Psychology & Neuroscience
ISSN: 1984-3054
landeira@puc-rio.br
Pontifícia Universidade Católica do Rio de Janeiro
Brasil

Scheffer, Morgana; Kieling Monteiro, Janine; Martins de Almeida, Rosa Maria
Frontal stroke: problem solving, decision making, impulsiveness, and depressive symptoms in men and women
Psychology & Neuroscience, vol. 4, núm. 2, 2011, pp. 267-278
Pontifícia Universidade Católica do Rio de Janeiro
Rio de Janeiro, Brasil

PSYCHOLOGY & NEUROSCIENCE

Psychology & Neuroscience, 2011, 4, 2, 267 - 278
DOI: 10.3922/j.psns.2011.2.012

Frontal stroke: problem solving, decision making, impulsiveness, and depressive symptoms in men and women

Morgana Scheffer[1], Janine Kieling Monteiro[1] and Rosa Maria Martins de Almeida[2]

1 - Universidade do Vale do Rio dos Sinos, RS, Brazil

2 - Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

Abstract

The present study compared men and women who suffered a frontal lobe stroke with regard to problem solving, decision making, impulsive behavior and depressive symptoms and also correlated these variables between groups. The sample was composed of 10 males and nine females. The study period was 6 months after the stroke. The following instruments were used: Wisconsin Card Sort Test (WCST), Iowa Gambling Task (IGT), Barrat Impulsiveness Scale (BIS11), and Beck Depression Inventory (BDI). For the exclusion criteria of the sample, the Mini International Psychiatric Interview (M.I.N.I Plus) and Mini Mental Stage Examination (MMSE) were used. To measure functional severity post-stroke, the Rankin Scale was used. The average age was 60.90 ± 8.93 years for males and 60.44 ± 11.57 years for females. In females, total impulsiveness (p = .013) and lack of planning caused by impulsiveness (p = .028) were significantly higher compared with males, assessed by the BIS11. These data indicate that females in the present sample who suffered a chronic frontal lesion were more impulsive and presented more planning difficulties in situations without demanding cognitive processing. These results that show gender differences should be considered when planning psychotherapy and cognitive rehabilitation for patients who present these characteristics. **Keywords:** frontal stroke, sex, executive function, inhibition, depressive symptoms.

Received 19 January 2011; received in revised form 17 April 2011; accepted 7 May 2011. Available on line 10 October 2011

Introduction

Stroke is characterized by an acute onset of neurological impairment with a minimum duration of 24 h. It affects the central nervous system and causes blood circulatory impairment attributable to a brain artery clot of hemorrhagic or ischemic origin (Cancela, 2008). Various controllable factors can cause a stroke including obesity, hypertension, diabetes mellitus, smoking, high cholesterol, lack of physical activity, and cardiovascular disease (Alves, Wajngarten, & Busato Filho, 2005; Godoy, & Silva, Moura, 2005).

The anatomy and physiology of brain blood flow comprise two main vascular systems: (1) internal carotid, medial cerebral artery (ACM), and anterior cerebral artery and (2) vertebral arteries, basilar artery, and hindbrain arteries (Whisnant et al., 1990). After a 6-month lesion, the stroke is considered chronic (Latimer, Keeling, Lin, Henderson, & Hale, 2010) and includes three types: ischemic (80% of cases), hemorrhagic (15% of cases), and transitory ischemic (5% of cases; Luna-Matos, Mcgrath, & Gaviria, 2007). A study conducted in Brazil found that 86% of patients who suffered an ischemic stroke were over 36 years old (Zétola et al., 2001). This neurological event is responsible for nearly six million deaths per year (World Health Organization [WHO], 2008).

Among the damage caused by a stroke are emotional disorders and executive dysfunction (Zinn, Bosworth, Hoenig, & Swartzwelder, 2007) that correspond to the lesion area. Executive function in the brain includes the processes and functions related to appropriate planning and strategies (Lezak, 2004) and serves to adapt individuals to new situations (van der Linden, Ceschi, Zermatten, Dunker, & Perroud, 2005). It requires flexibility, control, and the regulation of information processing in the brain (Gazzanigra, Ivry, & Mangum, 2002; Was, 2007). The basis for the development and execution of plans and actions is the frontal region, which is responsible for the interpretation of one's surroundings (Dalgalarrondo, 2000). Executive function is able to control the

