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Safety Culture in the Spanish Nuclear Power Plants through the Prism of High Reliability Organization, Resilience and Conflicting Objectives Theories

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Featured Application: The description of safety culture traits within the Spanish nuclear power plants, both globally and at the particular level, can benefit the safe performance of facilities.

Abstract: Safety culture is the result of values, attitudes, and perceptions of the members of an organization that prioritize safety over competing goals. Previous research has shown the impact that organizational aspects can have in safety performance. Under the prism of the theoretical approaches from the high reliability organizations theory (HROT), resilience engineering (RE), and conflicting objectives perspective, this study was aimed at describing the overall main safety culture traits of the Spanish nuclear power plants, as well as identifying particularities associated with subcultures. For this purpose, a statistical analysis of safety culture surveys and behavioral anchored rating scales (BARS), handed over to all the operating Spanish nuclear power plants, was carried out. Results reveal that safety is a recognized value that prevails over production, there is a high degree of standardization, power plants are better prepared to organize plans and strategies than to adapt and cope with the needs of a crisis, and there is a critical and fragmented perception about the processes of resources allocation. Findings also identify that sociodemographic aspects, such as work location and contractual relationship, seem to be shaping differentiated visions. Several safety implications linked to the results are discussed.

Keywords: safety culture; organizational culture; organizational subcultures; nuclear industry; high reliability organizations; resilience engineering; conflicting objective perspective

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1. Introduction

The Spanish nuclear industry faces gradual, definitive decommissioning within as part of a new energy model change. Over the next 15 years, all operating plants will have to shut down. Within this end-of-cycle stage, the framework of safety culture is an essential aspect to guarantee safe operation until plants permanently shutdown.

This paper aims to describe the organizational culture for the safety of Spanish nuclear power plants, taking three relevant theoretical approaches within the scope of high reliability organizations as a reference. To do that, quantitative data obtained from safety culture surveys were analyzed. These were administered to all workers at currently operating nuclear power plants, together with a behavioral anchored rating scale (BARS) distributed to a representative sample of workers.

Outlined below are the theoretical foundations of this research: (a) What is considered organizational culture? (b) What is considered safety culture (or organizational culture for safety)? (c) Based on the theory of high reliability organizations, resilience engineering, and conflicting objectives perspective, what are the theoretical approaches used to describe the safety culture of Spanish nuclear power plants?

1.1. Organizational Culture

Studies on culture have an interdisciplinary nature and are widely diverse in their purpose and scope. Cooper [1] points out that when researchers address culture, some focus on the way people think, while others focus on behavioral aspects.

Within the scope of the theory of organizations, Schein [2] considers that organizational culture comprises the experience gained by individuals within an organization, with the aim to adapt to their environment and solve problems.

Although some authors such as Edwards et al. [3] (p. 71) define organization culture as "culture held by members of a given organization", this culture is not necessarily uniform or homogeneous amongst all members [4–6]. Different groups may have different points of view concerning their environment [7]. This lack of consensus and the existence of subcultures could be the result of multiple external or internal factors, including power, leadership, layout, experience, or knowledge, among others [8].

On the other hand, investigations resulting from catastrophic industrial accidents have contributed to acknowledging that safety is influenced by the cultural context of work practices [9]. From an organizational perspective, safety can be conceived as "the ability of individuals or organizations to deal with risks and hazards so as to avoid damage or losses and yet still achieve their goals" [10] (p. 5). In that sense, studies on organizational culture can contribute to identifying aspects that should be considered in order to further prioritize safety [11]. Over the last 40 years, the emphasis on various system aspects relating to safety has evolved from a purely technological perspective to a more inclusive vision. Simultaneously, new catastrophic accidents have been taken as reference. At the first stage, Hale and Hovden [12] pointed out that after the Seveso accident in 1976, it was considered that technology could explain the cause of accidents. After the Three Mile Island event (1979), more emphasis was placed on the unsafe acts of individuals carrying out tasks. In a third stage, linked to the accidents affecting Bhopal (1984), Chernobyl (1986), and the Challenger (1986), the importance of safety management was highlighted. After the events of Tokaimura (1999), Davis–Besse (2002), and Columbia (2003), the focus of attention shifted towards organizational aspects. Finally, the Fukushima accident (2011) also revealed the impact of organizational aspects on safety, as well as the importance of an organization's resilience in the face of an unexpected situation [13].

Therefore, it can be said that the evolution of safety paradigms has tended to a more inclusive vision with the aim to understand the complex relationship between technology, humans, and organizations [14]. The last two stages link safety to adaption, meaning that an organization's capacity to adapt to changing circumstances [15] and to adequately manage uncertainties [16] is considered paramount to safety.

1.2. Safety Culture

The term "safety culture" was coined after the Chernobyl nuclear accident in 1986. As abovementioned, the investigation report of this event revealed the role of cultural and organizational aspects as contributors to this accident. Ever since, many developments, definitions, and models on the term "safety culture" have been carried out by nuclear industry agencies referenced and reported in scientific literature.

Originally, the International Atomic Energy Agency (IAEA) defined safety culture as "the assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance" [17] (p. 4). The IAEA's vision of safety culture has broadened in time towards convergence with the concept of organizational culture [18]. As for the Institute of Nuclear Power Operations (INPO) and the U.S. Nuclear Regulatory Commission (NRC), they describe the term as "the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment" [19,20] (p. iv; p. 34773).

From an academic sphere, there has been some discussion around the link between safety culture and organizational culture. Hopkins [11] points out that according to some authors, each organization has a specific safety culture, whereas for others this only exists if there is an overriding commitment to safety. Other researchers consider that safety culture is just a part, an aspect, or an effect resulting from the organizational culture [9,11,21,22]. According to Clarke, [23] safety culture is a subset of the organizational culture comprising beliefs and values specifically related to health and safety. Richter and Koch [5] (p. 705) define safety culture as "the shared and learned meanings, experiences and interpretations of work and safety ... which guide peoples' actions towards risks, accidents, and prevention".

Despite this disparity of perspectives, there seems to be a basic agreement in that (a) safety culture takes place in organizations which highly prioritize beliefs, values, and attitudes related to safety [1,21], and (b) it is a multidimensional concept which includes numerous elements of an organizational nature [24]. Some authors claim the need to deviate the attention from the concept of "safety culture" to the concept of "organizational culture" in order to avoid potential ambiguities [11,21,25]. It is assumed that organizational culture influences safety by providing reference frameworks through which risks and hazards are detected, assessed, or dismissed, as well as by determining conventions for behavior, interaction, and communication between individuals within the organization [9].

1.3. Theories of Organizational Safety

Taken as a reference for this study, the main features of the three safety theories for complex organizations are described in the following subsections.

1.3.1. Theory of High Reliability Organizations

The theory of "high reliability organizations" (HRO) was developed with the aim to understand which factors determine that complex, high-risk organizations, such as those in the aeronautics sector and the nuclear industry, are able to maintain high safety levels [26]. HRO are seen as organizations capable of maintaining an error-free performance for long periods of time [27]. In this way, even if they are organizations operating in complex, high-risk environments, they are mostly accident-free [28].

A central element shared by the authors of this approach is the principle that accidents are unavoidable. The theory of HRO stands, in practice, as an academic counter-proposal to the "normal accident theory" (NAT) formulated by Perrow [29]. The NAT assumes a certain fatalism on the unavoidability of accidents in complex organizations. An unavoidability caused by high-coupling between technology and organization and the unpredictability of the system, in which a failed part could affect all others and the system as a whole.

On the contrary, the theory of HRO proclaims that technologically complex organizations have a set of processes that effectively prevent and detect catastrophic failure [27,30]. The consistency and stability required for failure-free operation would be achieved through a set of technical and organizational features, such as (a) management commitment to ensure safety is an overriding priority at all levels, (b) existence of redundancy systems, (c) decentralization of the decision-making process, (d) ongoing technical training of personnel, (e) organizational learning based on operational events, (f) promotion of communication, and (g) reward for individuals who report problems [31,32].

It is worth noting that the approach of the HRO theory ended by converging with some aspects of resilience engineering, integrating an approach both preventive and adaptive within safety management. Prevention requires the identification of events that should not occur and precursor events which might lead to them, as well as the creation of procedures to prevent undesirable events [33]. In addition to prevention, organizational reliability requires resilience [34] to handle organizational variations while maintaining stable systems [33,35].

In this sense, Weick and Sutcliffe [36] point to five key aspects to maintaining high safety standards: (1) a preoccupation with failure, (2) a reluctance to simplify, (3) a sensitivity to operations, (4) a commitment to resilience, and (5) deference to expertise. The first three address the capacity of an organization to anticipate unexpected problems, whereas the last two refer to the capacity of the organization to contain unexpected problems once they have occurred. In other words, high reliability organizations are able to detect and manage unexpected events while sustaining reliable performance.

1.3.2. Resilience Engineering Perspective

According to Grabowsk et al. [37], complex high-risk systems need to have two characteristics to ensure safety: reliability during routine activities and capacity to adapt to inherent system variability. From the theory of organizations, the term resilience is used to define the organizational capacity to prepare for, respond to, and recover from unexpected emergencies and crises [38,39].

