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Influence of and Resistance to Nudge Decision-Making in Professionals

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Abstract: This study investigated how professionals' decision-making is influenced by nudging and their resistance to such a form of conditioning. A total of 61 professionals performed a nudge task in which three different scenarios related to wellbeing and sustainable behaviours were presented to the participants under boosted and soft nudge conditions. After the presentation of each scenario, participants were required to decide between two options of choice: one choice was more nudge-induced, the other was not. Electrophysiological (EEG), autonomic, behavioural, and self-report data were collected to determine the correlates of resistance with nudge conditions. The findings showed that professionals' resistance to nudging is high and not influenced by boosted or soft nudges. Also, while the generalized increase in EEG delta, theta, and beta power localized and lateralized in the right temporoparietal regions can lay the foundation of "the neural architecture" of resistance to nudging, the significant increase in SCR for the boosted compared to soft condition highlighted the pivotal role of this marker as the only indicator that differentiates the two nudge conditions. Overall, evaluating the correlates of the resistance to nudge can be useful to render professionals aware of the explicit and implicit factors to be strengthened to resist to such form of conditioning.

Keywords: nudge; bias; decision making; EEG; biofeedback; sustainable behaviours

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1. Introduction

When we have to make decisions, the environment that surrounds us can influence our decisions in ways that we are not always conscious of. Among the shortcuts that can favour information processing when facing a decision, nudging represents a concept derived from the field of behavioural economics that has gained significant importance in recent years due to its ability to influence human decision-making processes and alter people's behaviour in a predictable way.

In this article, we present the results of an ecological neuroscientific study conducted in the organizational field and aimed at exploring the neural and psychophysiological correlates of professionals when facing nudge conditions. Regardless of the nudge's beneficial or harmful effects, this article discusses the importance for professionals to be knowledgeable about how to resist being influenced by nudging tactics for a more aware decision-making process. To the best of our knowledge, this is the first time that a neuroscientific approach has been applied in an organizational ecological context to explore the construct of resistance to nudging, an aspect that constitutes an element of originality of the study.

1.1. Theoretical Framework

According to its classical definition, nudging entails subtly modifying the architecture of choice in order to steer individuals toward desired decisions while still preserving their freedom of choice [1]. This concept has been defined as the strategic and deliberate use of a decision-making environment designed to influence people's choices without resorting to coercive measures. Various types of nudges [1] have been exploited in several different fields, ranging from health care [2,3] to public health lifestyles [4,5], and from the financial market [6] to consumer psychology, as a behavioural strategy to influence consumer behaviour [7–10].

Recently, several studies showed how nudging can positively promote sustainable consumer behaviour, such as sustainable shopping lifestyles and fashion consumption [7,8,11] and reduce food waste behaviour [12–14]. Other works highlighted how individuals should be fully aware of their decision-making behaviour and choice in order to adopt and maintain sustainable behaviours [15].

Regardless of the value dimension, nudging consists of a reinforcement strategy, which is a form of conditioning, that indirectly influences the individual's decisions, based on the architecture of choice [16–18]. As a behaviour change strategy, nudging has been criticized by several authors in the field of ethics and raised conceptual and controversial issues regarding the conditions under which nudging can be used effectively and acceptably [19–23].

So far, relatively little attention has been devoted to the concept of "resistance to nudge", considering nudging as a form of conditioning. In fact, the influence of cognitive biases and the nudging mechanisms on decision-making processes can, on one hand, assist individuals in simplifying complex choices, guiding them towards advantageous options, or promoting desirable behaviours. On the other hand, such influences can also lead to unconscious decisions and favour choices that are not fully aligned with individual interests or limit full decisional autonomy. Therefore, in our opinion, to be able to resist a nudge (regardless of its positive or negative purpose) means to be able to resist a form of conditioning and lays the foundations to become the "true choice architect" of one's own decision-making process, to say it in Thaler's terms, especially when a critical, risky, and professionally impactful choice must be made. However, to the best of our knowledge, considering professional contexts, no previous studies have explored how professionals' decision making is influenced by nudges, and, specifically, if professionals are able to resist such form of conditioning.

In fact, recent research has demonstrated that professionals' decision making (across different occupational areas: management, finance, medicine, and law) is often influenced by heuristics, i.e., simple strategies for processing information, which might end in predictable errors named cognitive biases [24]. Just as it is relevant for professionals to become aware of the existence of cognitive biases in general and more specifically of their own cognitive biases to make a more conscious choice, we think it is also important to become aware of nudged choices and know what aspects to work on to become resistant to the nudge so as not to suffer conditioning of choice.

With reference to the application of nudging in various contexts, it has been demonstrated that different types of nudges can induce a certain type of choice. For example, Roozen and colleagues [8] explored whether verbal and visual nudges influence consumers' choices for sustainable fashion. Through an online survey, the results showed a significant positive influence of verbal nudges and, to a lesser extent, of visual nudges on choosing a sustainable version of clothing. The relationship between individual differences and nudge effects has also been previously explored [25,26]. Adhering to nudged choices is not always positive; indeed, the support for nudging policies can be detrimental for sustainability issues, as they are seen as a good alternative to other more effective policies [27]. Also, a recent meta-analysis showed no behavioural effects of nudging after adjusting for publication bias, except for on food choices [28,29]. Nevertheless, not enough attention has been given to the ability to resist nudging mechanisms in applied contexts, such as in organizations, or from a neuroscientific perspective.

