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Cognitive brain mapping of auditors and accountants in going concern judgments

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ABSTRACT

This study aims to explain the extent to which brain mapping patterns follow behavioral patterns of auditors and accountants' judgments when assessing evidence for decisions involving going concern. This multidisciplinary research involved investigating the relation between the theory of belief revision, neuroscience, and neuroaccounting with a sample of auditors and accountants. We developed a randomized controlled trial study with 12 auditors and 13 accountants. Auditors and accountants presented similar judgments about going concern, specially demonstrating greater sensitivity to negative evidence. Despite similar judgments, results showed diverging brain processing patterns between groups, as distinct reasoning was used to reach going concern estimates. During the decision process, auditors presented homogeneous brain processing patterns, while accountants evidenced conflicts and greater cognitive effort. For both groups, the occurrence of maximization (minimization) of judgments is observed in brain areas associated with identification of needs and motivations linked to individuals' relations with their social group. This was strengthened by the lack of significant differences between the regression maps of auditors and accountants, leading to interpretation of the groups' findings as homogeneous brain behavior. Despite familiarity with the executed task and knowledge of auditing standards, as a result of the greater use of algorithmic reasoning the auditors' judgments were similar to that of accountants. On the other hand, the accountants' greater cognitive effort, due to the experiencing of greater conflict in the decision-making process, made them use more quantic brain processing abilities, which are responsible for conscious reasoning. This was observed in the maximizations (minimizations) of the estimates in brain areas related to concerns with the judgments' social repercussions, which culminated in some degree of "conservatism" in their decisions. Furthermore, these findings reveal another opportunity to discuss the assumption of the brain as the original accounting institution.

Keywords: neuroaccounting, cognitive brain mapping, going concern, belief revision.

1. INTRODUCTION

In accordance with the hypothesis of Basu and Waymire (2006), modern organizations and markets would not be possible if human beings had not invented the systematic technology of bookkeeping, which is at the heart of modern accounting. A reflection on this hypothesis departs from the observation of how relevant accounting is for organizational management as well as for all stakeholders, who shows a relevant dependence on accounting information.

In addition, the dynamic evolution of accounting implies improvements in the quality of provided information, which is fostered by a significant number of accounting choices and the standardization of accounting language used in a wide range of markets. To the extent that International Financial Reporting Standards (IFRS) are adopted in Brazil, changes related to the profile of accounting professionals involving greater demands for judgments and decision-making are needed. Indeed, the Brazilian legal system remains within the code law paradigm, while experiencing a departure from rules-based generally accepted accounting principles (GAAP) to principles-based one. Researchers have been interested in the mind of the independent auditors mainly because of their institutional relevance for financial infrastructure. A significant evaluation of the judgments about the going concern assumption of companies is clearly observed in behavioral research (Ahlawat, 1999; Ahlawat & Fogarty, 2003; Asare, 1992; Ashton & Kennedy, 2002; Defond, Raghunandan, & Subramanyam, 2002; Shelton, 1999).

Nevertheless, to what extent can these individuals' judgments be explained using more traditional instruments such as behavioral studies? In light of this question, it is important to expand the research horizons in search of more modern instruments that may be stronger when explaining elements that can go by unnoticed when traditional methods are used. According to these arguments, a trend is observed when studies try and establish the brain correlates of economic decisions and, more recently, of accounting decisions (Basu & Waymire, 2006; Dickhaut, 2009; Dickhaut, Basu, McCabe, & Waymire, 2010).

Recent major events, such as the subprime crisis, have shown the increase risk of companies not being able to remain as a going concern, what elevate the relevance of judgments around that assumption. Thus, independent auditing is increasingly associated with the validation of audited companies' economic and financial position, mainly regarding management use of the going concern assumption, which enhances the institutionalization of independent auditors' role in the global economy. For this reason, this study adapted the experimental protocol used by Stephen K. Asare (1992), that includes cognitive brain mapping and testing of the belief revision theory (Hogarth & Einhorn, 1992), seeking to answer the following research question: to what extent does brain mapping patterns follow behavioral patterns of auditors and accountants' judgments when assessing sequential evidences for going concern decisions? Therefore, this multidisciplinary study, involving medical science and accountancy, aims at explaining the extent to which brain mapping patterns follow behavioral patterns of auditors and accountants' judgments.

2. THEORY AND HYPOTHESES

In auditing, the concept of verifiability is associated with the availability of evidence that supports the validity of the considered information. In this sense, it is observed that independent auditing requires an auditor's judgment to find a reasonable basis to issue opinions on the appropriateness of financial statements, where the validity and fittingness of the accounting treatments are assessed (Boynton, Johnson, & Kelly, 2002).

When executing their activities in a deficient manner, auditing companies only outline problems that cooperate with managers in the manipulation of results. Consequently, their reputation increases the demand for auditing services. Some mechanisms can be used to enhance the reputation of auditing, such as: professional societies, organizational forms of auditing firms, the size of auditing firm, and specialization in a field of activity (Jennings, 2004; Watts & Zimmerman, 1986).

In Brazil, the standard NBC TA 570, which adheres to the international standards of auditing (ISA 570), holds that the auditor is responsible for assessing the ability of an entity to continue in business for the foreseeable future by obtaining sufficient auditing evidence. The standard highlights some examples of events and conditions that, individual or collectively, raise significant doubt on the entity's ability to continue as a going concern. Finally, the auditor should present a conclusion on the existence of

significant uncertainty about going concern assumption.

2.1 Belief Revision Theory

In regards to the variables inherent in the execution of the tasks, three were considered in the establishment of the scientific model for the belief revision theory. One of these variables relates to the complexity of processing individual items of evidence. Here, complexity is a function of the amount of information from each piece of evidence to be processed and also a function of lack of familiarity with the task. It is noteworthy to state that familiarity refers to the decision maker expertise in a specific type of decision, which cannot be confounded with the familiarity threat evidenced in the code of ethics of independent auditors that means the repetitive nature of a long-term engagement between the auditor and his/her client, and this may lead to complacency and to the underweighting of warning signs. The importance of the complexity for belief revision relates to human processing ability (Hogarth & Einhorn, 1992). Thus, the greater the complexity, the greater the individual's search to simplify strategies to minimize cognitive efforts.

The second variable relates to the extent of the series of items and the size of the information blocks presented. The extent is associated with the amount of evidence that is to be assessed. The authors classified the series into short (between two and 12 items) and long (17 or more items).

The third variable is called the response mode or processing mode. According to the authors, the response mode is the way in which judgments are made and emphasizes step-by-step (SbS) and end-of-sequence (EoS) approaches. SbS is a sequential procedure in which individuals express their beliefs each time they get new evidence. In the EoS method, opinions are only expressed after all information has been presented (Hogarth & Einhorn, 1992).

