Cognitive Screening in HTLV-1 Infected People Using a Self-Perceived Memory Score and Auditory P300

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Research

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Abstract

Background: The HTLV-1-associated myelopathy/tropical spastic paraparesis (HAM/TSP) is the most common neurological manifestation associated with Human T-cell Lymphotropic Virus type-1 (HTLV-1) infection. Although cognitive impairment has been highlighted in the spectrum of HTLV-1 neurological manifestations, it may go unnoticed in those who do not spontaneously report it. We aimed at evaluating the applicability of a self-perceived memory score (SMS) and the cognitive event-related potential (P300) for the early detection of cognitive impairment in HTLV-1-infected people.

Methods: The SMS was measured by a 0-10 visual analog scale combined with a sad-happy faces rating scale. The higher the number, the better was the SMS. The P300 was obtained through an oddball paradigm with a mental counting task. The participants were 15(21,4%) individuals with HAM/TSP, 20(28,6%) HTLV-1-asymptomatic carriers, and 35(50%) seronegative controls.

Results: SMS ($p<0.001$) and P300 latency ($p<0.001$) got progressively worse from asymptomatic to HAM/TSP. A SMS <7.2 points and a P300 latency >369.0 milliseconds were considered as altered result and indicated cognitive impairment. The HAM/TSP group showed the highest prevalence of altered P300 (80%) and SMS (87%). Interestingly, the asymptomatic group also presented significant higher prevalence of altered SMS (60%) and P300 (35%) when compared to controls ($<10\%$). The frequency of cognitive impairment was 16 times higher in the asymptomatic group and 69 times higher in the HAM/TSP group when compared to controls.

Conclusion: The use of SMS in the medical consultation was a useful and easy-to-apply method to screen HTLV-1 infected subjects for everyday memory complaints.

Background

The first descriptions of the neurological disease associated with HTLV-1 infections were based on the motor function assessed by mobility and strength disability [1, 2]. The HTLV-1 associated myelopathy / tropical spastic paraparesis (HAM/TSP) is a chronic, slow-progressing neurological inflammatory disease that affects approximately 4% of the infected individuals [3, 4]. However, the prevalence of neurological disorders that do not meet the criteria for definite HAM/TSP, such as urinary disorders, sexual dysfunction and skin lesions, can occur in around 30% of those individuals classified as HTLV-1-asymptomatic carriers [4–6]. In fact, non-medullary symptoms have been neglected in the HTLV-1 infection [7].

Recent evidences have showed that HTLV-1 is related to a complex of neurological manifestations that are not limited to the clinical spectrum of HAM/TSP, affecting all the segments of the central nervous system to a greater or lesser extent [3, 8–18]. In this context, cognitive impairment has been reported as one of the manifestations of the HTLV-1 infection [11, 13, 19–24]. On the other hand, HAM/TSP remains as the most important neurological disease associated with HTLV-1 [25, 26]. Therefore, cognitive impairment can be underdiagnosed and may go unnoticed in those individuals who do not spontaneously report the decline in cognitive functions [27].

Memory difficulties are present in HTLV-1 infection at different stages of the neurological disease and the worsening in the performance of daily tasks, together with electrophysiological changes, can be an early sign of cognitive impairment when the individual is in the stage of asymptomatic infection [11, 12, 20, 21, 28, 29].

The working memory reflects the capacity of retaining crucial information for immediate processing and use. It is important for everyday tasks, for everyday reasoning and decision-making processes [30]. The working memory difficulties have been reported as a sign of cognitive impairment associated to HTLV-1 infection at different stages of this neurological disease [12, 20, 21, 28, 29]. Recently, it has been suggested, based on a complete neuropsychological exam battery, that memory dysfunction in the HTLV-1-neurological spectrum may occur between the asymptomatic and the HAM/TSP stages [21] and it could be related to a neurological impairment caused by subcortical and cortical white matter lesions [28, 31]. The worsening in memory functioning, along with electrophysiological alterations, may be an early sign of cognitive impairment in HTLV-1 asymptomatic infection [11]. Therefore, a challenge in the diagnosis and clinical management of this population is to differentiate the true asymptomatic infection from the “non-HAM/TSP” neurological signs since the clinical phenotype of HTLV-1 neurological manifestations appears to be wide and underdiagnosed.