In a relatively recent contribution, Felsen and Reiner [30] highlighted that neuroscience is the big absentee in the debate and claimed that neuroscience can contribute to making nudges more effective. Indeed, a neuroscientific approach can provide a range of information on the neural basis of the information processing related to nudging. For instance, through the application of neuroscience techniques such as the electroencephalogram (EEG), it is possible to explore the neural correlates supporting the decision-making process [31,32]. In particular, the analysis of the EEG cortical oscillations (delta, theta, alpha, beta, and gamma) that occur in specific brain areas can be informative in terms of understanding the cognitive and emotional processing of information associated with decision making; moreover, their functional meaning can take on a specific connotation based on their cerebral location, or the area in which they occur [33–35]. For instance, frontal theta accounts for individual differences in the cost of conflict in decision making [36]. A higher presence of the delta band in the frontal and parietal areas has been associated with the coordination of somatosensory aspects during the decision-making process [37]. Also, the higher presence of the beta band in the right posterior regions was previously associated with endogenous switching between rivalling precepts during a perceptual decision-making task [38].

So far, relatively few studies have investigated the effects of nudging with the adoption of EEG metrics and have mainly used compound EEG indices of engagement and enjoyment to explore the effectiveness of feedback in energy demand management [39], or tested the effects of default options, as a form of nudge, in the framework of distributive justice through event-related potentials [40]. To the best of our knowledge, no previous studies have exploited EEG frequency bands to examine the neurophysiological responses of people when exposed to nudge conditions or the processes related to nudge resistance.

To obtain a more comprehensive account of these phenomena, the combination of multiple neuroscience techniques through a multimethodological approach [41–44] could also provide information on the underlying cognitive and emotional processes supporting the resistance to nudging. Indeed, for instance, the collection of autonomic nervous system activity through a biofeedback (BIO) device allows individuals' levels of personal involvement and emotional engagement experienced during decision-making process in different contexts to be investigated.

For example, taking into consideration a moral decision-making scenario, previous studies demonstrated that cardiovascular (heart rate, HR) variations can provide information on the emotional impact and salience of a moral decision context for individuals [45]; meanwhile, as showed by other studies [46,47], variations in the skin conductance response (SCR) can provide information on individuals' level of emotional arousal experienced according to the benefits or losses of moral decisions. Previously, the application of autonomic measure recording was applied in the organizational context to investigate the autonomic correlates of moral decision-making processes in a sample of professionals [48]. However, no previous BIO-EEG studies have explored the resistance to nudging in an applied context, such as the organizational one.

In this context, the integration of BIO-EEG measurements with behavioural and self-report metrics could prove useful to prevent classical method and social desirability biases [39,49,50]. On the other hand, to obtain a complete overview of the phenomenon, the application of neuroscientific techniques can be also complemented with self-report scales exploited to measure individuals' personality traits and decision-making styles. Indeed, previous studies that investigated nudging exploited the Big Five Inventory (BFI) [51] and the General Decision-Making Style (GDMS) [52] to highlight that the nudge mechanism can have a different effect based on individuals' personality traits [25] and decision-making styles [26].

1.2. The Current Study

Given these premises, in this study, a neuroscientific multimethodological approach that integrates both behavioural and neural measures to investigate the explicit (self-report measures) and implicit (EEG and autonomic measures) was adopted to study the resistance to nudging in a sample of professionals. To the best of our knowledge, no previous neuroscientific studies have investigated the resistance to nudging, or, especially, its significance in the professional field.

For this experiment, different realistic scenarios related to the promotion of wellbeing in terms of physical health, environmental sustainability, and healthy eating were presented to the participants. A sample of professionals who work in the company was selected, as a more ecological sample, halfway between university students and consumers, to which to propose scenarios related to wellbeing and conscious and sustainable choices in everyday life. For each scenario, different situations were randomly presented to the participants, with a different "degree of nudging", and at the same time there was a request to use increasingly significant skills to resist the nudge: in the soft nudge condition, the picture of the scenario was followed by a verbal indication that confirmed the nudge mechanism, while in the boosted nudge condition the picture of the scenario was followed by a verbal indication that confirmed the nudge mechanism showed in the picture, but also reinforced the importance of adopting wellbeing behaviours.

Following the presentation of the scenario, the participants were required to make a decision between two options of choice: one choice was more nudge-induced, and the other was not.

During the task, the electrophysiological (EEG frequency bands) and autonomic data (cardiovascular indices of HR and the electrodermal activity, including SCR) were collected to obtain the cognitive effort and control needed for making a decision and the emotional implicit correlates of the resistance to the nudge. Moreover, response times (RTs) were collected as an indirect measure of cognitive workload to evaluate the effort exerted by participants in formulating a choice for each realistic sub-scenario. The inclusion of this measure of cognitive effort allowed for evaluating participants' responses while considering the cognitive load involved in the identification and decision-making processes that underlie the resistance to nudging. In addition to the behavioural measures, the self-report BFI and GDMS were administrated to measure the participants' personality traits and decision-making styles.

On this basis, this study exploited for the first time a multimethodological neuroscientific approach to explore how professionals' decision-making is influenced by nudges, and if professionals are able to resist such form of conditioning.

Firstly, it is hypothesized that both boosted and soft nudge conditions can influence professionals' decision-making process to varying degrees. Specifically, in line with previous evidence [8], the boosted nudge condition is expected to influence the decision-making process, driving participants to select the nudged option more often (in terms of the total number of responses) and decrease RTs compared to the soft nudge condition.

Also, we expect to observe specific effects on the behavioural data linked to personality traits and decision-making styles. A negative correlation is expected between the BFI conscientiousness subscale scores and the resistance to nudging (in terms of a lower total number of boosted and soft nudge responses), since an organized and self-disciplined personality could be more rigidly goal-oriented and may yield a nudged option more often. Additionally, we expect a positive correlation between the BFI openness and emotional stability subscale scores with the resistance to nudging (in terms of longer boosted nudge RTs), since being emotionally stable, with an imaginative attitude and being open to new experiences, could support an aware consideration of multiple alternatives and not only the nudged one, with a longer time needed to process the alternatives. Similarly, high avoidant GDMS style scores could correlate with resistance to nudging (in terms of greater total boosted nudge responses and boosted nudge RTs), as having an avoidant approach to a decision could translate into more non-nudged choices and more reaction time needed to make the decision.