Furthermore, the authors also acknowledge the impact of the method through which individuals process information in their subsequent judgments. According to Hogarth and Einhorn (1992), two additional coding variables affect the predictions of the proposed model: (i) processing mode (SbS and EoS) and (ii) type of task (assessment and estimation). When the SbS mode is used, an individual adjusts his opinion incrementally for each new piece of evidence that is processed. As a result of the EoS processing mode, an individual adds all items before integration with an anchor, which can be cognitively demanding. In addition, it is observed that the processing mode depends on the cognitive requirements of the task. The use of the SbS mode is expected for more complex tasks, where an individual continuously integrates information with an anchor, while the EoS mode is used for simpler tasks, where adding more recent information is cognitively easier.

Emphasizing the distinction between the types of tasks, the authors indicate that in the assessment tasks information is coded in a binary manner (positive/negative; true/false). In regards to the assessment of estimation tasks that involve a unipolar scale, the moving average reflects the position of each new piece of evidence in relation to the current opinion. Thus, it is assumed that the individual's personal beliefs are reviewed through processes of sequential anchoring and adjustment. In these processes, the current opinion serves as an anchor that is adjusted by the impact of the subsequent information.

The belief revision model forecasts and takes into account the information that is being assessed. It also questions the conditions in which the following effects take place: (i) primacy effect (e.g., if you assess a long list of numbers, it is more likely that you will remember the numbers you assessed first - at the beginning of the list - than numbers that occurred in the middle): this effect is always forecasted for a small series of simple information, which is assessed through EoS processing, and occasionally forecasted for processing a long series of information; (ii) recency effect (e.g., if you assess a short list of numbers, you should note that you will be likely to remember numbers at the end of the list more than numbers in the middle): for small series of simple and complex information (with many details), the model predicts this effect for SbS processing of mixed evidence; (iii) no order effect (e.g., if you assess a short list of numbers and you will be likely to remember numbers at the beginning, middle, and the end of the list without distinction): this effect is observed for invariable evidence in the SbS processing of small series of simple and complex information.

The behavioral hypotheses in this study also consider the recency effect in SbS evidence processing. In line with belief revision theory, the first block of behavioral hypotheses (H_1) assesses the adjustment weight of three presented blocks of evidence (information from the company and financial statements, favorable evidence, and unfavorable evidence). These hypotheses allow one to assess an individual's levels of sensitivity to positive (favorable) and negative (unfavorable) evidence, as follows:

H_1: the individual presents greater sensitivity to unfavorable evidence when revising initial estimates;

H_{1a}: the first revision of the estimates after the analysis of the first block of (favorable) evidence is not significantly

greater than the previous estimate;

H_{1b}: the second revision of the estimates after the analysis of the second block of (unfavorable) evidence is significantly lower than the previous estimate.

As the control group used in the study consisted of accountants, the second block of behavioral hypotheses (H_2) suggests that similar effects are suffered by auditors and accountants when they have access to favorable and unfavorable evidence during execution of a task. Although independent auditors have a professional responsibility associated with the assessment of the entity's ability to continue as a going concern (Conselho Federal de Contabilidade, 2010), both groups (auditors and accountants) have an educational background in Accounting and Finance. These characteristics allow them to understand the company's economic and financial situation and to be equally sensitive to the premises of belief revision theory.

H_2: based on the evidence presented, auditors and accountants judge going concern in a similar way;

H_{2a}: there are no significant differences between the judgments of auditors and accountants;

H_{2b}: there is no significant difference between independent audit reports issued by auditors and accountants.

2.2 Neuroaccounting

In view of the belief revision theory's strength to predict judgments through sequential evidence processing, the subjective assessment of *k* evidence and sensitivity to negative (α) and positive (β) evidences are highlighted as unexplored "black boxes" of behavioral decision assessment, according to the details presented in the next section. To answer the proposed research problem according to trends in recent studies (Basu & Waymire, 2006; Dickhaut, 2009; Dickhaut et al., 2010), physiological hypotheses were used to analyze the behavioral results, which indicate how these "black boxes" are accessed by the reasoning of individuals.

Although they are equally sensitive to the evidence presented, as assumed in the behavioral hypotheses of this study, auditors and accountants are affected differently by the complexity of evidence. In view of the definitions by Hogarth and Einhorn (1992) regarding the complexity of individual items in evidence that is to be processed, the auditors would only feel the effects associated with the amount of information contained in each group of evidence, while the accountants are affected by the same, as well as by the lack of familiarity with the task.

Familiarity with a task being executed minimizes the auditor's cognitive effort that results in a decrease of conflict when assessing risks and benefits associated with the evidence, as well as a greater use of algorithmic reasoning responsible for unconscious decisions. The accountants would therefore experience greater conflict in the decision-making process, which demands greater quantic brain processing ability that is responsible for conscious reasoning. To detect and solve conflicts during the task, the accountants need a more intense activation of the neurons in the anterior cingulate cortex (ACC) (assessed with the use of functional magnetic resonance imaging), as well as two brain processing patterns when the produced factorial maps based on the electroencephalogram (EEG) are assessed (Botvinick, Cohen, & Carter, 2004; Egner, Delano, & Hirsch, 2007; Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Gehring & Fencsik, 2001; Rocha & Rocha, 2011).

Furthermore, the assumptions used in this research depict the brain as a quantum processor, which differs from the binary feature as the elements are processed in a traditional computer (on = 1 or off = 0). The quantum processing accepts that elements can be simultaneously in any intermediate state between on or off, which causes the phenomenon of quantum coherence (Rocha & Rocha, 2011). Emotional perceptions and feelings are results of the brain quantum processing in the decision-making process. This processing is responsible for conscious reasoning, since taking unconscious decision is supported by traditional algorithmic processing when the conflict generated in risk and benefit assessments is small. Whenever the conflict in risk and benefit assessment is high, it requires the brain to use more processing power to solve it through a conscious reasoning. This type of reasoning is originated from a brain quantum processing, which also unifies the information processed simultaneously in the brain, such as visual and sound, and unifies the sensory perception to the emotional valence, resulting in the consciousness of determined emotion.

Rocha and Rocha (2011) present some evidences that correlate the assessment of the conflict in decision-making with the activity of neurons in the ACC. Botvinick et al. (2004) were among the first to make this correlation, presenting evidence about the theory of monitoring conflicts where specific brain areas, highlighting the ACC, respond to conflicts during the development of cognitive tasks. The cognitive effort occurred in the decision-making process also appears correlated to brain activity in the ACC.