Event-related potentials (ERPs) are the brain’s response to specific sensory or cognitive events. The auditory P300 ERP is commonly elicited through an oddball task and consists of neural activity originating from presumably the prefrontal cortex, the temporoparietal junction, the primary auditory cortex and possibly more sources [32]. The P300 ERP has been associated with the stimulus driven frontal attention mechanisms during task processing and working memory [33, 34]. P300 has a relatively large size wave in comparison to the other components of the ERPs, which makes it easier to detect, so that it has been used to test early cognitive impairment in the clinical practice [35–38].

One study evaluated patients with HAM/TSP and controls using different evoked potentials, including P300, and found that P300 latency was significantly increased in the HAM/TSP group when compared to the health controls. Delayed P300 response in the HAM/TSP group was associated with higher prevalence of cognitive impairment that was detected by cognitive screening and image exams [19].

Another electrophysiological test that has been used to improve the diagnostic accuracy in HTLV-1 neurological manifestation is the vestibular evoked myogenic potential (VEMP) [10, 15–17, 39]. VEMP was able to assess the extent of neurological impairment in HTLV-1 infection and to detect mesencephalic alteration in 70.1% of the HAM/TSP patients and in 11.5% of the asymptomatic carriers [10]. In fact, recent publications have called attention to global cognitive impairment and the executive dysfunction as long-term clinical manifestations linked to a persistent inflammatory activity in the central nervous system that usually occurs in this disease [13].

The memory complaint, especially for everyday tasks and situations, is frequent in individuals with some degree of cognitive impairment. Although some studies have refuted the association between self-reported measures and the diagnosis of cognitive impairment [40, 41], the presence of subjective memory

complaints has been systematically used as a starting point for a more detailed investigation of possible cognitive changes [42–45]. The self-report of a subjective cognitive decline has been accepted to have a predictive value for mild cognitive impairment and it has been seen in the earliest stages of Alzheimer's disease [43–46]. The visual scales, either presenting numbers, figures, or both, have been used to test the self-perception of cognitive impairment [46, 47]. These scales are easy to apply during a medical consultation and could be included in the HTLV-1 neurological exam battery.

The objective of the present study was to evaluate the applicability of a self-perceived memory score and P300 for the early detection of cognitive impairment in HTLV-1-infected people going from the stage of asymptomatic carrier to the definite HAM/TSP.

Methods

This cross-sectional comparative study was conducted with HTLV-1-infected people (asymptomatic carrier and HAM/TSP) and seronegative controls. The participants were asked about their self-perceived memory score (SMS) and then, were tested for the P300 ERP.

Participants

The included participants were recruited from an open cohort of HTLV-1-infected ex-blood donors and health blood donors (controls) that have been followed by the Brazilian HTLV Interdisciplinary Research Group (GIPH) since 1997 [48]. The seropositivity for HTLV-1 was tested by ELISA screening and confirmed by Western blot analysis (WB HTLV 2.4, Genelabs Diagnostics, Singapore) and by qualitative PCR of DNA extracted from blood cells [49].

From a cohort database of approximately 600 HTLV-1 infected individuals and 200 seronegative controls, 133 individuals were included. One of them was not contacted due to address and phone number change, and seven refused to participate due to logistic reasons. From the 125 contacted individuals, 55 were excluded because of the following reasons: 36 HTLV-1-infected persons presented some neurological symptom, but they did not meet the criteria for definite HAM/TSP; 2 had HIV co-infection; 2 had syphilis co-infection; 8 presented hearing loss at the basic audiological evaluation [50]; 4 had uncontrolled diabetes mellitus, and 3 had depression complaints and scores above five at the 15-item Geriatric Depression Scale [51, 52].

The final selected participants consisted of 15 (21.4%) with definite HAM/TSP, 20 (28,6%) HTLV-1-asymptomatic carriers (AC), and 35 (50%) HTLV-1-seronegative controls. The classification of neurological status was previously defined by physical and neurological exam [25]. These 70 participants have signed an informed consent form. The study was approved by the Ethics Committee from the academic institution, number CAAE: 92928518.3.0000.5149, and was conducted according to the World Medical Association Code of Ethics (Declaration of Helsinki).

Self-perceived memory score – SMS

We adapted the use of a visual pain scales to measure the self-perception of memory loss, resulting in the self-perception memory score – SMS. The participants were instructed to score their memory for everyday tasks and situations with a grade from zero to 10, with zero being the worst grade and 10 being the best grade. This numerical scale was combined with a sad–happy faces rating scale to facilitate the self-perception assessment. During the medical consultation, the examiner asked the following question: "From zero to ten, which grade do you give to your memory in everyday tasks and situations?" and then it was presented the analog scale together with the sad-happy faces scales on a sheet of paper to make the options clearer (Fig. 1).