For the EEG data, we expect to observe a higher presence of the frontal theta band as a mechanism of the heightened cognitive control [36,53] needed to resist the boosted compared to the soft nudge condition, since theta EEG power typically increases with increasing attentional demands and/or task difficulty [43]. Moreover, a greater frontal and parietal delta band, as a marker of the arousing power of stimuli [54] and the need for high-level information integration mechanisms due to nudge resistance [37,55], is expected for the boosted compared to the soft nudge condition. Finally, we hypothesize a greater presence of the beta band in the right posterior regions (TP10) in relation to a heightened cognitive control in conflictual conditions [38] as a marker of resistance to nudging for the boosted compared to the soft nudge condition.

Finally, concerning the autonomic data, we expect to observe higher HR and SCR values for the boosted compared to soft nudge condition, representing the high cognitive and emotional engagement involved in processing a choice in the boosted condition.

2. Materials and Methods

2.1. Sample

A group of 61 professionals, including 40 females and 21 males (mean (M) age = 34.58, standard deviation (SD) age = 11.44), were recruited for this study, considering multiple organizations and different job specializations (e.g., management of human resources, marketing, training and professional learning, engineering and maintenance management, monitoring of service quality, management of infrastructures, and others) to ensure the sample's heterogeneity. At the time of data collection (from October 2022 to March 2023), all participants were employed by the firm for at least one year. This inclusion criterion was developed in an effort to minimize biases in data collection caused by contextual circumstances, such as increased stress from recent job changes or increased workload from adjusting to new jobs or responsibilities.

The following exclusion criteria were considered for this work: the presence of psychiatric or neurological disorders, severe levels of depression, any impairment in the level of global cognitive functioning, and ongoing psychoactive-drug-based therapy that could alter cognitive or decision-making abilities. All participants had normal or corrected-to-normal hearing and vision.

Each professional participated in the study voluntarily, without receiving any compensation, and signed a written informed consent form prior to participation. The study was conducted in accordance with the Helsinki Declaration (2013) and approved by the Ethics Committee of the Department of Psychology, Catholic University of the Sacred Heart, Milan, Italy (approval code: 2021 TD—for thesis dissertation; approval date: December 2021). This study was not preregistered. The data and materials that support the findings of this study are available from the corresponding author upon request by researchers, in order to discuss the data within a collaborative research development framework.

2.2. Method

To answer the research question and test the research hypothesis, a multimethod research protocol, which allows multilevel measurements to be collected, was applied to all participants. The selected sample of professionals performed a behavioural task, during which behavioural, autonomic, and EEG data were collected. Also, two scales were administered to collect participants' personality traits and decision-making styles. In the following sections, the experimental procedure; the behavioural task; the methods of acquiring the behavioural, autonomic, EEG, and self-report data; and how these data were analysed through statistical analysis will be described.

2.3. Experimental Procedure

The setup and procedures of the experiment were explained to the participants in a quiet meeting room at their workplace: a place selected to carry out the experiment with high ecological validity.

Participants we asked to sit comfortably in a chair positioned approximately 80 cm away from the computer on which the task was presented. After giving their informed consent, surface sensors for non-invasive monitoring and recording of EEG and autonomic activity were installed on participants. A 120 s eyes-open baseline was collected before participants were given the instruction to perform the task. At the end of the task, a set of scales and questionnaires were administrated to collect self-report data. The experimental procedure had a duration of about 20 min.

2.3.1. Behavioural Measures: Experimental Task and Data Processing

In this study, the professionals were asked to perform a nudging task developed to measure resistance to nudging that was administered through a web-based survey and experiment management platform (Qualtrics XM platform; Qualtrics LLC, Provo, UT, USA). The examinee was presented with three different scenarios related to wellbeing and sustainable behaviours (physical health, environmental sustainability, and healthy eating), on which they must make behavioural decisions.

Each scenario was composed of a picture and a verbal indication presented in boosted and soft nudge conditions (designed to render a different "degree of nudging", and, at the same time, requiring the use of increasingly significant skills to resist the nudge). In the soft nudge condition, the picture of the scenario was followed by a verbal indication that confirmed the nudge mechanism, while in the boosted nudge condition the picture of the scenario was followed by a verbal indication that confirmed the nudge mechanism shown in the picture, but also reinforced the importance of adopting wellbeing or sustainable behaviours.

After the presentation of each scenario, the participants were explicitly asked to provide a behavioural response by choosing one of the two options: one option was more nudge-induced, and the other was not.

For instance, in the healthy eating scenario, a picture of a vending machine was shown to the participants. In the "boosted" nudge condition, the participant was presented with the picture accompanied by the following verbal indication containing a verbally reinforced nudge:

> *"You are very hungry; you need to get something for lunch, but you have little time, so you go to the vending machines. Remember, health is important! What do you take?".*

Meanwhile, in the "soft" nudge condition, the same scenario was proposed without the verbally reinforced nudge (since the following sentence emphasizing that health is important was missing: *"Remember, health is important!"*). That is, the verbal indication was "*You are very hungry; you need to get something for lunch, but you have little time, so you go to the vending machines. What do you take?*").

For both conditions, there was the possibility of choosing to eat a healthy food (a salad box) or an unhealthy food (a pack of chips). In the soft nudge condition, the participant was told that he/she was very hungry and had limited time. This is a condition that verbally nudges the person to reach for the pack of chips (the quickest solution). The participant demonstrates an ability to resist the nudge if he/she chooses the salad box.

Meanwhile, in the boosted nudge condition, the picture of the scenario was followed by a verbal indication that stressed a specific nudge option (i.e., the salad) and the importance of adopting wellbeing or sustainable behaviours was explicitly reinforced ("Remember, health is important!"). The participant demonstrates the ability to resist the nudge if he/she chooses the pack of chips. The participants were explicitly asked to provide a behavioural response by choosing whether to eat the salad box or the package of chips (see Supplementary Materials).