Morgana Scheffer and Janine Kieling Monteiro, Universidade do Vale do Rio dos Sinos. Rosa Maria Martins de Almeida, Laboratory of Experimental Psychology, Neuroscience and Behavior, Institute of Psychology of Development and Personality, Universidade Federal do Rio Grande do Sul. Correspondence regarding this article should be directed to: Rosa Maria Martins de Almeida, Departamento de Psicologia, Universidade Federal do Rio Grande do Sul, Rua Ramiro Barcelos 2600, Bairanta Cecília, Porto Alegre, Brazil, CEP 90035-003. Phone: +51-3308-5363. E-mail: rosa_almeida@yahoo.com, rosa.almeida@ufrgs.br

execution of different activities or evoke the command of various events. With regard to emotion, emphasis has been increasingly placed on the relationship between depression and frontal lobe dysfunction, which is frequently observed as the most common psychiatric disorder after stroke, with a prevalence of 80% in stroke cases (Capaldi & Wynn, 2010; Hill, West, Hewison, & House, 2009). Epidemiological data show that women present more internalization, such as depression, and are affected twice as much by this disorder in their lifetime compared with men (Angst et al., 2000; Appelros, Stegmayr, & Terént, 2010). This disorder, in most cases, is misdiagnosed or untreated (Poynter et al., 2009). Corroborating these data, we found that women have less control over negative emotions than men (Mak, Hu, Zhang, Xião, & Lee, 2009). According to Ramasubbu (2000), post-stroke depression is directly related to etiology, not including psychosocial factors, and may manifest as affective, cognitive, behavioral, motivational, and physiological symptoms (American Psychiatric Association [DSMIV-TR], 2002).

Men have a higher prevalence of impulsive personality traits, with low self-control or impulsiveness and less willingness to express negative emotions (Strüber, Lück, & Roth, 2008). Among the impulsive behavior traits are lack of planning, responding too quickly, inability to delay gratification, and a deficit in inhibitory control (Kalenscher, Ohmann, & Güntürkün, 2006). This behavior has various potential causes including stimulus limit, low capacity to inhibit responses in a timely manner, and diminished insight related to premature, risky, and unelaborated actions (Correa, Triviño, Pérez-Dueñas, Acosta, & Lupiáñez, 2010).

The frontal brain has been the focus of many studies of the executive processes of inhibition and emotional and social decision-making processes (Bechara, Tranel, & Damasio, 2000; Stuss & Alexander, 2000). Frontal lesions may cause the inappropriate emotional expression of social behavior and damage decision-making ability, especially that which is advantageous (Phan, Wager, Taylor, & Liberzon, 2002). The latter appears to be linked to emotional aspects when the individual experiences everyday situations (Espiridião-Antonio et al., 2008). In a cognitive model, decision-making is defined as a complex activity that includes the choice of more than one option, which demands judgment of the characteristics of the options and evaluation of the consequences that may arise from the choice made (Ballesteros Jiminez & Garcia Rodríguez, 1996; Eysenck & Keane, 1994). Damásio (1996) suggested that the decision includes the knowledge of the situation to be adopted, the different possible actions, and the immediate and long-term consequences of the decision. Sweitzer, Allen, and Kaut (2008) studied 18- to 54-year-old students of both sexes and found support for the association between impulsivity and performance on neuropsychological tests that are sensitive to prefrontal lobe function, with high impulsivity associated with the poorest performance on tasks that assess decision-making.

Corroborating these data, Berlin, Rolls, and Kischka (2004) found greater impulsivity measured by the Barratt Impulsiveness Scale (BIS11) in the motor and lack of planning subdomains in individuals between 30 and 63 years of age who presented chronic frontal and orbital, unilateral and bilateral lesions. This region plays an important role in the control of reward, and a lesion in this area can cause perseverative behavior and is also related to impulsive decision-making (Winstanley, Theobald, Dalley, Cardinal, & Robbins, 2006).

The manifestation of impulsive behavior may be determined by the chronicity of the lesion, and it is often seen in the acute phase of recovery from frontal lesions. Miller (1992) tested individuals 2 and 3 weeks after frontal and temporal lobe surgery. A third of the sample who had frontal lobe surgery showed impulsive behavior. This behavior can be modified over time (Floden, Alexander, Kubu, Katz, & Stuss, 2008), and the cognitive profile may appear differently during the chronic phase of injury (Rousseaux, Godefroy, Cabaret, Benaim, & Pruvo, 1996).

Using impulsivity self-reports in healthy individuals, Sweitzer et al. (2008) demonstrated that this behavior is inversely related to good performance in advantageous decision-making in motivational or emotional situations in which executive function is generally undamaged. When examining the association between impulsivity and problem-solving in a nonclinical sample using the BIS11 and Wisconsin Card Sorting Test (WCST), the same study found no significant association between the study variables. Troubleshooting is the ability to choose and adjust the contingencies while determining the possible consequences, modify the view, and inhibit a previous choice in favor of a new choice (Gil, 2002). Verifying the motor aspects of impulsivity is possible using the perseverative errors in score of the WCST (Bechara, Damasio, & Damasio, 2000) and Iowa Gambling Task (IGT). Verifying the aspects of planning and cognitive impulsivity is also possible (Bechara, Damasio, Damasio, & Anderson, 1994).