Fan et al. (2003), assuming that the ACC is responsible for monitoring the conflicts, while the prefrontal cortex is

involved in the resolution of conflicts, show evidence of significant activation in the ACC and the left prefrontal cortex in resolving conflicting tasks. In addition, Gehring and Fencsik (2001) highlighted the role of the medial frontal cortex and the ACC in the hypothesis test raised by the error detection theory (increased activation of these cortical areas associated with the difference between the error and the correct answer) and conflict detection theory (associated with cortical activation to detect conflicts with greater brain activity when the mistake and the correct answer are similar). Research on brain function using the methods employed in neuroeconomics can be valuable to discover how the brains of accounting professionals are able to solve conflicts present in different decisions (Dickhautet al., 2010). As presented in the first block of physiological hypotheses, the auditor's specialization guarantees the use of well-defined rules in the subjective assessment of *k* evidence as well as the calculation of benefits and risks in determining the probability of the audited company continue as a going concern. In regards to accountants as nonexperts, they would show greater cognitive effort and use of analogue reasoning (company valuations for other purposes) to assess the task.

H_3: auditors present a homogeneous brain processing pattern, while the accountants show greater conflict (cognitive effort) when assessing the going concern assumption;

H_{3a}: auditors reveal a greater correlation among the patterns of brain processing in the course of the assessment;

H_{3b}: accountants show two brain processing factors (patterns) in the execution of the task.

Dickhaut (2009) emphasizes the brain as the original accounting institution in a study published in *The Accounting Review*, which strengthens the hypothesis of Basu and Waymire (2006). The author proposes that society has developed various artificial institutions (grouping of rules and standards that organize human interaction) with properties similar to the brain in order to attend to the demands of complex environments. As the brain is seen as the original accounting institution (Dickhaut, 2009), artificial institutions are therefore needed to cope with complex transactions, storage, and recovery of data, which would not be possible to do with the brain's mental faculties alone. According to the hypothesis of Basu and Waymire (2006), accounting generates confidence and reciprocity, factors that trigger cooperation among stakeholders in economic transactions. Dickhaut et al. (2010) affirm that independent auditing is perceived as a guarantee of the presented accounting information's reliability, mainly by sustaining the social and economic interactions provoked by the risk of "altruistic punishments," which may be contained in the independent auditor's reports.

Based on the hypothesis of Dickhaut et al. (2010) about the possible association between the going concern assumption and the brain's desire to have information about third parties' abilities - which is associated with the hypotheses of Basu and Waymire (2006) and Dickhaut (2009) - the second block of physiological hypotheses in this study considers the assessment of social risks and benefits of the action that is to be implemented, which may be able to support judgments about companies' going concern. The brain processes risk and benefit assessments in the social decision space (SDS), which is in charge of identifying needs and motivations linked to the individual's relation with social groups they have contact. Aiming to produce trust and reciprocity, judgments about the entity's ability to continue as a going concern would therefore be supported through the activation of the prefrontal medial cortex, superior temporal sulcus, parietal-temporal junction, and temporal lobe, which are brain areas that are activated in the assessment of the possible intentions attributed to third parties (Rocha & Rocha, 2011; Singer, 2009).

H_4: the assessment of risks and benefits in the judgment about the entity's ability to continue as a going concern is processed in SDS;

H_{4a}: auditors and accountants maximize (minimize) the probability of the entity's ability to continue as a going concern according to the perceived benefit (risk) from the perspective of SDS;

H_{4b}: auditors and accountants choose the type of independent audit report according to the perceived benefit (risk) from the perspective of SDS.

3. METHOD

The sample consisted of 25 accounting professionals, including 12 independent auditors and 13 accountants, who had no experience with independent audits. The auditors have a lower average age (30.67 and 33 years for auditors and accountants, respectively) despite the greater standard deviation (SD) in the sample (10.84 for auditors and 6.68 for accountants) and a little greater average years of experience (7.83 and 7.69 years for auditors and accountants, respectively) despite the greater SD in the sample (10.13 for auditors and 3.68 for accountants). In regards to gender, it is observed that the sample was mainly male (83.3% of auditors and 92.3% of accountants). Data was collected during December 2011, mostly at the university where a specific laboratory was established, with some cases collected at the firm's offices where the laboratory environment was simulated in isolated rooms. All the noises were controlled by the minimum contact between subjects and researcher and the good fit of EEG cap, with the electrodes placed along the subjects' scalp, as well as the constant monitoring of the brain waves screen. The small sample size lies at the heart of criticism against the use of neuroscience methods, despite of the well known high cost data collection. In this kind of study, however, small samples show significant results due to the activation of the same brain nuclei in all participants (Birnberg & Ganguly, 2012; Eskenazi, Hartmann, & Rietdijk, 2016; Harbaugh, Mayr, & Burghart, 2007).

To enhance the experiment's sensitivity, the probabilities for type I (α) and type II (β) errors were considered in the statistical significance test of the differences between the individuals' judgments. The statistical power is the probability (1 – β) that the statistical significance will be reached, given that an intervention effect truly exists (Bickman & Rog, 2001; Lipsey & Hurley, 2001). Cohen (1977), cited by Lipsey and Hurley (2001), presents a β of 0.20, suggesting a minimal statistical power of 0.80. Thus, for applied research of potentially practical value, the use of a convention triggers the adoption of similar α and β probabilities, assuming that a type II error is as important as a type I error.

As a contribution to behavioral accounting research, it is suggested that the design of this kind of study (including sample size) should be adopted to reach the minimum statistical power of 0.80 (β = 0.20), assuming a controlled type I error of α = 0.05 (Borkowski, Welsh, & Zhang, 2001). It should also be highlighted that both the used statistical test and the effect size (ES) (difference of means found for the experimental and control group divided by the common SD of the sample) are key to increase the statistical power of applied experiments (Lipsey & Hurley, 2001).

Bausell and Li (2002, p. 19) highlighted the use of the smallest possible number of groups in the experiment as well as the use of less strict α significance levels. The authors also discuss the directional hypothesis test (one-tailed) that can be used in case of strong empirical and theoretical evidence about the direction of an effect found in "scenarios in which intensive pilot studies have been conducted" or "in case of a sufficiently strong theoretical reason". In this study, only two groups were used (auditors and accountants), as presented earlier. In view of the abovementioned factors, the sample size demonstrates the main limitation of this study. Making independent auditors and accountants spend some minutes of their day to participate in an academic experiment is not one of the easiest tasks. The ES needed to achieve the suggested minimal statistical power was calculated (statistical power = 0.80 and α = 0.05) and, considering the sample size, it is equal to 1.201, which adheres to the previously calculated results (Lipsey & Hurley, 2001, p. 48) to be explored under O'Keefe's (2007) approach to statistical power.

These research characteristics led to the use of the experimental model, considering that the used research design is responsible for guaranteeing the credibility, utility, and feasibility of the study (Bickman & Rog, 2001). Despite the strictness inherent in the method, some factors can weaken the strength of the experiment (internal and external validity). Internal validity is the extent to which the researcher controls external variables, so that any effect observed can be credibly attributed to the treatment. External validity is the extent to which the results of an experimental study can be applied to individuals and places beyond those that were studied, that is, directly associated with the generalization of the findings (Gall, Gall, & Borg, 2003).