For the behavioural data, both response scores and RTs were collected for each type of scenario.

To calculate the response scores, a score of 1 or 0 was assigned, which, respectively, corresponds to the ability to resist the nudge (i.e., the selection of the non-nudged option) or the inability to resist it (i.e., the selection of the more nudge-induced option). The scores assigned to the boosted nudge condition and the soft nudge condition for the physical health, environmental sustainability, and healthy eating scenarios were then summed to obtain a final score for resistance to nudging. A higher total score for the boosted or soft nudge responses means that participants were able to resist the nudges in the two conditions.

Similarly, RTs were taken for each of the three scenarios in the two conditions and then averaged to obtain the RTs for the boosted nudge condition and for the soft nudge condition. A longer RT indicates task-related effort due to a more effective ability to resist the presence of the nudge and evaluate different alternatives before making a decision. Shorter RTs represent less cognitive workload and cognitive conflict in making a decision.

For the statistical analysis, the total number of responses and the average of the RTs in the three scenarios were considered.

2.3.2. EEG Data Acquisition and Biosignal Analysis

To collect the EEG data during the resting state and in the task-related condition, the Muse™ headband (version 2; InteraXon Inc., Toronto, ON, Canada) was employed. Muse is a wearable EEG system with dry sensors placed following the international 10–20 system [56] and that are able to detect variations in spectral activity (standard frequency bands power: delta, theta, alpha, beta, and gamma) in a non-invasive manner (Figure 1). Specifically, the electrodes are made up of a conductive material (silver) and silicon rubber, respectively, and four of them were placed in the frontal (AF7 and AF8 on the left and right forehead, respectively) and temporoparietal (TP9 and TP10 on the left and right forehead, respectively) regions, while the remaining three were used as a reference. The data, which were collected through a system equipped with an accelerometer, gyroscope, and pulse oximeter, were transmitted via Bluetooth to a smartphone using the Mind Monitor mobile application and were sampled at a constant of 256 Hz and a 50 Hz notch frequency filter. The Power Spectral Density (PSD) of the raw EEG data from each channel was used as the logarithm in Mind Monitor's automatic processing of the raw data to acquire the brain waves at the following frequency bands: delta (1–4 Hz), theta (4–8 Hz), alpha (7.5–13 Hz), beta (13–30 Hz), and gamma (30–44 Hz). All EEG PSD readings evaluated via Mind Monitor were typically in the -1: +1 range. All data were visually inspected and artifacts such as eye blinks and movements were removed. The recording of a 120 s baseline took place at the beginning of the experimental phase and, for each participant, EEG activity during the experimental conditions was weighted over baseline values.

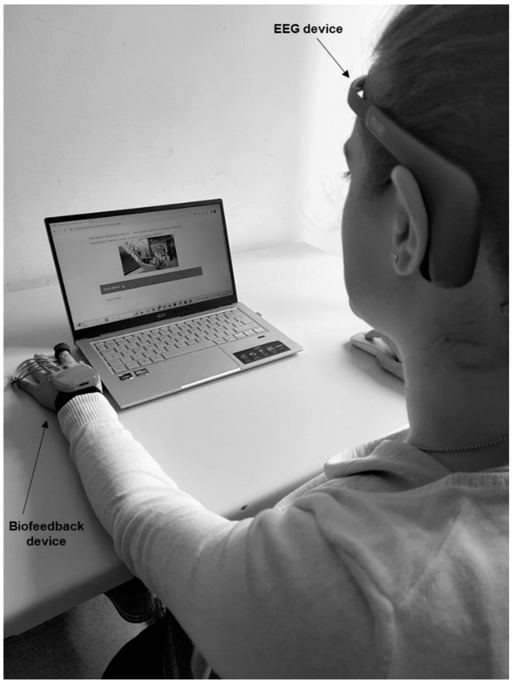

Figure 1. Experimental setting with the EEG and autonomic devices applied on the participant.

2.3.3. Autonomic Data Acquisition and Biosignal Analysis

To collect autonomic data, the X-pert2000 portable biofeedback equipment with a MULTI radio module (Schuhfried GmbH, Modling, Austria) was employed. This system is composed of a peripheral sensor attached to the second finger's distal phalanx of the non-dominant hand and it is able to detect variations in electrodermal activity (EDA), including skin conductance level (SCL) and skin conductance response (SCR), and cadiovascular indices, including HR and HR variability (HRV). Specifically, SCL and SCR were expressed in μS and were recorded with an EDA gold electrode using current–current measurement at a sampling frequency of 2 kiloHertz (kHz). The use of an alternating voltage prevents polarisation. The measurement resolution for the SCL calculation was 12 nanoseconds (ns) with a sampling frequency of 20 Hz. HR, on the other hand, was expressed in beats per minute (bpm) and was measured via photoplethysmography with a sampling frequency of 500 Hertz (Hz). Finally, to prevent hand movements from interfering with the recordings, the sending unit's accelerometer, calibrated in meter/square second (m/s^2), was used to track the movement of the non-dominant hand (Figure 1). For each participant, autonomic activity during the experimental conditions was weighted over baseline values.

2.3.4. Self-Report Data Acquisition

To collect self-report data, the General Decision-Making Style (GDMS) [52] and the Italian version of the 10-item Big Five Inventory (BFI) scales [51] were adopted to explore individuals' decision-making styles and personality traits.

Specifically, the GDMS allows the individual decision-making style to be categorized by attributing it to one of the following decision-making styles: rational, intuitive, dependent, avoidant, and spontaneous. The rational style is typical of an individual who considers all alternatives and their consequences through an in-depth and detailed search of information; the intuitive style identifies a person who tends to decide on hunches, focusing on global aspects; the dependent style corresponds to an attitude in which one prefers to receive suggestions and advice; the avoidant style defines an avoidant approach to a decision; and the spontaneous style is characterized by making decisions as quickly as possible.