Neuroimaging studies revealed the specific regions that are considered the basis for inhibiting responses, including the inferior frontal rotation, medial frontal regions (Aron et al., 2007; Chambers, Garavan, & Bellgrove, 2009; Verbruggen & Logan, 2008) and dorsolateral and ventrolateral regions in both hemispheres (Goghari & MacDonald, 2009). Baudic, Benisty, Dalla Barba, and Traykov (2007) showed that depressed patients had normal performance on a test that assessed inhibitory processes, and the psychomotor aspects were not linked to performance. However, the same study found a negative association between the severity of depression and the time required to complete the tasks. Must et al. (2005) studied individuals diagnosed with major depression using the IGT and WCST and found that performance was impaired in both tests. Porter, Bourke, and Gallagher (2007) presented four important aspects that may affect neuropsychological performance in patients diagnosed with unipolar depression: diminished motivation that involves, among others, cognitive function, catastrophic responses, focused attention, and different interpretations of information.

With regard to performance differences between sexes, healthy adult males performed better on a test of executive function compared with women, but the same result was not found in WCST performance. Women showed a higher degree of depression (Souza, Ignácio Cunha, Oliveira, & Moll, 2001). Additional evidence indicates that women with high depressive symptoms have fewer strategies for coping with emotions compared with men with high depressive symptoms (Thayer, Rossy, Ruiz-Padial, & Johnsen, 2003). This may occur because women, while experiencing negative emotions, exhibit activation of the frontal areas associated with emotion, and men exhibit activation of the frontal regions associated with cognitive processing (Koch et al., 2007).

With regard to performance related to executive function, Bolla, Eldreth, Matochik, and Cadet (2004) showed that men performed better on a decision-making task and engaged a larger area of the orbiofrontal region of the prefrontal cortex. In contrast, a study of brain/skull trauma victims found better performance in women on the WCST in the number of categories completed and perseverative responses (Niemeier, Marwitz, Lesher, Walker, & Bushnik, 2007). Sweitzer et al. (2008) found that women completed more categories compared with men, and impulsivity was significantly associated with this performance. However, few studies have compared performance between the sexes when assessing executive function.

Focal lesions may cause changes in the functional structure of the brain and may have delayed effects on network function, which may be applicable to the recovery and prognosis of stroke (Carter et al., 2010). The concern with producing scientific knowledge using rigorous research methodology has been increasing, and we clearly still lack a full understanding of the nature of mental disorders (White et al., 2008). Beginning with advances in biochemistry, neuropsychology addresses the physical basis of emotions and the functions of cortical and subcortical regions and considers the consequences of prefrontal lesions (Damasio, 1996; Fuster, 1997).

One of the methodologies that guides the process of neuropsychological assessment is a specific method that suggests that, even when the systems work together, each aspect of each cognitive function may be affected by a disease or neurological trauma (Alvoeiro, 2001). The present study compared problem-solving performance, decision-making skills, impulsive behavior, and depressive symptoms in men and women who suffered a frontal lobe stroke. We also sought to correlate cognitive performance, impulsivity, and depressive symptoms in these groups.

Methods

Design

The present study was cross-sectional, quantitative, descriptive, and correlational.

Participants

The sample was non-random, consisting of 19 individuals (10 men and nine women) who were hospitalized in a private hospital in Porto Alegre, Brazil, for stroke with chronic cortical/subcortical ischemia or hemorrhage and frontal lobe injury. Non-ruptured aneurysms were excluded. Because of the low incidence of stroke found in the frontal lobe, cases of stroke not restricted to this brain region were also included. All participants were literate, naturalized Brazilian citizens, and fluent in Portuguese, with a maximum age of 75 years. People older than 75 years were excluded because of the influence of age on executive function performance. All participants were hospitalized from 2007 to early 2010.

The exclusion criteria were the following: neurological problems other than stroke (e.g., hydrocephalus and head injury), dementia (including vascular dementia), other diseases that affect the central nervous system (except risk factors for stroke), changes in thyroid gland function, pregnancy or postpartum, cognitive, motor, visual, or hearing impairment that obstructs the application of the research tools, psychiatric disorders (with the exception of depression), current or past history of chemical dependency, and participation in cognitive rehabilitation programs or psychological treatment after stroke. In addition to the criteria mentioned above, we chose to exclude individuals with abnormal neuroimaging not compatible with normal aging, such as a prominence of cortical sulci.

Four female participants were excluded, two because they had aphasia that precluded them from the application of the research tools, one because of a low score on the Mental State Examination, and one because of mental confusion identified through telephone contact. Of the participants contacted, only one man refused to participate.

Procedure

This study followed the standards established for the conduct of human research by the Federal Council of Psychology (resolution no. 016/2000) and Regional Health Council (1996; resolution no. 196/96). Thus, the project was approved by the Ethics in Research (CEP) of the hospital where the research was conducted. After approval by the CEP (protocol no. 347/10), patients hospitalized because of stroke were selected based on the lesion found on neuroimaging reports and notes contained in the medical records of the hospital.

