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NEUROSCIENCE APPLIED TO NUCLEAR ENERGY TEACHING

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ABSTRACT

Science and technology play a key role in helping countries increase the quality of life of their inhabitants. The development of peaceful nuclear applications offers important contribution for several fields. However, nuclear accidents are reported as factors that lead to the formation of prejudiced beliefs and attitudes against nuclear technology. The media also influence on what people believe about it. Holding prejudice against nuclear technology will lead to misconceptions and interfere with authorities' decision on the development of new technology. There are evidences in the literature that implicit prejudices might be avoidable, reduced and even reversed. Interest in prejudice and stereotyping is currently shared by emerging disciplines such as neuroscience. The field of educational neuroscience has developed several types of implicit association tests aiming to assess implicit prejudices that individuals are consciously unaware. As far as prejudices are reported in the nuclear energy education scenario implicit measurement techniques can be an effective tool to identify and measure prejudices against nuclear technology. The Implicit Association Test (IAT) is a valuable tool used worldwide as a measurement technique to assess implicit attitude toward discriminatory behaviors. This study aims to demonstrate the design and development of a neuroscience-based methodology, which will include a future administration of the IAT to school teachers to assess their implicit associations regarding nuclear energy. The procedure will contribute for understanding implicit prejudices interfering with teaching practices. Teaching a balanced view about the applications of the nuclear technology will contribute for the acceptance of nuclear technology.

1. INTRODUCTION

Science and technology play a key role in helping countries increase the quality of life of their inhabitants. The development of peaceful nuclear applications offers important contribution for several fields such as medicine, pharmaceutical industry, and agriculture, among others. Despite all benefits that result from the peaceful uses of nuclear technology, it is still addressed with prejudice.

A literature review demonstrated that the theme is still addressed with prejudice due to an incorrect view of nuclear energy and a limited view of its benefits [2]. Even knowing about the benefits of nuclear technology, people retain their fears of the potential for nuclear energy to cause widespread damage or disaster.

Nuclear accidents are reported as factors that lead to the formation of prejudiced beliefs and attitudes against nuclear technology. The atomic bombing of Hiroshima and Nagasaki during World War II (1945), the Three Mile Island accident (1979), the Chernobyl accident (1986), the crash of the cesium-137 in Goiânia, Brazil (1987), and the recent accident in Fukushima (2011) may have been responsible for the negative image of nuclear energy [3].

Holding prejudice against nuclear technology will lead to misconceptions and interfere with authorities' decision on the development of new technology. There are evidences in the literature that implicit prejudices might be avoidable, reduced and even reversed [4,5]. Interest in prejudice and stereotyping is currently shared by emerging disciplines such as neuroscience.

The field of educational neuroscience has developed several types of implicit association tests aiming to assess implicit prejudices that individuals are consciously unaware [6-9]. As far as prejudices are reported in the nuclear energy education scenario implicit measurement techniques can be an effective tool to identify and measure prejudices against nuclear technology. The Implicit Association Test (IAT) is a valuable and reliable tool used worldwide as a measurement technique to assess implicit attitude toward discriminatory behaviors [10].

This study aims to demonstrate the design and development of a neuroscience-based methodology, which will include the administration of the IAT to school teachers to assess their implicit associations regarding nuclear energy.

2. MATERIAL AND METHODS

The first step of the methodology consisted of reviewing the literature about nuclear energy education worldwide. The literature review provided a clear visualization of the global nuclear energy educational scenario. The data provided by the literature review showed that: a) people still retain their fears of the potential for nuclear energy to cause widespread damage or disaster; b) nuclear technology should be better addressed by science textbooks and students should be encouraged to research more about it; and c) there was absence of a neuroscience-based approach to the process of teaching and learning about nuclear energy. The literature review served as a reference for the design of the proposed methodology [2].

