hemispheric Preference	*N*	*Mean*	*SD*	*min*	*max*
Number of errors before stressor	Left hemisphere	13	2.85	2.85	0	10
	Right preference	14	.50	.65	0	2
	No preference	3	.67	1.16	0	2
Number of errors after stressor	Left hemisphere	13	2.31	2.56	0	8
	Right hemisphere	14	1.00	1.57	0	5
	No preference	3	.33	.58	1	1
Speed before stressor	Left hemisphere	13	98.00	37.42	51	187
	Right hemisphere	14	70.14	23.38	38	120
	No preference	3	63.67	32.87	34	99
Speed after stressor	Left hemisphere	13	95.77	38.55	45	194
	Right hemisphere	14	66.36	22.12	31	106
	No preference	3	60.67	27.30	36	90

Descriptive statistics for measures of number of errors are shown in Table 3. A one-way ANOVA found that the number of errors before stressor differed significantly across brain hemisphere preferences (*F*(2,27)5.05, p=.014). More specifically Tukey HSD *Post hoc* analyses showed that there was a significant difference in number of errors before stressor between left hemisphere preference (*M* = 2.85, *SD* = 2.85) and right hemisphere preference (*M* = .50, *SD* = .650, *p* = .013). The number of errors after the stressor showed no significant differences (*F*(2,27) 1.95, p=.162). In terms of speed, the one-way ANOVA found that the scores of speed before stressor did not differ significantly across brain hemisphere preferences (*F*(2,27) 3.26, p=.054), however the scores of speed after stressor showed a significant difference across brain hemispheres preferences (*F*(2,27) 3.63, p= .040). A Tukey HSD *Post hoc* analyses found that the differences bordered significance between left brain hemisphere preference (*M*=95.77, *SD*=38.55) with the right brain hemisphere preference (*M*=66.36, *SD*=22.12, p=.050).

Discussion

A goal of this study was to complement a growing body of literature that seeks to understand the mechanisms of the decision making process, especially the decisions of men and women influenced by stress. A secondary aim was to explore the role of hemispheric preference on the decision making mechanism, particularly decisions taken under stress, complementing and augmenting the low number of previous research on the topic.

Stress reactivity was induced by exposing participants to the Cold Pressor Test (CPT), which in previous research was found to cause in healthy subjects a vascular sympathetic activation and sustained increased in blood pressure (Cui, Wilson, & Crandall, 2002; Garg, Kumar, & Singh, 2010; Jauregui-Renaud et al., 2001; Sendowski et al., 2000). Based on that, it was primarily predicted that there would be a significant difference on scores of blood pressure following the stressor task. It was also predicted that there would be significant difference in scores of heart rate after the stressor task, compared to scores before the stressor task. The results of the present study however are not in accordance with the previous literature. The mean scores of blood pressure, condensed into pulse pressure, shows no significant difference between before and after scores, and the heart rate, although having a small decrease in scores after stressor task, did not reach statistical significance. A few plausible explanations could be considered for the mechanisms underlying the lack of significant findings of stress reactivity. It is known that the stress response to cold pressor test is less extreme than in other stressor task, such as public speaking (McRae et al., 2006; Schwabe, Haddad, & Schachinger, 2008). Considering that, it is possible that blood pressure and heart rate were not the adequate measures to check stress reactivity for this specific task. Perhaps, the experiment lacks the use of a measure that is more sensitive to the dynamics of SNS activation, such as salivary cortisol measures (Nater et al., 2005; Nater & Rohleder, 2009). Alternatively, it is presumed that the cold pressor test is not a reliable and effective method of inducing stress.

The assessment of decision making was made through a modified version of the Trail Making Task (1944). Decision making was operationalised into speed and accuracy (number of errors). It was predicted that there would be significant differences in speed and accuracy before and after the stressor task. The results however did not confirm these hypotheses since they did not reach statistical significance. Analysing the results however, there was a decrease on the scores of speed after stressor, followed by an almost imperceptible decrease also on the number of errors after the stressor, which could be explained by the Speed-accuracy trade-off, with lower speed being motivated by lower number of errors.