The 10-item BFI, instead, represents a short version of the Big Five and allows an individual to be categorized by attributing to them one of the following four personalities: extrovert (typical of enthusiastic people), agreeable (likeable and warm individual), conscientiousness (organized and self-disciplined personality), emotionally stable (being calm, stable, and balanced), and open (imaginative attitude and open to new experiences).

2.4. Data Analyses

Firstly, repeated measures ANOVAs (analyses of variance) [57] were applied to behavioural, EEG, and autonomic data [41,43,58,59] using IBM SPSS (version 25, IBM Corp., Chicago, IL, USA).

For behavioural data, two ANOVAs with *Condition* (2: boosted nudge and soft nudge) as the within-subject factor were applied to the behavioural scores (total responses and RTs).

For EEG data, five ANOVAs with *Condition* (2: boosted nudge and soft nudge), *Localization* (2: frontal and temporo-parietal), and *Lateralization* (2: right and left) as the independent within-subject factors were performed for each frequency band (delta, theta, alpha, beta, and gamma) of EEG data.

For autonomic data, four ANOVAs with *Condition* (2: boosted nudge and soft nudge) as the within-subject factor was applied to autonomic indices (SCL, SCR, HR, and HRV).

Pairwise comparisons were applied to the data in cases of significant effects. Simple effects for significant interactions were further checked via pairwise comparisons, and Bonferroni correction was used to reduce potential biases in multiple comparisons. For all the ANOVA tests, the degrees of freedom were corrected using Greenhouse–Geisser epsilon where appropriate. Furthermore, the normality of the data distribution was preliminarily assessed by checking kurtosis and asymmetry indices. The normality assumption of the distribution was supported by these preliminary tests.

The size of statistically significant effects was estimated by computing partial eta-squared (η^2) indices.

Secondly, Pearson correlations, with Bonferroni corrections for multiple comparisons, were applied to behavioural scores (total boosted nudge responses, total soft nudge responses, boosted nudge RTs, and soft nudge RTs) and the GDMS and 10-item BFI for the entire sample.

3. Results

3.1. Behavioural Results

The ANOVAs for behavioural data did not show any statistically significant differences. The graphs below show the average trends of the behavioural data in terms of percentage of nudge responses and RTs for both boosted and soft nudge conditions (Figure 2).

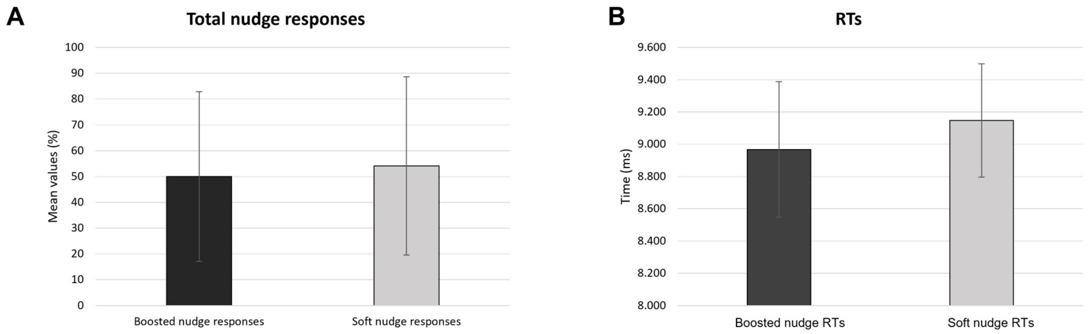

Figure 2. Behavioural data results. The bar charts show mean trends for the following behavioural data: percentage of total responses (**A**) and RTs (**B**) between boosted nudge condition and soft nudge condition.

3.2. Autonomic Results

The ANOVAs applied to autonomic data showed a main effect of the within-subject factor *Condition* only on SCR, with an increase in the boosted nudge condition compared to the soft nudge condition (F [1,44] = 5351 p = 0.025 η^2 = 0.106) (Figure 3). No other significant differences were found for the ANOVAs performed on the other autonomic indices (SCL, HR, and HRV).

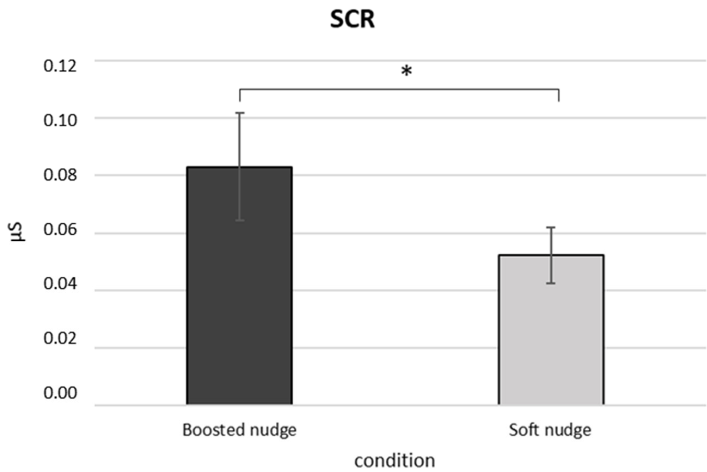

Figure 3. Autonomic data results. The bar chart shows the higher SCR values observed in the boosted nudge condition compared to the soft nudge condition. Bars represent ±1 standard error and the star (*) marks a statistically significant comparison.

3.3. EEG Results

The ANOVAs for EEG data showed a significant interaction effect of *Localization* × *Lateralization* in the delta band (F [1,44] = 9.635 p = 0.003 η^2 = 0.183), with an increase in the power of this band in the right temporo-parietal area compared to the frontal area (p = 0.001) and in the left side of the frontal region compared to the right neural region (p = 0.023) (Figure 4A).

