ISSN 2683-345X
journal homepage: http://ijiemjournal.uns.ac.rs/

International Journal of Industrial Engineering and Management

2026 / ARTICLE-IN-PRESS / 419

Original research article

Framework for Understanding Design Heuristics and Sources of Bias in New Product Development

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ABSTRACT

Product development, whether incremental or radical, is inherently complex and uncertain, requiring rational decision-making by product designers to enable effective ideation. However, heuristics (or mental shortcuts) often impact this decision-making process, introducing cognitive biases that can significantly impact design outcomes. This is especially problematic for New Product Development (NPD). Despite this impact, research on the sources of these cognitive biases within NPD, particularly during the ideation phase, remains limited. Through a systematic literature review, the present study first identifies the body of research dealing with heuristics and cognitive biases in NPD. Secondly, the study identifies a comprehensive set of available design heuristics and cognitive biases, which are four design heuristics and 37 cognitive biases, and subsequently provides an overview. Finally, we develop a framework that proposes a new view on cognitive bias sources composed of three perspectives: 1) information related to the product design, 2) the nature of the design problem, and 3) designers' cognitive reasoning. We expect this framework to be of value to product designers and design managers in identifying potential cognitive bias sources and implementing actions to mitigate their negative effects on NPD.

ARTICLE INFO

Article history:
Received December 16, 2025
Revised April 30, 2026
Accepted May 5, 2026
Published online June 26, 2026

Keywords:
Cognitive biases;
Design heuristics;
Decision-making;
New product development (NPD);
Systematic literature review

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1. Introduction

New Product Development (NPD) is a complex and uncertain process requiring collaboration among professional designers, practitioners, managers, and employees involved in the product development process [1]-[4]. The process typically follows six stages: strategic planning, idea development and concept selection, market analysis, technical development, product testing, and commercialization [5]. Although success in each stage involves strategic decision-making to address challenges and opportunities [6], decisions made during product idea development and concept selection are particularly critical to NPD [7]-[9]. Recent research [10] indicates that decision-making in NPD is often suboptimal and prone to errors. These errors can stem from various sources, such as the patterns of information involved in the design process [2], [11]; employees' personalities, their academic backgrounds, and experience [11], and the designers' own reasoning, and the effect of ecological rationality [1], [12] as a result of design heuristics [13], [14].

Heuristics are mental shortcuts or rules of thumb that personnel involved in the design process use to make rapid decisions [15], [16]. Although they can be

Published by the University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia.

https://doi.org/10.24867/IJIEM-419

useful in facilitating rapid decisions, they often introduce cognitive biases [16]-[18]. For instance, designers and employees involved in the product ideation process rely on availability heuristics [19], [20], generating ideas that are similar to existing products. This reliance on previous design practices often results in cognitive bias and restricts designers from exploring new product ideas [18], [21]. Numerous studies [10], [12], [22], [23] have examined the effect of heuristics and cognitive biases across various fields. However, there remains a lack of research exploring where cognitive biases typically emerge during the design process.

This study conducts a systematic literature review of the design heuristics and cognitive biases in NPD, filling the existing research gap. First, the present study identifies the relevant literature. Secondly, it extracts the types of design heuristics and biases that manifest during NPD. Finally, the study adds to the existing research by developing a framework that systematizes the source of biases and provides new value for practitioners and future research, named *Cognitive Bias Origins in New Product Development: A Three-Perspective Framework*.

The remainder of this article is organized into four sections. Section 2 provides the theoretical background for the study. Section 3 details the review methodology employed. Section 4 provides results with publication trends, a review of design heuristics and cognitive biases in NPD, and the explanation of the newly proposed framework. Finally, Section 5 discusses results, summarizes the main implications of the research, identifies limitations, and proposes directions for future research.

2. Theoretical Background

2.1 Product Ideation and Strategies for Generating New Product Concepts

The present study refers to the six-stage NPD process, namely: 1) strategic planning, 2) idea generation and concept selection, 3) opportunity analysis, 4) technical development, 5) product testing, and 6) commercialization [5]. Notably, the idea generation and concept selection stage accounts for 75% to 85% of the reduction in manufacturing and marketing costs, enabling product vendors to survive longer in the market [8]. Furthermore, this stage accounts for 80% of the overall product lifecycle cost [14]. Therefore, a thorough understanding of concept generation within NPD is essential. While heuristics and biases occur in many design contexts, NPD is particularly sensitive due to its inherent complexity, uncertainty, and the high impact on early-stage decisions for its outcomes.

An idea for a new product can be generated through two fundamental strategies: 1) *using ideation tools*, such as considering a technical organizational chart [14], SCAMPER (i.e., the decision guided by questions), and TRIZ (i.e., product modification) [1], [14] ; and 2) *without specific ideation tools*, such as analogical thinking and benchmarking, user observation, or emotional experience [24], distinctive stimuli (e.g., color, dynamism, and comfort) [18], design experience, and preference for problem-solving [1], and case-based reasoning [14]. Notably, recent findings, including Calle-Escobar et al. [14] and Yilmaz et al. [1] emphasize how concepts for NPD can be generated using *design heuristics*. Several studies [18], [19], [22] agreed that although this strategy enhances both expert and novice designers' creativity during product ideation, it introduces cognitive biases.