The comparison of male and female scores of decision making was made through measures of speed and accuracy. Considering the interaction of oestrogen with stress hormones during menstrual cycle, and the previous research on higher stress reactivity for males (Kajantie & Phillips, 2006; Kudielka & Kirschbaum, 2005), it was hypothesised that there would be a significant difference in decision making of men and women before and after stressor. Although the results were not significant, some difference was found. The mean score of number of errors before and after of men was half of that of women, and in terms of speed, male had also lower scores, meaning that they finished their task much faster than women. No comparative of hemispheric preference was made between genders. Perhaps that would help also to explain the difference in results. The results are consistent with many studies that found that men, focusing only in long-term goals, make faster decisions than women, which balance short and long-term goals before deciding (Overman, 2004; Seock & Bailey, 2008; van den Bos, Homberg, & de Visser, 2013). However, when analysing their progress individually, men showed a poorer performance than women in number of errors with a higher mean after stressor, while women decreased the amount of errors following the stressor task. As oppose to that, the results of speed showed men with faster results after stressor, while women increased their speed. Basically, what the second analysis show is that women were slower, but had less errors, and men had more errors, but were faster, which matches the concept of speed-accuracy trade-off, since one ability was clearly sacrificed while other was increased (Forster, Higgins, & Bianco, 2003; Heitz & Schall, 2012; Lan, Sartori, Neumann, Sourjik, & Tu, 2012).

The hemispheric preference was determined by the Zenhausern Preference Test questionnaire (Zenhausern, 1978). Given the lack of previous research investigating the hemispheric preference response to decision making under stress, no directional hypotheses were made. It was however predicted that there would be a significant difference in decision making across hemispheric preferences before and after stress. Although stress scores were not significant, interestingly the results of a one-way ANOVA partially confirmed this hypothesis. It was found that there is a difference in number of errors before stressor between left and right hemisphere, with left hemisphere showing significantly more errors than right, and after stressor, although not significant, the number of errors of left hemisphere were still higher than right hemisphere and no preference. In terms of speed, there were no significant results before stressor, however after stressor people with a left brain hemispheric preference showed a significant difference, being slower in their decisions in comparison to people with a right hemispheric preference. As oppose to the Speed-accuracy trade-off theory, which would explain the sacrifice of one variable in detriment to the other (Forster, Higgins, & Bianco, 2003; Heitz & Schall, 2012; Lan, Sartori, Neumann, Sourjik, & Tu, 2012), the left hemisphere showed a poorer performance in both variables, i.e. a higher number of errors in a higher amount of time. A cause of that could be, the already identified, switch from one hemisphere to another in a situation of stress, being the left hemisphere the one to show greater drop in activity. This way, the analytical characteristics, and great facility to deal with numbers would give space to a slow numerical ability and less focus to detail (Cerqueira, Almeida, & Sousa, 2008; Gidron, Germeys, & Shani, 2010; Lewis, Weekes, & Wang, 2007).

Limitations

This study was primarily limited by financial constraints, translated into lack of proper equipment for adequate measurement of variables. Lacking measures of cortisol, the whole research got compromised with records of heart rate and blood pressure, which did not have enough sensitivity to register the low levels of stress reactivity caused by the cold pressor test. The lack of a properly functioning EEG equipment also posed obstacles to the experiment since records of shifts in hemispheric preference were not possible to be collected. A second limitation was the lack of control over participant's medical background or drug intake for ethical purposes. It is known that many drugs can affect people's cognition such as antipsychotics, as well as many psychological disorders, such as post-traumatic stress disorder or anxiety disorders which could highly affect the overall results of the experiments, since there are a relatively small number of participants in the study.

Future Research

A greater depth of information may have been obtained by using neuroimaging techniques to check if there is a shift of hemispheric preference during decision making after stress. Moreover, this type of technique would allow the researcher to go further on the research of hemispheric preference and emotions in general, making possible the observation of the exact location of brain activity.

A replication of the study with different tasks would also be of great interest. The introduction of a psychosocial stress task and different measures of decision making could greatly affect the scores of stress, as well as the difference between genders. Additionally, the use of decision making tasks that involves images, rather than numerical abilities, would perhaps show different results for hemispheric preferences and decision making under stress.

Implications

The results of this study gave a better understanding of stress and how it can affect specific cognitive functions of men and women, considering neurological particularities of hemispheric preference. Apart from that, it can be of great interest to organisations, especially for recruitment stage. Psychometric tests allow the recruiter to fit the best candidate in the best position for the company, resulting in higher revenues and lower turnover. It is also an important collaboration to the academic environment, as an extra source of research on stress, decision making, hemispheric preference and comparison of genders.