Hollnagel [40] describes two different modes through which safety can be attained. The first approach, "Safety-I", or centralized control, is associated with a concern to understand things that go wrong. The second approach, "Safety-II", or guided adaptability, includes the knowledge of how and why things go well, and is defined as the capacity to be successful under changing conditions. The term "Safety II" is also used to refer to resilience engineering (hereinafter, RE).

Hollnagel et al. [41] (p. xxxvi) define resilience as "the intrinsic ability of a system to adjust its operation before, during, or after changes or disturbances, so as to ensure the operations required, under expected or unexpected conditions". It implies variability in the performance and capacity of individuals and organizations to adapt continuously to situational changes in their daily work with the aim to ensure a good outcome [40] (p. 137). According to Hollnagel, engineering resilience has four main pillars: (1) capacity to respond, (2) to monitor, (3) to anticipate, and (4) to learn to adapt or recover from accidental events [41].

In some organizations, adaptation could be a prerequisite of safe performance, whereas in others it might lead to significant damages [42]. Thus, performance adjustments are seen as a precursor to both success and failure. It is considered that the more tightly coupled (interdependence between parts of the system) and intractable (complex systems subject to change) performance is, such as in the case of nuclear power plants, the more necessary it is to have an adaptive response because the risk of adverse results is high [43].

1.3.3. Conflicting Objectives Perspective

The "conflicting objectives perspective" (COP) by Rasmussen [44] is supported by the basic idea that human activities are characterized by an ongoing search for balance against pressures resulting from partially conflictive goals. According to Rasmussen, high-risk technological systems are subject to multiple pressures: activities have to be profitable, safe, and imply a reasonable workload for personnel. It is a dynamic, complex sociotechnical system in which safety and quality could be gradually relegated in favor of other goals such as production and time pressure. This conflict between goals often generates a dilemma due to the inability to balance them correctly. It is precisely that lack of balance, caused by antagonism between goals, which can lead to accidents.

It is worth noting that, at every organizational level, people respond to pressure by taking compensatory measures without knowing how such actions will integrate with decisions made by others [45]. When individuals and organizations constantly make compensatory decisions to deal with the pressure resulting from differing goals, activities tend to move towards potentially unacceptable limits.

In the case of complex systems, these decisions and adaptions to balance all types of pressure are made locally, without central coordination or understanding their impact on safety [46]. These uncoordinated adaption attempts could accumulate in time, taking the system away from its design parameters [44]. According to Dekker [46], some organizations seem to head for failure even if they appear to operate well and have success, whereas others seem to avoid significant organizational accidents even if they have faced similar risk situations with potential catastrophic consequences many times before.

Based on the "conflicting objectives perspective", Rasmussen develops the "drift to danger" model, which he defines as a "systemic migration of organizational behavior toward accident under the influence of pressure toward cost-effectiveness in an aggressive, competing environment" [44] (p. 189). This model seeks to effectively manage conflicting goals, making unacceptable risk limits both explicit and known.

In short, it is important to mention that for the COP, accidents are the result of a normal organizational behavior that is altered by environmental pressures, complex technology, and social system processes. From this approach, the resolution of some organizational dilemmas eventually leads to decisions which, from an accumulative sense, could negatively impact the safety of an organization.

1.4. Objectives and Theoretical Framework of This Study

The objective of this study is to describe the main safety culture characteristics of Spanish nuclear power plants, taking as an analysis framework the traits of the three theoretical approaches on the safety of high-risk organizations: theory of HRO, resilience engineering, and the conflicting objectives perspective. This study is conducted with secondary data obtained from independent safety culture evaluations in all Spanish nuclear power plants using the same methodology, hence providing a source of information that is reliable and consistent with the purpose of the study. The nature of the data favors the assessment of key aspects of each theoretical perspective. It is important to emphasize that this study is not aimed at engaging in theoretical discussions or comparing theoretical approaches, but to describe safety culture using available instruments and data. We adopt an eclectic theoretical perspective based on the complementarity of theoretical approaches resulting from the multidimensional nature of safety. That implies, as pointed out by Le Coze [47], the need to consider that concepts may overlap or complement each other, as explained in different theories. All three theories highlight how important aspects such as reliability, resilience, and decision-making are for the safety of complex organizations. There are also specific elements to each of these approaches that grant greater amplitude to the description of the subject matter. In short, our study takes note of the following statements to describe safety culture:

- Theory of HRO: (a) the central value of safety as an aspect conditioning values and behaviors within the organization, (b) the necessary awareness of risk inherent to work activities and processes, and (c) a constructive work environment enabling discrepancies without fear of retaliation;
- Resilience engineering perspective: (a) the capacity to anticipate crisis situations and (b) the capacity to respond to unexpected events;
- Conflicting objectives perspective considers three dilemmatic organizational aspects whose resolution does impact safety: (a) safety vs. production, (b) resources vs. shortage, and (c) formalization vs. informalization.

Lastly, our research is also based on a concept of safety culture as an inseparable part of organizational culture [9]. Although the term "safety culture" is used, it actually serves as a conceptually useful label that links the organization's culture to its safety focus.

2. Method

2.1. Sample Characteristics

The collaboration agreement from 1999 between the Spanish Nuclear Regulator (CSN), the Public Research Agency for Energy, Technology and Environment (CIEMAT), and the Electrical Industry (UNESA), favored the development of a research program and the establishment of independent safety culture evaluations of Spanish nuclear facilities. Within the framework of this agreement, the evaluation methodology of Nuclear Organization and

Management Analysis Concept (NOMAC), used by the Canadian nuclear industry [48], was adopted. This methodology has been used in all Spanish nuclear facilities ever since.

The aim of this study was to analyze quantitative data obtained during external independent safety culture evaluations in all Spanish nuclear power plants currently in operation (seven reactors). As shown in Table 1, the survey sample includes a total of 4326 workers. The name of the three nuclear organizations is not disclosed due to confidentiality obligations. Thus, they will be referred to as nuclear power plant (NPP) NPP1, NPP2, and NPP3.

Table 1. Study survey sample and descriptives.

Variable		Survey Sample N (%)	Total N (%)
Organization	Nuclear Power Plant 1	533 (12.32%)	
	Nuclear Power Plant 2	1975 (45.70%)	
	Nuclear Power Plant 3	1818 (42.03%)	4326 (100%)
Personal workplace (Location)	Facility	3767 (88.84%)	
	Headquarters	473 (11.16%)	4240 (100%)
Contractual situation of workforce (Contract)	Own staff	1715 (42.85%)	
	Contractors	2287 (57.15%)	4002 (100%)

The analysis was performed for the entire sample and according to some demographic variables with the aim to identify potential differences (subcultures) between groups, as shown in previous studies [49–52]. Analyzed variables were as follows:

- Organization (three different nuclear organizations with a total of five reactors);
- Location (working at the facility or at the headquarters);
- Contractual relationship (own staff or contractors).

The variability of these three variables in relation to the entire sample (organization, location, and contract) is due to the fact that some individuals did not provide all the sociodemographic data when taking the survey (this option was allowed if they believed it necessary to ensure anonymity).

2.2. Data and Measurement Instrument

This study was conducted with secondary data obtained from independent safety culture evaluations. Analysis data were obtained by administering the following measurement instruments: (1) a survey including four standardized scales given to all nuclear power plant members and (2) three behavioral anchored rating scales given to a representative sample of each nuclear power plant. Both BARS and surveys were administered physically on paper (years 2015, 2018, and 2019).

The survey comprised four scales, all of them with Likert-type responses with seven fixed-choice options: safety [53], risk perception [53], safety conscious work environment (SCWE) [54] and organizational resilience. The authors of this last scale also suggested that it could be approached as two subscales: planning capacity and adaptive capacity [55,56]. The upper part of Table 2 shows a content summary of these scales together with theoretical elements identified to describe safety culture.

In addition to surveys, the NOMAC methodology uses BARS as a measurement instrument. BARS are an evaluation instrument used to establish behavioral norms within a continuous scale [57]. They are scales providing specific examples of behavioral norms to which a numerical value is assigned. In other words, they are an evaluation tool linking a set of specific narrative examples of behavior to a numerical scale [58], meaning each example is associated with a score (1 through 5) for favorable, moderate or unfavorable behaviors (high > 3, medium = 3, low < 3) related to a specific attribute. The design of BARS includes the definition of an attribute followed by five graded behavioral examples, from which individuals are asked to choose the one which best describes the organizational scenario in that specific attribute [59,60]. As explained by Jacobs et al. [61] (p. 606), "BARS methodology results in explicit statements regarding requisite job behaviors and their perceived value."

Table 2. Measurement scales.

