Bias reconsidered: Ecologically rational heuristics in design cognition

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Abstract: Design cognition is often described through a heuristics-and-biases lens that foregrounds systematic errors such as anchoring, fixation, and premature narrowing. Yet in professional practice, the same patterns may function as adaptive strategies for coping with ambiguity, constraint, and ill-defined problems. This paper examines how bias-like tendencies appear in expert data visualization work using a multi-phase qualitative study with 11 professional designers. We analyze situated episodes through two contrastive interpretive lenses: a bias lens that highlights potential distortions, and an adaptive-expertise lens that treats the same tendencies as resource-rational strategies. We situate these interpretations within a broader design cognition perspective, drawing on concepts such as framing, problem–solution co-evolution, and judgment. Our findings show that putative biases often enable tractable progress and sensemaking under bounded project conditions. We argue for a context-sensitive account of cognitive bias in design and discuss implications for theory, methods, and education.

Keywords: Design Cognition; Cognitive Bias; Heuristics; Design Judgment

1. Introduction

Designers routinely make consequential judgments under ambiguity, time pressure, and shifting constraints. To explain how such judgments succeed or fail, many accounts of design reasoning draw on the heuristics-and-biases tradition in cognitive psychology (Tversky & Kahneman, 1974), where emphasis is placed on systematic deviations from rationality that can distort judgment or constrain creative exploration. This perspective has shaped how design cognition is often discussed, foregrounding limitations such as fixation, confirmation bias, and anchoring. Yet these bias-centric accounts typically presume conditions, such as stable goals and well-defined criteria, that rarely characterize the fluid, ill-structured situations of professional design practice.

In parallel, work in ecological rationality and naturalistic decision making challenges the assumption that more information and computation necessarily improve judgment and

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offers an alternative account of how expert practitioners confront complexity. This research demonstrates that the same mechanisms commonly labeled as biases can also function as *heuristics*—simple, experience-based strategies that support effective performance under uncertainty and constraint (Gigerenzer & Brighton, 2009; Klein, 2011). In noisy or ill-defined environments, frugal rules can be more robust than optimization, precisely because they ignore part of the available information. From this standpoint, similar cognitive tendencies may be interpreted as bias or as heuristics depending on context. Studies of design methods echo this—e.g., Daalhuizen et al. (2014) show that students using heuristic-oriented strategies experience the design process differently from those using a more systematic method, but do not simply produce worse outcomes. Building on this shift, we examine how bias-like reasoning appears in professional design work, and how these tendencies contribute to the situated management of ambiguity, constraint, and evolving problem frames.

Within design research, bias has largely been treated as a problem to be mitigated (Bay, 2002; Camarda et al., 2024; Crilly, 2019; Hallihan et al., 2013; Janssen & Smith, 1991; Jimenez et al., 2024; McCollough et al., 2014; Nelius et al., 2020; Nikander et al., 2014; Schauer et al., 2025). Recent analysis of visualization research suggests a similar tendency to frame bias primarily in terms of error, limitation, and mitigation, while giving comparatively less attention to heuristic reasoning as an adaptive resource (Baigelenov et al., 2025). Yet heuristic reasoning may offer a productive lens for understanding how designers manage the ambiguity, time pressure, and incomplete information that characterize professional work. Conceptual work further suggests that bias and heuristics may reflect different interpretations of similar cognitive tendencies rather than entirely separate phenomena (Belvedere et al., 2013; Lockton, 2012; Rau et al., 2020). Together, these strands of work create an opportunity to investigate how such dynamics unfold in situated professional practice.

This paper provides an empirical, situated perspective by drawing on an existing dataset that captures designers' reasoning across a multi-phase design exercise. The material—comprising a design challenge, diary reflections, and in-depth interviews—offers a detailed view of how practitioners articulate decisions, manage ambiguity, and navigate constraints. This dataset is well-suited for examining how cognitive tendencies commonly described as biases or heuristics surface within professional design work, and for situating empirical findings such as preference effects (Nikander et al., 2014) and availability bias (Schauer et al., 2025) within richer process narratives. To guide this analysis, we use two contrastive interpretive lenses: (1) a *cognitive bias lens* that foregrounds potential distortions or premature narrowing, and (2) a *heuristic or adaptive-expertise lens* that interprets the same behaviors as efficient, resource-rational strategies. We then situate these interpretations within a broader design cognition perspective, drawing on concepts such as framing, abductive moves, and problem–solution co-evolution (Cross, 1982; Dorst, 2019; Kolko, 2010; Schön, 1984).