Electrophysiological assessment of cognitive function – P300

The objective assessment of the cognitive function was performed through the P300 ERP using the single-channel MASBE / ActPlus system (Contronic Ltda., Pelotas, Brazil) to generate the auditory stimulus and capture the electrophysiological response. The participant was accommodated in a reclining chair and the skin was cleaned with abrasive paste before positioning the electrodes. An electrolytic paste was used for a better conductivity of the electric current. The positioning of the electrodes followed the pattern of the international electrode 10–20 system with the active electrode being fixed in the midline frontal (Fz); the negative electrodes was fixed in the lobes of the right (A1) and left (A2) ears; the earth electrode was fixed on the forehead (Fp1) [53]. Commonly, the active electrode is fixed in the mid-parietal line (Pz) which is better for detecting the P300 electrophysiological wave, however, in case of HTLV-1 cognitive assessment, previous studies considered the placement of the electrode in Fz position, which is more specific to detect HTLV-1 cognitive changes [9, 19]. The electrodes were connected to the preamplifier and the impedance was checked, with the maximum accepted impedance being 3k Ω and the difference between electrodes should not exceed 1k Ω . Silver electrodes were used in all the sites.

Auditory stimuli were presented using TDH-39 headphones. A tone burst with the binaural presentation was used, with the frequencies of 1,000 Hz as the frequent stimulus and 2,000 Hz as the rare stimulus. The intensity presented was 90 dBHL. For each exam, 300 stimuli were presented, 80% frequent and 20% rare. The presentation rate was 0.8 stimuli per second and the individuals were instructed to identify and count the rare stimuli in silence. Before starting the exam, the stimuli were presented so that the participants were become used to the test. The initial tracing amplitude was 5 μ V, the 1 Hz high-pass filter, 20 Hz low-pass filter and 60 Hz filter were used. The temporal window was 750 milliseconds, and the electroencephalogram was enlarged 50,000 times. The procedure was repeated once time to guarantee the replication of the electrophysiological wave. Participants were instructed to react to the rare (infrequent) stimuli by mental counting.

The first positive peak after 250 milliseconds was considered as the P300 response. P300 latency values (milliseconds) and amplitudes (microvolts) were measured at this peak [38]. The acquisition of the P300 was performed by an expert in electrophysiological evaluation and the waves were analyzed by two

different specialists in a blind analysis process to control inter-observer agreement. Figure 2 shows a sample of P300 waveforms for each group.

Statistics

Electrophysiological and self-perception responses were transformed into descriptive frequencies. They were compared and analyzed using the SPSS statistical package version 23.0 (SPSS Inc, Chicago, IL). The continuous variables that presented non-normal distribution (Kolmogorov-Smirnov; $p < 0.200$) were analyzed using the non-parametric Kruskal-Wallis and Mann-Whitney tests. Those with normal distribution (Kolmogorov-Smirnov; $p \geq 0.200$) were compared by One-way ANOVA and Student-T tests. Categorical variables were analyzed using the Chi-square and Fisher's exact tests. The results were presented using frequencies (percentages), means $\pm$ standard deviation, and medians [interquartile]. The inter-rater agreement of the P300 latency value was assessed by an intra-class correlation (ICC) analysis that was considered acceptable if greater than 0.75 [54]. The variables SMS and P300 latency were categorized aiming at their use in clinical practice. The statistical significance adopted was 5% ($p < 0.05$).

Results

General characteristics

The characteristics of each group regarding age, sex, years of education, SMS, P300 latency and P300 amplitude are shown in Table 1. The groups were comparable in sex (Fisher's exact test, $p = 0.139$), age (One-Way ANOVA, $p = 0.487$) and years of education (Kruskal-Wallis, $p = 0.274$). The female sex predominated among the HTLV-1-infected participants ($n = 40$; 66.7%), representing the GIPH demographic characteristic which is in accordance with the worldwide higher prevalence of HAM/TSP in women [3].

Inter-rater agreement of the P300 analysis - Intraclass correlation coefficient (ICC)

Concerning the P300 measurement errors and variability, the inter-rater agreement analysis showed an intraclass correlation coefficient $ICC = 0.878$ (95% confidence interval = 0.758–0.941), indicating a “good” to “excellent” reliability of the P300 response measurement [54].