Safety Theories	**Measurement Instrument**	**Scale Definition** *(Sample Items)*
		Survey Scales:
Theory of high reliability organizations	"Safety" [53]	Safety (40 items): measures individual perception of the importance of safety in relation to the success or achievement of the organization. Safety is defined as the act of operating while ensuring that the likelihood of error is low because the consequences of making a mistake are considerable *(To which extent does error reporting help you to do your job well while complying with expectations?).*
Theory of high reliability organizations	"Hazard" [53]	Hazard (4 items): It measures people's perception of how dangerous their job is *(What is the level of hazard in your job?).*
Theory of high reliability organizations	"Safety conscious work environment" (SCWE) [54] (Elaborated following Nuclear Energy Institute [63] and Nuclear Regulatory Commission [64] guidelines on SCWEs).	SCWE (7 items): It measures the perception of respondents with regards to the freedom to make questions or express concerns relating to nuclear safety without fear of retaliation or discrimination *(Can I openly question the decisions of my managers?).*
Resilience engineering perspective	"Organizational resilience" [55,56]	Global Resilience global (13 items): It measures the organization's capacity to plan, respond to, and recover from emergencies and crises (composed of 2 factors). Factor 1, Planning (5 items): It refers to the development of plans and strategies to effectively manage crises *(Are we aware of how a crisis could impact us?).* Factor 2, Adaptive Capacity (7 items): It refers to the act of facing organizational needs before they become critical *(Is our organization capable of making difficult decisions quickly?).*
		Behavioral anchored rating scales (BARS) [62]:
Conflicting objectives perspective (safety priority vs. production priority)	"Attention to Safety"	Attention to safety: Safety refers to the characteristics of the work environment, such as the norms, rules, and common understandings that influence facility personnel's perceptions of the importance that the organization places on safety. It includes the degree to which a critical, questioning attitude exists that is directed toward facility improvement *(Individuals in the facility believe safety is the number one priority and that perspective is reinforced by senior (high-level) management and clearly disseminated to all individuals in the facility).*
Conflicting objectives perspective (precise objectives and sufficient resources vs. vague objectives and resource shortage)	"Resources allocation"	Resources allocation: Refers to the manner in which the facility distributes its resources including personnel, equipment, time, and budget *(Most employees are aware of the goals of the organization but are not sure how the goals affect their own job. Personnel do not always have the support or resources necessary to correct).*
Conflicting objectives perspective (formalization vs. informalization)	"Formalization"	Formalization refers to the extent to which there are well-identified rules, procedures, and/or standardized methods for routine activities as well as unusual occurrences *(No system of updating is apparent, and many procedures are outdated. Procedural adherence is lacking in day-to-day operations).*

As opposed to surveys that were distributed to all nuclear power plant members, BARS were administered only to personnel participating in individual interviews and focus groups (some 10–15% of personnel in the organization).

This study analyzes the following three BARS: attention to safety, formalization, and resource allocation [62]. The lower part of Table 2 shows the aspects measured by each of the BARS.

2.3. Data Analyses

All data analyses were conducted using IBM SPSS Statistics v22.0 [65]. The distributions of scores, skewness, and kurtosis suggested that quantitative data were normally distributed. Cronbach's alpha (α) internal consistency reliability [66] was calculated for the six scales, considering acceptable values of α ranging from 0.7 [67].

Paired samples *t*-test was carried out to assess within-subject differences in the scores obtained in the six scales and in the three BARS. The *t*-test and one-way ANOVA were carried out to compare responses by organization, by location, and by contractual relationship. Effect sizes were calculated using Cohen's δ, considering effect sizes as small ($\delta \geq 0.2$), medium ($\delta \geq 0.5$), or large ($\delta \geq 0.8$) [68].

In contrast to the analyses of the six scales (Hazard, Perception, Safety, SCWE, Planning, Adaptive capacity, and Overall resilience) applied to the entire population of Spanish nuclear power plant workers, responses to BARS (Attention to safety, Formalization, and Resources allocation) were only available from a representative sample of these workers. Thus, in addition to effect-size measures to assess the magnitude of differences, *t*-test and one-way ANOVA, with corrected degrees of freedom if Levene's test for equality of variances is statistically significant, were adjusted to carry out comparative analyses between groups for the three BARS administered to a representative sample in each nuclear power plant.

Bonferroni-corrected *p*-values were calculated for between-groups post hoc comparisons. Tests were considered significant at $p < 0.05$. The five possible BARS scores were also grouped in three categories (scores higher than 3 were considered "high", equal to 3 were "medium", and lower than 3 were "low") to represent results by means of stacked graph bars.

3. Results

3.1. Reliabilities, Factorial Components and Global Descriptives of the Scales

The reliability analysis of all six survey scales provides good internal consistency values (Cronbach's α over 0.80).

Table 3 shows results obtained from scale reliability analyses, percentages of categorized BARS, and descriptive information from all.

A two-factor solution resulted from factor analysis of the organizational resilience scale. The two factors are comparable to those found in previous research [55,56], except for the item 5, with factorial loading values within adaptive capacity instead of planning. To ensure a more accurate comparison between our results and those of previous studies, and considering the high internal consistency in both indicators, analyses within our study maintained the definitions for the two factors within the organizational resilience scale as proposed by the authors. Table 4 includes the results of factorial analyses of the organizational resilience scale.

Analyses for nuclear power plants show that the average for the six scales is above the midpoint. The highest scores are obtained in the safety scale, with an average of 5.89. As for the risk perception scale, it has the lowest scores with an average of 4.24.

Within-subjects comparisons between the six scales (upper part of Table 5) show magnitude differences of $\delta > 0.20$ in all cases except between the hazard perception and adaptive capacity scales ($\delta = -0.13$) and the SCWE and adaptive capacity ($\delta = 0.19$) scales. It is worth mentioning the significant differences between the hazard perception and safety scales ($\delta = -0.95$) and the planning and adaptive capacity scales of resilience ($\delta = 0.92$). Comparisons by pairs for the BARS (lower part of Table 5) show magnitudes of large effect ($\delta > 0.80$).

Table 3. Reliability and descriptive statistics of scales for the Spanish nuclear power plants.

	Spanish Nuclear Power Plants (4326)						
Scales	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**	**Cronbach's α**
Hazard perception	4317	4.24	1.66				0.85
Safety	4319	5.89	0.77				0.96
SCWE	4317	4.69	1.42				0.89
Planning	3777	5.40	1.08				0.81
Adaptive capacity	3777	4.51	1.31				0.91
Overall resilience	3778	4.95	1.10				0.92
Attention to safety	479	4.40	0.72	87.89	11.06	1.04	
Formalization	144	4.10	0.76	87.50	7.64	4.86	
Resources allocation	183	3.39	1.08	53.30	20.33	26.37	

Table 4. Principal factor component analysis of the organizational resilience scale.

		Factors	
	Resilience Items [55]	**Planning**	**Adaptive Capacity**
1	We are mindful of how a crisis could affect us	0.70	
2	We believe emergency plans must be practiced and tested to be effective	0.75	
3	We are able to shift rapidly from business-as-usual to respond to crises	0.73	0.31
4	We build relationships with organizations we might have to work with in a crisis	0.59	0.50
5	Our priorities for recovery would provide direction for staff in a crisis	0.52	0.63
6	There is a sense of teamwork and camaraderie in our organization		0.76
7	Our organization maintains sufficient resources to absorb some unexpected change	0.40	0.67
8	People in our organization "own" a problem until it is resolved	0.35	0.74
9	Staff have the information and knowledge they need to respond to unexpected problems	0.42	0.68
10	Managers in our organization lead by example		0.83
11	Staff are rewarded for "thinking outside the box"		0.75
12	Our organization can make tough decisions quickly	0.31	0.67
13	Managers actively listen for problems		0.83

Furthermore, it is worth highlighting that in terms of organizational resilience, personnel assign a higher score to the organization's development of plans and strategies for effective crisis management (planning M = 5.40) than to the capacity to address organizational needs before they become critical (adaptive capacity M = 4.51) (Table 3 and Figure 1).

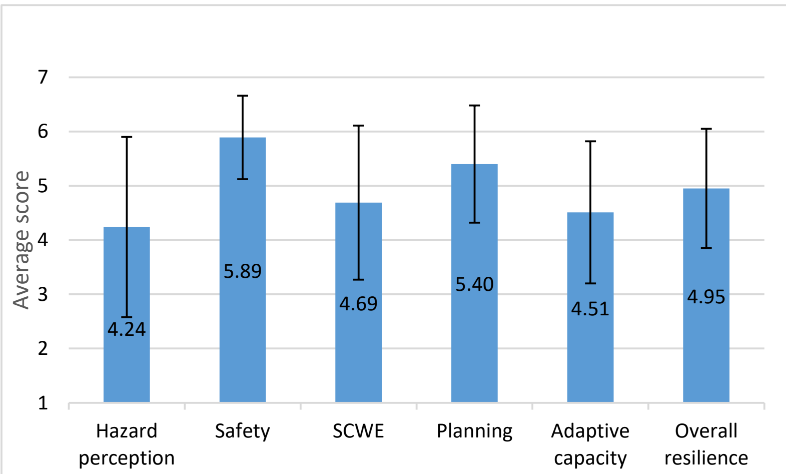

Figure 1. Scale averages with error bars (SD).

Table 5. Within-subjects comparisons for scales and BARS.