The second step consisted of selecting a reliable implicit memory test to measure implicit attitudes [11].Among the various types of tests reported in the literature, the Implicit Association Test (IAT) demonstrated to be widely administered with successful results [12-14].

2.1. The Implicit Association Test (IAT)

The IAT is a chronometric procedure that measures the relative strength of associations by contrasting latencies across conditions. It is designed to reveal the automatic associations subjects hold between concepts (e.g. nuclear and oil) and attributes (e.g. good or bad) by asking the participant to rapidly pair concepts and associated constructs.

The *Free*IAT software was used to administer the IAT proposed by this study [15]. Besides being highly customizable, the main features of the software include scoring using D algorithm provided in output and two output files being one with full raw data and one with only scores. By following the steps provided by the *FreeIAT*, a customized IAT was built aiming to compare the implicit associations of participants towards the use of nuclear energy and oil.

For this purpose, the word stimuli for the first stimuli set was labeled and specified. Ten words were chosen being 5 positive and 5 negative. The positive words (good) were: peace, safety, protection, healthy, and joy. The negative words (bad) were: tragedy, horrible, bad, harmful, and sadness.

Additionally, the word stimuli for the second stimuli set was labeled and specified. 20 words were chosen being 10 for "nuclear" and 10 for "oil". The words for "nuclear" were: *fission*, *radiotherapy, radioisotopes, neutron, uranium, Angra 2, radiation, reactor, radiopharmaceuticals*, and *plutonium*. The words for "oil" were: *gasoline, kerosene, asphalt, pre-salt, platform, Petrobrás, pipeline, drilling, diesel,* and *fossil.*

The IAT procedure has five steps, with steps 3 and 5 providing critical data. The participants see the stimuli (words) that are presented sequentially in the center of the computer screen and are asked to respond as fast as possible by pressing the "E" key if the word belongs to the category on the left and the" I" key if the word belongs to the category on the right. Participants perform this categorization task until all stimuli have been presented several times.

Typically, there are 40 trials within each critical block (3 and 5). For each trial in all stages, the stimulus name and the response time (in milliseconds) is recorded. A counter tracks how many trials have been administered in each stage. When the maximum number of trials has been reached for a given stage, the program clears the screen and displays the relevant category labels for the next stage's stimuli so that respondents may examine them before beginning the next stage.

During each trial, information is stored regarding the current stage, what stimulus was administered, how long (in milliseconds) until a correct response was entered, and whether an incorrect response was given. This information is used to compute scores and is reported in the output. Two output files are created: the 'AllData.txt', which is a file containing all raw data from all trials and the 'ScoresOnly.txt', a file containing only the most relevant "final" scores. The IAT effect is calculated by using latency data from steps 3 and 5.

In order to demonstrate the 5 steps of the IAT designed for this research, one example of possible association will be provided in Figures 1 to 5.