2.2 Designer's Cognitive Reasoning and Decision-Making in NPD

Decision-making tasks in new product concept generation and selection help in shaping the cognitive reasoning of both expert and novice designers, whether working individually or in teams [25]. However, designers often prioritize a workable design concept over ensuring its consistency, as this approach allows them to save time, which can lead to decision biases. To address this problem, Badke-Schaub and Gehrlicher [25] and Ruelas et al. [6] applied the concept selection decision phases: goal clarification, realization (i.e., searching for a solution), evaluation, and final decision. However, each phase still needs the designer's rational cognitive reasoning.

Notably, designers with different cognitive reasoning exhibit distinct behaviors during decision-making due to variations in information processing, which leads to uncertainty [26]-[28]. In behavioral economics [16], [17], [27], researchers have explored various methods for making rational decisions under uncertainty. For instance, Simon and Newell [29] introduced the concept of bounded rationality and satisficing, a heuristic model for making decisions [30], [31]. Based on Simon's work, Tversky and Kahneman [17] linked heuristics and cognitive biases, identifying *availability, representativeness*, and *anchoring* heuristics as key sources of biased decision-making. Furthering Simon's model but contrasting Tversky and Kahneman, Gigerenzer and Goldstein [32] extended heuristics as normal for making fast and frugal decisions, called *recognition heuristics*.

Building on the findings of behavioral economists, Marzi [33], V. Belvedere et al. [34] and Lockton [18] investigated how cognitive limitations lead product designers to make less rational decisions. Lockton [18] further explained that such limitations arise from *bounded rationality*, where decisions are an adaptive response to situational constraints in which designers prioritize self-interest while selecting the design concept. As a result, their reasoning is prone to cognitive biases due to the frequent reliance on *design heuristics* to simplify such complex decisions [1], [14], [34].

2.3 Heuristics and Cognitive Biases in NPD

2.3.1 Design Heuristics and Cognitive Biases Duality

In product design research, various terminologies have been used to describe design heuristics, making it sometimes difficult to follow the discussions in the relevant field. For example, Dahl and Moreau [24] discussed heuristics as both a *cognitive psychology* and a *cognitive strategy*, a notion later emphasized by Yilmaz et al. [35]. To describe the application of heuristics in product design, Antioco et al. [2] used the term *cognitive opportunity*. Years later, Yilmaz et al. [1] detailed the application of heuristics in product ideation and formalized the term *design heuristics*. Design heuristics remain ambiguous, as many authors interchangeably use the terms heuristics and cognitive biases. For example, V. Belvedere et al. [34] and Ruelas et al. [6] referred to *anchoring bias,* which Tversky and Kahneman [17] termed *anchoring heuristics*. This suggests that heuristics and biases are sometimes indistinguishable. Lockton [18] contextualized the relationship between heuristics and biases in design, concluding that they constitute a *twofold effect* (i.e., two sides of the same coin and, in fact, indistinguishable).

Even though the duality effect can work to an extent [36], a clear distinction exists between heuristics and cognitive biases by definition. As mentioned in the introduction section, heuristics are mental shortcuts that can be raised either from intuitive thinking (System 1), which is fast and automatic, or analytical thinking (System 2), which is slow but more rational [37]. However, analytical thinking is often influenced by intuitive decision-making, which is irrational and prone to cognitive biases [26], [38], [39]. Therefore, cognitive biases are often systematic errors rooted in intuitive thinking that affect decision-making and deviate from rationality, depicting their distinction from heuristics [16], [27].

2.3.2 The Notion of Cognitive Biases in NPD

Building on the theories of Tversky and Kahneman [17], several product design researchers [6], [12] suggested that cognitive biases result from design heuristics. For example, representativeness heuristics can lead to biases such as insensitivity to prior probabilities and the illusion of validity [13], which has the same effect as analogical reasoning. Although analogical reasoning is sometimes considered a distinct cognitive process [24], in NPD it largely overlaps with representativeness heuristics, as designers often generate new concepts by drawing analogies from previous designs and competitors. Zheng and Miller [12] examined the overdesign bias and its effect on creativity within design teams, highlighting its contribution to customer loss due to increased price and usability complexity.

In some cases, designers prefer their own ideas, reflecting an interest bias [20], [34], and over featuring design [33], which can be linked to anchoring heuristics (Table 1). Cognitive biases can also arise from the available source of information [10], potentially leading designers to misunderstand the information [40]. For example, overconfidence and optimism are often common biases among product inventors due to information misinterpretation [10], [40]. Additionally, biases arising from users' psychology and emotional experiences influence product creativity by shaping the designers' perceptions into a different context, as noted by Wang et al. [41]. Overdesign, resulting from designers' perceptual differences, is a common example [33], [34], [42]. Kurz et al. [42] further noted that this bias often occurs when designers empathize too deeply with customers' needs. Ambiguous design instructions and resource limitations (e.g., time) can also contribute to bias [1], [14]. Furthermore, misinterpreted information filtered through employees, such as front office staff and managers, can further influence designers [2].

Notably, some recent findings highlight the positive effect of cognitive biases in design, such as impact bias and exclusivity bias, which contribute positively to product ideation, reshaping product managers' mindsets [22] and boost inventors' performance [43]. This insight challenges the notion that cognitive bias is always detrimental. As a result, regardless of whether their effect is positive or negative, presenting a comprehensive set of cognitive biases, along with their source, is essential for raising awareness among designers and staff involved in the design process, as it helps shape their design behavior.