						95% CI Cohen's δ	
	SCALES	**N**	**M**	**SD**	**Cohen's δ**	**Inferior**	**Superior**
Pair 1	Hazard—Safety	4317	−1.65	1.73	−0.96	−0.99	−0.93
Pair 2	Hazard—SCWE	4315	−0.46	2.13	−0.21	−0.24	−0.18
Pair 3	Hazard—Planning	3776	−1.16	1.93	−0.60	−0.63	−0.57
Pair 4	Hazard—Adaptive capacity	3776	−0.27	2.11	−0.13	−0.16	−0.10
Pair 5	Hazard—Overall resilience	3777	−0.72	1.96	−0.36	−0.40	−0.33
Pair 6	Safety—SCWE	4317	1.20	1.26	0.95	0.92	0.98
Pair 7	Safety—Planning	3777	0.49	0.95	0.52	0.49	0.55
Pair 8	Safety—Adaptive capacity	3777	1.38	1.18	1.17	1.14	1.20
Pair 9	Safety—Overall resilience	3778	0.93	0.95	0.98	0.95	1.01
Pair 10	SCWE—Planning	3777	−0.69	1.22	−0.57	−0.60	−0.54
Pair 11	SCWE—Adaptive capacity	3777	0.20	1.02	0.19	0.16	0.23
Pair 12	SCWE—Overall resilience	3778	−0.25	1.01	−0.25	−0.28	−0.21
Pair 13	Planning—Adaptive capacity	3776	0.89	0.96	0.92	0.89	0.96
Pair 14	Planning—Overall resilience	3777	0.45	0.48	0.92	0.89	0.96
Pair 15	Adaptive capacity—Overall resilience	3777	−0.45	0.48	−0.92	−0.96	−0.89
	BARS						
Pair 1	Attention to safety—Formalization	145	0.31	0.87	0.35 *	0.19	0.52
Pair 2	Attention to safety—Resource allocation	182	1.16	1.09	1.06 *	0.91	1.21
Pair 3	Formalization—Resource allocation	24	0.74	1.03	0.72 *	0.29	1.14

Note: * statistically significant differences (Bonferroni-corrected $p < 0.017$).

On the other hand, BARS results for all Spanish nuclear power plants show that the highest score is recorded in the attention to safety scale, with an average of 4.40 (Figure 2). Nearly 88% of workers consider that the organization highly prioritizes safety in favor of production (BARS attention to safety), and that norms are well defined, with normalized methods and procedures (BARS formalization). On the contrary, it is also important to mention that 11.06% of workers consider that the balance between plant safety and operation is compromised, and 1.04% of them believe production is prioritized over safety (BARS attention to safety) (Figure 3).

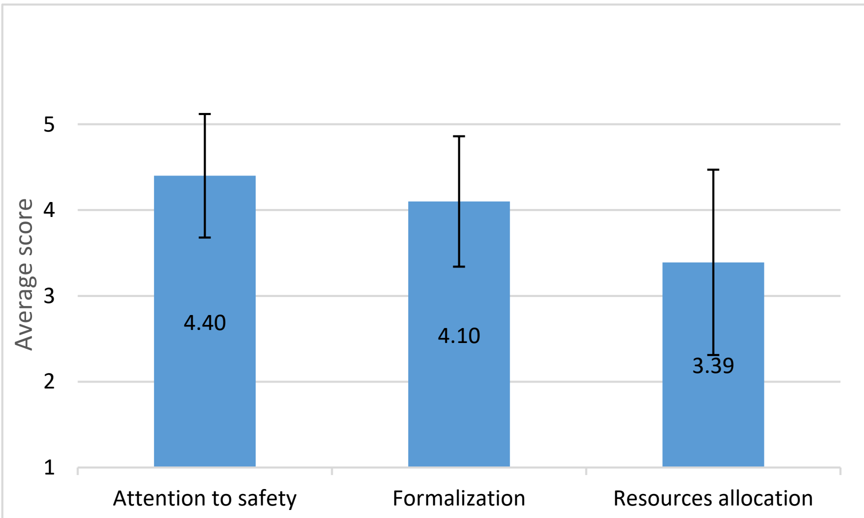

Figure 2. BARS averages with error bars (SD).

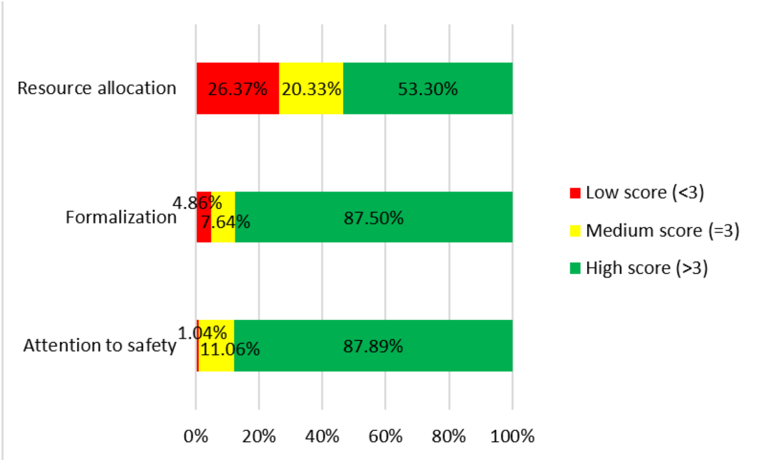

Figure 3. Global percentages of categorized BARS.

The BARS with the lowest score is resources allocation (BARS resources allocation) with a 3.39 average (Table 3, Figure 2). The result of this scale shows that perception of organizational resources allocation (both in terms of personnel, equipment, time, and economic budget) is positively valued by 53% of workers. On the contrary, 26.37% of them have a negative opinion (Figure 3). This is the study scale with the lowest scores (in both surveys and BARS).

3.2. Cultural Differences by Demographic Variables

3.2.1. Differences by Company

The comparative analysis of the six survey scales by the demographic variable "company" shows that, generally speaking, there is a high level of homogeneity between nuclear power plants ($\delta < 0.20$) (Table 6, Figure 4). The only difference is found in the risk perception scale, which has a lower score in NPP2 than in NPP3, even if this difference is very small (NPP2 M = 4.07; NPP3 M = 4.41; $\delta = -0.20$).

Table 6. Descriptive statistics of the scales by company.

	NPP1 (N = 533)			NPP2 (N = 1975)			NPP3 (N = 1818)		
Scales	**N**	**M**	**SD**	**N**	**M**	**SD**	**N**	**M**	**SD**
Hazard perception	532	4.25	1.60	1973	4.07	1.66	1812	4.41	1.65
Safety	533	5.94	0.72	1974	5.91	0.70	1812	5.86	0.85
SCWE	532	4.61	1.49	1974	4.81	1.40	1811	4.58	1.42
Planning				1972	5.32	1.08	1805	5.48	1.07
Adaptive capacity				1972	4.45	1.25	1805	4.57	1.36
Overall resilience				1972	4.89	1.07	1806	5.02	1.13

	Cohen's δ		
	NPP1-NPP2	**NPP1-NPP3**	**NPP2-NPP3**
Hazard perception	0.11	−0.10	−0.20
Safety	0.05	0.10	0.06
SCWE	−0.14	0.02	0.16
Planning			−0.15
Adaptive capacity			−0.09
Overall resilience			−0.13

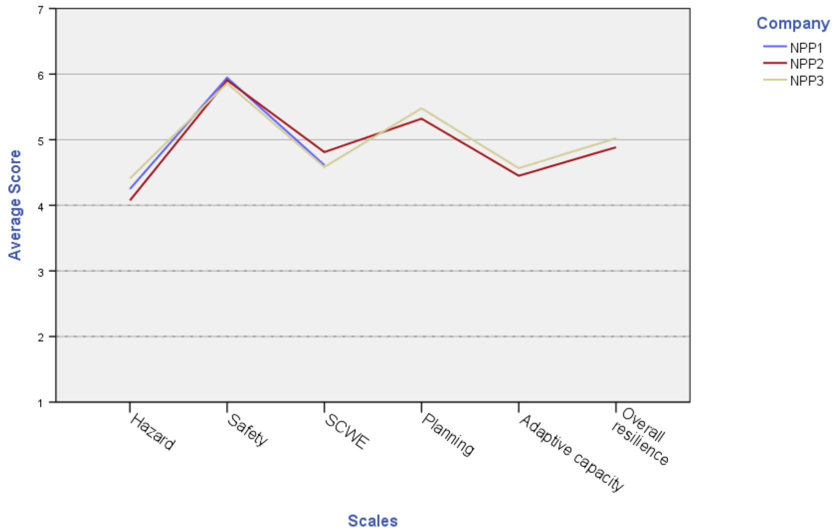

Figure 4. Scale averages by company.

The comparison between BARS attention to safety in the nuclear power plants provides quite a compact vision, as shown by Cohen δ values (F(2476) = 0.835, p = 0.434; δ < 0.20) (Table 7, Figure 5). However, it is worth noting that although the three nuclear organizations have a favorable vision of how the organization prioritizes safety, over 12% of personnel in NPP1 and NPP2 think there is a fragile balance between plant safety and production. The most negative visions on this topic (1.71%) are found in NPP 2 (Figure 6).

Table 7. Descriptive statistics of the BARS by company.

	NPP1 (N = 126)						NPP2 (N = 175)						NPP3 (N = 180)					
Scales	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**
Attention to safety	125	4.33	0.70	87.20	12.00	0.80	174	4.40	0.73	90.86	7.43	1.71	180	4.44	0.73	85.56	13.89	0.56
Formalization	45	4.07	0.65	86.67	13.33	0.00	54	3.92	0.92	81.48	7.41	11.11	45	4.36	0.56	95.56	2.22	2.22
Resources allocation	42	3.19	1.13	42.86	19.05	38.10	59	3.47	0.97	63.33	18.33	18.33	82	3.41	1.12	52.44	21.95	25.61

	Cohen's δ (CI95%)		
	NPP1-NPP2	**NPP1-NPP3**	**NPP2-NPP3**
Attention to safety	−0.10 (−0.24. 0.09)	−0.15 (−0.27. 0.06)	−0.05 (−0.19. 0.12)
Formalization	0.19 (−0.17. 0.47)	−0.47 (−0.54. −0.03) *	−0.57 (−0.75. −0.13) *
Resources allocation	−0.27(−0.70 0.13)	−0.20 (−0.65. 0.20)	0.06 (−0.30. 0.42)

Note: * statistically significant differences by company (Bonferroni-corrected p < 0.017).