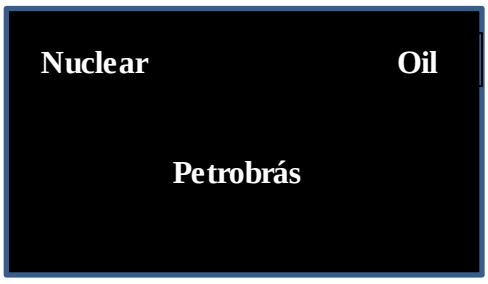

Figure 1: Demonstration of step 1: the concept dimension

Figure 2: Demonstration of step 2: the attribute

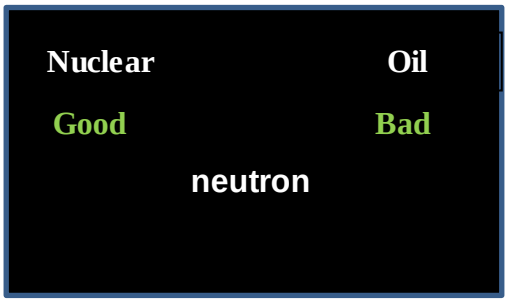

Figure 3: Demonstration of step 3: concept-attribute

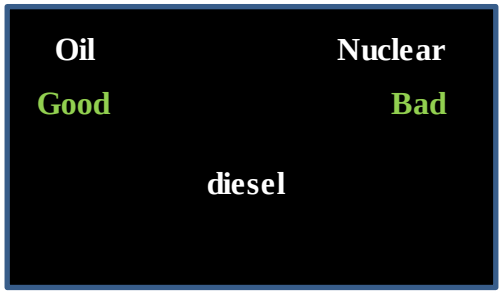

Figure 4: Demonstration of step 4: switching the spatial location of the concepts

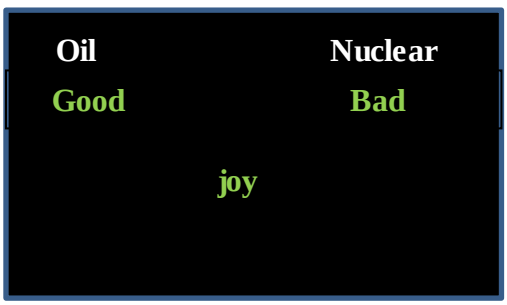

Figure 5: Demonstration of step 5: the categories are combined in an opposite way

2.1.1. Pretest

According to Hair et al., when items of a measurement instrument are developed specifically for a study, a pretest should be taken before the main experiment is carried out [16].

To measure the strength of implicit associations towards nuclear energy and oil a pretest using the customized IAT was administered to 24 professionals from the Nuclear Engineering Center at the Instituto de Pesquisas Energéticas e Nucleares (IPEN), being 14 male and 10 female subjects.

The participant´s age ranged between 29 and 69 years old and time of professional activity at IPEN ranged between 5 and 40 years. Of the 24 respondents, 41.6% are engineers, 45.8% are physicists and 12.6% are environmental experts.

3. RESULTS AND DISCUSSION

Of the 24 respondents, 87,5% demonstrated positive automatic associations towards nuclear energy and 12,5% towards oil. The high percentage of positive associations towards nuclear energy was an expected result since the subjects have deep knowledge about the applications of nuclear energy (Fig 6).

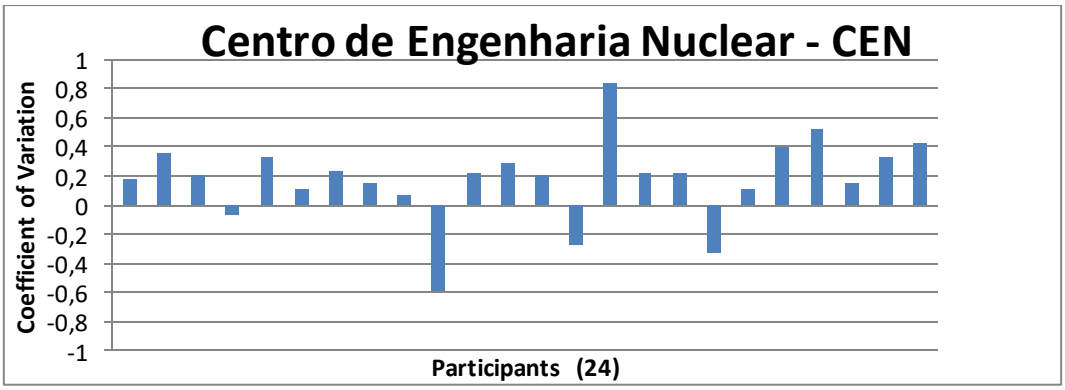

Figure 6: Representation of the scores of the implicit associations towards nuclear energy and oil

100% of the physicists, 80% of the engineers, 50% of the environmental experts demonstrated more positive associations towards nuclear energy than to oil. The time of professional activity did not demonstrate to be a significant aspect for the results (Fig. 7,8).

