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Beyond Simplicity: Visual Organization as a Determinant of Perceptual Efficiency in Product Design

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ABSTRACT

This study examines visual organization as a primary determinant of perceptual efficiency in product design. While contemporary design practices often emphasize simplicity, this research argues that perception is governed by how visual relationships are structured rather than reduced. A controlled comparative experiment was conducted using three configurations of a single product: high visual density, minimal reduction, and structured hierarchy. Forty-four participants evaluated the designs based on clarity, ease of understanding, attention capture, and overall preference.

The results revealed statistically significant differences across all conditions ($p < .001$), with the structured configuration consistently achieving the highest performance. Effect size analysis indicated strong agreement among participants, while distributional patterns showed reduced variability under structured conditions. These findings introduce perceptual consistency as a key dimension of design effectiveness.

The study demonstrates that perceptual efficiency emerges from structured organization rather than visual simplification, contributing to a structure-based approach to product design.

ما وراء البساطة: التنظيم البصري كمحدد للكفاءة الإدراكية في تصميم المنتجات

ر أفت بن صالح سليمان مدني[1]

تتناول هذه الدراسة التنظيم البصري كعامل أساسي في كفاءة الإدراك في تصميم المنتجات. فبينما تُركز ممارسات التصميم المعاصرة غالبًا على البساطة، تُجادل هذه الدراسة بأن الإدراك يتأثر بكيفية تنظيم العلاقات البصرية لا باختزالها. أُجريت تجربة مقارنة مضبوطة باستخدام ثلاثة تكوينات لمنتج واحد: كثافة بصرية عالية، واختزال بسيط، وهيكلة هرمية. قيّم أربعة وأربعون مشاركًا التصاميم بناءً على الوضوح، وسهولة الفهم، وجذب الانتباه، والتفضيل العام.

كشفت النتائج عن فروق ذات دلالة إحصائية بين جميع الحالات ($p < 0.001$)، حيث حقق التكوين الهيكلي باستمرار أعلى أداء. وأشار تحليل حجم التأثير إلى اتفاق قوي بين المشاركين، بينما أظهرت أنماط التوزيع انخفاضًا في التباين في ظل الظروف الهيكلية. تُقدم هذه النتائج الاتساق الإدراكي كبعد رئيسي لفعالية التصميم.

تُبين الدراسة أن كفاءة الإدراك تنبع من التنظيم الهيكلي لا من التبسيط البصري، مما يُسهم في اتباع نهج هيكلي في تصميم المنتجات.

الكلمات المفتاحية: التنظيم البصري، الكفاءة الإدراكية، الحمل المعرفي، التسلسل الهرمي البصري، الاتساق الإدراكي.

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Beyond Simplicity: Visual Organization as a Determinant of Perceptual Efficiency in Product Design

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1.Introduction

Perceptual efficiency has emerged as a critical concern in contemporary product design, particularly within contexts characterized by time-constrained interactions and high cognitive demand. In such environments, perception operates as a rapid and largely automatic process, enabling users to interpret visual information and initiate action without reliance on deliberate analytical reasoning (Norman, 2013; Goldstein, 2021). However, recent research in human–computer interaction and visual cognition suggests that perceptual performance is not merely a function of visual exposure, but of how visual information is structured, prioritized, and cognitively processed (Ware, 2021; Huang et al., 2020; Chen et al., 2020).

Despite this shift toward perception-centered design, dominant approaches within product design continue to privilege form and function as primary evaluative criteria. While these dimensions remain fundamental, they do not sufficiently explain how users initially encounter and interpret visual interfaces. Increasing empirical evidence indicates that products with comparable functional and aesthetic qualities may produce significantly different perceptual outcomes depending on the organization of their visual elements (Ma et al., 2021; Reinecke & Gajos, 2014). This suggests that perceptual inefficiencies often arise not from the elements themselves, but from the absence of coherent structural relationships governing those elements.

From a theoretical perspective, visual organization constitutes a foundational mechanism through which meaning is constructed. The human visual system does not process stimuli as isolated units; rather, it actively organizes sensory input into coherent configurations based on principles such as proximity, similarity, continuity, and figure–ground segregation (Wagemans et al., 2012; Palmer, 1999). These processes enable the perception of structured wholes rather than fragmented components, thereby reducing interpretive effort and enhancing perceptual stability (Ware, 2021). When such organizational cues are weak or inconsistent, perception becomes effortful, requiring users to reconstruct relationships between elements through conscious cognitive processing.

The role of attention further reinforces the importance of visual organization. Visual attention is inherently selective and capacity-limited, necessitating efficient structuring of information to guide perceptual focus (Pashler, 1998; Wolfe, 2021). In poorly organized visual environments, attention is distributed across competing stimuli, resulting in increased search time, reduced accuracy, and higher cognitive demand (Djamasbi et al., 2012; Rosenholtz et al., 2007). Conversely, structured visual hierarchies guide attention along predictable pathways, enabling faster detection, prioritization, and interpretation of information (Lidwell et al., 2010; Ma et al., 2021).