The analysis of BARS formalization shows heterogeneity between the stations. Some differences are statistically significant (F(2141) = 4.399; p = 0.014) and have magnitudes with a moderate effect between NPP1/NPP3 (NPP1 M = 4.07; NPP3 M = 4.36; δ = −0.47) and NPP2/NPP3 (NPP2 M = 3.92; NPP3 M = 4.36; δ = −0.57) (Table 7, Figure 7). The larger number of employees with a critical score in terms of norm definition and procedure and method normalization is found in NPP2 (11.11%) (Figure 7).

On the contrary, BARS resources allocation only shows a small and statistically insignificant difference (F(2180) = 0.921; p = 0.400) between NPP1 and the other two nuclear plants (NPP2 and NPP3)—with NPP1 more critical in terms of resources allocation. Results also reveal that opinions about resources allocation within the organization are quite polarized. Over 25% of personnel in NPP1 and NPP3 have a critical vision on this issue (Figure 8).

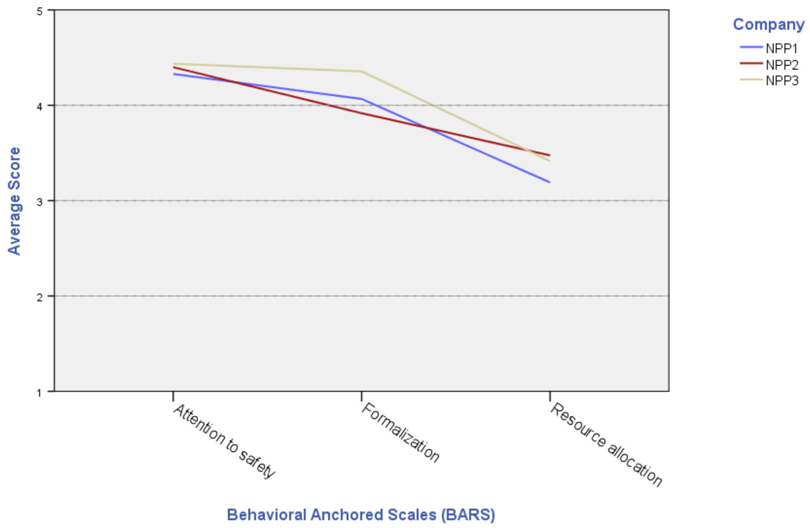

Figure 5. BARS averages by company.

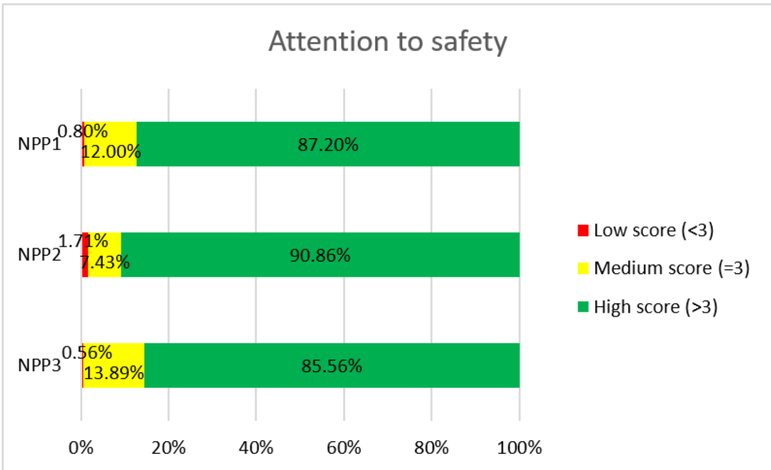

Figure 6. Categorized BARS percentages for attention to safety, by company.

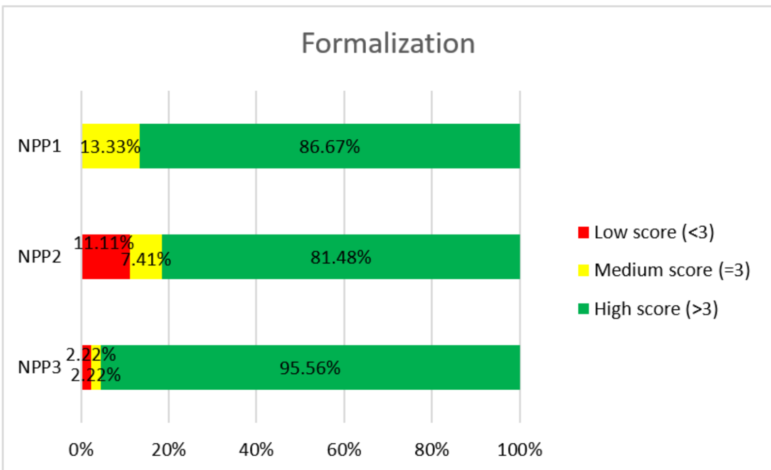

Figure 7. Categorized BARS percentages for formalization, by company.

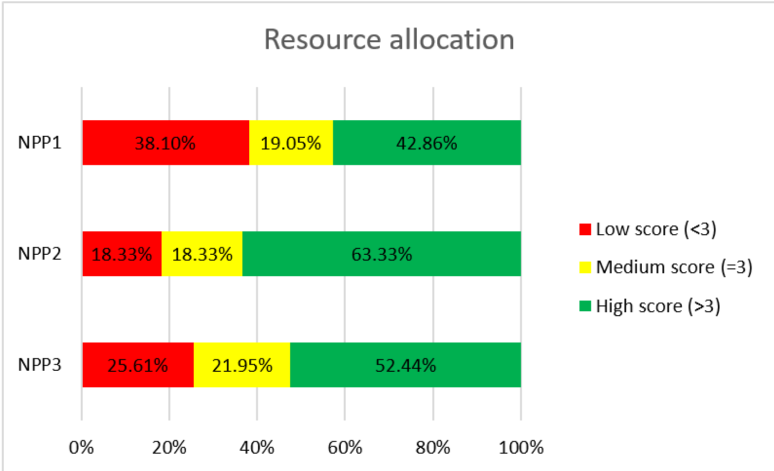

Figure 8. Categorized BARS percentages for resource allocation by company.

3.2.2. Differences by Work Location (Facility/Headquarters)

Generally speaking, the analysis of survey scales by workplace shows homogeneous results between headquarters personnel and facility personnel (δ < 0.20). The only relevant difference is found in the hazard perception scale (facility M = 4.38; headquarters M = 3.16; δ = 0.76) (Table 8, Figure 9). Within this scale, personnel working at the facility have a higher average score than headquarters personnel.

Table 8. Descriptive statistics of the scales by work location.

	Facility (N = 3767)			Headquarters (N = 473)			
Scales	**N**	**M**	**SD**	**N**	**M**	**SD**	**Cohen's δ**
Hazard perception	3759	4.38	1.62	473	3.16	1.54	0.76
Safety	3761	5.89	0.78	473	5.89	0.68	0.00
SCWE	3759	4.66	1.42	473	4.92	1.44	−0.18
Planning	3318	5.38	1.08	432	5.53	1.04	−0.14
Adaptive capacity	3318	4.48	1.31	432	4.68	1.28	−0.16
Overall resilience	3319	4.93	1.10	432	5.11	1.08	−0.16

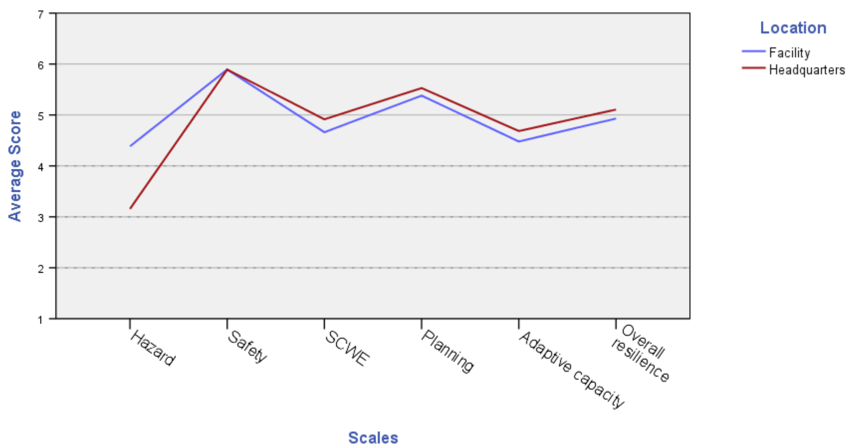

Figure 9. Scales averages by location.

However, this workplace-based homogeneity in scores is not present in the three BARS within this study, all of which show differences that are statistically significant and have magnitudes of medium effect (attention to safety: facility M = 4.33; headquarters M = 4.74; t(75.05) = −4.99; p = 0.000; δ = −0.58), (formalization: facility M = 3.93; headquarters M = 4.46; t(17.55) = −2.67; p = 0.002; δ = −0.67), (resources allocation: facility

M = 3.25; headquarters M = 3.84; t(83.48) = −3.85; p =0.000; δ = −0.60) (Table 9, Figure 10). Headquarters personnel score higher than facility personnel in terms of emphasis on safety (97.92% vs. 86.77%) (Figure 11), formalization level (100% vs. 86.36%) (Figure 12), and resources allocation (82.86% vs. 46.62%) (Figure 13). It is interesting to mention the BARS for resource distribution in the case of facility personnel is interesting, as only 46.62% of them give it a positive score.