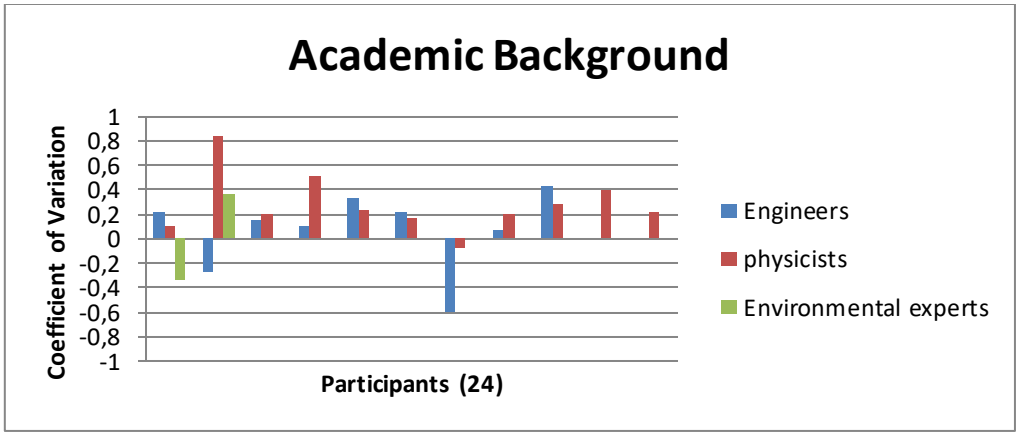

Figure 7: Representation of the scores of the implicit associations towards nuclear energy and oil according to academic background

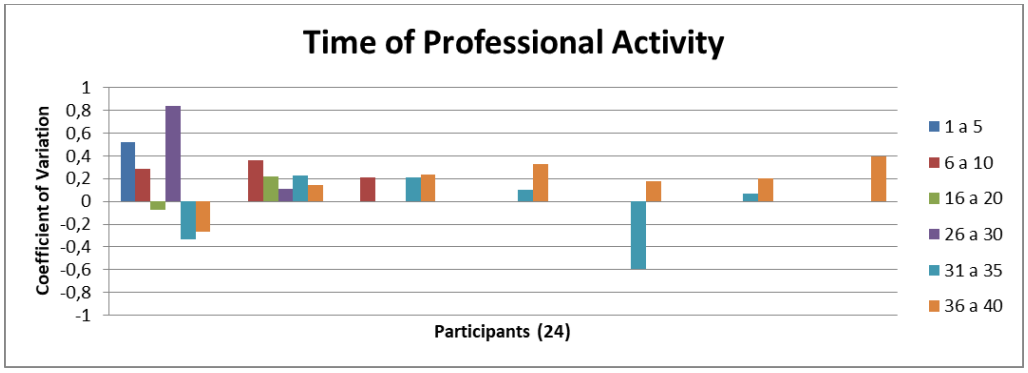

Figure 8: Representation of the scores of the implicit associations towards nuclear energy and oil according to time of professional activity

Regarding gender, 85,7% of male subjects and 90% of female demonstrated positive associations towards nuclear energy; however, the strength of positive associations held by the female had higher values (Fig. 9).