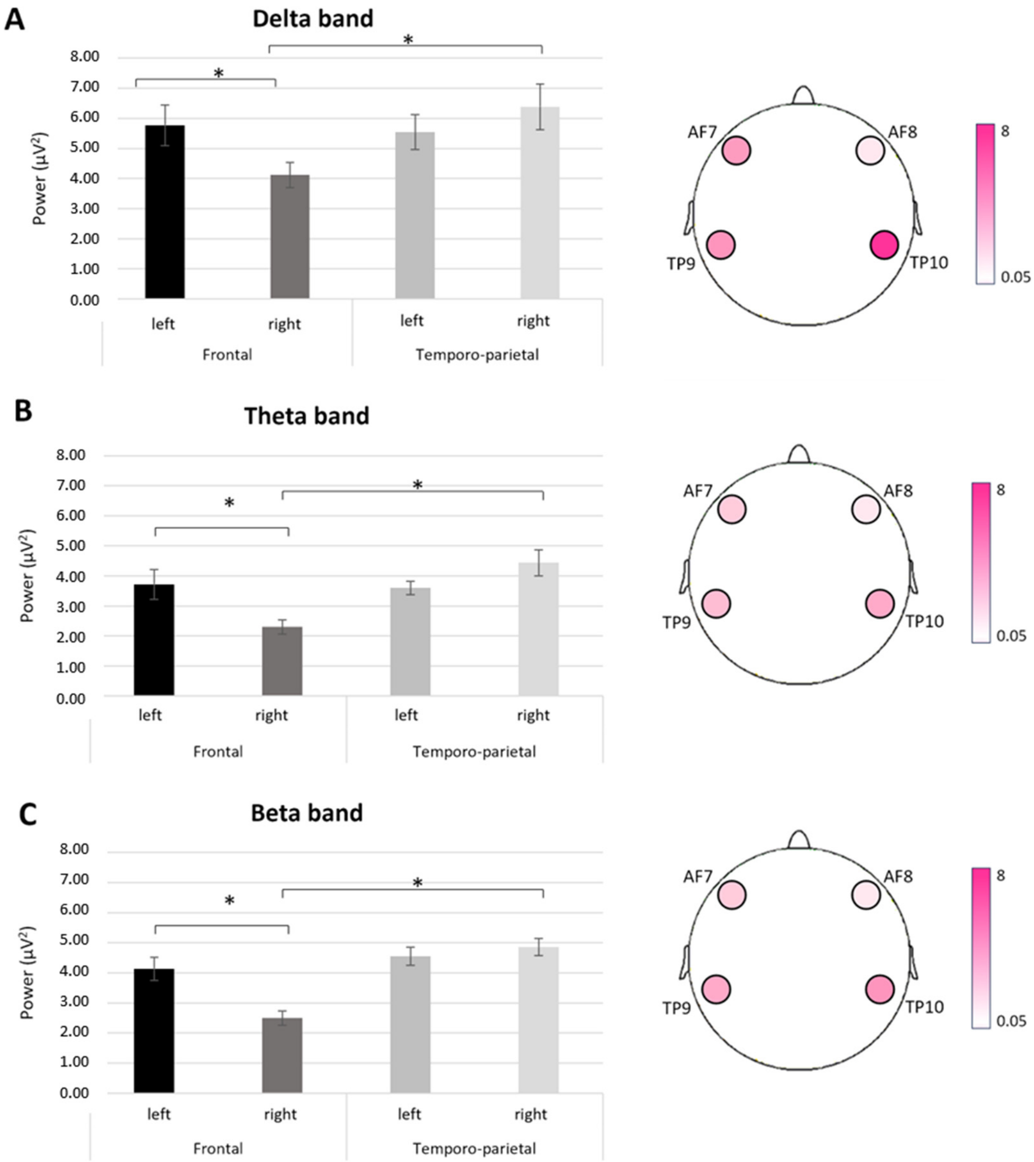

Figure 4. EEG results. The bar charts show significant differences observed for the interaction effect *Localization* × *Lateralization* for the following frequency bands: delta (**A**), theta (**B**), and beta (**C**). For each frequency band, the more intense colour in the rendering of the head (on the left) represents the increase in EEG power at the specific EEG electrode. For all graphs, bars represent ± 1 standard error and stars (*) mark statistically significant comparisons.

In the same way, for the theta band a significant interaction effect of *Localization* × *Lateralization* (F [1,44] = 13.293 $p \leq 0.05$ η^2 = 0.245) was found, and the pairwise comparisons revealed an increase in theta activity in the right temporo-parietal area compared to the frontal area ($p \leq 0.05$) and in the left compared to the right frontal area (p = 0.010) (Figure 4B). No other significant differences were found for EEG frequency bands.

For the beta band, a significant interaction effect of *Localization* × *Lateralization* (F [1,44] = 17.178 $p \leq 0.05$ $\eta^2 = 0.290$) was found, with increased beta power in the right temporo-parietal area compared to the frontal one ($p \leq 0.05$) and in the left compared to the right frontal regions ($p \leq 0.05$) (Figure 4C). No other significant differences were found for the ANOVAs performed on the EEG data.

3.4. Correlational Results

The Pearson correlation performed between the 10-item BFI scores and the behavioural scores (total boosted nudge responses, total soft nudge responses, boosted nudge RTs, and soft nudge RTs) showed a negative correlation between BFI conscientiousness personality subscale score and total boosted nudge responses ($r = -0.352$, $p = 0.035$), as well as with total soft nudge responses ($r = -0.392$, $p = 0.018$); a negative correlation between BFI emotional stability subscale score and boosted nudge RTs ($r = -0.401$, $p = 0.015$); and a negative correlation between BFI openness personality and soft nudge RTs ($r = -0.389$, $p = 0.019$).