This relationship can be further explained through Cognitive Load Theory, which emphasizes the limited capacity of working memory and the influence of information structure on cognitive processing (Sweller, 2011; Paas et al., 2003). While cognitive load has traditionally been associated with information quantity, recent studies demonstrate that it is more accurately understood as a function of **organizational structure**. Poorly organized visual configurations impose high extraneous cognitive load by requiring users to actively interpret relationships between elements, whereas structured designs embed these relationships within the visual arrangement itself, thereby reducing cognitive demand and enhancing processing efficiency (Huang et al., 2020; Mayer, 2014).

Importantly, perceptual efficiency cannot be reduced to visual simplicity alone. Although minimal designs are often assumed to improve usability by reducing visual clutter, empirical findings suggest that excessive reduction may eliminate critical perceptual cues, leading to ambiguity and interpretive uncertainty (Tuch et al., 2012; Reinecke & Gajos, 2014). Similarly, visually dense configurations may fail to support efficient perception when lacking structural clarity, resulting in perceptual overload and fragmentation (Rosenholtz et al., 2007). These findings challenge the dominant assumption that "less is more," and instead point toward the importance of structured organization as the primary determinant of perceptual efficiency.

Despite extensive research in visual perception, interface design, and usability, the role of visual organization as an independent and controllable variable remains insufficiently explored within product design research. Existing studies often focus on performance outcomes, aesthetic evaluation, or isolated interface features, without systematically examining the structural mechanisms that shape perception. In particular, few studies have adopted controlled experimental approaches that maintain consistency in product form while manipulating only the organization of visual elements.

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To address this gap, the present study adopts a controlled comparative design in which a single product is presented through three distinct visual configurations: high visual density, minimal reduction, and structured visual hierarchy. By maintaining identical physical attributes across all conditions and isolating visual organization as the sole independent variable, the study enables a precise examination of how structural differences influence perceptual outcomes.

Perceptual responses are evaluated across multiple dimensions, including clarity, ease of understanding, attention capture, and overall preference. In addition to performance-based measures, the study introduces perceptual consistency as a critical dimension, examining the degree to which users interpret visual information in similar ways across conditions. This approach extends existing research by moving beyond average performance metrics toward a more comprehensive understanding of perceptual stability.

Accordingly, this study seeks to answer the following research question: **How does visual organization influence perceptual efficiency in product design?**

2. Literature Review

2.1 From Visual Elements to Relational Structures

Contemporary product design has long been evaluated through the dual lenses of form and function; however, this perspective increasingly fails to explain how users initially engage with visual artifacts. Recent advances in perceptual science and human–computer interaction suggest that perception is not driven by the presence of individual elements, but by the **relational structures** that organize these elements into meaningful wholes (Ware, 2021; Reinecke & Gajos, 2014; Chen et al., 2020).

Empirical studies in visual cognition demonstrate that the human perceptual system operates as an active organizer rather than a passive receiver of information. According to Gestalt theory and its contemporary extensions, visual input is immediately structured through principles such as proximity, similarity, continuity, and figure–ground segregation (Wagemans et al., 2012; Palmer, 1999; Chang et al., 2014). These principles do not merely describe visual grouping; they define the conditions under which perception becomes efficient, stable, and interpretable (Goldstein, 2021; Ware, 2021).

Recent research in interface design reinforces this perspective by showing that users do not process visual components sequentially, but rather perceive structured configurations holistically (Ware, 2021; Djamasbi et al., 2012; Rosenholtz et al., 2007). When relational organization is absent or inconsistent, perception becomes fragmented, forcing users to reconstruct meaning through effortful cognitive processing (Huang et al., 2020; Chen et al., 2020). This shift from element-based to structure-based perception represents a fundamental transformation in how design effectiveness should be conceptualized.

Furthermore, studies in visual complexity and interface evaluation indicate that perceptual performance is significantly influenced by how visual relationships are structured rather than by the quantity of elements alone (Tuch et al., 2012; Reinecke & Gajos, 2014). Poorly organized visual environments increase perceptual ambiguity and cognitive effort, whereas well-structured configurations facilitate faster interpretation and more stable perceptual outcomes (Ma et al., 2021; Ware, 2021).

Despite this theoretical advancement, much of the design literature continues to treat visual organization as a secondary compositional attribute rather than a primary perceptual mechanism. As a result, the structural dimension of perception remains under-theorized within product design research, particularly in studies that prioritize aesthetic evaluation or usability outcomes without isolating the underlying relational mechanisms that shape perception.