In regards to internal validity, behavioral and social science studies are always questioned because they use human beings as the focus of experiments. This kind of study should therefore control for a wide range of external variables. For this reason, the present study accounted for the major threats related to the external variables described by Gall et al., (2003), which guarantee the internal validity in the following ways: (i) sample of individuals with similar characteristics; (ii) experiment with a short duration; (iii) revision of going concern estimates; (iv) use of the same measuring instrument in the

pre and posttest; (v) sequential application of the pre and posttest; (vi) absences of classic control and experimental groups; (vii) data collection from each subject in the experiment on the same day; and (viii) individual data collection.

Concerning external validity, the study's results can only be generalized to the specific population of the experiment. The factors inherent in the ecological validity of the experiment were controlled, based on the following measures: (i) the individuals received no previous warning of this treatment; (ii) administration of a single experimental treatment; (iii) none of the participants knew about the study hypotheses and all individuals received the same treatment; (iv) contact with the researcher was restricted to the preparation period (instructions related to the software and adjustment of the EEG electrodes); (v) the administration of the posttest measures the treatment effects and it does not create any form of dependency from the results; (vi) the generalization is exclusively valid for decisions about the audited companies' going concern; (vii) the measuring of the posttest was not applied in subsequent periods.

3.1. Research Protocol

The planning of this research considered the main aspects of a representative experimental design (Gall et al., 2003). The protocol is an adaptation of that used by Asare (1992), who conducted an experiment to analyze the occurrence of recency effects in going concern assumption decisions, which tested the belief revision theory (Hogarth & Einhorn, 1992). Therefore, the auditors were submitted to judgments of a company's going concern after the sequential analysis of evidence.

In this study, the evidence is classified as supporting or rejecting the going concern hypothesis. It is highlighted that provided negative information is aligned with the events and conditions presented in the Brazilian audit standard NBC TA 570, which raises significant doubt on the going concern assumption. Figure 1 shows the instrument used to collect the data, where the first section allows the individuals to become familiar with the audited company, and analyzes the balance sheets and income statements from the last four years. Next, the first judgment is presented through a probability estimate of the company's going concern. In the second section, the individuals were submitted to three further rounds of judgments, two revisions of going concern assumption estimates, and one choice of the type of independent auditor report. Regarding the estimated revisions, the groups in the experiment received stimuli by positive information (before the judgment 2) followed by negative information (before the judgment 3).

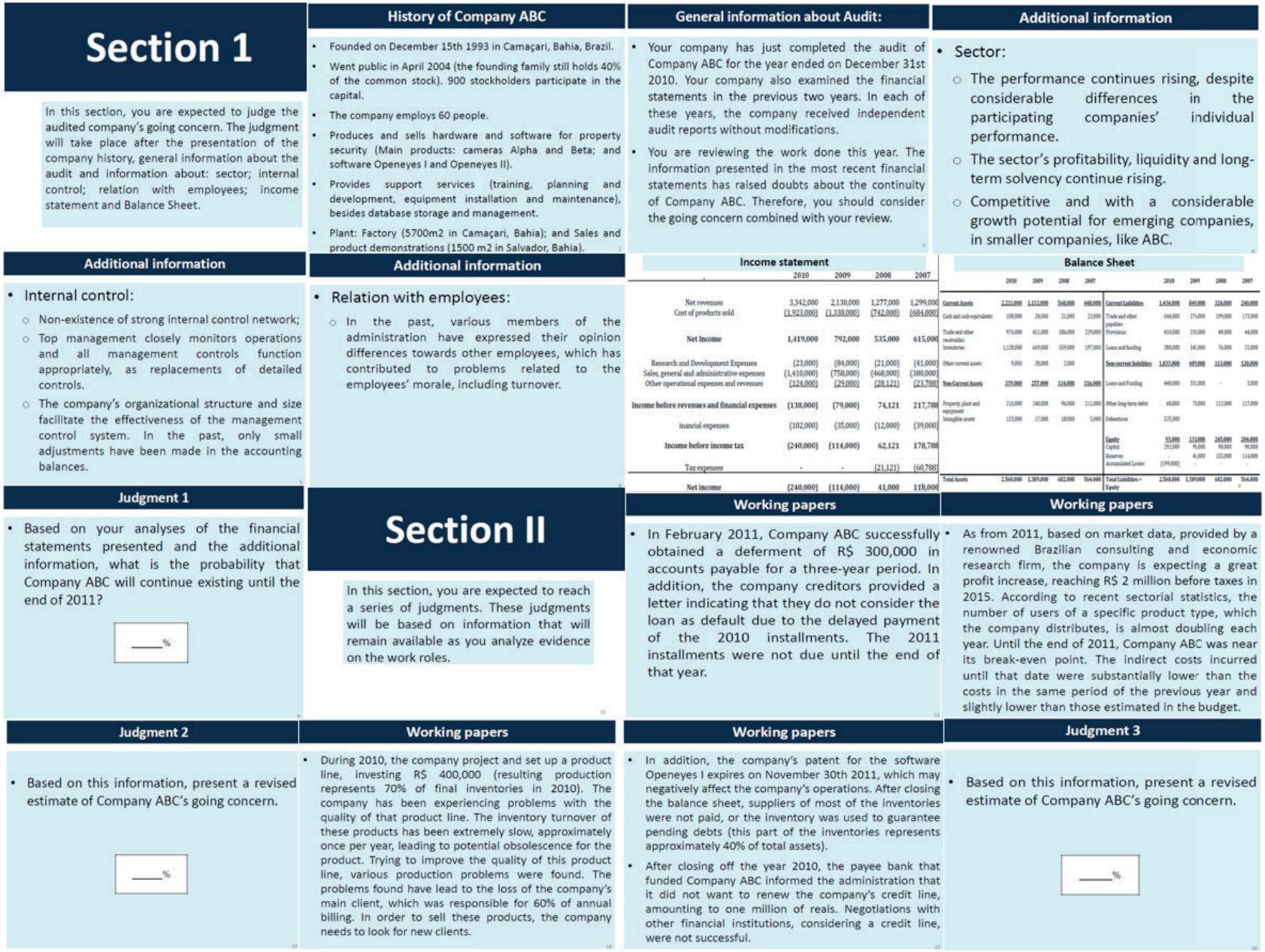

Figure 1 *Instrument*
Source: *Prepared by the authors.*

For validation, the data collection instrument was assessed by four auditors with more than 20 years of experience in the area. The Asare (1992) adapted protocol was assessed by these experts and the perceptions of the evidence were consistent with the intended manipulation, providing doubts about the entity's ability to continue as a going concern in section 1 (forming an initial belief or anchor) and additional contrary information (bad news) and mitigating factors (good news) in section 2. We recorded the experts' voices while they spoke about each part of evidence perceptions (think aloud protocol). In general, the auditors confirmed that the information presented was appropriate to simulate the going concern assumption judgment. The professionals also showed the complexity of the judgment, as it potentially exposes the audited company and demands great responsibility and caution by the auditing firm.