3. Research Method

This study applies the systematic literature review method [44]-[46] to analyze the impact of design heuristics and cognitive biases in NPD and their effect on product designers. Specifically, the literature review included four search and selection phases (Figure 1) based on the systematic literature review method from [47]-[49]. Albeit the third step of publication quality selection was omitted since the research field is still young, to have a comprehensive coverage of the existing articles. Further, a subject area selection step [49], [50] has been added to focus the research on the field of engineering management and related fields.

The research focused on examining the impact of design heuristics and cognitive biases, along with their potential sources and effects, in the NPD process. It considered key elements such as designers and other involved participants (e.g., design managers, supervisors, and employees). Accordingly, some preliminary keywords were chosen (i.e., "heuristics and cognitive bias*", and "new product develop*") based on literature sampling and discussion of the research team. After the preliminary literature review and multiple iterations, the final list of keywords was established (using "OR" and "AND" operators – Figure 1) and used in the Initial search (step 1 – Figure 1). Upon conducting the search in the Scopus database and maintaining only English-written articles, the Initial search yielded 402 articles. In step 2, the selection of publications was further refined based on the subject area (i.e., Engineering, Business, Management and accounting, and Decision science), leaving 285 articles (Figure 1). Next, in step 3, article abstracts were read, and only those claiming to contribute to the understanding of the designer's cognitive reasoning were kept for the next step, leaving 54 articles in the selection. Notably, if in doubt, researchers opted to apply the inclusion strategy, leaving the article under question for the full text reading (Criterion 1 – Figure 1). Finally, during the full-text reading (step 4 – Figure 1), we analyzed if the article provided details about heuristics, cognitive biases, and the designer's cognitive reasoning associated with NPD (Criterion 2 – Figure 2). As a result, 22 articles were found to be relevant (for the full list of relevant articles, see Appendix 1) and were subsequently analyzed.

The findings are then systematically synthesized and presented through a structured summary of the relevant articles. The results are supported by tables and figures, finally drawing directions for future research.

4. Results

Our systematic literature review revealed that only rare research linked heuristics and cognitive biases to NPD [9]. Specifically, Cossete [10] conducted a review on *heuristics and cognitive biases in entrepreneurs* linked to new product launches, demonstrating that their impact varies depending on the context. Although Cossete [10] provides a good understanding

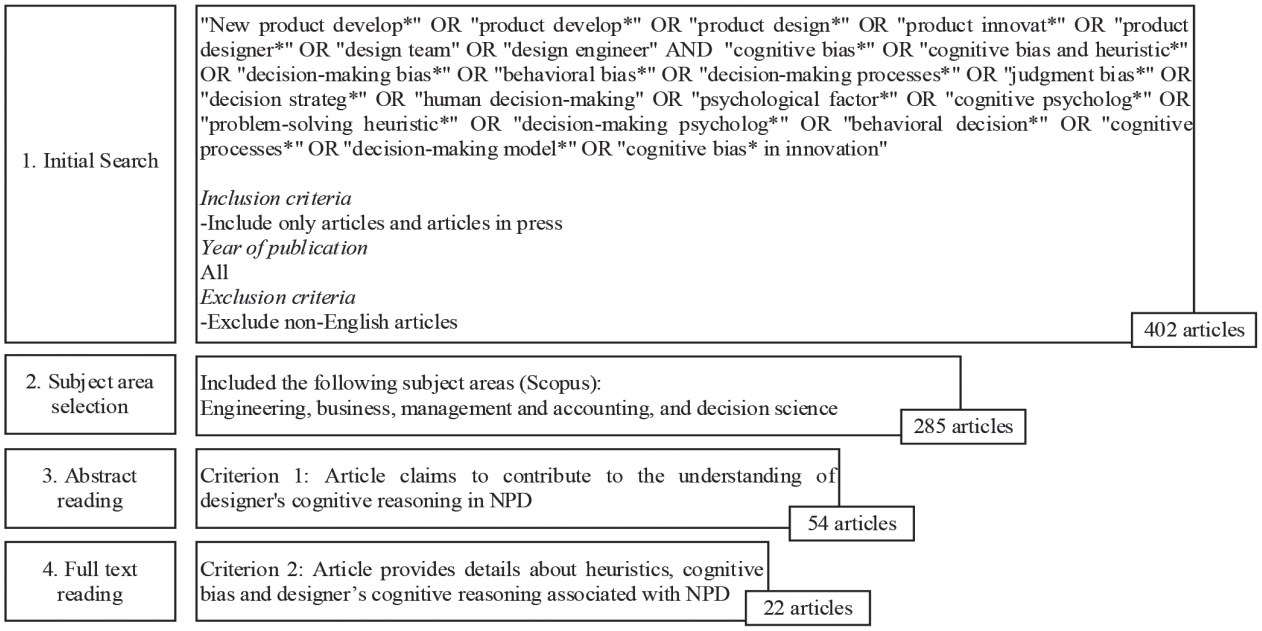

Figure 1. Search and selection process

of design heuristics and cognitive biases, it does not delineate their comprehensive set and the potential sources where they emerge, warranting further investigation.