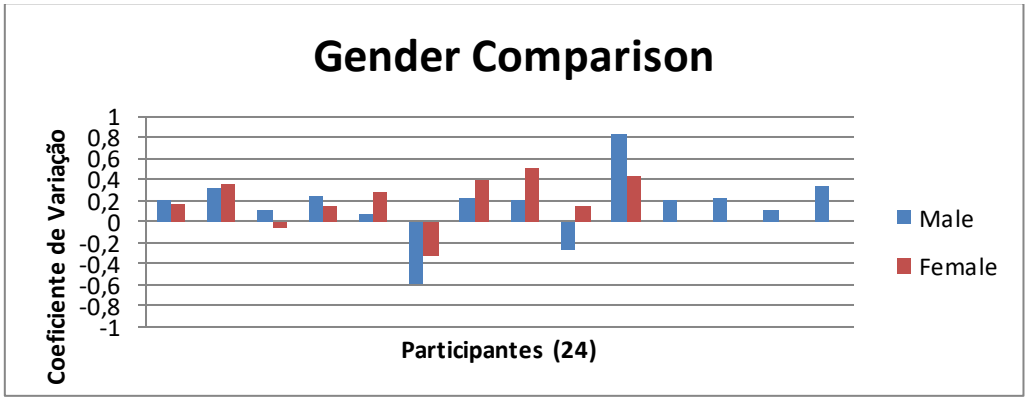

Figure 9: Representation of the scores of the implicit associations towards nuclear energy and oil according to gender

Regarding age profile, 12,5% of the subjects who demonstrated more positive associations towards oil were over the age of 50 years. Younger respondents tended to demonstrated more positive associations to nuclear technology (Fig 10).

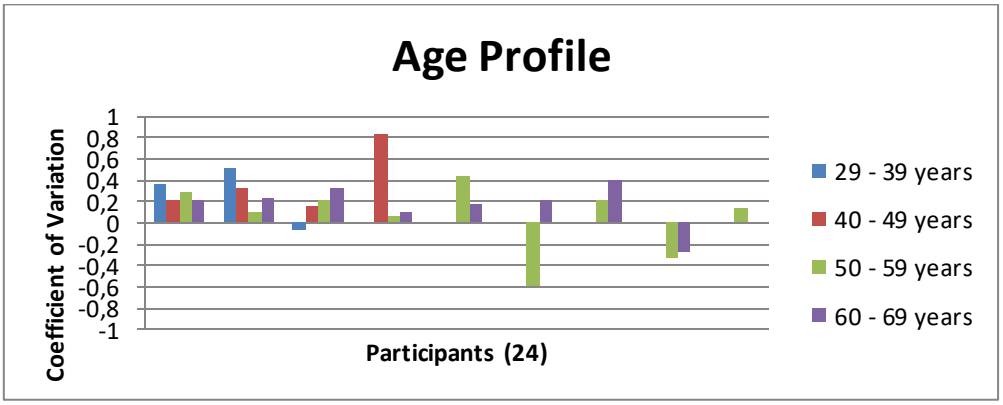

Figure 10: Representation of the scores of the implicit associations towards nuclear energy and oil according to age

The Cronbach´s alpha was applied to measure the reliability of the test The value of *alpha* ranges from zero (unreliable) to one (perfect reliability), with a value of .70 or greater considered acceptable for most purposes. Internal consistency should be determined before a test can be employed for research or examination purposes to ensure validity.

Table 1 shows the rule for describing internal consistency using Cronbach's alpha provided by George and Mallery [17].

Table 1: Cronbach´s alpha reliability coefficients

Internal Consistency	Unacceptable	Poor	Questionable	Acceptable	Good	Excellent
Cronbach's alpha	$0.5 > \alpha$	$0.6 > \alpha \geq 0.5$	$0.7 > \alpha \geq 0.6$	$0.8 > \alpha \geq 0.7$	$0.9 > \alpha \geq 0.8$	$\alpha \geq 0.9$

The statistical software program SPSS was used in this study to run a Cronbach`s alpha test. The value of alpha was .869, suggesting that the items have good internal consistency.

The previous steps of the methodology in progress have provided reliable data for the next steps of the research.

3. CONCLUSIONS

A neuroscience-based methodology has been designed aiming to contribute for understanding implicit prejudices interfering with teaching practices. The methodology is in progress and the steps so far have demonstrated it to be an innovative tool for educational purposes. A future step consists of administering the IAT to Brazilian Science teachers to measure the implicit associations towards nuclear energy and the results will be presented in future works.

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