2.2 Visual Hierarchy as an Attentional System

While visual organization determines how elements are grouped into coherent units, visual hierarchy governs how attention is distributed and dynamically allocated across those units. Within traditional design discourse, hierarchy is often framed as a stylistic or compositional device used to enhance visual clarity. However, contemporary research in perceptual psychology and human–computer interaction increasingly positions hierarchy as a cognitive control system that regulates perceptual flow and guides attentional sequencing (Wolfe, 2021; Itti & Koch, 2001; Ware, 2021).

Attention, as established in cognitive science, is inherently selective and capacity-limited, requiring efficient mechanisms to prioritize relevant stimuli within complex visual environments (Wolfe, 2021; Pashler, 1998). In the absence of hierarchical structuring, attention tends to disperse across competing elements, leading to inefficient visual search, increased cognitive effort, and reduced interpretive accuracy (Rosenholtz et al., 2007; Djamasbi et al., 2012). By contrast, well-defined visual hierarchies act as guiding structures that channel attention along predictable perceptual pathways, enabling users to rapidly identify focal points, establish priorities, and interpret information with minimal effort (Lidwell et al., 2010; Ma et al., 2021).

Empirical evidence from interface design and eye-tracking studies further supports this view, demonstrating that hierarchical structuring significantly influences visual navigation patterns, task completion time, and decision accuracy (Djamasbi et al., 2012; Faraday, 2000). Rather than merely enhancing aesthetic clarity, hierarchy

actively determines the order and sequence in which visual information is processed, shaping both perceptual and cognitive outcomes.
Crucially, visual hierarchy operates as a relational system rather than an intrinsic property of individual elements. Hierarchical perception emerges from variations in contrast, scale, spatial positioning, and contextual relationships between elements, rather than from any isolated visual attribute (Ware, 2021; Bertin, 2011). This relational nature aligns with broader perceptual theories, which emphasize that meaning arises from structured differences and interactions within the visual field rather than from discrete components (Wagemans et al., 2012).
Despite its central role, hierarchy is frequently examined in isolation or reduced to a set of design heuristics within specific interface contexts. Such fragmented approaches fail to account for its integration with other perceptual mechanisms, particularly visual organization and cognitive load. As a result, the role of hierarchy as a mediating system—linking structural organization to perceptual efficiency—remains insufficiently theorized. Addressing this limitation requires situating visual hierarchy within a broader, system-level understanding of perception, where attention is not merely directed, but continuously regulated through structured visual relationships.

2.3 Cognitive Load as a Structural Phenomenon
Cognitive Load Theory (CLT) has been extensively applied across educational psychology, human–computer interaction, and interface design to explain how processing demands influence user performance (Sweller, 2011; Paas et al., 2003). Traditionally, cognitive load has been conceptualized primarily in relation to the quantity and complexity of information presented to the user. However, recent research increasingly challenges this quantitative perspective, suggesting that cognitive load is more accurately determined by the structure and organization of information rather than its volume (Huang et al., 2020; Mayer, 2014; Chen et al., 2020).
Emerging empirical studies reinforce this structural interpretation. For instance, recent interface research demonstrates that variations in visual complexity and layout organization significantly influence users' cognitive load and information processing efficiency, particularly in task-based environments and mobile interfaces . Similarly, studies on interface evaluation and dashboard design confirm that poorly structured layouts increase cognitive demand, while organized information flow reduces processing effort and improves decision-making efficiency . These findings indicate that cognitive load is not simply a function of information density, but of how effectively visual relationships are structured.
From this perspective, poorly organized visual configurations impose high levels of extraneous cognitive load, as users are required to actively infer relationships between elements, resolve ambiguities, and reconstruct meaning through effortful processing (Sweller, 2011; Huang et al., 2020). In contrast, structured visual systems reduce cognitive demand by embedding relational information directly within the visual layout, allowing users to rely on perceptual cues rather than working memory resources (Mayer, 2014; Ware, 2021). This shift from interpretive processing to perceptual processing represents a key mechanism underlying cognitive efficiency.
Recent advances in eye-tracking and human-centered interface studies further support this interpretation, showing that cognitive load is closely linked to visual attention patterns and gaze behavior, where disorganized layouts increase fixation time and visual search effort, while structured interfaces enable more efficient attentional allocation . Moreover, contemporary UX research highlights that managing cognitive load through structured interface design is essential for improving usability, engagement, and decision accuracy in complex systems .
Importantly, the relationship between cognitive load and visual organization is neither linear nor solely dependent on reduction. Minimalist designs, often assumed to decrease cognitive demand, may in fact increase interpretive effort when essential structural cues are removed, leading to ambiguity and uncertainty (Tuch et al., 2012; Reinecke & Gajos, 2014). Conversely, visually dense configurations can support efficient perception when their elements are hierarchically organized and perceptually aligned, reducing unnecessary cognitive effort despite higher information density (Rosenholtz et al., 2007; Ma et al., 2021). Recent studies further confirm that visual complexity alone does not determine cognitive load; rather, the interaction between complexity and organization plays a decisive role in shaping user perception and performance .
Accordingly, cognitive load must be reconceptualized as a structural phenomenon, emerging from the interaction between visual organization, attentional guidance, and perceptual processing. Rather than focusing on reducing the amount of information, effective design should aim to structure information in ways that align with cognitive and perceptual mechanisms, thereby optimizing processing efficiency and minimizing unnecessary cognitive effort.