Our study provides a much-needed summary of design heuristics and cognitive biases, and their effect on NPD, especially in the NPD ideation phase. The findings are organized and presented in two parts: 1) understanding the research trends in the field with analysis of the research methods used to date, and the sets of design heuristics and cognitive biases (sub-section 4.1), and 2) developing and discussing a literature-based framework (*Cognitive Bias Origins in New Product Development: A Three-Perspective Framework*) for NPD – sub-section 4.2.

4.1 Publication Trends and Research Methods Used

4.1.1 Publication trends

The field of design heuristics and cognitive biases in NPD is relatively young, with the first article published in 2002 [24]. The analysis of publications from 2002 to 2024 reveals a gradual increase in research focused on design heuristics and cognitive biases in NPD. Although initial interest was limited, publications began to increase substantially from 2021 onward. Notably, there was a significant increase in publications in 2024, as shown in Figure 2, implying greater interest and development in this research field. However, the limited number of relevant articles indicates that the field remains underexplored, presenting an opportunity to explore a new framework that categorizes the sources of cognitive biases in NPD.

The majority of the articles remain dispersed between different journals, with the majority of them publishing only one paper (Appendix 1). This is largely due to the interdisciplinary nature of the topic and the lack of publications

Of the 22 identified journal articles, 9 (i.e., 41%) examine the overall impact of design heuristics and cognitive biases in the NPD process, 5 (i.e., 23%) detail their effects, and 8 (i.e., 36%) focus particularly on cognitive biases and discuss their impact (Figure 3). From these findings, four design heuristics were extracted from nine articles (Table 1), and 37 cognitive biases were extracted from fourteen articles (Table 2), along with their definitions. Notably, there is a lack of clear consensus on the type of heuristics and cognitive biases among researchers, designers, practitioners, and involved employees [10], [42]. Nevertheless, they all agree on the importance of a deep understanding of both heuristics and cognitive biases in NPD.

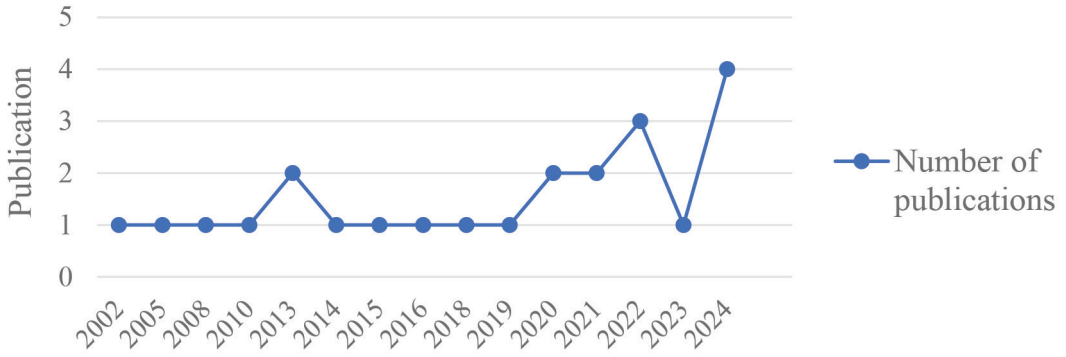

Figure 2. Trends of publications on design heuristics and cognitive biases in NPD

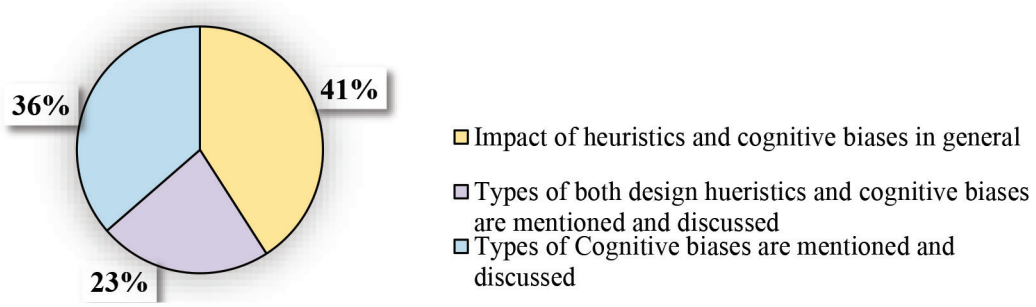

Figure 3. Distribution of articles by content

4.1.2 Research methods used

Among the 22 relevant articles, 18 employed empirical research methods, including interviews, surveys, and case studies, utilizing content analysis and statistical techniques for data interpretation [2], [39], [41]. To address the generalizability of these findings, we filtered the literature based on participant expertise. Studies by Yilmaz et al. [35], Ensici et al. [25], Alkhars et al. [13], and Fillingim et al. [19] focused on design students, which limits direct application to real-world engineering due to the absence of professional constraints. In contrast, Dahl and Moreau [24] and Yilmaz et al. [1] included both professional designers and design students, offering a more balanced perspective on how expertise affects heuristic use. Additionally, 13 articles featured professional designers, while others concentrated on conceptual frameworks.