Pearson correlations performed between behavioural scores and GDMS scores showed a positive correlation between the GDMS avoidant decision-making style and total boosted nudge responses ($r = 0.391$, $p = 0.002$).

No other significant correlations were found.

4. Discussion

Through a multimethodological neuroscientific approach, the current work explored how professionals' decision-making is influenced by different nudge conditions, and their resistance to such form of conditioning. For testing the individuals' responses to nudging, a novel behavioural nudge task was designed, in which three different scenarios related to wellbeing and sustainable behaviours (in terms of physical health, environmental sustainability, and healthy eating) were presented to the participants. Each scenario was proposed in boosted and soft nudge conditions: two different conditions designed to render a different "degree of nudging", and, at the same time, requiring the use of increasingly significant skills to resist the nudge. After the presentation of each scenario, the participants were explicitly asked to provide a behavioural response by choosing one of the two options: one option was nudge-induced, and the other was not.

The following main outcomes were obtained from the analysis performed on behavioural, electrophysiological, autonomic, and self-report data: first, at the behavioural level, it was shown that professionals' resistance to nudging is quite high and not influenced by the degree of nudging; secondly, the power of the delta, theta, and beta bands shows two main parallel trends with significant activation of the left compared to right frontal areas and a significant increase in the power of these three frequency bands in the right temporoparietal regions compared to the ipsilateral frontal areas, regardless of the nudging condition; thirdly, higher SCR values were found in the boosted compared to the soft nudge condition; and finally, significant correlations were found between the BFI personality subscales (conscientiousness, openness, and emotional stability), the GDMS avoidant decision-making style, and the behavioural scores collected from the behavioural nudging task.

Starting from the first result, at the behavioural level, it was shown that the resistance to nudging is not influenced by the degree of nudging. For both forms of nudging, professionals demonstrate an ability to resist nudging in half of the cases, thus suggesting that the evaluation of each scenario with its alternative option induced a similar cognitive workload. Also, we observed comparable RTs for both conditions. Differently from what was expected, in the current work, the RTs showed a slight increase in the soft nudge compared to the boosted condition, perhaps due to a cognitive cost overload experience by the professionals in the soft condition. The lengthening of RTs is a typical effect observable in the case of attentional bias; for example, in the case of addiction, individuals' attention is attracted by selective factors that take longer to be processed because of their affective properties, such as addiction-related stimuli compared to neutral stimuli [60]. Even if this difference did not have an impact on the number of responses between the conditions, it deserves deeper exploration in future research. Moreover, Mertens and colleagues' (2021) [28] meta-analysis showed no behavioural effects of nudging after adjusting for publication bias, except for food choices; however, the authors did not include the evidence collected in neuroscientific studies on nudging. Moreover, there is a gap in the literature on neuroscientific studies deepening knowledge of nudging and resistance to nudging. Neuroscientific studies showed some specific neural responses to nudging [7,8,61]; thus, we believe nudging and resistance to nudging could deserve further exploration at the neurophysiological level to explore the processing of nudges at the implicit level.

About EEG data, the power of the delta, theta, and beta bands showed two main significant patterns of neural response regardless of the nudging condition: (i) a significant activation of the left compared to right frontal areas, and (ii) a significant increase in the power in the right temporoparietal regions compared to the ipsilateral frontal areas. The evidence that even the electrophysiological data do not differ for the condition variable can be still considered relevant information.

Considering its localization, the "resistance to nudge" mechanism appears to be mainly localized in the right temporo-parietal areas and lateralized to the right hemisphere, especially when compared to both the left and right frontal regions. Interestingly, previous work in the field of decision making highlighted the role of the right-temporoparietal junction (rTPJ) as an important component of a brain network that encourages the delay of gratification by promoting mental orientation to future rewards [62,63]. The greater presence of the delta band in right posterior regions seems to signal the occurrence of somatosensory integration processes in the sample of professionals [37]; in parallel, the increase in the beta band indicates heightened cognitive control in a potentially conflictual condition [38] evoked by both the boosted and soft nudge conditions. In addition, contrary to what was predicted, a significantly greater power of the theta band was found in the right temporoparietal regions compared to the frontal areas. Considering the role of the theta band in mediating the reciprocal frontal parietal communications during decision making and the subsequent attention deployment [64], this result can be interpreted as an information integration or encoding process [65] when professionals are faced with both nudge conditions.

Taken together, these outcomes suggest that nudging, both in the soft and strong forms, activated in this sample of professionals a coherent and systematic EEG response in the same neural region, which can be involved when information connected to the nudge processes is elaborated, perhaps suggesting that the increase in delta, theta, and beta power localized and lateralized in the right temporoparietal regions can lay the foundation of "the neural architecture of resistance to nudging". Given the lack of research exploiting the EEG frequency bands to explore the neurophysiological response to nudging and resistance to nudging, these interpretations should be considered with caution.

Moreover, in previous neuroscientific studies related to the decision process, the different phases of the decision process were taken into consideration and examined [66]. In a previous study, both slow- and high-frequency EEG bands were found to characterize the different temporal stages of the decision-making process [66]. In future studies, in order to better detail the contribution of the EEG frequency bands in the decision process under nudge conditions, it will be useful to distinguish between the scenario elaboration phase in which participants are presented with the scenario and the verbal indication (which consists of the evaluation of the alternatives and anticipates the decision itself), and the phase in which they select the choice option (which consists of the selection of only one alternative and coincides with the behavioural decision outcome). In this contribution, such level of detail was not investigated, since we intended to provide the first evidence of the BIO-EEG markers involved in the elaboration process of scenarios in which the nudge mechanisms intervene; still, it should be explored in future studies.