2.4 Beyond Simplicity: Rethinking Minimalism in Design
Minimalism has emerged as a dominant paradigm in contemporary design, frequently associated with clarity, elegance, and enhanced usability. Within both professional practice and academic discourse, the reduction of visual elements is often assumed to facilitate perception by minimizing visual clutter and cognitive demand

(Lidwell et al., 2010; Norman, 2013). However, this assumption has been increasingly challenged by recent research in visual cognition and user experience, which suggests that reduction alone does not guarantee perceptual efficiency (Tuch et al., 2012; Reinecke & Gajos, 2014).

Empirical studies on visual complexity demonstrate that excessively simplified interfaces can produce unintended perceptual consequences. When essential relational cues are removed, users are required to infer missing connections between elements, leading to increased cognitive effort, ambiguity, and reduced interpretive accuracy (Tuch et al., 2012; Chen et al., 2020). In such cases, the absence of structure—not the presence of complexity—becomes the primary source of perceptual difficulty. This finding challenges the conventional equation between simplicity and usability.

Conversely, research indicates that visually rich or information-dense interfaces can support efficient perception when their elements are coherently structured and hierarchically organized (Rosenholtz et al., 2007; Ware, 2021; Ma et al., 2021). In these configurations, visual organization enables users to process information holistically, reducing the need for conscious interpretation despite the presence of multiple elements. This suggests that perceptual efficiency is not determined by the quantity of visual information, but by the quality of its organization.

This apparent contradiction reveals a critical limitation in traditional interpretations of minimalism. Rather than functioning as a universal solution, minimalism operates effectively only when it preserves the structural relationships necessary for perception. In this context, minimalism should be reconceptualized as structured reduction, where elements are selectively removed without compromising the relational logic that supports perceptual grouping, attentional guidance, and cognitive processing (Ware, 2021; Wagemans et al., 2012).

From a theoretical standpoint, this reframing aligns with broader perceptual principles, which emphasize that meaning emerges from organized relationships rather than isolated elements. The removal of visual components without maintaining structural coherence disrupts these relationships, leading to perceptual fragmentation. Accordingly, effective design should not aim to minimize elements indiscriminately, but to optimize the organization of those elements in ways that align with perceptual and cognitive mechanisms.

Despite these insights, much of contemporary design discourse continues to equate simplicity with effectiveness, often privileging reduction over structure. This conceptual bias has contributed to a persistent gap between design practice and perceptual theory, where visually simplified solutions are favored even when they compromise interpretability. Addressing this gap requires a fundamental shift from a quantity-based paradigm (less vs. more) toward a structure-based paradigm (organized vs. unorganized), in which perceptual efficiency is understood as a function of relational coherence rather than visual reduction.

2.5 Toward an Integrated Structural Model of Perception

The literature reviewed above points to three interdependent mechanisms that shape perceptual efficiency: visual organization, attentional guidance, and cognitive load regulation. While each mechanism has been discussed in prior research, they are rarely examined as part of one integrated perceptual system within product design. Most studies isolate either layout clarity, attentional hierarchy, or usability outcomes, without explaining how these mechanisms interact simultaneously during visual interpretation.

Figure 1 presents the conceptual structure adopted in this study. The model positions visual organization as the primary design variable and proposes that its influence on perceptual efficiency is mediated through two interconnected processes: attentional guidance and cognitive load regulation.

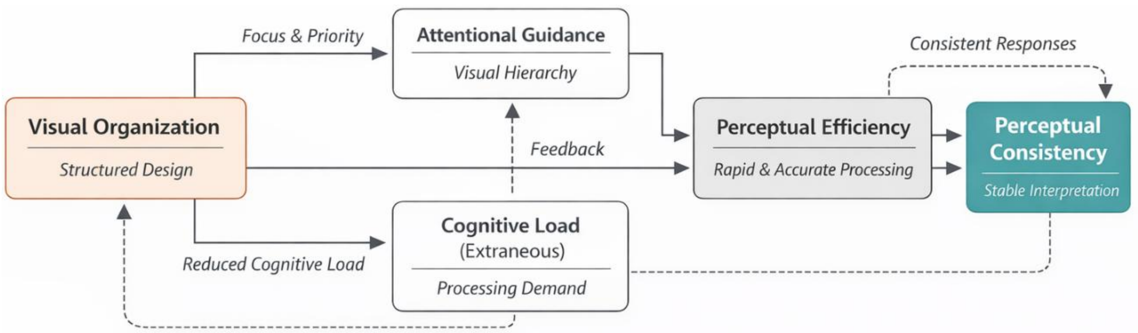

Figure 1. Integrated conceptual framework showing the effect of visual organization on perceptual efficiency through attentional guidance and cognitive load regulation.