Conclusion

The findings of this research are not consistent with the previous literature in its totality. The Cold Pressor test did not give significant results of stress, which invalidated the following analysis. Comparisons between gender showed to be consistent with speed-accuracy trade-off with females showing fewer errors in more seconds, and males showing more errors in fewer seconds. Hemispheric preference was the only variable to show significant results, with left hemispheric presenting lower performance in speed and number of errors, contrasting with speed-accuracy trade-off. However, the result is consistent with the idea of switch of hemispheric preference after stress, suggesting that participants with left hemispheric preference switched their preference after the stressor task. Future research needs to be made in the topic to analyse this possibility.

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Appendices

Appendix A – Informed Consent

Dear participant,

My name is Priscila Brandao and I am a final year mature student of BA (Hons) Psychology in Dublin Business School.

My research will investigate the impact of stress in decision making and the role of hemispheric preference in this process.

Your participation in this research is voluntary, and you may change your mind later and stop participating even after signing this informed consent.

At the end of college examinations, the data will be kept for a year and then destroyed.
All the information collected in this research will be kept confidential, as well as any personal information. Nobody but the researcher will have access to it.

The knowledge gained in this research will be shared during examination time as statistical data, and may also be shared in publications and Psychology Congresses. However, confidential information will not be released, and all information will be kept anonymous.

If you have any questions during the study you may ask the researcher. If you have any queries later, or would like to know the results of the study, you may contact the researcher on:

Thank you for your participation.

I have read the above information. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate in this research.

Male [ ] Female [ ] Age: ______

Date___/___/___

Signature of Participant ____________________________________

Appendix B – Zenhausern Preference Test

Zenhausern's PREFERENCE TEST

This is a questionnaire designed to measure your consistent style of learning, thinking, and living in general. One style is not better than another. The ability to do a particular style well, rather than the style itself, is important for quality.
For each question, circle the number that best describes the way that you are (not how you would like to be). Some of the questions may seem similar. These are not trick questions, but involve either subtle differences or a different perspective.