Participant selection criteria vary by experience, seniority, and academic background, except for random selection (*see Dahl and Moreau [24]*) and interest-based participation (*see Zheng and Miller [12]*). All empirically validated studies emphasize target-oriented participants in examining the effect of design heuristics and cognitive biases in NPD, particularly during the ideation phase [1]. However, by distinguishing between these groups, we acknowledge that while student experiments provide foundational insights into how biases occur, the *practical impact* in industrial settings may vary due to higher stakes and professional experience. As a result, relying on these empirical findings limits the generalizability for new product developers across industries, presenting us with an opportunity to establish a novel framework that unifies product developers with varying ideation strategies.

Table 1. The four types of heuristics in NPD literature and their definitions

References	Heuristics	Definition
Cossette [10], Zhang et al. [43]	Availability	If something is easily recalled in people's minds, they overestimate its likelihood; if not, they underestimate it.
Alkhars et al. [13], Cossette [10], Zhang et al. [43]	Representativeness	The probability of an event occurring is assessed based on its similarity (implicit or explicit) to other events as if they belong to the same class.
Cossette [10]	Anchoring and adjustment	The initial design or work practice is used as a starting point and then adjusted before the final decision.
Marzi, G. [33], Cristofaro et al. [22], Trott et al. [20]	Recognition	Ability to recognize problems and quickly reach the correct solution.

Table 2. Cognitive biases in NPD literature and definitions

References	Biases	Definition
Alkhars et al. [13], Åstebro and Michela [8], Cossette [10], Kurz et al.,[42], Ruelas et al. [6], Zhang et al.[43]	Illusion of control or Illusion correlation,	Predicting personal future outcomes as more favorable than the suggested value.
	Unrealistic optimism, or overestimate (over empathizing)	The tendency to overestimate positive outcomes while underestimating risks.
	Hindsight bias	Being optimistic with trusting the previously obtained result.
Ruelas et al.[6], Querbach et al. [23]	Salience bias	Making decisions due to distinctive stimuli or reasons that might not be relevant.
	Loss aversion or	Preferring to take risks to avoid losses (segregate gains, integrate losses).
	Endowment effect or Sunk cost fallacy	The tendency to overvalue ownership (endowment effect) and persist in losses (sunk cost fallacy) both arise from an emotional attachment
	Framing effect	Understanding the same situation differently (by different people), results in different decisions.
Ruelas et al. [6], Zheng and Miller [12]	Confirmation bias	Overweighing the evidence that supports their point of view under bounded circumstances.

References	Biases	Definition
Cossette [10]	Status quo bias	Making a decision based on default values (present state or take the default setting).
Trott et al. [20]	Action-oriented bias	Being excessively optimistic often leads to decision-making to confirm the existing belief.
	Interest bias	Employees tend to interpret information and make decisions in ways that align with their interests rather than corporate interests.
	Pattern recognition	Identifying patterns or trends based on experience and often relying on readily available information.
	Stability bias	Preferring or relying heavily on pieces of information that people have on hand at the moment.
Marzi, G. [33]	Social bias	Simply accepting the group's decision rather than encountering or justifying the argument.
Cossette [10], Feiler and Tong [40] Ruelas et al. [6], Zhang et al.[43]	Overconfidence	Overestimating one's abilities to predict future outcomes.
	Law of small numbers or Avoidance of information	Generalizing from small samples (data).
Ruelas et al. [5]	Anchoring bias	Considering a reference point that people have already in their minds (so less likely to try other means).
Fillingim et al. [19]	Bandwagon effect	Adopting certain behaviors simply because others are doing so, without solid proof that it is the right behavior.
	Choice overload	Preferring to choose by not choosing.
Alkhars et al. [13]	Insensitivity to prior probability of outcomes	Ignoring the prior probability information, due to the representativeness heuristic.
	Insensitivity to sample size	Giving a high probability to a parameter if it is highly represented in the population (sample).
	Insensitivity to predictability	Referring to a description received beforehand, when asked to predict things.
	Misconception of chance	Assuming a random outcome from a random process both locally and globally.
	Misconception of regression	Expecting for the extreme outcome that occurred in the past to repeat subsequently.
Zheng and Miller [12]	Ownership bias, opposite to social bias	Preferring one's own ideas over the ideas of others during the design process.
Zhang et al. [43]	Base-rate fallacy	Neglecting the base-rate statistics in favor of unimportant personal information.
	Regression fallacy	Explaining statistical phenomena with causality instead of recognizing natural fluctuations around the mean.
Ruelas et al. [6]	Bounded awareness	Failing to notice obvious information available in a situation prevents people from seeing the full picture.
	Search type	Using default search strategy with little effectiveness when looking for a solution, options, information, and so on.
	Inconsistency	Cognitive errors may occur in the control phase. The errors are not biased to one or the other direction but spread in both, (all things being equal) so that designers may fail to give a constant value to the same figure.
	Redundancy	Believing (falsely) that adding redundant inputs will linearly increase system reliability.
Cristofaro et al.. [22]	Impact bias	The tendency to outline ongoing methods, solutions, and processes as suboptimal.
	Exclusivity bias	Valuing more the work where others are less likely to succeed.
	Novelty appreciation bias	Recognizing novelty under an extremely positive lens.
	Efficacy of tenacity bias	The tendency to view novelty over-positively which favors effort as a solution to setbacks in novel tasks.
	Malleability of social norms bias	The involvement of participants in an environment with dynamic rules rather than rigid.
Reinhardt et al. [35]	High-end bias	Favoring premium (high-end) over economy (low-end) products, all else being equal (employees and managers).