This approach moves beyond the binary of "biased" versus "rational" to examine how bias-like tendencies, heuristics, and design judgments overlap within practice. Our analysis highlights that tendencies resembling anchoring, confirmation, or selective simplification can

play multiple roles: they may introduce risk, support tractability, or serve as provisional structures that enable designers to act within ill-defined situations. Rather than treating bias solely as a deficit, we show how its manifestations must be interpreted in relation to the ecological and organizational conditions of professional practice.

The paper offers three contributions. First, it provides empirical, episode-level illustrations of how bias-like tendencies surface within professional design practice, extending prior work beyond highly abstracted or tightly controlled tasks. Second, it introduces a multi-perspectival approach for interpreting these episodes, enabling researchers to consider how the same cognitive move may carry different implications depending on the interpretive frame applied. Third, it advances a context-sensitive view of cognitive bias in design, positioning bias-like tendencies as contingent features of reasoning under uncertainty rather than inherent defects. Taken together, these contributions deepen ongoing discussions about design expertise by situating cognitive bias within the broader ecology of design practice.

2. Methods

This paper draws on an existing dataset from a multi-method investigation of expert data visualization practice, first reported in Parsons & Shukla (2026), which describes the study design and dataset in greater detail. The broader study combined a shared design challenge, reflective documentation of an ongoing professional project, and follow-up interviews. Here, we offer a focused re-analysis of challenge-related materials through two contrastive interpretive lenses—cognitive bias and heuristics/adaptive expertise—while drawing on design cognition as a broader account of how such tendencies arise within situated design activity.

2.1 Study design and participants

Eleven expert data visualization designers were recruited. Inclusion criteria reflected a multifaceted view of expertise, including years of practice, portfolio quality, leadership or mentoring roles, external recognition such as awards, invited talks, or peer visibility. All participants self-identified as data visualization designers. To preserve confidentiality, we use pseudonyms (e.g., John, Priya, Carlos, Laila, Omar).

2.2 Data collection

All participants completed a common design challenge based on a historical London theatre dataset from a public “Data Is Plural” release. The challenge was intentionally open-ended but bounded: participants were asked to spend about 90 minutes independently exploring the dataset and producing an initial visualization, with emphasis on process rather than polish. They could complete the task at a time and place of their choosing and were encouraged to submit rough artifacts such as sketches, screenshots, notes, or code. Participants also submitted brief reflections at two points: after initially scanning the dataset and after completing the challenge. These materials captured early framing moves, shifts in understanding, and rationales for narrowing, selecting, or restructuring the data. In a subsequent phase lasting 6–8 weeks, participants documented challenges, activities, and decisions in their ongoing professional work. Semi-structured interviews then revisited both

the design challenge and the diary entries, probing rationales, discarded alternatives, turning points, and broader design habits. In this paper, we focus on the design-challenge reflections, artifacts, and interview segments that explicitly referenced the challenge; diary materials were consulted selectively when they provided corroborating or contrasting examples of similar reasoning patterns.

2.3 Analysis

We conducted a theory-driven, lens-based rereading of the challenge-related corpus. First, we identified discrete episodes in which participants described or enacted recognizable decisions, strategies, or pivots (e.g., prioritizing a particular variable, discarding messy data, narrowing the dataset, reverting to a familiar chart type). For each episode, we drafted analytic memos from two contrastive interpretive perspectives: (1) a cognitive-bias lens, reading the behavior as a potential deviation from normative rationality; and (2) a heuristic/adaptive-expertise lens, reading the same behavior as a resource-rational strategy for managing uncertainty and limited information. We then situated these interpretations within a broader design cognition perspective, using constructs such as framing, abductive moves, problem–solution co-evolution, and reflection-in-action to examine how the episode functioned within situated design activity. From the broader challenge-related corpus, we selected vignettes that most clearly illustrated recurring patterns central to the present argument; these were intended as analytically representative examples rather than exhaustive case reports.