Within this framework, visual organization operates first as a structuring mechanism that arranges visual elements into coherent relational patterns. Once these relationships are clearly established, attention is guided more predictably across the interface, allowing users to identify priorities, follow visual pathways, and interpret

functions with less search effort. At the same time, this structured arrangement reduces unnecessary cognitive demand by minimizing the need to reconstruct visual relationships mentally.
The model therefore assumes that perceptual efficiency does not emerge directly from simplicity or density as isolated formal conditions, but from the degree to which visual relationships are organized in a way that supports both perceptual grouping and cognitive economy. In this sense, attentional guidance and cognitive load are not separate outcomes; they are mutually reinforcing mechanisms through which structure becomes perceptually effective.
This integrated view also helps explain why users may respond more consistently to some visual configurations than to others. When relationships are explicit and hierarchically organized, interpretation becomes more stable across individuals. Accordingly, perceptual efficiency should be understood not only as improved performance, but also as reduced interpretive variability.

2.6 Research Gap and Contribution

Despite substantial advances in perceptual theory, visual cognition, and interface design, a critical gap persists in the empirical investigation of visual organization as an independent and controllable variable within product design research. While prior studies have provided valuable insights into usability, aesthetic preference, and visual complexity, they have largely examined these outcomes without isolating the structural mechanisms that govern how visual information is organized and interpreted (Ware, 2021; Huang et al., 2020).
A central limitation of the existing literature lies in its methodological approach. Many studies simultaneously manipulate multiple design variables—such as form, color, layout, and interaction—making it difficult to determine the specific contribution of visual organization to perceptual outcomes (Reinecke & Gajos, 2014; Ma et al., 2021). As a result, the causal relationship between visual structure and perceptual efficiency remains insufficiently established. Controlled experimental designs that maintain consistency in product form while systematically varying only the organization of visual elements are notably scarce.
Furthermore, current research predominantly evaluates perceptual performance through aggregate measures such as speed, accuracy, or user preference, often overlooking the stability and consistency of perception across users. The concept of *perceptual consistency*—defined as the degree to which individuals interpret visual information in similar ways—remains underexplored, despite its critical importance for design reliability and shared understanding (Wagemans et al., 2012; Ware, 2021). This omission limits the ability to fully assess the effectiveness of visual systems, particularly in contexts where consistent interpretation is essential.
In addition, existing studies frequently treat visual organization, attentional guidance, and cognitive load as separate or loosely connected constructs, rather than as components of an integrated perceptual system. This fragmentation restricts the development of comprehensive theoretical models capable of explaining how these mechanisms interact to produce efficient and stable perception.
To address these limitations, the present study adopts a controlled comparative experimental approach that isolates visual organization as the primary independent variable while maintaining all other design attributes constant. By doing so, it enables a direct examination of how variations in structural configuration influence perceptual outcomes.
Specifically, this study contributes to the literature in three key ways:

- It conceptually reframes visual organization as a primary determinant of perceptual efficiency, rather than a secondary compositional attribute.
- It methodologically isolates visual structure, allowing for the establishment of a clearer causal relationship between organization and perception.
- It extends evaluation beyond performance metrics by incorporating perceptual consistency as a critical dimension of design effectiveness.

Through these contributions, the study advances a structure-based paradigm of design, in which perceptual efficiency is understood not as a function of visual quantity or reduction, but as an emergent property of well-organized relational systems that align with perceptual and cognitive processes.

3. Methodology

3.1 Research Design

This study adopts a controlled comparative experimental design to investigate the effect of visual organization on perceptual efficiency in product design. The experiment is structured to isolate visual organization as the primary independent variable, while maintaining all other design attributes constant.
In many design studies, multiple variables—such as form, material, or aesthetic style—are modified simultaneously, making it difficult to determine the source of perceptual differences. In contrast, the present study eliminates such confounding factors by fixing all physical properties of the product and manipulating only the organization of visual elements.
This approach enables a direct examination of how visual structure influences perception and ensures that any observed differences in user responses can be attributed exclusively to variations in visual organization.

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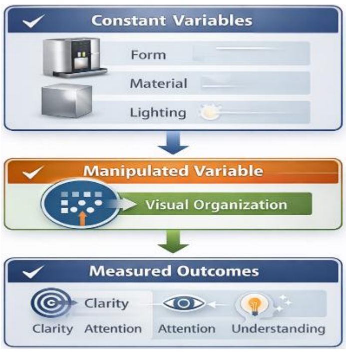

Figure 2. Experimental control and manipulation of variables.