After telephone contact, the participants were individually assessed in a single encounter that lasted between 90 and 180 min in a quiet and well-lighted location to maintain the minimum possible distractions. Initially, we conducted a first interview to sign the Informed Consent of Free Will form and survey sociodemographic data based on a questionnaire. The questionnaire was first assessed by a pilot study to verify the appropriateness of the questions to the population under study.

The researchers of the present study underwent training for the application of the tools for cognitive evaluation adapted to and validated for the Brazilian population. The same order of instrument application was maintained, alternating between scale/inventory and neuropsychological tests. Participants with no familiarity with computers or a computer mouse underwent brief training before applying the IGT. Data collection was performed between June and October 2010.

Instruments

Mini International Neuropsychiatric Interview (MINI Plus; Sheehan et al., 1998)

This is a brief diagnostic interview based on the DSM-IV and ICD-10 that includes the main Axis I disorders. This instrument, which was translated and adapted by Amorin (2000), assesses mental disorders throughout an individual's life. The reliability of the diagnostic categories was 0.86 to 1. The average psychotic symptoms was 0.62 to 0.95. The application time was 15-30 min.

Mini Mental State Examination (MMSE; Kochhann, Varela, de Macedo Lisboa, & Chaves, 2010)

The version of Bertolucci, Brucki, Campacci, and Julian (1994) was used. The instrument consisted of questions grouped into seven specific categories organized to assess cognitive functions including temporal orientation, spatial orientation, registration of three words, attention and calculation, recall of three words, language ability, and visuo-constructive ability. The instrument is considered to have excellent sensitivity and specificity. The application time was 5-10 min.

Barratt Impulsiveness Scale (BIS11; Barratt, 1959; von Diemen, Szobot, Kessler, & Pechansky, 2007)

This instrument is a self-administered scale that consists of 30 items with Likert-type responses ranging from rarely/never to always/almost always, and provides a total score of impulsivity and three subscores including attention, lack of planning, and motor impulsivity. The scores range from 30 to 120. It has an internal consistency of .62 for the 30 items of the scale. The intraclass correlation coefficient was .90 for total score, .93 for lack of planning, .88 for attention, and .90 for motor impulsivity.

Beck Depression Inventory (BDI; Beck & Steer, 1993; Cunha, 2001)

This instrument consists of a self-reported scale composed of 21 items, each containing four alternatives with increasing levels of depression severity (minimal, moderate, and severe). The inventory showed satisfactory internal consistency, discriminant validity, criterion validity, concurrent validity, and test-retest reliability, with a cutoff of 20 (moderate depression). The instrument has sensitivity and specificity of .77 and .95, respectively. The average time for administration of the instrument was 10 min.

Wisconsin Card Sorting Test (WCST; short form; Nelson, 1976; Fonseca et al., in press)

This instrument consists of four stimulus cards and 48 answer cards that show figures of different shapes (e.g., circles, stars, crosses, and triangles), colors (e.g., red, green, yellow, and blue), and numbers (e.g., one, two, three, and four). The subject must associate the consecutive cards in the pack to the stimulus card that the subject thinks it fits. This test evaluates executive function and requires the ability to develop and maintain appropriate strategies to solve problems by changing the stimulus and seeking a future goal (Luria, 1973; Shallice, 1982). Because of its sensitivity to the effects of frontal lobe lesions, the WCST is considered a measure of operational frontal, prefrontal, and dorsolateral regions. The average application time was 15 min.

Iowa Gambling Task-Br (IGT; computerized version; Bechara et al., 1994; Schneider & Parente, 2006)

This instrument contemplates a situation of decision-making under uncertainty and includes monetary choices. It assesses aversion or the search for risky behavior. The test provides a total net score determined by subtracting the total number of cards drawn from the disadvantageous packs (A + B) from the cards drawn from the advantageous packs (C + D). The score is based on mental calculation (aversion risk). Each pack is pre-programmed with rewards and punishments. The most frequent but lowest value punishment occurs in packs A and C, and the less frequent but greatest value occurs in packs B and D. In total, there are 100 moves that can be divided into five blocks of 20 each, which provides five scores that separately show whether learning occurred during the test. The classification is the following: > +18 (unimpaired), -18 to +18 (borderline), < -18 (impaired; Schneider-Bakos, 2008). A study of standardization of the instrument was performed by Cardoso, Zimmerman, and Carvalho (2010). The average time for application of this task was 20 min.

Rankin Scale (Caneda, Fernandes, Almeida, & Mugnol, 2006; Rankin, 1957)

This instrument is used to measure post-stroke functional severity. The score ranges from 0 to 5. The higher the value, the greater the level of dysfunction. The scale provides an alpha coefficient that indicates moderate agreement between examiners, a cautious kappa coefficient, and an excellent intraclass correlation coefficient.