3. Findings

We organize our findings around short vignettes that trace designers' reasoning through concrete episodes. From the larger corpus reported in Parsons and Shukla (2026), we selected four vignettes that most clearly illustrate recurring cross-case patterns relevant to the present argument. We foreground moments of narrowing, sticking, and shifting—where participants fixate on an initial question, adopt a simplifying rule, or reframe the problem in response to resistance from data, tools, or stakeholders.

3.1 Vignette 1 – Omar filters to "clean" data to gain traction

When Omar first opened the CSV for the London theatre challenge, he was struck by how irregular it was: many rows lacked dates, authors, or complete performance titles. Rather than attempt full cleaning up front, he imposed a simple rule for his first pass:

> "Everything that does not have a clean value I'm not taking into account. So if it doesn't come with a clean date or author or name of the performance or whatever other thing I am extracting, I don't take it into account."

He immediately recognized that this was not a neutral sampling. As he put it, "this could actually be a bias… maybe certain types of performances or theaters are more likely to have more complete data." He nonetheless accepted the trade-off as a necessary move:

> "That would be a bad bias into my first approach but it's just a first approach so I kind of accept that. It allows me to move faster… I am aware of the bias I am introducing into the subset of data I am using."

In other parts of his interview, Omar described his general approach to such datasets as starting with a "naive methodology"—focus first on simple structures, get something working, then revisit deeper issues later.

Bias lens: Selection bias and ambiguity aversion. Through a bias lens, Omar's move is a textbook case of selection (survivorship) bias combined with ambiguity aversion. By excluding all records with missing fields, he restricts his initial understanding of the theatre scene to the best-documented performances. If completeness correlates with institution, period, or genre, his sample will systematically misrepresent the underlying population. His explicit preference for "clean" entries over messy ones reflects a tendency to avoid ambiguous cases, potentially suppressing peripheral or historically under-recorded activity.

Adaptive-expertise lens: Resource-rational simplification. Under an adaptive-expertise lens, the same rule becomes a fast-and-frugal heuristic for getting traction under severe constraint. Omar faces a large, noisy dataset, limited time, and the dual task of exploration and design. The clean-data rule is a resource-rational simplification: it sharply reduces complexity and lets him build a provisional mental model without first solving the full data-quality problem. Crucially, he treats the resulting bias as explicit and temporary— "just a first approach," adopted because "it allows me to move faster." Rather than an unexamined error, it is a consciously managed trade-off between speed, effort, and coverage, with the expectation that he could later re-open the scope if the project demanded more exhaustive analysis.

Design cognition perspective: Provisional scoping and reflective control. Omar's decision is a deliberate scoping move that contracts the problem space from "all available data" to "records I can safely trust right now." It functions as a framing device: he defines, for this stage, what will count as relevant material. His self-commentary is a clear instance of reflection-in-action—he monitors the consequences of his own move while making it. The episode illustrates how designers actively shape the terrain to act within ill-structured situations, using provisional constraints to maintain forward momentum while keeping an eye on potential costs.

3.2 Vignette 2 – John reviews prior challenge entries

For John, the design challenge arrived as a familiar but open-ended type of task: a rich historical dataset, a short timeframe, and a vague brief. Before committing to any specific direction, he chose to browse earlier public submissions built from the same data: "I also checked the entries of the Nightingale Challenge, what other people have submitted." This was not idle curiosity. He explicitly wanted "to get a sense of the dimensions of the dataset and what types [of solutions] are already out there." That quick review surfaced a pattern: many entries were, in his words, "kind of summaries of the dataset"—overviews of performances per year, per theatre, or across the full period.

Rather than taking these as templates, he treated them as a contrast. He concluded that "summarizing the dataset is not what I would be looking for" and instead articulated a different ambition: to capture "the characteristics of this dataset" and evoke "what it would be like going to a theatre in this period." He framed his goal as creating "a custom view of

the dataset" that conveyed the "mood of that time" not just counts and distributions. The precedents thus became a backdrop against which he positioned his own emerging concept.