Table 9. Descriptive statistics of the BARS by work location.

	Facility (N = 274)						Headquarters (N = 48)						
Scales	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**	**Cohen's δ (CI95%)**
Attention to safety	272	4.33	0.72	86.77	12.06	1.16	48	4.74	0.47	97.92	2.08	0.00	−0.58 (−0.89. −0.28) *
Formalization	91	3.93	0.81	86.36	8.33	5.30	12	4.46	0.45	100.00	0.00	0.00	−0.67 (−1.28. −0.06) *
Resources allocation	82	3.25	1.09	46.62	22.30	31.08	35	3.84	0.68	82.86	11.43	5.71	−0.60 (−1.00. −0.20) *

Note: * statistically significant differences (Bonferroni-corrected $p < 0.025$).

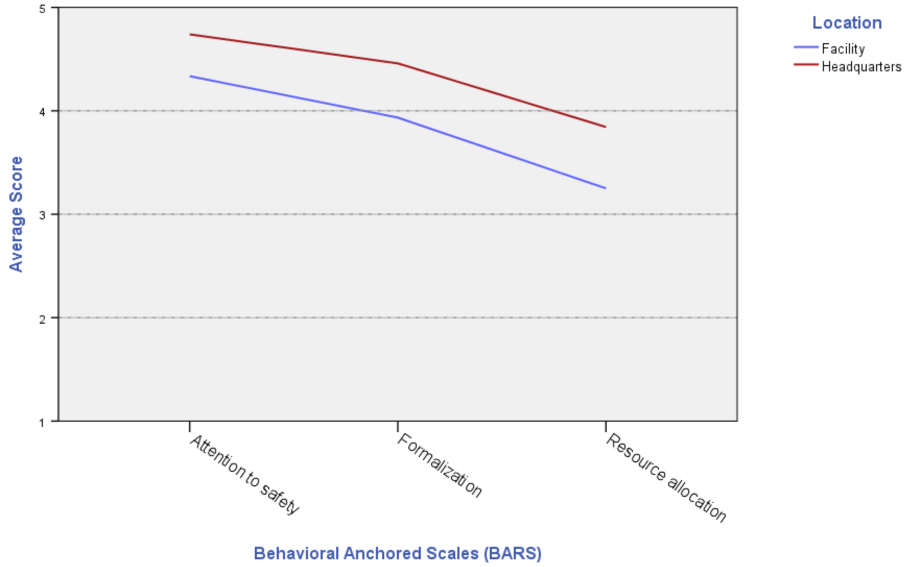

Figure 10. BARS averages by location.

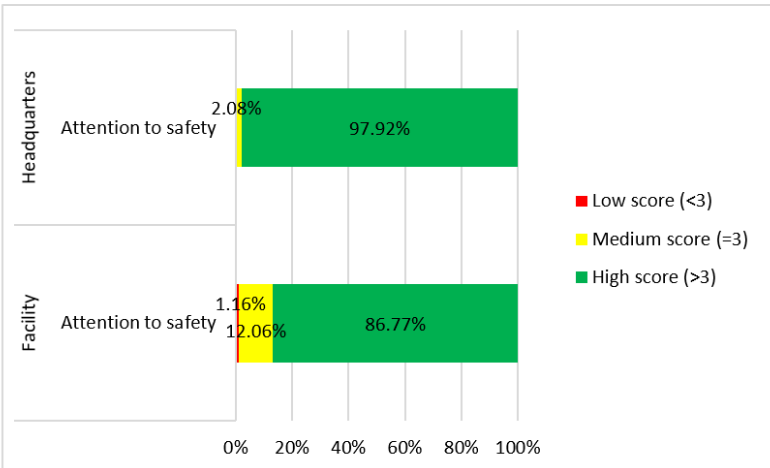

Figure 11. Categorized BARS percentages for attention to safety, by location.

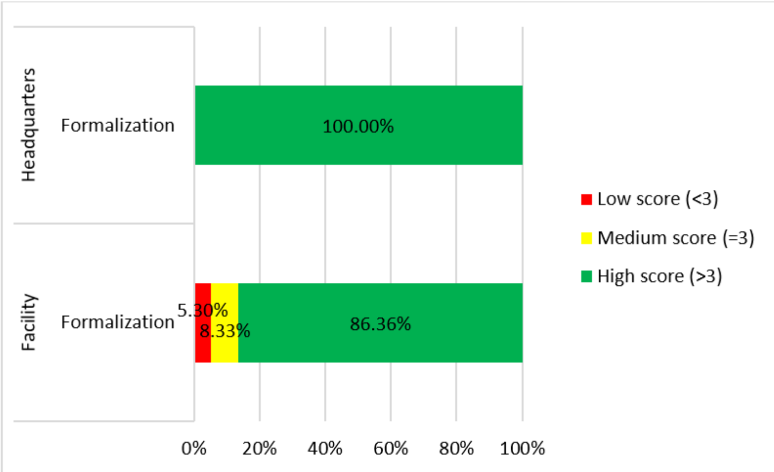

Figure 12. Categorized BARS percentages for formalization, by location.

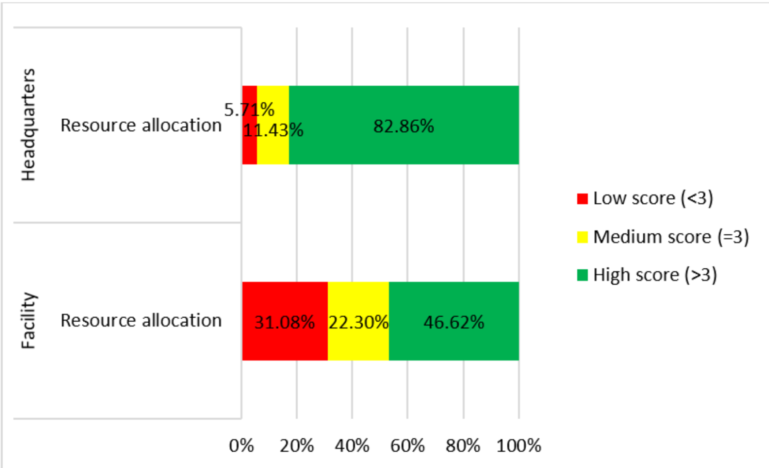

Figure 13. Categorized BARS percentages for resources allocation, by location.

3.2.3. Differences by Contractual Relationship (Own Staff/Contractor)

Personnel in nuclear power plants score homogeneously in the safety and hazard perception scales, but show differences in the remaining survey scales. Own staff score higher than contractors in SCWE scales (own M = 5.07; contractor M = 4.47; δ = 0.43), planning (own M = 5.69; contractor M = 5.24; δ = 0.44), adaptive capacity (own M = 4.77; contractor M = 4.38; δ = 0.31), and overall resilience (own M = 5.23; contractor M = 4.81; δ = 0.40). That is, contractor personnel have a lower perception of blame-free environment and lower organizational resilience (Table 10, Figure 14).

Table 10. Descriptive statistics of the scales by contractual relationship.

	Own staff (N = 1715)			Contractor (N = 2287)			
Scales	**N**	**M**	**SD**	**N**	**M**	**SD**	**Cohen's δ**
Hazard perception	1714	4.39	1.65	2286	4.10	1.66	0.18
Safety	1715	5.99	0.70	2287	5.85	0.78	0.19
SCWE	1715	5.07	1.42	2286	4.47	1.35	0.43
Planning	1376	5.69	0.95	2114	5.24	1.10	0.44
Adaptive capacity	1377	4.77	1.24	2113	4.38	1.30	0.31
Overall resilience	1377	5.23	1.02	2114	4.81	1.09	0.40

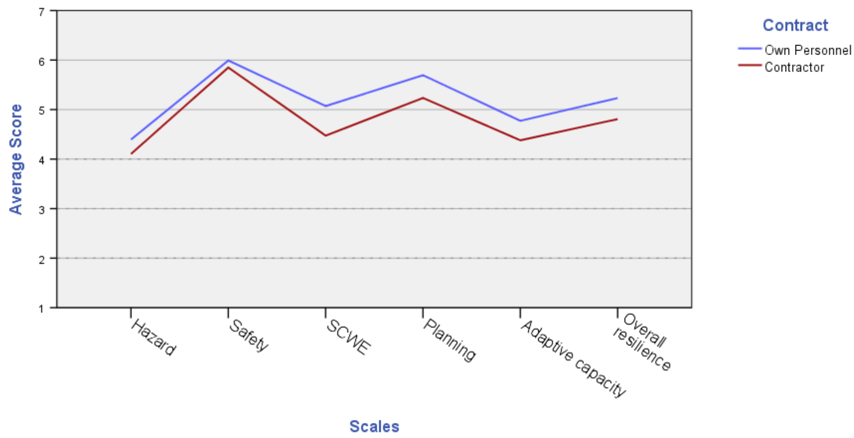

Figure 14. Scales averages by contract.