Between groups comparisons

The comparison of means among HAM/TSP, asymptomatic, and control groups have shown an association between the worsening in the neurological status and a lower SMS grade (One-Way ANOVA, $p < 0.001$) together with shorter P300 amplitude (One-Way ANOVA; $p = 0.001$) and prolongation in P300 latency (One-Way ANOVA; $p < 0.001$) (Table 1).

Table 1

Descriptive and comparative analysis of age, sex, years of education, self-perceived memory score (SMS), P300 latency, and P300 amplitude results among HAM/TSP, asymptomatic, and control groups.

Variables		HAM/TSP (N = 15)	Asymptomatic (N = 20)	Control (N = 35)	p- Value	Comparison groups	p- Value
Age (years)		57.9 ± 4.7	54.7 ± 7.6	52.8 ± 8.6	0.108 ¹	Controle x AC	0.421 ⁴
						Controle x HAM	0.059 ⁴
						AC x HAM	0.163 ⁴
Sex	Female	11 (73)	11 (55)	20 (57)	0.487 ²	Controle x AC	0.593 ²
						Controle x HAM	0.351 ²
	Male	4 (27)	9 (45)	15 (43)		AC x HAM	0.312 ²
Years of education		7 [5/7]	8 [8/11]	9 [6/9]	0.274 ³	Controle x AC	0.608 ⁵
						Controle x HAM	0.218 ⁵
						AC x HAM	0.122 ⁵
SMS (number from 0 to 10)		5.9 ± 1.3	7.0 ± 1.3	8.43 ± 0.6	< 0.001 ¹	Controle x AC	< 0.001 ⁴
						Controle x HAM	< 0.001 ⁴
						AC x HAM	0.019 ⁴
P300 Latency (milliseconds)		394.5 ± 45.1	357.3 ± 47.0	327.4 ± 20.8	< 0.001 ¹	Controle x AC	0.002 ⁴
						Controle x HAM	< 0.001 ⁴
						AC x HAM	0.024 ⁴

Legend: N = number of participants; HAM/TSP = HTLV-1 associated myelopathy/tropical spastic paraparesis; SMS = self-perceived memory score; mean ± standard deviation for continuous variables with normal distribution; median [1st quartile-3rd quartile] for continuous variables with asymmetric distribution; absolute number (percentage) for categorical variables. ¹One-way ANOVA test; ²Fisher's exact test; ³Kruskal-Wallis test; ⁴Student-T test; ⁵Mann-Whitney test; bold mark = statistically significant result (p < 0.05)

P300 Amplitude (microvolts)	5.1 ± 2.77	4.1 ± 1.8	7.1 ± 3.5	0.001¹	Controle x AC	0.001⁴
					Controle x HAM	0.054 ⁴
					AC x HAM	0.185 ⁴
Legend: N = number of participants; HAM/TSP = HTLV-1 associated myelopathy/tropical spastic paraparesis; SMS = self-perceived memory score; mean ± standard deviation for continuous variables with normal distribution; median [1st quartile-3rd quartile] for continuous variables with asymmetric distribution; absolute number (percentage) for categorical variables. ¹ One-way ANOVA test; ² Fisher's exact test; ³ Kruskal-Wallis test; ⁴ Student-T test; ⁵ Mann-Whitney test; bold mark = statistically significant result (p < 0.05)						

The age (p = 0.477), sex (p = 0.974) and years of education (p = 0.581) showed no significant correlation to the variation in the SMS results p = 0.223; R = 0.216). The lack of significant correlation was also found for the influence of age (p = 0.140), sex (p = 0.503) and years of education (p = 0.311) on the P300 latency variation between groups (p = 0.245; R = 0.211) (Table 1). These findings indicate that the neurological status, and not the general characteristics of each participant, could explain the progressively worse in SMS and P300 latency when comparing the control, the asymptomatic and the HAM/TSP groups.

Progressively worse results

The comparison of means showed that SMS and P300 latency were progressively worse from the asymptomatic to the HAM/TSP groups. The P300 mean latency in the asymptomatic group was between the values found in the HAM/TSP group and the controls, suggesting a progressive P300 latency prolongation that begun in the clinical asymptomatic phase of the HTLV-1 infection. The P300 amplitude was not significantly different between the control and the HAM/TSP groups, and between the asymptomatic and the HAM/TSP groups (Table 1). Thus, the amplitude was not an accurate parameter to differentiate normal from altered cognitive function in this scenario.