4.2 Cognitive Bias Origins in New Product Development: A Three-Perspective Framework

The present research identified and defined 4 heuristics and 37 types of cognitive biases present in the NPD literature. In the last step of the research, deepening this investigation, we made an effort to map the main sources of these cognitive biases. Thus, the goal was to provide practitioners and researchers with a framework that would pinpoint where cognitive biases emerge and try to reconstruct the associated information flow pattern within NPD. We found that cognitive biases emerge from heuristics characterized by *three perspectives*: 1) the information designers receive; 2) the nature of the design problem; and 3) the designer's reasoning [6], [10], [22]. We argue that understanding these three perspectives is crucial for understanding the cognitive biases and design heuristics, as well as mitigating their impacts or positively using them. We proceed to detail these three perspectives below, modeling their relationships to one another in Figure 4.

Perspective 1 - Information as a Source of Cognitive Biases: Cognitive biases can originate from the information designers receive from R&D members implicitly involved in the design process, managers, employees, customer feedback, and emotional experiences [1], [11], [41]. The misinterpretation of technical details of this information can lead designers to heuristic reliance, resulting in cognitive biases (Figure 4, Perspective 1).

Perspective 2 - The Nature of Design Problem as a Source of Cognitive Biases: The design problem encompasses the activities the new product aims to address, resolving demand issues. The research argues that a well-defined design problem reduces cognitive biases by providing clear guidance [4], [20], [34]. However, complex design instructions, novelty, and resource constraints, like time during sketching, can drive designers to depend on heuristics, resulting in bias. As can be seen in Figure 4, Perspective 2, designers receive an uninterpreted design problem either from the initial information or through disseminators, but the design could be ambiguous.

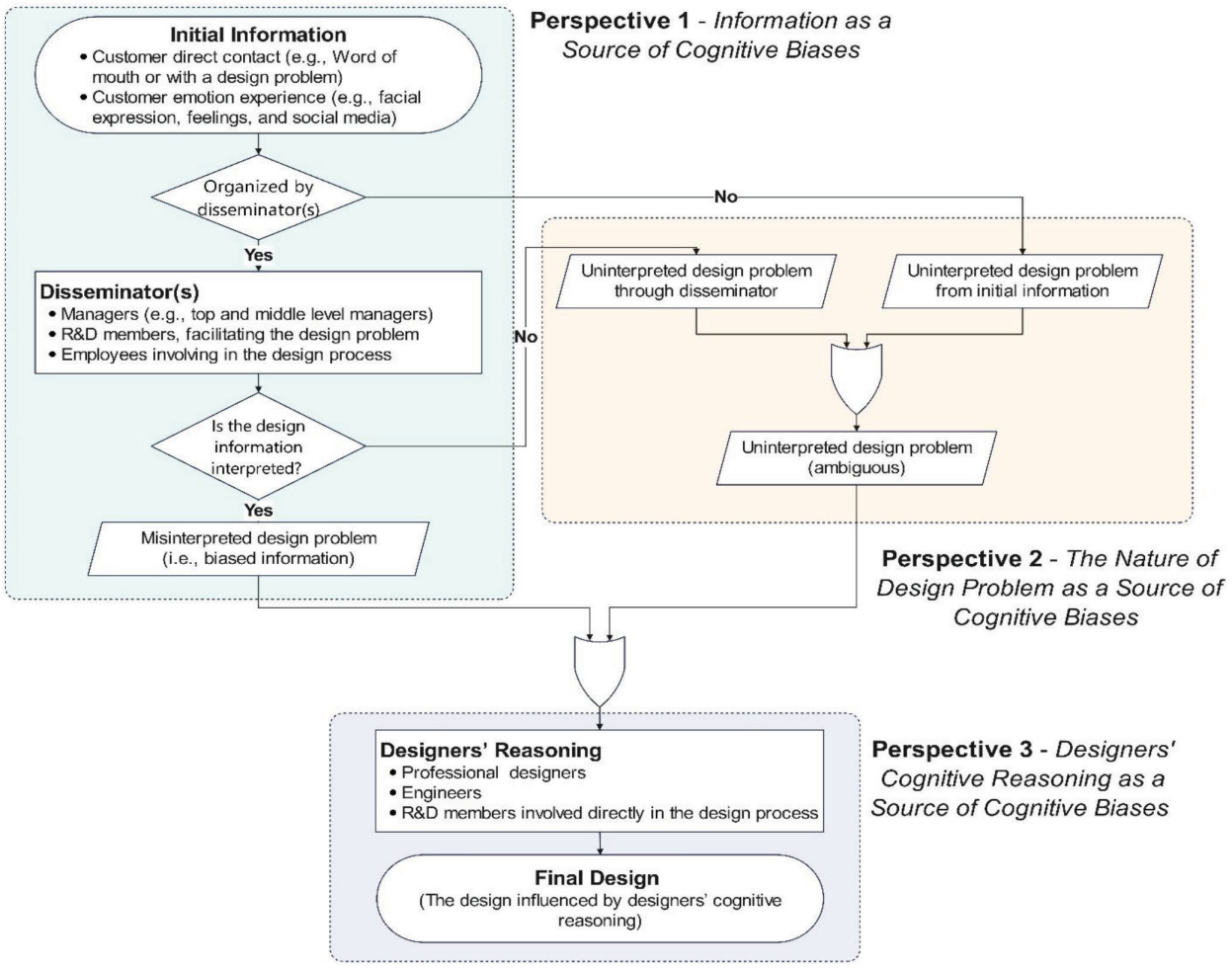

Figure 4. Cognitive Bias Origins in New Product Development: A Three-Perspective Framework (Source: Authors own work)