BARS results are not homogeneous when it comes to contractual. On the one hand, some differences are statistically significant and have magnitudes with a small effect in terms of safety and norm and procedure quality (attention to safety: own M = 4.46; contractor M = 4.20; t (96.62) = 2.66; p = 0.009; δ = −0.38), (formalization: own M = 4.17; contractor M = 3.80; t (33.30) = 1.80; p = 0.081; δ = −0.48). On the other hand, no significant differences are observed, although their magnitudes have a small average effect in resource distribution scores (resources allocation: own M = 3.49; contractor M = 3.06; t (167) = 1.49; p = 0.138; δ = 0.39) (Table 11, Figure 15).

Table 11. Descriptive statistics of the BARS by contractual relationship.

	Own staff (N = 367)						Contractors (N = 76)						
Scales	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**	**N**	**M**	**SD**	**% High**	**% Med**	**% Low**	**Cohen's δ (CI95%)**
Attention to safety	365	4.46	0.66	91.51	7.67	0.82	76	4.20	0.81	77.63	21.05	1.32	0.38 (0.14. 0.63) *
Formalization	111	4.17	0.68	90.99	5.41	3.60	28	3.80	1.01	71.43	17.86	10.71	0.48 (0.06. 0.90) *
Resources allocation	153	3.49	1.04	58.82	18.95	22.22	16	3.06	1.34	31.25	25.00	43.75	0.39 (−0.13. 0.91)

Note: * statistically significant differences (Bonferroni-corrected $p < 0.025$).

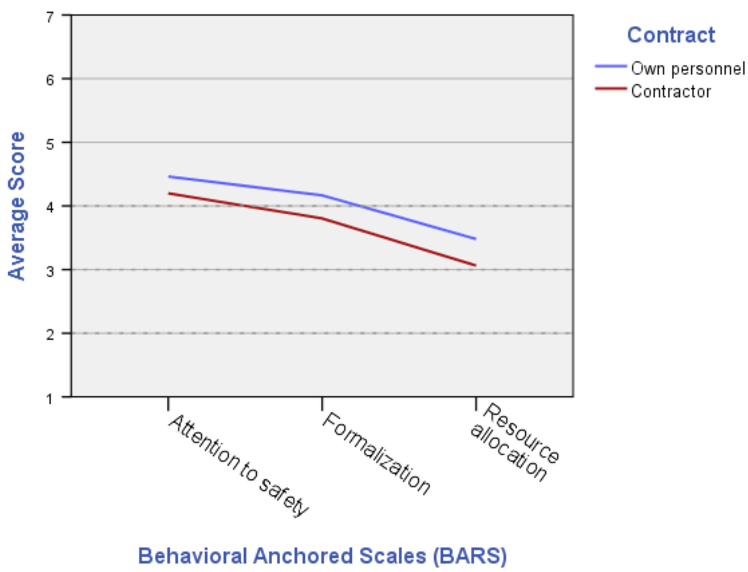

Figure 15. BARS averages by contractual relationship.

Own staff score higher in emphasis on safety (Figure 16), formalization (Figure 17), and resources allocation (Figure 18) than contractor personnel. The score obtained by contractors in the BARS for resource distribution is interesting, because 43.75% (low) of them have a negative impression, as opposed to 22.22% in the case of own staff.

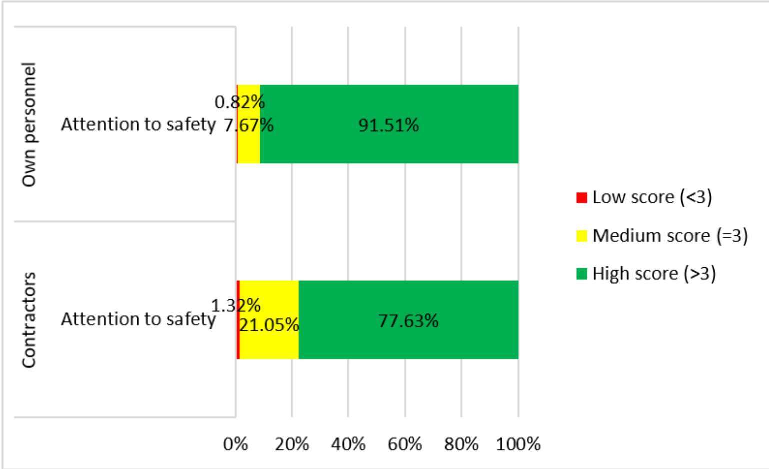

Figure 16. Categorized BARS percentages for attention to safety, by contractual relationship.

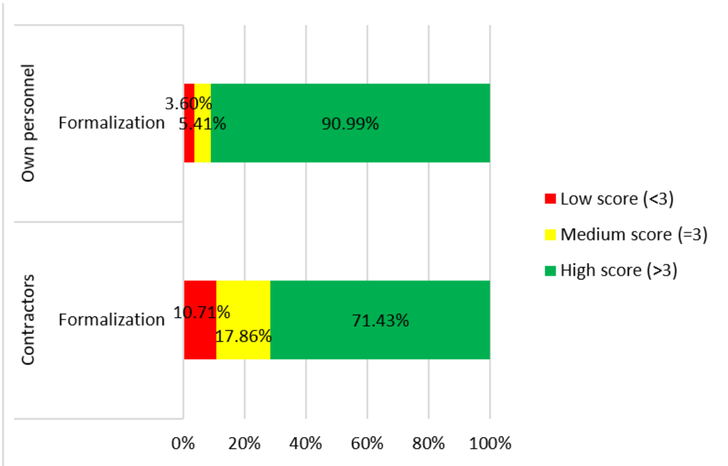

Figure 17. Categorized BARS percentages for formalization, by contractual relationship.

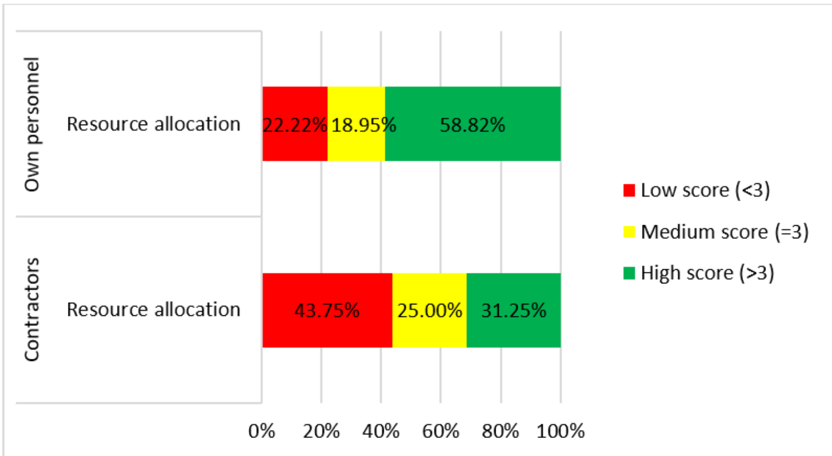

Figure 18. Categorized BARS percentages for resources allocation, by contractual relationship.

4. Discussion

The results of this study contribute to characterizing the safety culture traits of Spanish nuclear power plants (SNPPs) in accordance with some of the main theoretical approaches of the high-risk industry. As abovementioned, it is important to clarify that this study is not focused on contrasting or revising theories from a theoretical point of view, but on describing some safety culture traits within the Spanish nuclear industry. This is therefore a descriptive study that uses secondary data obtained from all nuclear power plants. The measurement instruments used in this study have been in use for 20 years in the Spanish nuclear industry as part of the NOMAC methodology, except for the resilience scale, which was added in the last few evaluations. Continued use of the same methodology has favored an overall analysis of the safety culture of the industry, as well as comparative analyses between different groups and organizations.

Therefore, results are interpreted by taking into account the need for high-risk organizations to (a) prioritize safety (HRO theory); (b) manage unexpected events (resilience engineering), and (c) manage existing organizational dilemmas adequately so as to ensure decision-making does not lead to accidents (conflicting objectives perspective).

Analysis of these results revealed both current uniformity and heterogeneity aspects relating to safety culture in SNPPs [49,69,70]; i.e., the results of this study reflect the existence of a global safety culture pattern that goes beyond the actual organization but which, at the same time, facilitates the identification of differentiating traits potentially linked to subcultures.

4.1. General Safety Culture Traits of SNPPs

To ensure error-free operation, the theory of HRO considers that it is absolutely necessary to prioritize and focus on safety at all organizational levels [31,32]. In this regard, high scores obtained in the safety and planning scales and in the attention to safety and formalization BARS are relevant aspects of our study. These results reveal four key defining characteristics of safety culture in SNPPs: (a) the perception of safety as an essential condition to successfully operate the plant (safety scale); (b) the assessment of solid organizational preparation and proactiveness to address potential problems (scale of resilience planning); (c) the belief that the organization prioritizes safety against production aspects (BARS attention to safety); and (d) the perception of a high level of activity standardization and documentation (BARS formalization). These four attributes are features of high reliability organizations [26].

Our results also show a certain level of ambivalence concerning the capacity to manage organizational variability while maintaining system stability, in line with the postulates of Weick et al. [35] and Schulman [33]. This characteristic is postulated from the theory of HRO and the engineering of resilience as a requirement for safe and reliable plant operation [37]. In this regard, workers in nuclear power plants perceive stations as organizations using robust preparatory practices to effectively and proactively manage future crises (planning scale). On the contrary, the perception of their strength to manage crisis is not as high (adaptive capacity). Thus, considering the paradigm of resilience and uncertainty management [16,71], SNPPs are satisfactorily perceived as organizations that promote planning activities. Having stated that, the perception of their capacity to adapt to uncertainty and the unexpected is not as satisfactory.