Individuals executed the task while their EEG was registered by 20 electrodes that were placed on the scalp and arranged according to the 10/20 system, with impedance inferior to 10 kV, a low-pass filter of 50 Hz, and a sampling rate of 256 Hz and 10 bits of resolution (Rocha, Rocha, Massad, & Menezes, 2005). Each electrode is designated with a capital letter corresponding to the area of the brain cortex where it was placed: central (C), frontal (F), occipital (O), parietal (P), and temporal (T). Two computers were used in the data collection: one to record the EEG and another to present the task and register the estimates. The data on the audited company, as well as the information on the work roles and measuring of the auditors' estimates, were adapted in the software Enscer® (developed by EINA – Estudos em Inteligência Natural e Artificial). Thus, the collected behavioral variables (estimates) were associated with the data collected by the individuals' EEGs.

In the analysis of the data obtained through the EEG, the linear correlation coefficients $r_{i,j}$ were calculated for the mean activity of the register of each electrode e_i in relation to the activity of the other 19 electrodes e_j. This calculation happens for each cognitive activity event per individual (Ribas, Rocha, Ortega, Rocha, & Massad, 2013; Rocha, et al., 2005). For the individuals' brain mapping, two-second excerpts from EEG were analyzed at the end of each of the 17 steps in the protocol. Next, factorial mapping (FM) was applied and the regression cognitive mapping (RCM) was elaborated [Estudos em Inteligência Natural e Artificial (EINA), n.d.; Rocha et al., 2005]. The extraction of factors through the use of principal components analysis and the normalized varimax method were used to elaborate the FMs. These mappings show how the regression entropy $h(r_i)$ of the electrodes co-varies in a certain cognitive task. If the extracted factors explain more than 50% of the total variability of the entropy $h(r_i)$, the analysis is considered acceptable. In general, three factors explain more than 60% of the co-variation of $h(r_i)$ (EINA, n.d.; Rocha et al., 2005).

In this study, the main component's analysis of the calculated entropy showed the existence of three factors (F1 to F3) that explain 85% of the co-variance in the data: factor one explains 70%, factor two, 10%, and factor three, 5%. In these factors, the loadings for each electrode were normalized and used to generate the FMs. The coefficients superior to 0.5 are displayed in green and dark blue. The visual analysis of these maps shows the occurrence of three brain activity patterns (P1 to P3), which do not necessarily correspond to the same factor.

In the second phase of the brain mapping, a regression analysis among the going concern estimates and the entropies $h(r_{i,j})$ of each electrode was applied to construct the RCM. The RCM shows the contribution of each electrode to the individuals' cognitive activity (EINA, n.d.). The regression analysis presents a correlation between the declared probabilities and the entropy calculated for the 20 electrodes. The angular coefficients are used to generate the regression maps. The coefficients were normalized and any statistically insignificant coefficients were equaled to 0.5, while the maximum positive coefficient is established as 1 and the maximum negative coefficient as 0. Positive coefficients are displayed in green and dark blue and negative ones in pink and dark red.

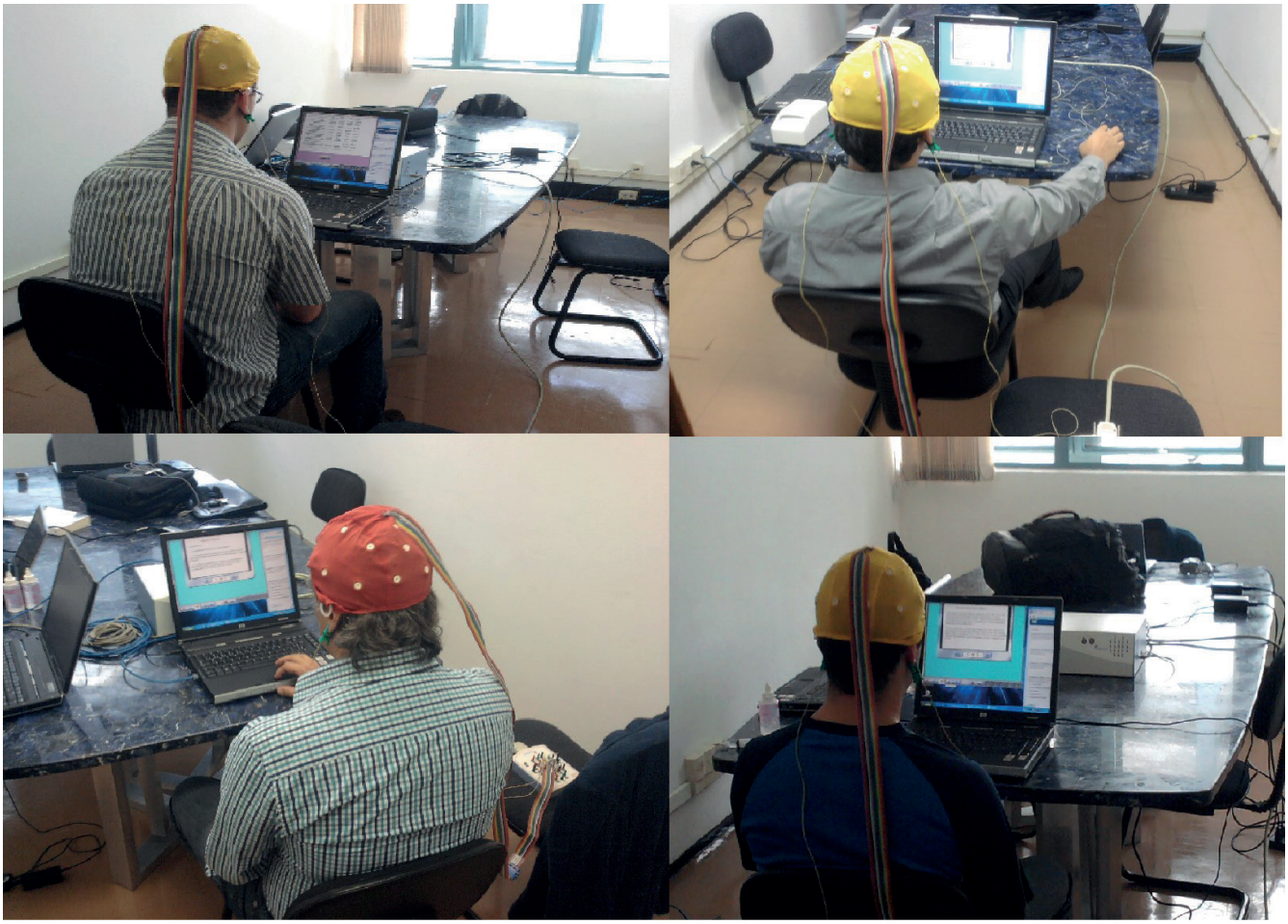

Figure 2 *Volunteers during the task*

3.2 Analysis

For the behavioral analysis of the findings, parametric and nonparametric statistics were used in the test of the presented operational hypotheses after the use of the Shapiro-Wilk test to assess the adherence of the behavioral variables to normality (Razali & Wah, 2011). Thus, the Wilcoxon test and the *t* test for related samples were used for the hypotheses H_{1A} and H_{1B}. To test the hypothesis H_{2A}, the Mann-Whitney *U* test and the *t* test for independent samples were used, while the chi-square test was used for hypothesis H_{2B}. Pearson's coefficient and nonparametric multivariate analysis of variance (MANOVA) were used to quantify similarity and assess the existence of significant differences between the groups' brain processing patterns and regression maps, which supports the test of the physiological hypotheses (H_3 and H_4).