Bias lens: Anchoring and fixation on precedents. A bias-focused reading sees clear potential for anchoring and fixation. Early exposure to polished examples can set strong expectations for what "counts" as a reasonable solution: familiar structures, popular motifs, and canonical chart families become cognitively privileged. Even John's decision to go in a different direction can be read as anchored reasoning: the precedent set supplies the initial frame ("this is what people usually do"), and his alternative is articulated as a deviation from that frame. In this perspective, the risk is that prior entries narrow the conceivable space, making it harder to imagine solutions that depart more radically from established patterns.

Adaptive-expertise lens: Precedents as fast orientation. John's behavior can be viewed as an efficient orientation heuristic in an otherwise unbounded problem. Reviewing earlier entries is a quick way to sample the landscape: he learns what others have already tried, which storylines and encodings recur, and where redundancy might lurk. This helps him eliminate directions that feel overused or misaligned with his aims, without having to explore each one from scratch. In this reading, precedents are not trapped but structuring devices: they provide a compressed map of the design space that supports rapid differentiation and positioning under time pressure.

Design cognition perspective: **Precedents as framing and judgment resources.** John's use of precedents can be seen as framing operations. The existing entries are conceptual materials that help him articulate what his project is and is not about. His judgment that others provide "summaries" while he wants to convey the experience of "going to a theatre in this period" reflects a shift in problem framing—from representing the dataset's structure to evoking a historical lifeworld. That shift co-emerges with his sense of solution direction: as he reflects on the precedent set, he simultaneously clarifies his own stance and the kind of representation that might embody it.

3.3 Vignette 3 – Priya's "if I see time, I see a timeline" pattern

On first encounter with the theatre dataset, Priya described a quick mental inventory of possible organizing fields: "we have a category, we have people involved, we have time, we have location." Almost immediately, time took precedence. She explained that when she notices a temporal field, "always it's gonna be in my mind… let's see how it looks if we paint everything in chronological order." Even before extensive wrangling, she sketched a timeline-like arrangement on paper and saw it as "a good way to show a general overview in a very simple way."

This early structural choice then guided the rest of her work. The main design question became how to layer additional dimensions—color for theatre, size for cast, perhaps faceting—onto a temporal backbone while avoiding aggregation that would "lose the richness" of individual performances. Priya briefly considered an alternative, map-based framing using location as the primary axis. However, she dismissed it as "too specific" and technically risky given the challenge's informal time constraint. The timeline, by contrast, felt

"quite obvious," "easy," and "something that could work easily." No alternative frame ultimately displaced this temporal structure; it remained the organizing principle through to her final visualization.

Bias lens: Salience-driven anchoring and premature structuring. Viewed through a bias lens, Priya's behavior is a case of salience-driven anchoring. The presence of time acts as a salient cue that triggers a well-practiced representational pattern. Her remark that a timeline will "always" come to mind in such cases indicates a habitual coupling between cue and response. This can be seen as premature structuring: she commits to a temporal frame before systematically considering whether time is the most analytically revealing dimension in this dataset, or whether other structures might expose different stories. The quick rejection of a spatial framing as "too specific" can be read as an expression of availability bias—chronological layouts feel more available and less risky given her repertoire and the time pressure.

Adaptive-expertise lens: Ecologically rational pattern-priming. Under a heuristic or adaptive-expertise lens, the same tendency functions as ecologically rational pattern-priming. In many contexts Priya works in, temporal structure is both meaningful and intuitive for audiences, and timelines often provide a robust default. In a constrained exercise, the timeline heuristic offers immediate scope reduction: it stabilizes the overall layout and frees cognitive resources for more fine-grained decisions about encoding and density management. It also supports her goal of preserving item-level granularity—each performance remains visible while temporal pulses and gaps still emerge. In this view, the timeline is not merely the easiest option but a well-matched heuristic.

Design cognition perspective: **Interpretive anchoring and representational focus.** Priya's temporal commitment is an act of interpretive anchoring: it defines what the visualization is fundamentally about. Once time is the backbone, meaningful variation is understood in terms of temporal density, lull periods, and changes over eras. Her later choices—how to encode theatres, how to avoid "losing richness," how to talk about "how the evolution was"—are evaluated against this frame. The episode illustrates how a single structural choice simultaneously constrains and enables subsequent judgment: the same move that could be read as anchoring or as a heuristic is also a design move that stabilizes inquiry and aligns representation with an evolving sense of the story she wants to tell.