One last critical aspect of the SNPPs safety culture identified in our results is the organizational process relating to the establishment of objectives and resources allocation (BARS resources allocation). This is the study's range scale with the lowest average score and the one showing the highest level of polarization, that is, of opposite opinions confronted. Considering the dilemmatic aspect of this scale, it is worth noting that a considerable percentage of respondents perceive a scarcity of resources (including people, equipment, time, and budget) and deficiencies in the way the organization establishes and communicates its objectives.

4.2. Specific Safety Culture Traits of SNPPs

The comparative analysis based on the three study variables (company, location, and contractual relationship) shows an interesting paradox: the existence of a uniform safety culture amongst the organizations, but also the coexistence of significant differentiating traits relating to location and contractual relationship.

In general terms, these data suggest that there is strong cultural homogeneity amongst the three nuclear organizations included within this study. In all three, the same resulting pattern is obtained, with high scores for safety (scale and BARS), anticipative capacity (subscale of resilience), level of formalization (BARS), and, to a lesser extent, the processes of resources allocation and establishment of objectives (BARS). However, it is important to point out that within the scope of formalization there are significant differences between two out of the three organizations.

Concerning differentiation, the analysis reveals that the variables ″place of work″ and ″contractual relationship″ may potentially lead to the creation of subcultures and to conform a safety culture with unique traits. This differentiation is present both in terms of the entire sector and within each of the organization's part of this study.

As for ″location″, results show that personnel working at the facility score higher than personnel at the headquarters in the hazard scale. This is in fact the most statistically significant difference of the entire study. This finding is coherent with previous studies [72], which show that individual perceptions on hazard levels at the workplace in a nuclear organization seem to be associated to proximity to the technological element. That means workers within the group directly linked to plant operations, i.e., facility personnel, score higher in risk perception. Differentiated grades are also observed in all BARS. Headquarters personnel have a more favorable vision than facility personnel of the importance given by the organization to safety (BARS attention to safety), quality of standards, and procedures (BARS formalization) and allocation of resources (BARS resources allocation). The difference in this last BARS is quite significant, revealing that headquarters personnel have a much more positive view of resources allocation processes (82% vs. 46%). In short, it can be concluded that the safety culture of facility personnel differs from global safety culture mainly in their risk awareness, and also in a less categorical resolution of the safety–production dilemma (less clearly positioned towards safety), and a more critical vision of the processes for resources allocation and establishment of objectives.

The analysis based on "contractual relationship" shows the level of variability in relation to overall safety culture traits. Contractors score lower than personnel in all measurement instruments used to describe the purpose of this study (the safety culture of SNPPs). On the one hand, contractors are less categorical when it comes to the priority of safety, level of formalization, and adequacy of resources allocation. Their score is also more aligned to safety culture at the facility. On the other hand, there are also significant differences in the perception of both a blame-free environment (SCWE scale) and the organization's capacity to respond to crises (resilience subscale). Contractors point to a lower level of freedom to express concerns and seem to be more concerned about the consequences of dissenting. They also assign a lower score to the organization's capacity to plan, respond to, and recover from crisis.

Considering these results and an increasing number of contractors in nuclear power plants (exceeding the number of own staff), it is necessary to consider the impact these cultural differences may have on the overall safety of Spanish nuclear power plants. Although own staff and contractors both perceive organizational culture norms within the same order of magnitude [52], this study reveals that, on the contrary, such uniformity does not exist when it comes to other determining safety culture aspects, such as blame-free environment, management of variability, assessment of safety priority, level of formalization, and availability of resources. Uneven labor conditions (in terms of contractual stability, wages, or the nature of the job to carry out) may determine this differentiated perception of SNPPs safety culture by contractor personnel.

4.3. Implications of This Study

This study reveals the usefulness of the three theoretical approaches to understand the practical reality of the industry. The aim is, in terms of the Turner and Pidgeon analogy [6], to reduce "blind spots" affecting the safety of Spanish nuclear power plants during their end-of-cycle stage, within prospects of gradual shutdown over the next few years. The diversity of these theories provides, as if they were watchtowers, a comprehensive, wide, and detailed view of the status of safety culture within the industry. The idea is to apply a pragmatic approach that integrates concepts not necessarily aligned but certainly complementary—a kind of theoretical crossbreeding that makes it possible to understand a concept as polyhedral and complex as organizational culture. The "real" safety of high reliability organizations is more robust if theoretical diversity is added as an interpretative framework for its "reading", rather than with a monolithic view from a single theoretical prism. In this regard, this study shows some valuable safety-related contributions provided by other, less known theoretical approaches, such as the conflicting objectives perspective (COP). Measuring how organizations solve organizational dilemmas provides insights that complement knowledge about the value they place on risk and safety (HRO) and how they manage uncertainty (RE). In short, the analysis of results under the interpretative framework of the three theoretical approaches of reference in our study favors practical reflections on safety culture at SNPPs.

According to the theory of HRO, organizational culture should be focused on safety and to prevent catastrophic failures, and to promote a constructive work environment that tolerates discrepancies [27,30]. Based on the results of our study, one could wonder to what extent the existence of workers who perceive that safety is not always the priority could be considered as a warning. Perhaps one could also consider that the resolution of the safety–production dilemma is sensitive towards safety once the local context or executing activity (facility, contractor) is the actual focus. Similarly, it is necessary to wonder about the impact of differentiated perceptions when it comes to the possibility to dissent without fear of retaliation (contractors).

The theory of resilience includes the stages before, during, and after disruptions [73]. Nuclear power plants are complex organizations that operate under variable conditions and comprise highly interdependent parts. Thus, their adaptive capacity is paramount to prevent disastrous consequences [43]. In fact, the essence of organizational resilience is the capacity to recover the system's dynamic stability following critical disturbances [74]. Considering this approach, results show that SNPPs are perceived as solid organizations in their development of anticipative activities, but less solid and robust in their coping capacity. Accordingly, it is necessary to consider the impact of this differentiated perception as a question to be addressed in order to make SNPPs more resilient.

Lastly, within the COP framework [44] it is necessary to ask if SNPPs take into consideration the importance of correctly managing conflicting objectives. In other words, to which extent is the resolution of the dichotomy "precise objectives and sufficient resources" versus "vague objectives and resource shortage" coherent with the emphasis on safety? Similarly, from a perspective that is both dynamic and changing over time, to what extent could safety and quality be gradually displaced in favor of an increased sensitivity towards economic costs and time pressures? In this respect, it is necessary that top management address objectives that are partially conflicting, making unacceptable risk-related limits both visible and known, as proposed by Rasmussen [44] (p. 189).

4.4. Limitations

The use of secondary data allowed us to adopt a descriptive approach to safety culture, without being able to analyze theoretical questions in depth. In this sense, aspects such as the lack of demographic information on organizational seniority or professional groups, which could be potential moderating factors of the organizational culture, are a limitation for the current study.

Lastly, having a qualitative approach in the data collection strategy probably would have provided additional insights to deepen the understanding of some group differences and results observed.

5. Conclusions

There have always been multiple definitions and developments of safety culture [17]. Scientific literature conceives safety culture as a diverse, multidimensional construct of organizational culture [21], which is created in organizations that prioritize beliefs, values, and attitudes relating to safety [1,9]). This multidimensional characteristic of safety makes it possible to study culture from different theoretical approaches in which concepts may overlap or complement each other [47].

Based on this concept, our study's reference framework is based on core items of the theories HRO [27,30], RE [37,43,72], and COP [44], with the aim to describe the main traits of safety culture in Spanish nuclear power plants. To do that, quantitative secondary data obtained from surveys and behavioral anchored rating scales in all Spanish nuclear power plants was taken as an object of analysis. Both the industry as a whole and the specificities of each possible subculture were considered by the statistical analysis [75].

Results show the following defining characteristics of safety culture: (a) high perception of the importance of safety, (b) clear resolution of the safety–production dilemma, (c) positive vision of the organization's capacity to prepare for crisis scenarios, and (d) high level of process and activity formalization. On the other hand, results show the existence of a critical, polarized vision amongst the workforce concerning the organization's distribution of personnel, equipment, time, and budget. In short, there is an organizational culture in which a shared view of the importance of safety, anticipative capacity, and level of formalization coexists with a more critical, fragmented perception of resources allocation and target establishment processes.

Regarding possible subcultures, the study reveals an interesting paradox, the existence of a uniform culture within Spanish nuclear power plants that coexists with differences linked to work location and contractual relationship. Facility personnel have higher risk awareness, as well as a more critical vision of the resolution of the safety–production dilemma and of processes for resources allocation and establishment of objectives. As for contractors, the analysis shows this group is clearly different from own staff in all study scales, with considerable differences in blame-free environment and the organization's adaptive capacity in case of crisis.

Future research should further analyze how safe plant performance is impacted by a fragmented perception of the resolution given to the resource availability dilemma (sufficient vs. insufficient) or clearly differentiated perceptions between own staff and contractors.

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Informed Consent Statement: All subjects involved in the study participated in the organizational culture and safety surveys on a voluntary basis.

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