In real NPD settings, the product design problem is influenced by structured processes, particularly during the requirement elicitation phase. This complexity can lead to ambiguities in the design process, stemming from how requirements are reformulated and communicated among stakeholders. It is important to distinguish between cognitive biases, which arise from heuristic reasoning due to design ambiguity, and miscommunication, which occurs inadvertently during information transfer. However, these two factors are interconnected and can significantly increase the risk of cognitive biases in the design process.

Perspective 3 – Designers' Cognitive Reasoning as a Source of Cognitive Biases: This perspective includes the work of designers (e.g., professional industrial designers, engineers, R&D members) directly involved in the design process [14], [35]. Designers receive design problems either as misinterpreted information through disseminators or as uninterpreted information (but ambiguous) from initial sources and disseminators (Figure 4, Perspective 3). Disseminators are personnel involved in the design process by transmitting information from its initial source to designers. Nevertheless, designers further interpret this information using cognitive heuristics, including representativeness, availability, anchoring, and recognition [10], [18], [43]. These heuristics are influenced by intuitive decision-making shaped by education, experience, and environmental adaptation, which can often be irrational and lead to cognitive biases during product ideation. Additionally, due to a lack of metacognition (i.e., lack of thinking about your thinking) [50], designers' analytical thinking can also result in irrational decisions because of cognitive biases. This perspective presents the *two-fold effect* of heuristics and cognitive biases in the designer's mind, operating interchangeably; they are two sides of the same coin. For example, "status quo bias is a heuristic that persists because overcoming it demands more cognitive attention and resources, as Fillingim et al. [19] noted.

Figure 4 presents the Cognitive Bias Origins in New Product Development: A Three-Perspective Framework that illustrates the flow of information patterns in the design process, connecting effectively initial information input, design problem, and designers' reasoning. The framework was developed based on our analytical reasoning and literature analysis. The identified heuristics and cognitive biases cannot be strictly linked to a single perspective, as they may arise from any of the three perspectives based on the context. For instance, the availability heuristic can be influenced by salient information (Perspective 1), the framing of the design problem (Perspective 2), or designers' prior experience (Perspective 3). Cognitive biases like overconfidence or anchoring can also emerge through various pathways in the NPD ideation phase. Consequently, the framework offers a flexible representation of cognitive bias emergence, helping practitioners better anticipate and mitigate their effects throughout product development.

To the best of the authors' knowledge, the Cognitive Bias Origins in New Product Development: A Three-Perspective Framework is the first framework to address and present the possible sources of cognitive biases in NPD. The framework supports the previous research findings from the relevant articles by reinforcing the critical role of design heuristics and identifying the source of cognitive biases within NPD. It emphasizes how the identified heuristics influence decision-making during product ideation, supporting the existing understanding that while heuristics enhance creativity, they also introduce cognitive biases. Notably, if cognitive biases arise from the use of heuristics, the three perspectives presented are core reasons why heuristics are used in the first place. Thus, raising awareness of practitioners about these *three perspectives* and further researching them becomes crucial for managing product development processes successfully.

5. Discussion and Conclusions

This study emphasizes the crucial impact of design heuristics and cognitive biases in the NPD process, particularly during the ideation stage. Having identified a growing but still limited body of literature focusing on heuristics and cognitive biases, we identified the potential sources of biases that commonly emerge within NPD. To address this gap, we provided the first comprehensive list of heuristics (Table 1) and cognitive biases (Table 2) available in the relevant literature, as well as an analysis of the potential sources of biases through the developed framework (Figure 4). The *Cognitive Bias Origins in New Product Development: A Three-Perspective Framework* presents three perspectives, namely: *initial information, the nature of design problem*, and *designers' cognitive reasoning*, as sources of cognitive biases in NPD. Finally, our findings contribute to both theoretical and practical applications in the field of NPD, as we argue in the following two sub-sections.

5.1 Theoretical Implications

The present study advances the theoretical understanding of heuristics and cognitive biases in the decision-making process during NPD. Applying the typologies established by Kahneman and Tversky [17], Gigerenzer and Goldstein [32], and later widely accepted by many researchers [6], [10], [13], [43]. This study systematically identified four heuristics (Table 1) and thirty-seven cognitive biases (Table 2) impacting the ideation in NPD. A novel three-perspective framework (Figure 4) has been introduced based on analytical reasoning on the analysis of relevant literature. The framework provides readers with a comprehensive understanding of where cognitive biases emerge, who and/or what creates them, and the reasons behind their occurrence during product design. This nuanced insight encourages researchers to conduct further empirical investigations into the impact of heuristics and cognitive biases, including their positive and negative effects on product development.