Data analysis

The scores from the instruments were obtained using published manuals or articles of validation and adaptation. After compilation, the data were tabulated and analyzed by SPSS (Statistical Package for the Social Sciences, version 17.0). The data were first subjected to descriptive statistical procedures to evaluate the variables in terms of frequency distribution, scores, averages, and standard deviation. To compare the averages between the groups, we used the nonparametric Mann-Whitney test. Spearman's correlation test was used to correlate the variables in the study. The accepted level of significance was $p < .05$.

Results

The sociodemographic data are shown in Table 1. The health aspects are shown in Table 2. No significant differences were found in age, education, and time of injury between men and women. Most participants from both groups were married (80% of the men and 67% of the women).

Table 1. Sample characteristics of both groups

Variable	Men		Women		*U*	*p*
	Mean	SD	Mean	SD		
Age	60.90	8.93	60.44	11.57	43.50	.905
Years of education	9.85	4.46	11.27	5.86	41.50	.780
Time since injury (months)	20.20	6.64	18.44	9.81	34.00	.400

Table 2. Frequency and percentage of stroke characteristics, medical comorbidity, and use of psychopharmacological drugs in both groups

Variable	Men		Women	
	n	%	n	%
Lesioned hemisphere				
Right	3	30.0	5	55.5
Left	3	30.0	3	33.3
Bilateral	4	40.0	1	11.1
Single lesion	6	60.0	6	66.6
Types of Stroke				
Ischemic	8	80.0	8	88.8
Hemorrhagic	1	10.0	-	-
Hemorrhagic transformation	1	10.0	1	1.1
Clinical comorbidity				
Depression	-	-	3	3.3
Hypertension	7	70.0	4	44.4
Cholesterol	3	30.0	5	55.5
Diabetes mellitus	1	10.0	1	11.1
Heart disease	5	50.0	4	44.4
Psychotropic drugs in use				
Antidepressants	3	30.0	3	33.3
Benzodiazepines	1	10.0	4	44.4
Neuroleptics	2	20.0	1	11.1

The participants from both groups showed a single frontal stroke injury of the ischemic type distributed among unilateral and bilateral lesions in the male group and female group. The lesions were most prevalent in the right frontal hemisphere. Participants of both groups presented as a medical co-morbidity only diseases considered as risk factors for stroke, the exception being depression, which was present only in women. Importantly, although some participants were diagnosed with depression prior to stroke, they were in remission at the time of onset of the neurological event. Less than half of the sample in both groups were using psychopharmacological drugs at the time of evaluation. None of the participants reported familiarity with the tests that involved monetary values.

The performance comparisons between groups are shown in Table 3. The mean score on the MMSE was found to be above the minimum cutoff (minimum score of 23) with regard to education and signs of dementia. On the scale of functionality after the stroke, no statistically significant difference was noted in the comparison between men and women, and both groups were capable of performing daily activities.

We found a statistically significant difference in the total score on the impulsivity scale (U = 15.5, z = -2.417; p = .013) and lack of planning subscale of impulsivity (U = 18.0, z = -2.223; p = .028), indicating that impulsivity and lack of planning were higher in women. The average depressive symptoms was not significantly different between men and women, with only minimal presentation in both groups. No significant differences in problem-solving, decision-making, and learning were found during the task. Although no significant difference in IGT performance (risk aversion) was found between groups, both men and women had negative performance that was considered borderline. Both groups preferred the B deck of cards, with no significant difference between groups, indicating that both men and women opt for risky choices.

Table 3. Average and standard deviations of MMSE, Rankin Scale, impulsivity scale (BIS11), Beck Depression Inventory (BDI), and neuropsychological tests that measure problem-solving (WCST) and decision-making (IGT)

Instruments	Men		Women		*U*	*P*
	Mean	SD	Mean	SD		
MMSE	26.40	2.06	27.33	2.34	29.00	.211
Rankin Scale	1.30	1.25	0.55	0.72	30.00	.243
BIS11						
Total score	56.20	6.66	63.88	7.81	15.5	.013*
Lack of planning	20.00	2.90	24.11	3.65	18.0	.028*
Attention	17.70	2.66	19.44	3.12	28.5	.182
Motor	18.50	3.97	20.33	4.94	33.5	.356
BDI	12.20	7.11	13.55	8.58	41.0	.780
WCST						
Tests administered	47.00	3.16	45.77	4.43	39.5	.661
Total hits	20.40	8.85	19.66	12.39	45.0	1.000
Errors total	26.60	11.09	26.11	15.97	41.5	1.000
Perseverative errors	24.20	10.95	24.33	16.65	41.5	.780
Non-perseverative errors	2.40	1.77	1.77	1.92	35.5	.447
Categories completed	2.70	1.41	3.00	2.00	43.5	.905
IGT						
Risk aversion	-15.00	19.39	-14.00	26.40	41.0	.780
Deck A	20.60	4.11	17.88	6.93	32.5	.315
Deck B	36.90	9.12	39.11	14.04	38.0	.604
Deck C	21;20	5.97	17.11	7.38	28.5	.182
Deck D	21.30	8.24	12.44	25.88	38.0	.604
Block 1	-1.60	3.50	-.066	7.54	39.0	.661
Block 2	-3.40	8.05	-4.66	6.70	44.0	.968
Block 3	-5.00	4.34	-3.55	8.53	43.5	.905
Block 4	-1.40	4.71	10.49	-1.11	43.0	.905
Block 5	-3.60	8.83	10.19	-4.00	44.5	.968

*Significant difference, $p < .05$.