Cognitive impairment in HAM/TSP, HTLV-1-asymptomatic carriers, and controls

The results of P300 latency and SMS were dichotomized into normal and altered considering the control group mean ± 2 standard deviations for SMS and P300 latency. Thus, the SMS results bellow 7.23 points and the P300 latencies above 369 milliseconds were considered altered. Figure 3 shows the scatter graphic distribution of participants for P300 latency and SMS according to normal and altered results in both tests.

HAM/TSP cases were concentrated around the area of altered results for both SMS and P300 while the asymptomatic cases were spread on both normal and altered areas; the control cases were concentrated around the area of normal results for both SMS and P300. Table 2 shows the comparative analysis of categorical results. HAM/TSP group showed the highest prevalence of altered results (87%). Interestingly, the asymptomatic carriers also presented a higher prevalence of altered SMS (60%) and P300 (35%)

compared to the healthy controls (< 10%). The comparative analysis of the SMS results showed that the frequency of cognitive impairment was 16 times higher in the asymptomatic group and 69 times higher in the HAM/TSP group when compared to the controls (Table 2).

Table 2

Comparison of normal and altered cognitive function defined by self-perceived memory score and P300.

Variables		HAM/TSP (N = 15)	AC (N = 20)	Control (N = 35)	Comparison groups	p-Value	OR	CI
SMS	Normal	2 (13)	8 (40)	32 (91)	Control x AC	< 0.001 ¹	16.0	3.6–70.5
					Control x HAM	< 0.001 ¹	69.3	10.3–464.4
	Altered (< 7.23 points)	13 (87)	12 (60)	2 (9)	AC x HAM	0.098 ¹	4.3	0.76–24.6
P300 Latency	Normal	3 (20)	13 (65)	35 (100)	Control x AC	0.008 ¹	19.4	2.2–173.1
					Control x HAM	< 0.001 ¹	144	13.6–1518.4
	Altered (> 369 ms)	12 (80)	7 (35)	0 (0)	AC x HAM	0.012 ¹	7.4	1.5–35.5
Legend: N = number of participants; HAM/TSP = HTLV-1 associated myelopathy/tropical spastic paraparesis; AC = HTLV-1-asymptomatic carriers; OR = <i>odds ratio</i> ; CI = confidence interval; ms = milliseconds; SMS = self-perceived memory score. ¹ Fisher's exact test (p < 0.05)								

Discussion

The main contribution of the present study was to show that the self-perceived memory score together with the P300 were able to detect cognitive impairment in the HTLV-1-infected individual classified as asymptomatic, and this alteration was more frequent than in the healthy controls. Many screening tests for cognitive impairment are available. The assessment of cognitive deficit includes testing various skills and memory processes and early detection depends on the use of instruments with adequate sensitivity and specificity. [55–57]. However, these screening methods are time-consuming.

P300 is an electrophysiological test that shows cortical activation in face of an auditory task associated with attention and memory processes, and thus is a valid method for the evaluation of cognitive impairment [34, 58]. It is not time-consuming, and it is easy to apply.

The cognitive processing can be influenced by aging, sex, years of education, and depressive symptoms, which were factors that we have controlled for the interpretation of the P300 as an indicator of cognitive deterioration in the present study (Table 1) [59–61]. P300 latency delay was observed in the HTLV-I-asymptomatic carriers and in HAM/TSP, showing a parallel and progressive worsening of the neurological disease and memory dysfunction when compared to healthy controls. We considered the use of a visual scale to screen memory dysfunction together with a 0–10 analog score [62]. Despite the limitation of focusing on defined aspects of cognitive skills, SMS assessed through faces and analog scales was useful for screening asymptomatic HTLV-1 carriers, since this population who is considered asymptomatic but who had reported an SMS < 7.23 presented a predominance of P300 > 369 ms, which was considered an altered P300 based on the average P300 result of the control group and of the HAM group evaluated herein (Table 2). P300 is an objective test of attention and working memory. [57, 63–65].

Deficits in memory and selective attention were described in the HTLV-1 infection and are closely linked to auditory processing [21, 23]. The alteration in the auditory processing represents a higher risk of cognitive impairment. In fact, the P300 alteration has already been reported for the early detection of cognitive impairment in the HTLV-1 infection [11, 19].