5.2 Practical Implications

5.2.1 Implications for designers

The types of heuristics and cognitive biases in NPD have been identified, along with their practical implications. We expect that the awareness of these heuristics and biases in the design process will help designers to effectively identify them and integrate their ideas with product design tools or guidelines, often offered by product development strategists [51]. This integration can enhance creativity while reducing the risks associated with biased decision-making.

The developed framework (Figure 4) offers designers actionable insights, aiding them in shaping decision-making strategies during NPD ideation. It also fosters improved communication and collaboration among engineers, designers, and other employees involved in the design activity.

5.2.2 Implications for managers

A deeper awareness of heuristics and cognitive biases among managers helps them understand their impact during product ideation. Moreover, the framework developed in this study guides managers to manage the exchange of information during the NPD process and supports them in implementing targeted interventions (e.g., awareness training for designers and involving employees) to navigate complex decisions and generate more innovative ideas. By utilizing these interventions, managers can refine their product development strategies, ensuring that design decisions are more closely aligned with the desired outcomes. This approach can significantly reduce decision bias and improve NPD outcomes. When design managers leverage these heuristics and biases along with the framework during the design process, they can promote a more informed, rational, and innovative approach to product design. In practice, the framework can be implemented through organized managerial strategies such as standardizing information inputs, utilizing problem-framing templates, enforcing formal evaluation criteria, demanding justification for design choices, and rotating decision-making roles. These actions aim to minimize over-reliance on design heuristics and mitigate biases. Further, the framework provides managers with a systemic view of project interactions, emphasizing the human cognitive factor in contexts often viewed as primarily technical, thereby supporting more informed decision-making and effective team management.

5.3 Limitations and Future Research

This study presents some limitations. First, the study took into account only journal articles. Thus, conference papers were excluded, which could be mended in future research. Second, the specific industry contexts were not considered. However, having completed the early stages of this research, we deemed it for the next research phases. In addition, the study focuses on NPD ideation and does not explicitly address product-service system engineering and requirements engineering, which integrates products and services into unified offerings and may introduce additional sources of cognitive biases.

As for future research, first, it could focus on refining the framework to enhance its generalizability. For example, the analysis of cognitive differences among novice, professional, and expert designers in NPD is not addressed in the present research. Furthermore, there is also a lack of empirical research on the influence of individual heuristics and cognitive biases at various product development stages. Finally, future research could aim to understand how the developed framework could be operationalized as an actionable tool for companies.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Appendix 1. The 22 relevant articles, including sources, publication year, and their focus areas

Authors	Source	Year	Focus area
Dahl and Moreau	Journal of Marketing Research	2002	Design heuristics during the new product ideation
Åstebro and Michela	Journal of Product Innovation Management	2005	The success factor for innovation and the role of heuristics
Antioco et al.	Journal of Product Innovation Management	2005	Product design and decision-making bias
Yilmaz et al.	Artificial Intelligence for Engineering Design, Analysis and Manufacturing: AIEDAM	2010	Effect of cognitive heuristics on design, particularly on designers
Ensici et al.	International Journal of CoCreation in Design and the Arts	2013	Design thinking for decision-making within the design team
Cossette	Journal of Small Business and Entrepreneurship	2014	The effect of heuristics and cognitive biases in the new product launch, entrepreneurial focus
Yilmaz et al.	Design Science	2015	The role of design heuristics is to generate new product ideas, designers focus
Calle-Escobar et al.	International Journal on Interactive Design and Manufacturing	2016	The effect of heuristics-based product design on the decision-making process
Alkhars et al.	Psychology Research and Behavior Management	2019	The effect of cognitive biases and heuristics in the decision-making process, the source of cognitive bias focus
Zheng and Miller	Journal of Mechanical Design	2019	The impact of cognitive bias on design professionals, ownership bias focus
Zhang et al.	International Journal of Entrepreneurial Behaviour and Research	2020	The effect of heuristics and cognitive biases in creating new ideas, entrepreneurial focus
Querbach et al.	Journal of Product Innovation Management	2020	The effect of heuristics and cognitive biases in the decision-making process, design for behavior change focus.
Ruelas et al.	Journal of Open Innovation: Technology, Market, and Complexity	2021	Decision-making and cognitive biases in the product design process
Wang et al.	Advances in Mechanical Engineering	2021	Heuristics, cognitive biases and user emotional experience in the product design process
Marzi, G.	Journal of Engineering and Technology Management	2022	The effect of heuristics and cognitive biases on overdesign, industrial designers focus
Feiler and Tong	Management Science	2022	The impact of cognitive bias in forecasting new products, the effect of overconfidence on design team
Cristofaro et al.	Journal of Manufacturing Technology Management	2022	The impact of cognitive bias on employees' product creativity
Fillingim et al.	Journal of Mechanical Design	2023	The impact of cognitive biases in the design process, error management focus
Annosi et al.	IEEE Transactions on Engineering Management	2024	The effect of intuitive and rational thinking on decision-making, product development focus
Trott et al.	IEEE Transactions on Engineering Management	2024	The serendipity of cognitive bias in creating new product development
Reinhardt et al.	Long Range Planning	2024	The impact of cognitive bias in the decision-making process during product innovation
Kurz et al.	Journal of Business Venturing	2024	The influence of over-empathy on new product development, social media, and cognitive bias focus