3.2 Development of Design Stimuli

A single product model—a compact coffee machine interface—was selected as the experimental base. The choice of a familiar household product supports realistic perception and minimizes contextual ambiguity.
Three design variations were developed, each representing a distinct mode of visual organization:

- Design A (High Visual Density):
  A configuration characterized by multiple competing elements presented simultaneously, with minimal hierarchical differentiation.
- Design B (Minimal Reduction):
  A simplified configuration with fewer elements, emphasizing visual reduction but providing limited structural guidance.
- Design C (Structured Hierarchy):
  A hierarchically organized configuration in which elements are arranged according to visual importance, grouping, and spatial relationships.

All three variations share identical physical properties, including product form, dimensions, materials, lighting conditions, and viewing angle. The only manipulated variable is the organization of interface elements.

Figure 3. Comparative product interface variations (A: High Density, B: Minimal, C: Structured).

3.3 Interface Decomposition

To establish a clear analytical foundation, the product interface was decomposed into its primary and secondary visual components, including control elements, display areas, and interaction zones.
This decomposition demonstrates that perception operates through multiple visual units rather than as a single holistic entity. It also defines the structural elements through which visual organization is manipulated in the experiment.


Figure 4. Interface decomposition diagram showing primary and secondary visual components.

3.4 Visual Hierarchy Representation

To illustrate how visual organization differs across the three conditions, a visual hierarchy model was developed. This model identifies levels of importance among interface elements and shows how attention is directed through structured relationships.
The model highlights that effective design is not achieved by reducing elements, but by organizing them according to perceptual priority.

Figure 5. Visual hierarchy representation indicating primary, secondary, and supporting elements.

3.5 Participants
A total of 44 participants took part in the study. The sample included individuals from diverse age groups, genders, and educational backgrounds, including both design-related and non-design participants.
This diversity ensures that the findings reflect general perceptual tendencies rather than specialized expertise. All participants were exposed to the same visual stimuli under consistent viewing conditions.

3.6 Data Collection Procedure
Data were collected using two complementary evaluation methods:
Comparative Evaluation
Participants were asked to select:

- The clearest design
- The design that attracts attention first
- The easiest to understand
- The overall preferred design

This method captures immediate perceptual judgments.
Likert-Scale Assessment
Participants evaluated each design using a five-point Likert scale across three dimensions:

- Clarity
- Ease of understanding
- Attention capture

This method provides a quantitative measure of perceptual performance (Tuch et al., 2012).
3.7 Variables

- Independent Variable:
  Visual organization (Dense / Minimal / Structured)
- Dependent Variables:
  Clarity
  Ease of understanding
  Attention capture
  Overall preference

These variables were selected based on their relevance to perceptual efficiency (Ware, 2021).
3.8 Data Analysis
Data analysis was conducted using descriptive, distributional, and inferential statistical methods.

- Descriptive statistics (mean and standard deviation) were used to compare performance across conditions.
- Distributional analysis (median and interquartile range) was used to examine response consistency.
- Inferential analysis was conducted using the Friedman test for repeated measures, followed by Wilcoxon signed-rank tests for pairwise comparisons.

These methods are appropriate for ordinal data and repeated-measures designs (Sweller, 2011).
3.9 Validity and Control
To ensure methodological rigor:

- All physical attributes of the product were held constant
- Visual organization was the only manipulated variable
- Stimuli were presented under identical conditions

- Visual representations (Figures 1–4) support transparency and reproducibility

These controls ensure that perceptual differences are directly linked to variations in visual organization.

4. Results

A total of 44 participants completed the visual perception evaluation. The results are presented through descriptive statistics, comparative selections, inferential analysis, and distributional patterns, providing a comprehensive understanding of both perceptual performance and response consistency.

4.1 Participant Profile

Table 1 presents the demographic characteristics of the participants. The sample includes a diverse distribution across age groups, gender, and educational background. The largest proportion of participants were above 40 years (38.6%), followed by the 20–30 age group (31.8%) and the 31–40 group (25.0%). Female participants represented 63.6% of the sample, while 52.3% had a design or arts background.
This diversity supports the generalizability of the findings and ensures that the results reflect broad perceptual tendencies rather than expert-specific judgments.

Table 1. Demographic profile of the participants.

Category	Group	n	%
Age	Under 20	2	4.5
	20–30	14	31.8
	31–40	11	25.0
	Above 40	17	38.6
Gender	Male	16	36.4
	Female	28	63.6
Background	Design / Arts	23	52.3
	Other	21	47.7

4.2 Descriptive Statistics

Table 2 presents the mean scores and standard deviations for the three design conditions across clarity, ease of understanding, and attention capture. A clear and consistent progression is observed across all variables, with Design C achieving the highest scores, followed by Design B, while Design A consistently records the lowest values.

Table 2. Mean scores and standard deviations for the three design conditions.