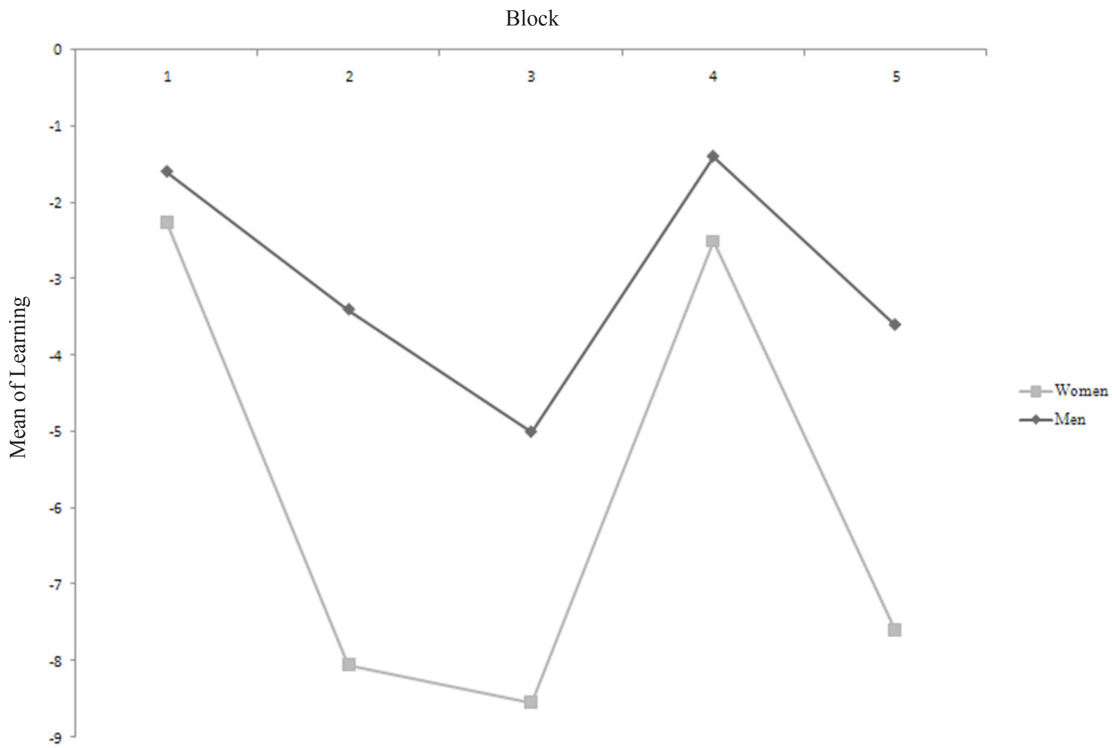

Figure 1. Learning curve obtained in the five blocks of 20 moves for both groups.

Figure 1 shows the learning curve of both groups in the five blocks of the task. No significant differences were found between groups on this variable. Both groups had negative performance, not changing their risk-seeking behavior during the task (i.e., no learning occurred). Between blocks three and four in both groups, improvements in performance occurred; however, performance continued to be risky in regard to decision-making.

In men, a significant negative correlation was found between perseverative errors on the WCST and risk aversion on the IGT (r = -.888; p = .001). These data indicate that the higher the perseverative errors in solving problems, the less risk aversion in decision-making and vice versa. A significant positive correlation was found between perseverative errors on the WCST and preference for the B deck of cards on the IGT (r = .685; p = .029) category completed in the WCST and risk aversion in the IGT (r = .849; p = .002). A significant positive correlation was also found between depressive symptom scores on the BDI and lack of planning subscale of the impulsivity domain (r = .681; p = .030). Finally, a significant positive correlation was found between depressive symptom scores on the BDI and total scores on the impulsiveness scale (BIS11; r = .801, p = .005). Thus, the higher the perseverative errors on the WCST, the greater the choice for the B deck of cards, which is a disadvantageous choice. Positive correlations were found between the categories successfully completed on the WCST and good performance on the IGT. The higher the scores on the BDI, the higher scores on the lack of planning subscale and total score of impulsivity. No significant correlation was found between the variables in women.

Discussion

The results of the present study showed significant differences when comparing the groups on the total impulsiveness scale and lack of planning subscale for impulsivity. No significant differences were found between groups in depressive symptoms or in performance in decision-making and problem-solving.