Despite the fact that the EEG electrodes generated 1,146 records in our brain dataset, we used a nonparametric test of significant difference between two or more groups based on any distance measure. This nonparametric MANOVA affords a direct additive partitioning of variation for complex models maintaining the flexibility and lack of formal assumptions. The test-statistic is a multivariate analogue to Fisher's F-ratio calculated directly from any symmetric distance or dissimilarity matrix and the p values are obtained using permutations (Anderson, 2001).

4. EXPERIMENTAL RESULTS

4.1 Behavioral Analysis of Judgments

After the Shapiro-Wilk test used to assess the adherence of the behavioral variables to normality, the results confirm that the initial judgment (J1) and the final decision (D) did not adhere to the normal curve (p =

0.036 and 0.000). In view of the experimental protocol, it is observed that the use of Wilcoxon's nonparametric test to assess the significant difference between judgments 1 and 3 produces a high statistical power level (0.9999059). Therefore, an ES of 1.136 was considered.

After calculating the statistical power, the groups showed homogeneous behavior in terms of the average percentages in each judgment (J1, J2, and J3), increasing the percentage in J2 and reducing it in J3. The accountants and auditors showed the following means and SDs for the judgments: $J1_{accountants}$ (M = 0.7385; SD = 0.22), $J2_{accountants}$ (M = 0.8192; SD = 0.1451), $J3_{accountants}$ (M = 0.4923; SD = 0.1956), $J1_{auditors}$ (M = 0.80; SD = 0.1492), $J2_{auditors}$ (M = 0.8208; SD = 0.1157), and $J3_{auditors}$ (M = 0.5167; SD = 0.2049). However, the test of hypothesis H_{1A} shows that auditors and accountants did not significantly increase percentages in the estimates presented in J2 and that auditors and accountants did not show significant differences between J1 and J2. The statistical significance of the Wilcoxon test statistics (z = -0.935 and -1.388) corresponded to 0.350 and 0.165, respectively. After testing hypothesis H_{1B}, it was observed that the groups significantly reduced the percentages in J3. Auditors and accountants showed significant differences between J2 and J3, as the statistical significance of the *t* statistics (*t* = 6.392 and 4.003) corresponded to 0.000 and 0.002.

The test of hypothesis H_{2A} shows that the two-tailed significance levels for Mann-Whitney's *U* test (J1 = 71.5) and the *t* test (J2 = -0.030 and J3 = -0.304) were equal to J1 = 0.721, J2 = 0.976, and J3 = 0.764. These results demonstrate that there were no significant differences between the groups regarding the issued going concern estimates. The test of hypothesis H_{2B} showed that 75% of auditors and 53.85% of accountants chose report 2 (no modification and with an emphasis paragraph). Although, the accountant group did not concentrate on the choice, as 46.15% chose report 3 (with reservation).

After assessing the frequency of the auditors and accountants' reports, the chi-square test reveals whether the reports' issues are associated with the groups in this experiment. The χ^2 coefficient was equal to 5.791 (p = 0.055), which supports the findings from the frequency analysis. The fact that the accountants did not follow the auditors' pattern of choice (report with an emphasis paragraph) may have been due to a lack of knowledge on the abovementioned audit standard. The accountants issued reservations for the financial statements without even obtaining information on how the companies used accounting standards in their elaboration. As the reports were without modifications, with an emphasis paragraph and with reservations, they obtained the highest frequencies in the accountants' decisions. Taking into account the lack of knowledge of the auditing standards, it is assumed that the choices were due to similar reasons.

Thus, the results confirm the similarity between the groups' judgments. Auditors and accountants did not show significant differences between the initial judgments (J1) and the first revision (J2) after accessing the block of positive evidence. After obtaining the negative evidence, the second revision (J3) was significantly lower than the second judgment (J2), showing a greater sensitivity to negative information. Although the two groups made similar decisions regarding the going concern probability, they diverge in terms of the pattern of the reports issued, which indicates decisions based on processes of reason that produce analogue judgments. Concerning the report chosen types, the specific knowledge about auditing standards can explain the pattern the auditors followed.

It should be highlighted that the original research protocol contained an initial bias in the general information about the audit, which would show a tendency towards adopting low probabilities in the first judgment (J1) (Asare, 1992). This bias was characterized by the indication that there were doubts about the entity's ability to continue as a going concern, relating to the financial statements, which showed increasing losses in the last two years despite having a rise in gross profits. Nevertheless, the auditors and accountants showed no sensitivity to this bias, concerning the continuity of high average percentages in J1.

4.2 Analysis of Cognitive Brain Maps

4.2.1 Factorial maps.

As highlighted earlier, the main components' analysis showed the factors that were classified as brain processing patterns in each of the executed task steps (R1 to R17), as presented in Figure 1. When testing physiological hypothesis H_{3A}, a higher frequency of strong and significant correlations was observed ($p \leq 0.05$) among the judgments J1, J2, and J3, and the decision (D) of the group of auditors (38.89% strong, 27.78% moderate, and 33.33% not significant), while the accountants showed a larger quantity of nonsignificant correlations (15.38% strong, 30.77% moderate, and 53.85% not significant). This supports the operational hypothesis H_{3A} and characterizes the greater homogeneity of the brain processing standards found in the group of auditors.