3.4 Vignette 4 – Carlos narrows an overwhelming dataset to "a human scale"

Carlos's first reaction to the theatre dataset was visceral: "I was shocked with the amount of information… I would get lost in the amount of possible angles to explore." Early hypotheses emerged quickly—exploring gender-swapped roles, building Sankey-style diagrams between performers and roles, or mapping overlaps in casting—but they faltered under closer contact with the data. Names were inconsistent, multiple performers shared identical names, roles were sometimes generic labels like "English gentleman," and he lacked the historical knowledge to judge which irregularities were meaningful and which were simply artefacts. He worried about "bad wrangling on my part" generating misleading patterns.

He then adopted a different strategy: "bring it back to a human scale." He chose Romeo and Juliet, a play he already understood, and identified the two individuals who appeared most frequently in those roles. This move anchored the project in familiar narrative ground. As he explained, "if I could narrow it down to something that I had some idea of… it would help me come up with stories." Once he had those two focal characters, exploratory plots in R gave immediate, interpretable feedback. Iterations comparing dots versus lines, adjusting encodings, and testing legibility led him toward a representation of how these two actors moved across venues and time—a story he could tell confidently.

Bias lens: Availability and representativeness. Under a bias lens, Carlos's decisions show the imprint of availability and representativeness. He gravitates toward Romeo and Juliet because it is cognitively prominent—"something I am familiar with"—and infers that the most frequently appearing performers are likely to be the "archetypical" Romeo and Juliet. This reliance on familiarity and frequency narrows attention to a segment of the dataset that is easiest for him to reason about, potentially overshadowing other plays, roles, or venues that might reveal different dynamics. His early hypotheses about gender-swapped casting also reflect expectation-driven reasoning: he initially projects contemporary ideas about casting diversity onto the data and explores those, only abandoning them when they fail to materialize.

Adaptive-expertise lens: Pragmatic reframing under uncertainty. Seen through an adaptive-expertise lens, the same episode highlights pragmatic reframing in the face of overwhelming uncertainty. Rather than persevering with fragile hypotheses that depend on domain knowledge he does not have, Carlos is willing to pivot: "I scratched that idea… and pivoted to Romeo and Juliet", and adopt a frame where he can reason responsibly. Centering the project on a familiar play and two focal individuals is a deliberate complexity-reduction heuristic: it restores interpretive control, makes the data legible, and supports coherent narrative construction. His quick plotting with GGplot as a feeler into the dataset further exemplifies fast-and-frugal practice: small experiments that guide which directions are promising enough to invest in and which should be abandoned.

Design cognition perspective: Problem redefinition and representational scaffolding. Carlos's work can be seen as a sequence of problem redefinitions driven by interaction with data and tools. Initial ideas inspired by precedents serve as tentative frames that are tested, critiqued, and set aside. The decision to focus on Romeo and Juliet transforms the problem from "find an interesting global pattern in this archive" to "tell a focused story about how two performers inhabited these roles across theatres and time." Exploratory plots in R act as representational scaffolds, externalizing candidate patterns and shaping his sense of what the final visualization could be. The episode illustrates how narrowing and storytelling are not simply ways of avoiding complexity, but central mechanisms through which designers construct problems they can engage with meaningfully under real-world constraints.

4. Discussion

Our analysis set out to understand how bias-like tendencies appear in professional design work when viewed through two contrastive interpretive lenses: cognitive bias and heuristic/adaptive expertise. Across vignettes, we saw designers anchor on salient

structures, truncate messy datasets, privilege familiar precedents, and narrow to "human-scale" problems. Through a bias lens, these moves resemble well-known vulnerabilities such as anchoring, availability, fixation, and premature narrowing. Through a heuristic and adaptive-expertise lens, the same moves appear as fast, experience-based strategies for managing ambiguity, data quality issues, and limited time. From a design cognition perspective, they are part of ongoing framing, hypothesis-making, and problem–solution co-evolution. In this section, we situate these findings in relation to prior work and consider implications for design research and practice.