The lack of difference in the level of depressive symptoms between men and women contrasts with the results in the literature, which show considerable differences between sexes (i.e., higher prevalence in women; Angst et al., 2000; Diflorio & Jones, 2010; Keers & Aitchison, 2010). The level of symptoms considered not clinically significant in both groups may have contributed to the lack of observed difference.

Impairments in decision-making, planning, and personality changes associated with frontal lobe damage have been revealed by neuropsychological tests in patients after surgery for a ruptured aneurysm of the anterior communicating cerebral artery (Beck & Steer, 1987; Laiacona et al., 1989) evaluated during the chronic period after the event (Tidswell, Days, Sagar, Mayes, & Battersby, 1995). In the present study, decision-making performance was similar in men and women. A higher preference for the deck of risky choices with less frequent punishment (i.e., B deck) in the IGT was evident in both groups. This finding suggests that men and women use similar strategies and are similarly affected by automatic processes of identifying frequency information (Schneider & Parente, 2006).

The "Somatic Marker" proposal of Damásio (1996) refers to the validity established by positive and negative past experiences, which in turn earns internal representation and thus stabilizes emotional and social behavior. Both sexes appear to have difficulty using these resources so that they derive benefits from the current choice. Lawrence, Jollant, O'Daly, Zelaya, & Phillips (2009) demonstrated that the higher the probability of the risk involved, the higher the level of evaluation needed, requiring greater activation of the circuit associated with the hypothesis of a "Somatic Marker." The same was found in a study of adult chronic prefrontal injury, with at least eight years of formal education, that showed insensitivity to future damage (Bechara, Tranel, Damasio, & Damasio, 1996). Thus, performance between blocks in the IGT remained unstable and was affected by disadvantageous choices, suggesting an inability to devise efficient decision strategies. However, Reavis and Overman (2001) found significant differences between the sexes in performance between blocks on the IGT in healthy individuals. Men showed better performance in blocks two and three, indicating that they had greater learning compared with women.

One study suggested that performance in the first block occurs through ambiguous choices because at that time the individual is experiencing the advantageous and disadvantageous cards, and performance tends to improve with an increase in the quantity of moves (Brand, Recknor, Grabenhorst, & Bechara, 2007). Men and women tend to have conflicting results on assessments of executive function, but these results are still controversial (Fry, Greenop, Turnbull, & Bowman, 2009; Reavis & Oveman, 2001).

The results showed no significant differences in performance between the sexes in tasks that involved executive function, suggesting that vascular injury and its specific location in the frontal lobe may have minimized the discrepancy in performance between men and women. Therefore, the groups had similar results on the neuropsychological tests, and lesions in specific regions are most often cited with regard to the difficulties presented in problem-solving and decision-making (Cardoso et al., 2010). Lawrence et al. (2009) observed that the frontal medial and lateral frontal cortices are involved in choosing a deck that is considered risky. Stuss and Levine (2002) showed that the dorsolateral frontal region is involved in tasks related to problem-solving. Regarding hemispheric laterality, individuals with bilateral frontal damage showed impaired performance in a problem-solving task compared with individuals with a unilateral lesion, indicating greater difficulty in devising a continuous solution strategy (Gouveia, Bricki, Malheiros, & Bueno, 2007).

As previously mentioned, Souza et al. (2001) observed no difference in performance in the categories completed and perseverative errors on the WCST between healthy men and women, but differences were found in the other measures of executive function, showing a better outcome in men. However, had significantly higher educational levels than women in the study and this variable may have influenced these results. This finding reinforces the results of the present study, in which men and women in the sample, without a significant difference in educational level, showed no differences in strategic planning, cognitive flexibility, and abstract reasoning. Perseverative errors made in the WCST were clearly higher compared with non-perseverative errors in both men and women. Bechara et al. (2000) suggested that perseverative errors on the WCST may suggest motor impulsivity and difficulty in the IGT, suggesting a lack of planning caused by impulsivity (Bechara et al., 1994).

However, the results from the impulsiveness scale revealed differences between groups with regard to general impulsivity and the lack of planning subscale. This subscale reflects more concern about the present than the future (Patton, Stanford, & Barratt, 1995), which is higher in women. Corroborating these findings, Marazziti et al. (2010) found higher impulsivity in women compared with men in a sample of healthy individuals, although some studies have reported greater impulsivity in males (D'Zurilla, Mayde-Olivares, & Kant, 1998; Stoltenberg, Batien, & Birgenheir, 2008).