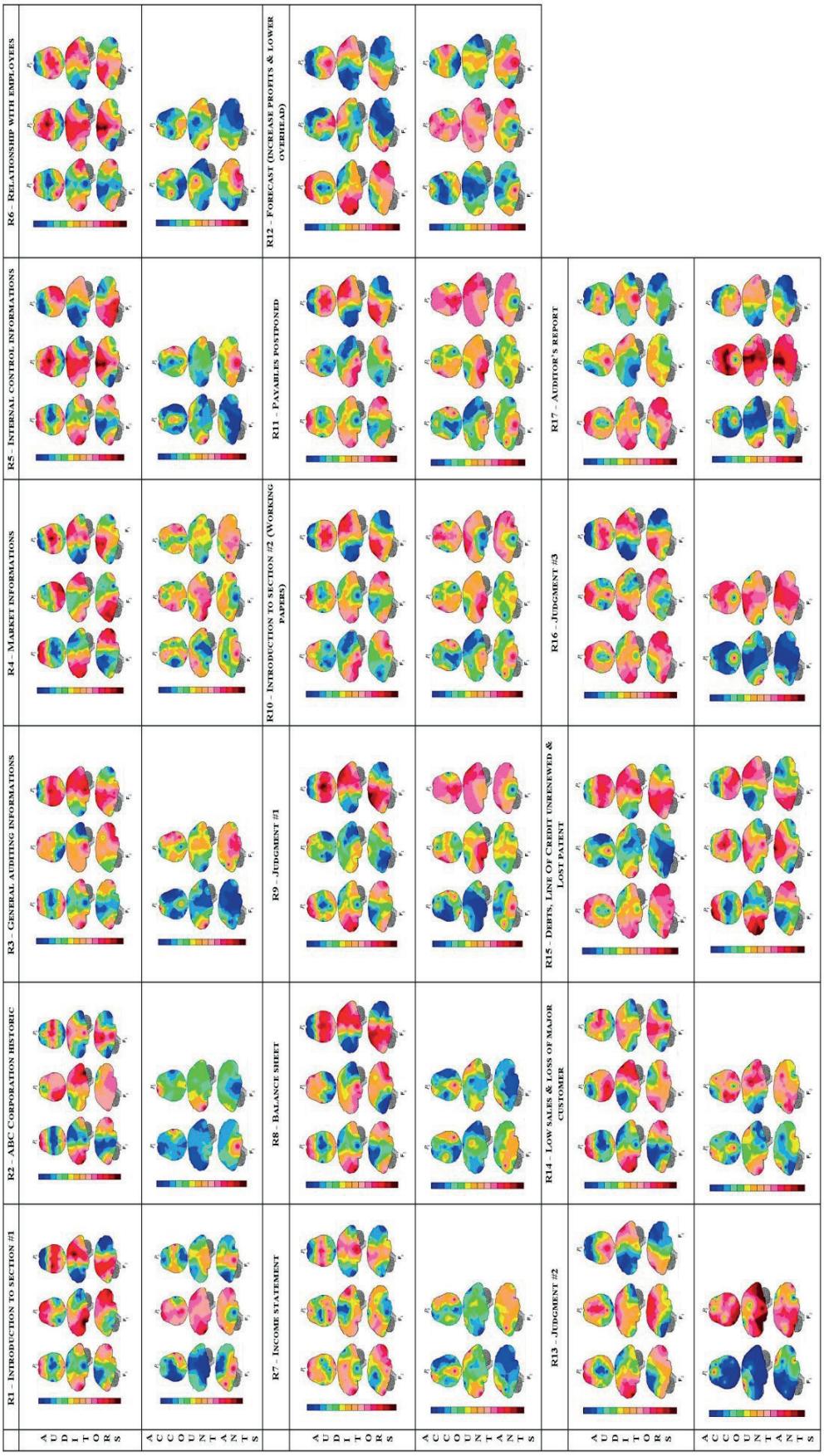

Figure 3 *Factorial maps of auditors and accountants (brain processing patterns)*
Source: *Prepared by the authors.*

With a view to falsifying hypothesis H_3, the operational hypothesis H_{3B} was also tested. In this case, neural evidence was sought for the conflict in the decision-making process as well as for the accountant group's greater cognitive effort. The frequency that groups presented only two brain processing patterns (P_1 and P_2) during the task was assessed and showed expected brain activity only for the accountant group, which supports hypothesis H_{3B} of this study. During the 17 information blocks presented in the course of the task, the accountants showed two processing patterns in nine blocks (52.94%), while the auditors presented three blocks in the course of the entire task. In addition, the activation volume of the front medial electrode was assessed as a proxy of the neuron activation in the ACC. In view of the brain activities captured through the EEG, where the accountants showed activation in 15 blocks (88.24%) and the auditors in seven (41.18%), the activation of the front medial cortex strongly indicates greater activity in the ACC, which also supports the operational hypothesis H_{3B}.

After analyzing the existing correlations between the brain processing patterns, nonparametric MANOVA was used to quantify the difference between the brain processing patterns of auditors and accountants (F = 6.095 and p = 0.0002). The results show that the combined dependent variables (brain processing patterns) differentiate between the two groups of professionals.

4.2.2 Cognitive maps of regression.

Brain mapping for the regression between the going concern assumption probability judgments (J1, J2, and J3), the type of independent audit report (D), and the EEG electrodes showed the brain areas where auditors and accountants' decisions were maximized (minimized), as highlighted in Figure 3. After calculating Pearson's coefficients, the RCM demonstrated that the auditors showed moderate and significant correlations between J1 and J2 (r = 0.665) and between J1 and J3 (r = -0.552). The remaining correlations between J1 and D (r = -0.397), J2 and J3 (r = -0.198), J2 and D (r = -0.294), and between J3 and D (r = -0.009) are not statistically significant. No negative correlations were found between the accountants' regression maps. The significant correlations of the maps found between J1 and D (r = 0.725) are highlighted, which were strong, besides the moderate and significant correlation between the maps of judgments J1 and J3 (r = 0.453) (Dancey & Reidy, 2006; Martins & Theóphilo, 2009).

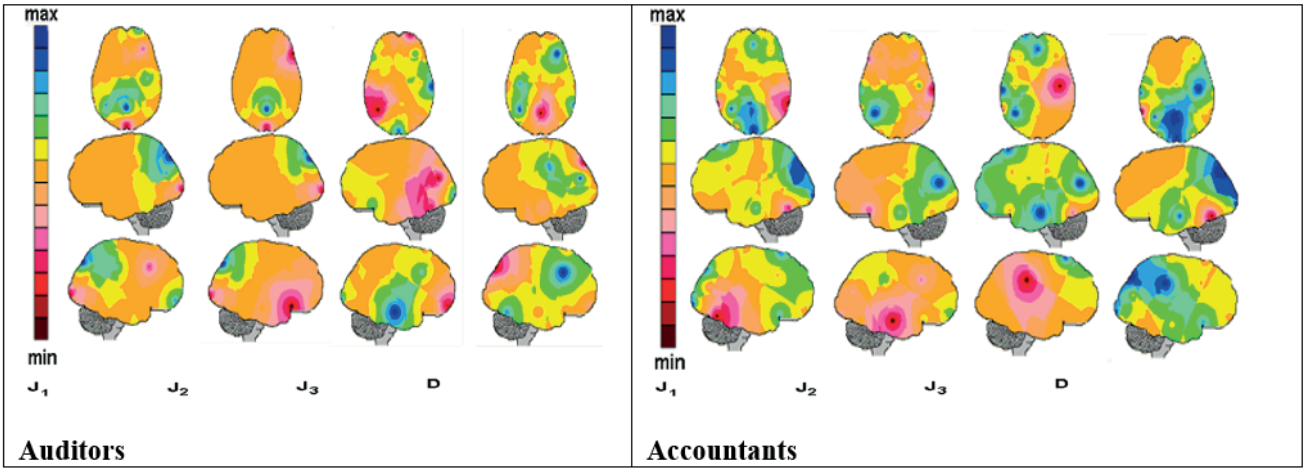

Figure 4 *Regression maps of judgments*
Source: *Prepared by the authors.*

Nonparametric MANOVA was used to quantify the existing differences between the RCM for auditors (A) and accountants (C). The analogue F statistics produced based on Anderson's (2001) algorithm (F = 0.4692, p = 0.763) shows that the combination of dependent variables (regression maps) does not differentiate between the two groups (auditors and accountants).