4.1 Beyond deficit views of bias in design cognition

Our vignettes complicate a purely deficit-oriented reading of bias that is common in design research. When Omar filters out incomplete records, he is keenly aware that this introduces selection bias, yet he adopts the strategy knowingly to "move faster" on an overwhelming data-cleaning task. When Priya defaults to a timeline because "if I see time in a dataset, [time] is going to be in my mind," this looks like anchoring on a salient variable, but it also gives her a workable structure that preserves item-level richness in a highly constrained challenge. When designers review precedents or focus on a culturally familiar play to restore interpretive control, these moves are not simply failures of rationality. They are situated responses to the structural realities of practice: messy data, unknown domain contexts, deadlines, and the need to ship something that is both legible and meaningful.

Rather than denying that risks exist, our analysis suggests that bias-like patterns in design are better understood as ambivalent tendencies. They create potential for distortion and lock-in, but they also provide tractable footholds in ill-structured problems. This ambivalence echoes long-standing tensions in the broader judgment and decision-making literature, where the same behaviors have been alternately interpreted as evidence of bounded rationality or as signatures of expert intuition (Gigerenzer & Brighton, 2009; Klein, 2011). This perspective echoes work that already hints at the dual nature of biases in design and human–technology interaction (e.g., Belvedere et al., 2013; Lockton, 2012), but adds episode-level detail showing how those dualities play out in practice.

4.2 Heuristics, ecological rationality, and adaptive expertise in design

A second contribution of this work is to connect these episodes more explicitly to ecological rationality, naturalistic decision making, and adaptive expertise. The designers we studied seldom follow slow, exhaustive comparison of alternatives. Instead, they use simple, frugal rules attuned to their environments and repertoires: "start with the idea that stands out," and "scale the problem down to something I can tell a story about."

From a classical heuristics-and-biases standpoint, such rules are suspected because they ignore available information and truncate the search space. From an ecological-rationality standpoint, that parsimony is precisely where their power lies. Naturalistic decision-making research reaches a similar conclusion: Klein's work on fireground command and other high-stakes domains (Klein et al., 2010) shows how pattern-based recognition, satisficing, and sequential evaluation—behaviors that would appear biased in laboratory tasks—are central mechanisms of skilled performance under time pressure and uncertainty. Heuristics can be

rational for bounded agents in noisy environments when they exploit reliable cues, map onto common task structures, and reduce the risk of overfitting or analysis paralysis. Work on design thinking "fast and slow" (e.g., Kannengiesser & Gero, 2019), on heuristic versus systematic modes of design (e.g., Daalhuizen et al., 2014) and on preference effects in concept evaluation (Nikander et al., 2014) all point to the importance of these fast, experience-based moves.

Our vignettes concretize this view for professional design practice. Omar's "first pass with only clean records" is a resource-rational heuristic for gaining traction in a dataset he cannot fully audit within the constraints of the challenge. Priya's immediate gravitation to time transforms an unbounded representational space into one she can navigate quickly, with known affordances for layering and narrative. John's habit of "going with the one stronger idea" reflects a satisficing strategy that channels attention into a testable hypothesis, which he is willing to abandon when it fails to work visually or analytically.

Seen through this lens, expert designers are not failing to be rational; they are exercising adaptive expertise. They shift between exploratory and exploitative modes, adjust problem scope to match available resources, and use heuristics as provisional scaffolds rather than final answers. What looks like anchoring, availability, or truncation in abstract becomes, in practice, a series of situated bets that keep work moving in contingent, uncertain environments.

4.3 Implications for how we study bias in design

Third, our findings speak to how biases are studied in design research. Much existing work on cognitive bias in design relies on abstracted tasks: laboratory-style concept-generation exercises, controlled evaluation tasks, or synthetic decision problems designed to elicit specific errors. These methods are valuable for isolating mechanisms, but they risk overemphasizing the negative side of heuristic behavior.

Recent integrative work on cognitive biases in design has argued for more context-sensitive approaches that combine multiple methods and levels of analysis (e.g., Jimenez et al., 2024). Our approach can be seen as one such integrative move. By deliberately viewing the same episode as (a) potentially biased, (b) potentially adaptive, and (c) embedded in framing and co-evolution, we foreground the interpretive work required to classify behavior as bias or heuristic at all. The normative benchmark—what counts as "error"—is no longer purely theoretical or statistical; it must be argued in relation to the task and the environment.