Fukushima and colleagues used P300 in conjunction with imaging exams to detect cognitive impairment in individuals with HAM/TSP [19]. They found that, compared to healthy controls, HAM/TSP individuals have presented an evident P300 latency delay. There was no correlation between magnetic resonance imaging and P300. However, individuals with HAM/TSP had white matter lesions and atrophy in cortical and subcortical areas, especially in the frontoparietal regions. Our study corroborates P300 as a complementary diagnostic tool for cognitive impairment in the HTLV-I infected population and expanded the analysis when we evaluated the HTLV-1-asymptomatic carrier and we found that altered P300 was correlated to the HTLV-1 neurological spectrum of going from the considered asymptomatic status to HAM and to the self-perception of memory dysfunction. The P300 latency was more prolonged in the HAM/TSP group when compared to the asymptomatic carrier, who, in turn, had worse results than healthy controls (Table 1 and Fig. 3). Therefore, the worse the P300 latency, the worse the neurological status was, something which confirms that cognitive damage is part of the HTLV-1 neurological disease [20, 22, 23].

Several studies have shown that the neurological manifestations related to HTLV-1 are frequent even at the asymptomatic stage [4, 11, 20–23, 66]. The involvement of the spinal cord has been the target in the neurological assessment of HTLV-1-infected patients for decades and cognitive screening is not routinely performed. However, cognitive impairment is part of the HTLV-1 neurological spectrum of damage [4, 20, 21]. In the present study, we found that 35% of the HTLV-1-asymptomatic carriers presented a delay in P300 latency comparing to the controls. This result confirms the broad subclinical impairment which is part of the neurological pathophysiology of HTLV-1 disclosed by the neurophysiological tests [10, 11, 17, 67].

A limitation of the present study in terms of cognitive assessment was the lack of a battery of neuropsychological tests to evaluate memory dysfunction. The reason was that a full battery of neuropsychological test for memory and attention is time consuming and tiring. Frailty is a characteristic of the HAM/TSP population, and our intention was to focus on a specific cognitive ability. The studies about the applicability of P300 as an electrophysiological measure of memory impairment in HTLV-1 are scarce and this test is effective to detect dysfunction in working memory and selective attention, that are the most common affected cognitive abilities in HTLV-1 infection [11, 13, 20, 21, 23].

Conclusion

The HTLV-1-asymptomatic carrier may have subclinical cognitive impairment. The use of a 0–10 visual numeric scale associated with a sad-happy faces scale as a measure of the self-perceived memory score in the medical consultation of people living with HTLV-1 can drive the attention to the non-medullary neurological symptoms.

Abbreviations

HTLV-1: Human T-lymphotropic virus type 1; HAM/TSP: HTLV-1 associated myelopathy/tropical spastic paraparesis; GIPH: Interdisciplinary HTLV Research Group; SMS: self-perceived memory score; ERP: event-related potential; VEMP: vestibular evoked myogenic potential; AC: HTLV-1-asymptomatic carrier; dBHL: decibels hearing level; ms: millisecond; ICC: intra-class correlation.

Declarations

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Authors' contributions

DU-G, LMR and ARRC conceived the study. DU-G, LMR, LL and ARRC contributed to the design and implementation of the research. ARRC, LL, RTSD and MRS performed the assessments and collected the data. ARRC and JFMC processed the data and performed the analysis. ARRC designed the figures. ARRC, JFMC and DU-G contributed to the analysis of the results and to the writing of the manuscript. ARRC and DU-G drafted the manuscript, and DU-G and LMR supervised the project. All authors contributed to and approved the manuscript.

Availability of data and materials

The data bank is available as a supplementary material.

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Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Federal University of Minas Gerais, Brazil, under the number CAAE 92928518.3.0000.5149.

Consent for publication

Yes

Competing interests

The authors declare that there are no competing or conflicting interests.

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Figures

Figure 1

Visual analog scale combined with sad-happy faces rating scale used for self-perceived memory score measurement.

Figure 2

P300 waveforms to represent the profiles of the control (A), asymptomatic (B), and HAM/TSP (C) groups. A = Resultant waveform; Ra = rare (infrequent) auditory stimulus; Fr = frequent auditory stimulus. The auditory evoked long latency potentials, denominated N1-P2-N2 complex and that precedes the P300 wave, were marked for each waveform record.

Figure 3

Scatter graph showing self-perceived memory score and P300 latency dichotomized as normal and altered results. N = number of participants; HAM/TSP = HTLV-1 associated myelopathy/tropical spastic paraparesis. The dashed line at the scattered graph represents the normality for P300 latency (horizontal) and self-perceived memory score (vertical). The marks that are located in the upper left square using the crossed dashed lines reference represent the cases with cognitive impairment in the sample.

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