1. How often are your decisions based upon objective facts rather than feelings?

   Never 1….2….3….4….5….6….7….8….9….10 Always

2. Are you psychic (i.e., can you read minds, can you predict well)?

   Never 1….2….3….4….5….6….7….8….9….10 Always

3. Do you like using symbols and/or definitions in solving problems?

   Never 1….2….3….4….5….6….7….8….9….10 Always

4. How good are you at teaching and/or explaining by manipulating objects?

   Never 1….2….3….4….5….6….7….8….9….10 Always

5. Are you artistically or musically creative?

   Never 1….2….3….4….5….6….7….8….9….10 Always

6. Are you logical?

   Never 1….2….3….4….5….6….7….8….9….10 Always

7. How good are you at solving crossword puzzles?

   Never 1….2….3….4….5….6….7….8….9….10 Always

8. How quickly do you read?

   Never 1….2….3….4….5….6….7….8….9….10 Always

9. How vivid are your daydreams?

   Never 1….2….3….4….5….6….7….8….9….10 Always

10. How good is your ability to think of synonyms for words?

   Never 1….2….3….4….5….6….7….8….9….10 Always

11. Do you remember your dreams often?

   Never 1….2….3….4….5….6….7….8….9….10 Always

12. How vivid are your dreams?

   Never 1….2….3….4….5….6….7….8….9….10 Always

13. Are you fluent in using words?

   Never 1….2….3….4….5….6….7….8….9….10 Always

14. Do you use a playful approach to solving problems?

   Never 1….2….3….4….5….6….7….8….9….10 Always

15. Do you use a serious, all-business approach to solving problems?

   Never 1….2….3….4….5….6….7….8….9….10 Always

16. Do you like experiences to be planned and structured?

   Never 1….2….3….4….5….6….7….8….9….10 Always

17. Do you like to think while sitting upright?

   Never 1….2….3….4….5….6….7….8….9….10 Always

18. How often does your thinking consist of words?

   Never 1….2….3….4….5….6….7….8….9….10 Always

19. How often does your thinking consist of mental pictures or images?

   Never 1….2….3….4….5….6….7….8….9….10 Always

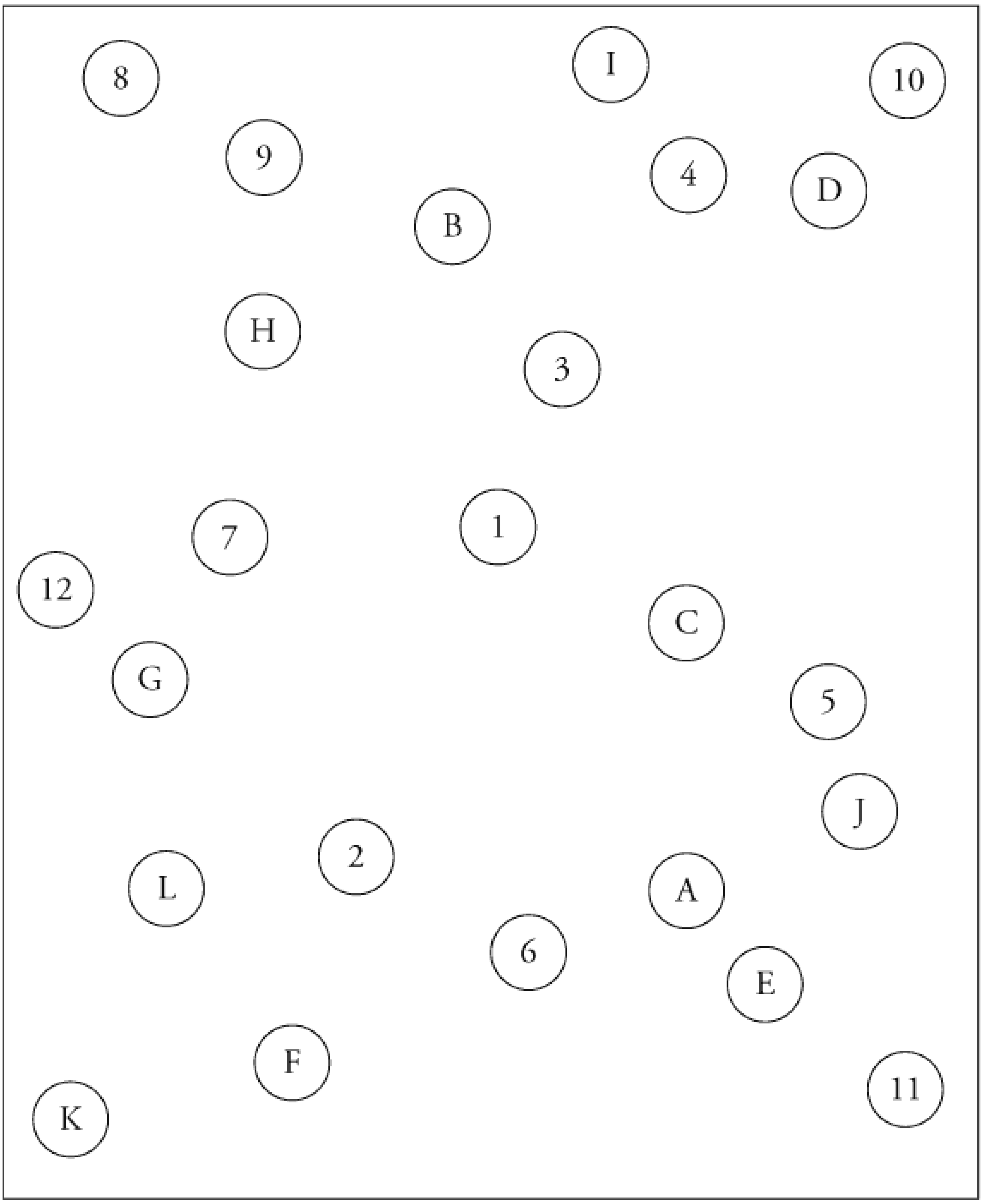
20. Do you like teaching or explaining by visual presentation?

   Never 1….2….3….4….5….6….7….8….9….10 Always

Scoring key:

Odd numbered items were viewed to be left hemisphere questions. The even numbered questions were thought to be right hemisphere. All items are scored 1 to 10 from left to right. The sum of the 10 right items and the sum of the left 10 items is compared, and the side with highest sum represents your hemispheric style.

Appendix C –Trail Making Task part 1



Appendix D – Trail Making Task part 2