Attempts to "debias" designers may indeed reduce some distortion. But they may also undermine the very heuristics that allow designers to cope with ambiguity and constraint. Our vignettes suggest that effective interventions should distinguish between unreflective lock-in and reflective, provisional scoping, and should support designers in monitoring and revisiting their own heuristic commitments rather than simply suppressing them.

4.4 Implications for design education and reflective practice

Finally, because our participants were experienced professional designers rather than students or novices, these episodes suggest several implications for design education and reflective practice. Across cases, participants demonstrated metacognitive awareness of their own tendencies—for example, Omar explicitly named his selection bias, and Priya articulated her tendency to impose a timeline structure on the data. These were not instances of bias simply being eliminated, but of practitioners noticing, interpreting, and managing their own simplifying moves as the work unfolded.

The fact that these are expert episodes matters for how such tendencies should be interpreted pedagogically. Strategies that are adaptive for experts—because they are grounded in rich domain knowledge, repertoires of precedents, and sensitivity to context—may become brittle when copied by novices as fixed rules. This is consistent with long-standing accounts of design expertise that emphasize repertoires, patterns, and reflection-in-action rather than procedure alone (Cross, 2004; Lawson, 2004; Schön, 1983). From this perspective, what distinguishes expert use of heuristics is not the absence of bias-like patterns, but the capacity to deploy them provisionally, monitor their consequences, and revise them as the framing of the situation evolves.

Design and HCI education have long introduced students to heuristic principles, precedents, and practical strategies for narrowing options and making progress. What our findings add is a more situated account of how such moves operate in expert practice: not as fixed prescriptions, but as provisional judgments that must be monitored and revised in context. If these tendencies are understood primarily as errors or premature narrowing, educators may underemphasize their adaptive and situational character in practice. The pedagogical challenge is therefore not whether students should learn heuristics at all, but how they develop the judgment to use, question, and revise them in context. This aligns with accounts of judgment as a practice-based capacity that develops through engagement with concrete design situations rather than through abstract rule-following alone (Dunne, 1997; Gray & Parsons, 2023; Stolterman, 2008).

Rather than teaching students that anchoring or truncation are categorically bad, educators might instead ask under what conditions an early anchor is productive, when it becomes limiting, and what practices of sketching, critique, or staged reconsideration can make such moves visible and revisitable. The implication is not to replace existing methods teaching, but to complement it with greater attention to reflective, situated, and revisable judgment in the use of heuristics.

4.5 Limitations

This study should be interpreted in light of its scope and design. The participants were expert data visualization practitioners, and the focal material analyzed here came primarily from a bounded design challenge intended to surface early framing, prioritization, and judgment under conditions of ambiguity and limited time. While this structure preserved important features of professional reasoning, it did not reproduce the full temporal, collaborative, organizational, or client-facing conditions of commissioned design work. Accordingly, the findings are not intended to generalize uncritically across all design domains, levels of expertise, or educational settings. Rather, they offer a theoretically useful account of how

bias-like tendencies may function within one form of expert design practice. Future research could examine whether similar dynamics appear in other design domains, in collaborative settings, or among students and less experienced practitioners.

5. Conclusion

This paper examined how bias-like tendencies manifest in expert design work by comparing two contrastive interpretations of the same episodes: one that reads them as potential bias, and another that understands them as adaptive, resource-rational strategies. We then situated these interpretations within a broader design cognition perspective to show how such tendencies operate through framing, hypothesis-making, and problem–solution co-evolution. Across situated vignettes, moves often labeled as anchoring, availability, or premature narrowing appeared not only as possible distortions, but also as ways of gaining traction in ill-structured problems. Rather than treating bias as a purely negative deviation from ideal rationality, our analysis positions these tendencies as ambivalent features of expert practice whose value depends on how they are used, monitored, and revised in context. This suggests a shift in research and education: from abstract debiasing toward a more reflective account of judgment, in which designers learn to recognize when heuristics are productive, when they become limiting, and how simplifying moves can be made visible, revisitable, and open to revision over time.

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