Metric	Design A Mean ± SD	Design B Mean ± SD	Design C Mean ± SD	Direction
Clarity	3.66 ± 0.71	3.98 ± 0.63	4.45 ± 0.66	A < B < C
Ease of Understanding	3.59 ± 0.62	4.02 ± 0.46	4.64 ± 0.49	A < B < C
Attention Capture	3.57 ± 0.55	4.00 ± 0.78	4.75 ± 0.44	A < B < C

For clarity, mean scores increased from 3.66 (SD = 0.71) in Design A to 3.98 (SD = 0.63) in Design B, reaching 4.45 (SD = 0.66) in Design C. Similarly, ease of understanding improved from 3.59 (SD = 0.62) to 4.02 (SD = 0.46) and 4.64 (SD = 0.49), while attention capture increased from 3.57 (SD = 0.55) to 4.00 (SD = 0.78) and 4.75 (SD = 0.44).
These results indicate a systematic improvement in perceptual performance as visual organization becomes more structured.

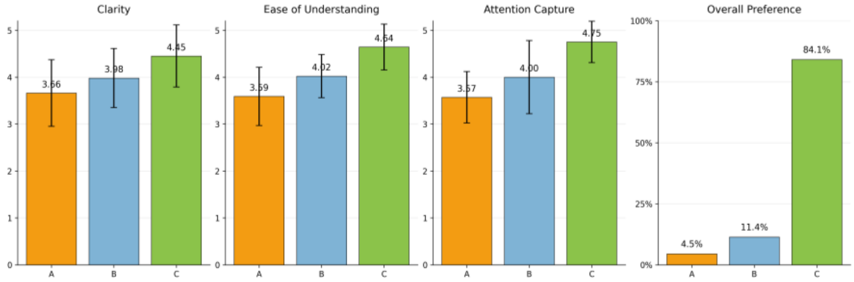

Figure 6. Perceptual evaluation results showing average ratings of clarity, ease of understanding, attention capture, and overall preference for the three interface designs

Figure 6 visually reinforces this pattern, illustrating a clear directional gradient from dense to minimal to structured configurations. The alignment between numerical results (Table 2) and graphical representation (Figure 6) confirms the consistency of this trend.

4.3 Comparative Selection Results

The comparative evaluation results demonstrate a clear dominance of the structured design condition. As shown in Table 3, Design C was selected by 65.9% of participants as the clearest design, by 72.7% as the first to attract attention, and by 84.1% as both the easiest to understand and the overall preferred design.
In contrast, Design A received minimal selections and was not chosen in the attention category, indicating weak perceptual salience. Design B showed moderate performance, consistently positioned between the other two conditions.

Table 3. Percentage distribution of comparative selections across the three designs.

Comparative Question	Design A	Design B	Design C	Most Selected
Clearest design	9.1%	25.0%	65.9%	Design C
First attention attraction	0.0%	27.3%	72.7%	Design C
Easiest to understand	6.8%	9.1%	84.1%	Design C
Overall preference	4.5%	11.4%	84.1%	Design C

These findings confirm that structured organization not only improves measured performance but also strongly influences intuitive user preference.

4.4 Inferential Statistics

The Friedman test revealed statistically significant differences across all variables ($p < .001$), as presented in Table 4. Effect sizes (Kendall's W) ranged from moderate to strong, with the strongest effect observed for attention capture ($W = 0.678$), followed by ease of understanding ($W = 0.592$) and clarity ($W = 0.372$).

Table 4. Friedman test results for repeated evaluations of the three design conditions.

Variable	Friedman χ^2	p-value	Kendall's W
Clarity	32.72	< .001	0.372
Ease of Understanding	52.08	< .001	0.592
Attention Capture	59.67	< .001	0.678

Post-hoc Wilcoxon signed-rank tests (Table 5) confirmed that all pairwise comparisons between the three design conditions were statistically significant. Effect size values (rank-biserial r) ranged from moderate to extremely large, with several comparisons approaching $r = -1.00$.
These exceptionally high effect sizes indicate a strong level of agreement among participants regarding the superiority of the structured design condition.

Table 5. Pairwise Wilcoxon signed-rank comparisons between the three design conditions.

Variable	Comparison	p-value	Rank-biserial r
Clarity	A vs B	0.006	-0.583
	A vs C	< .001	-0.859
	B vs C	< .001	-0.778
Ease of Understanding	A vs B	< .001	-0.704
	A vs C	< .001	-1.000
	B vs C	< .001	-1.000
Attention Capture	A vs B	< .001	-0.760
	A vs C	< .001	-1.000
	B vs C	< .001	-1.000

4.5 Distributional Analysis

To further examine response consistency, distributional analysis was conducted (Figure 7). The structured design (Design C) exhibits a concentrated distribution with higher median values and reduced variability, indicating strong agreement among participants.