The difference in the lack of planning subscale for impulsivity in the present study may reflect the domains of internal behavior considered by Bechara, such as the cognitive aspect of impulsivity, and women appear to have greater difficulty controlling negative internal aspects (Robichaud, Dugas, & Conway, 2003). This may explain the greater impulsivity in women. Regarding neurotransmitters, although Burke et al. (2011) suggested that impulsivity in healthy men and women is not associated with the subcortical availability of serotonin, frontal injury in women in the present study may have induced alterations in the serotonergic system that were significantly different from men, thus impacting impulsivity. Performance on the IGT may become more difficult because of the lack of planning characteristics of impulsivity. This variable was significantly greater in women only in the BIS11, which may be attributable to the fact the IGT evaluates a multidimensional and complex construct, and learning processes and the somatic marker hypothesis (Cardoso et al., 2010) may be essential for performance on the IGT.

The correlations between the studied variables were not significant in the women in the present study. Despite the higher impulsivity found in this group, this did not significantly influence decision-making and problem-solving. Significant correlations were found only in males (i.e., significant negative correlation between perseverative errors on the WCST and risk aversion on the IGT). These data suggest that perseverative errors in problem-solving are associated with poorer performance in making decisions in men, thus affecting the adjustment to external contingencies. This relationship can be strengthened by the significant positive correlation found between WCST perseverative errors and preference for the B deck of cards and between the categories successfully completed on the WCST and risk aversion on the IGT. Thus, the lack of cognitive flexibility and planning can jeopardize beneficial choices on the IGT, causing the individual to make risky choices without strategic planning. Importantly, perseverative errors are suggestive of frontal dysfunction (Parkin, 1997) and might significantly reduce performance. These results suggest that, in women, performance in problem-solving and decision-making appears to be independent of one another with regard to frontal areas such as dorsolateral, orbitofrontal, and ventromedial cortices (Mendonça, 2009).

Significant positive correlations were also found in men between depressive symptoms and the lack of planning subscale of impulsivity and between depressive symptoms and impulsivity in general. These data suggest that depressive symptoms do not necessarily impair inhibition, but rather make the process more difficult. De Rose and Fioravanti (2010) showed that impulsivity is an underlying personality characteristic in the presence of depressive symptoms. The lack of planning associated with impulsivity is characterized by a lack of organization in the future, with a focus more on the present. Depression may contribute to a pessimistic vision of the future and a lack of investment, in addition to changes in motivation (APA, 2002). To corroborate these findings, Moeller, Barratt, Dougherty, Schmitz, and Swann (2001) found a relationship between impulsivity and depression variables, providing further evidence that men are sufficiently impulsive to compromise devising the right strategies to regulate emotion in the face of negative events, thus making them more prone to depression (D'Acremont & van der Linden, 2007). Impulsive men also appear to be more vulnerable to the consequences of depressive symptoms and may exacerbate the lack of planning, motor impulsivity, and inattention. However, these aspects do not appear to significantly affect choices, gain, loss, momentary punishment, and choices to solve problems.

Conclusions

The present study showed that women had significantly higher impulsivity and presented a lack of planning associated with impulsivity compared with men during the chronic post-stroke period. These differences may be attributable to the characteristics of this impulsivity subscale, requiring the control of internal aspects that may have been a direct result of the injury. Men showed a link between decision-making and problem-solving and between depressive symptoms and impulsivity. Both groups showed greater preference for disadvantageous and risky choices, showing an inability to make decisions and committing more perseverative errors, indicating difficulty in cognitive flexibility. These results suggest that men and women do not cognitively differ after frontal vascular injury with regard to performance in decision-making and problem-solving.

Because of the small sample size, the present results may not be generalizeable. The use of psychopharmacological drugs, which was high in this study sample, can also be identified as a limiting factor of the study. However, considering that the present sample was comprised of a clinical population that did not allow the exclusion of certain conditions and characteristics, the present study may provide relevant data to draw a profile of this population. Finally, the present study did not seek to differentiate between ischemic and hemorrhagic lesions or determine hemispheric specificities, focusing instead on changes caused by vascular lesions of the frontal lobe. The study participants were not necessarily restricted to frontal lobe lesions; therefore, the results may have suffered from the influence of other brain regions, such as the role of the amygdala, in decisions that involve emotional aspects. However, homogeneity was found in the frontal lobe, and the other regions may negligibly affect the variables studied.

Many studies have compared men and women with healthy populations, but few studies have compared the differences between men and women in neurological populations with respect to their cognitive, emotional, and impulsive characteristics. Thus, further studies are needed to determine standard characteristics that may exist and develop cognitive and emotional rehabilitation programs that consider the neurological, behavioral, and emotional profiles of men and women who suffer from neurological injury.

Acknowledgements

This work was supported by the National Council of Scientific and Technological Development (CNPq) in the form of a scholarship AP granted to Morgana Scheffer. The authors thank Rochelle Paz Fonseca for distributing versions of the neuropsychological tests and assistance with individual analyses, Daniela Schneider Bakos and Christian Haag Kristensen for the adapted version of the Iowa Gambling Task, and Karla Rovatti for the permission to carry out the the neuropsychological assessments at the Hospital.

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