Another possible explanation could be that the cognitive conflict experienced by professionals when facing nudging conditions impacts them on a more automatic and emotional level, activating the correlates of the autonomic nervous system. Indeed, the significant increase in SCR for the boosted compared to soft condition highlight the pivotal role of this marker as the only indicator that truly differentiates the two nudge conditions. The increase in SCR could be interpreted as a need for an increase in the resistance skills necessary to respond to a strong nudging condition, with a high impact on the decision maker when he/she must contrast two strongly nudged choice options. In a sample of professionals confronted with a moral choice, the increase in SCR was interpreted as a positive subject response in terms of emotional arousal when professionals, although faced with a condition of cognitive and moral conflict, perceived the moral acceptability of the offer itself [67]. In the context of nudging, such increase in SCR can be explained as a potential emotional conflict in the decision induced by the boosted nudge condition, which generates in professionals a greater degree of uncertainty in the anticipatory phase of the decision. In other words, taking an example from the scenarios, such degree of uncertainty, in the first scenario, makes fatigue or physical health prevail in one's choice; in the second scenario, the convenience of choice (with a non-sustainable action) or the environmental ecology (sustainable action) are weighted; and in the third scenario, it is necessary to decide whether to make hunger or healthy eating prevail in one's choice. By splitting the two decision-making phases as previously shown in other studies [66,68], in future research we could also investigate the contribution of SCR in relation to the temporal intervals of the decision process. Thus, by proposing a conflict condition in which the two messages are in contrast and dividing the decision into two phases, it will be possible to explore more thoroughly which nudge the professional responds to, and, consequently, which nudge the professional must reject in order to choose the other response choice. Moreover, considering the autonomic indices and what was formerly hypothesized, no significant effects were found for HR, the role of which could be better explored in subsequent studies.

Finally, as far as the results of the self-report questionnaires are concerned, we found some significant correlations between the personality traits and decision-making styles (measured with the 10-item BFI and the GDMS) and the behavioural data collected with the nudge task.

As expected, a positive correlation between GDMS avoidant decision-making style and total boosted nudge responses and a negative correlation between BFI conscientiousness personality subscale score and total number of nudge responses were detected, regardless of the nudge condition. This evidence demonstrated that having an avoidant approach to a decision could translate into a higher resistance to nudged choices when making a decision, while professionals with an organized and self-disciplined personality could be more rigidly goal-oriented and less resistant to nudged options.

On the other hand, contrary to what was supposed, a negative correlation was found between BFI emotional stability subscale score and boosted nudge RTs and a negative correlation between BFI openness personality and soft nudge RTs, suggesting that professionals that are emotionally stable, with an imaginative attitude and that are open to new experiences, showed shorter RTs in processing the alternatives in the nudged conditions. Although there is no correlation with the number of total responses, this reduction in RTs would appear to be in contrast with nudge resistance. Therefore, future studies need to better delve into the relationship between personality traits and nudge resistance.

Overall, evaluating the neurophysiological, autonomic, behavioural, and self-report correlates of the resistance to nudging can be useful to render individuals aware of the explicit and implicit factors to strengthen to resist such form of conditioning. Just as it is important for professionals to become aware of their cognitive biases in order to make a more informed choice, we think it is also important to become aware of nudged choices, not only to decide whether or not to give in to them, but also to adhere to them with greater awareness. Personalized development of any intervention to enhance resistance to forms of conditioning (be it bias or nudges) can only be set up after having profiled one's resistance to these mechanisms. We believe resistance to nudging plays a significant role in balancing external influence with professionals' ability to make conscious and independent decisions:

it enables them to critically evaluate the suggestions proposed by nudging and choose only those that align with their goals and values.

5. Conclusions

To conclude, in this study, we aimed to elucidate the resistance to nudging in a sample of professionals from various angles, thereby making the design of our experiment improvable. Our findings are related to the behavioural and neurophysiological correlates of professionals' resistance to different nudge conditions, conceived as a form of conditioning. Such conception of nudging is relatively novel, and no previous research has investigated resistance to nudging from a neuroscientific perspective. The distinction between soft and boosted nudges has not been shown to have a significant behavioural or neurophysiological impact on the sample under consideration. EEG findings can be considered the first evidence of a localization of the phenomenon of "resistance to the nudge": the mechanism appears predominantly localized in the right temporo-parietal areas and lateralized to the right hemisphere, especially when compared to both the right and left frontal regions.

In the future, the soft and boosted nudge conditions could be compared to a further nudge-free control condition. A direct replication of this study may not distinguish between these conditions but test the decision process considering two distinct temporal phases; that is, the anticipation of the choice (when the participants are presented with the scenario and verbal indication) and the choice itself (when the participants are required to select one of two alternative options). The lack of a significant difference between the soft and nudge conditions in the behavioural data combined with a stable electrophysiological activation of only some specific neural areas makes our interpretation of a specific activation due to the nudge effect not induced by variables connected to the type of stimulus presented (i.e., the text or the different levels of attention devoted to the images used in the scenarios) plausible, even if not univocal.

Additionally, it must be noted that our sample size was modest, especially given the nature of the behavioural and self-report measures, so the total number of nudge responses and the RTs might differ in replications on statistical grounds. It should be acknowledged that the brain localization factor was derived from a limited number of EEG electrodes (AF7, AF8, TP9, and TP10) and this allows us to discuss data that are limited only to these scalp positions [69,70]. To overcome this limitation, future studies could consider using multichannel electrophysiological instruments to collect more comprehensive data on brain activity, although this choice could have an impact on the ecological validity of the study itself.

We expect that the outcomes of this study would also benefit from replication with university students and professionals across different occupational areas serving as participants. Also, it would be of great interest to test consumers' resistance to nudging when adopting sustainable consumer behaviour and produce useful information for marketers and strategies to promote sustainable employee behaviour within a company and when marketing to consumers outside the company. Indeed, we lack proof that the results will be ecologically valid outside of laboratory conditions; therefore, future studies could also test the resistance to nudging in applied contexts, such as in the case of resistance to purchasing sustainable products.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su151914509/s1, Scenarios A–C.

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