After discovering the associations between the RCM of auditors and accountants with the nonparametric MANOVA results, the operational hypotheses H_{4A} and H_{4B} are falsified according to each equality premise between the groups. These hypotheses were used to test hypothesis H_4, where concern for the judgment's social impact culminates in the assessment of risks and benefits, regarding the audited company's operational continuity, which is processed in the SDS, according to Rocha and Rocha (2011) and Singer (2009). Thus, the maximization of initial judgments (J1) for the group of auditors did not indicate an association between shown percentages and the SDS. This reveals a link between these percentages and the coding of the decision (parietal neurons) and action planning (frontal neurons). It should also be highlighted that the auditors and accountants showed high mean (statistically similar) going concern coefficients. The association between the maximization and activity of the frontal central area in accountants indicates the activation of ACC neurons that is characterized by the occurrence of conflicts and classified by Singer (2009) as part of the brain networks involved in understanding third parties.

In regards to the minimization of initial judgment percentages (J1) observed in the RCM, the accountants minimized the judgments according to the activation of neurons in the back temporal lobes. Thus, it is highlighted that SDS is associated with the assessment of social risks and benefits with going concern assumption judgments through the issuing of lower percentages in the required estimates.

In the RCM for the second judgment (J2), again signs are highlighted that link the accountants' assessment of risks and benefits with SDS. After accessing positive information, or evidence that supports going concern, the accountants activated neurons more intensely from the right temporal lobe, which showed a reduction in the percentages.

After accessing negative information or evidence that rejects going concern, the auditors maximized the entity's percentages to continue as a going concern (J3) in the right temporal lobe and minimized estimates in the parietal and temporal lobes, which could be registering activity of the cortex in the superior temporal sulcus, temporal-parietal junction, and temporal pole. The accountants also maximized judgments in the left temporal and frontal medial lobes, which features the assessment of risks and benefits in the SDS.

Considering the individuals' perceived risk of disruption of the audited company's activity until the end of the next year, the only acceptable alternative independent audit reports would be reports without modification (no risk of disruption) and no modification with an emphasis paragraph (with risk of disruption). Thus, minimizing opinions towards one of the correct reports demanded the activation of the accountants' left temporal lobe, which showed the influence risk and benefit assessment through the SDS. However, although less intense, neurons from the temporal lobe seemed to be associated with the maximization of the reports issued by auditors and accountants. This scenario reveals support for the physiological hypothesis H_4.

Although the accountants showed a more frequent maximization (minimization) of the going concern probability according to the perceived benefit (risk) from the SDS perspective, MANOVA yielded no significant differences between the groups. Thus, the accountants maximized judgments 1 and 3 in addition to showing moderate maximization of the opinion and minimization of judgments 1, 2, and the final decision. The auditors also revealed signs of reasoning based on the perception of third parties for judgment 3 (maximization and minimization) and the final decision (maximization).

5. FINAL REMARKS

At this moment, the proposed research problem can be answered as follows: the brain processing patterns shown through cognitive brain mapping follow the behavioral patterns in the sequential assessment of information for judgments about the entity's ability to continue as a going concern, according to the individuals' expertise. This study therefore demonstrates auditors' brain activity in the execution of this type of task, as opposed to the judgments of other accounting professionals.

The study was designed to collect exploratory evidence for the brain correlates of going concern assumption judgments, as well as for the brain processing patterns found while viewing the audited company's information. Different studies have presented behavioral evidence

related to the occurrence of errors in these kinds of judgments, besides possible forms to avoid them. The use of tools developed in neuroscientific and neuroeconomic research permitted the understanding of brain physiology that is associated with this accounting decision, as proposed by Dickhaut (2009) and Dickhaut et al. (2010). It also allowed for an explanation of the extent to which brain mapping patterns followed the behavioral patterns of auditors and accountants' judgments.

In agreement with belief revision theory, the behavioral hypothesis H_1, where the groups manifested greater sensitivity to negative information, was found. Hypothesis H_2 was also supported, as the groups showed no significant differences between their judgments. Both groups presented biased judgments with statistically similar proportions, which is in line with Hogarth and Einhorn (1992).

Hypothesis H_3 was supported, which demonstrated the auditors' well-defined reasoning and greater brain conflict during the accountants' decision-making process. Despite biased judgments, the auditors and accountants' brains process the information through the use of different neural resources. H_4 was also supported, as there was a lack of significant differences between the groups' RCM. There were signs of maximization (minimization) of judgments in brain areas associated with the identification of needs as well as motivations linked to the individuals' relation to their social group. This contributes to the hypotheses raised by Dickhaut (2009) and Dickhaut et al. (2010).

The main conclusion of this research is that the auditors use a well-defined set of rules to calculate the benefits and risks and subsequently determine the probability of the audited company's going concern, while the accountants try and solve the problem through analogue reasoning. When executing the task, the accountants' errors would be justified, while the auditors (experts) should consider the information and increase the level of conscious reasoning, which would (or should) guarantee "rational" decisions. However, the behavioral results show biased judgments in terms of the weight attributed to the negative evidence, despite revealing homogeneous brain processing patterns for auditors and greater cognitive efforts for accountants. This shows the use of different reasoning to produce similar judgments.

Despite familiarity with the executed task and knowledge of auditing standards (specifically NBC TA 570), as a result of the greater use of algorithmic reasoning, the auditors' judgments were similar to that of accountants. On the other hand, the accountants' greater cognitive effort, due to the experiencing of greater conflict in the decision-making process, made them use more quantic brain processing abilities, which are responsible for conscious reasoning. This was observed in the maximizations (minimizations) of the estimates in brain areas related to concerns with the judgments' social repercussions, which culminated in some degree of "conservatism" in their decisions (Botvinick et al., 2004; Egneret al., 2007; Fan et al., 2003; Gehring & Fencsik, 2001; Rocha & Rocha, 2011; Singer, 2009).

Moreover, these findings reveal another opportunity to discuss the assumption of the brain as the original accounting institution. In this sense, the signs of maximization (minimization) of the judgments in brain areas associated with the SDS contribute to the discussion of the initial hypotheses by Dickhaut (2009) and Dickhaut et al. (2010), regarding the historical evolution that originated the accounting principle of going concern.

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