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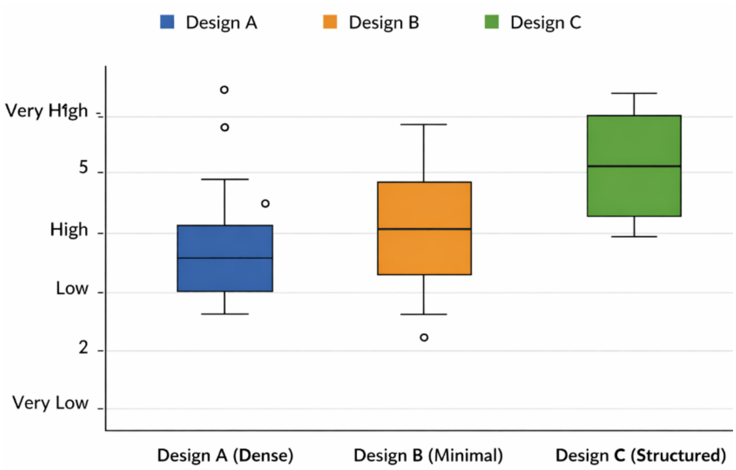

Figure 7. Distribution of participant ratings across the three design conditions using a five-point Likert scale.

In contrast, the dense design (Design A) shows a wider spread of responses, reflecting perceptual variability and inconsistency. The minimal design (Design B) demonstrates moderate dispersion, indicating partial improvement without achieving full perceptual stability.
The alignment between inferential results (Table 6) and distributional patterns (Figure 7) suggests that the superiority of the structured design is not only statistical but also perceptual.

4.6 Summary of Results
Taken together, the results from Tables 1–5 and Figures 6–7 demonstrate that structured visual organization produces the highest level of perceptual efficiency.
The structured design achieved superior performance across all measured variables and generated more consistent responses among participants. In contrast, dense visual organization resulted in lower performance and higher variability, while minimal reduction provided moderate improvement but lacked sufficient structural clarity.
These findings indicate that perceptual efficiency is determined not only by performance outcomes, but also by the consistency of interpretation across users.

5. Discussion
The findings of this study reposition visual organization from a secondary compositional attribute to a primary cognitive mechanism that governs how visual information is perceived, structured, and stabilized. The consistent superiority of the structured condition (Design C), observed across descriptive, inferential, and distributional analyses , indicates that perceptual efficiency is fundamentally a function of relational structure rather than visual quantity.

More critically, the results reveal that perceptual differences between design conditions are not incremental, but structural in nature. The progression from dense to minimal to structured configurations (A < B < C) reflects a transformation in perceptual processing itself. In the dense condition, the absence of coherent organization leads to perceptual fragmentation, where attention is dispersed across competing elements and users are forced to actively reconstruct visual relationships. In the minimal condition, although visual noise is reduced, the absence of sufficient structural cues results in a form of perceptual under-specification, limiting interpretive clarity. By contrast, the structured condition establishes explicit relational hierarchies, enabling perception to operate through immediate pattern recognition rather than effortful reconstruction.

This transformation can be directly interpreted through Gestalt theory, which posits that perception is inherently organizational, driven by the tendency to form coherent wholes from sensory input (Wagemans et al., 2012; Palmer, 1999). The structured design aligns with this principle by reinforcing grouping mechanisms such as proximity, alignment, and figure–ground differentiation. As a result, perceptual processing becomes both faster and more reliable. Conversely, the dense condition disrupts grouping through excessive competition, while the minimal condition weakens it by removing relational cues. Thus, perceptual efficiency emerges not from simplification alone, but from the presence of structured relationships.
From a cognitive perspective, the findings extend Cognitive Load Theory by demonstrating that cognitive load is not solely dependent on the amount of information presented, but on how that information is organized (Sweller, 2011; Paas et al., 2003). The dense configuration imposes high extraneous cognitive load by requiring users to interpret unstructured relationships, while the minimal configuration reduces visual complexity without fully

eliminating interpretive demand. The structured configuration, however, embeds relational information within the visual layout, allowing users to rely on perceptual processing rather than working memory. This significantly reduces cognitive effort and enhances processing efficiency (Huang et al., 2020).

A central contribution of this study lies in identifying perceptual consistency as a defining dimension of effective design. While traditional usability research emphasizes average performance metrics, the distributional analysis reveals that the structured condition produces significantly lower variability in user responses. This indicates that users not only perform better, but also interpret the interface in more similar ways. In contrast, the dense condition exhibits high variability, reflecting ambiguity and instability in perception.
This distinction is theoretically significant. It suggests that perceptual efficiency should be understood as a dual construct, encompassing both performance (accuracy and speed) and agreement (consistency across users). In this sense, effective design reduces not only cognitive effort but also interpretive divergence, thereby supporting shared understanding.

The exceptionally high effect sizes reported in the pairwise comparisons (approaching $r \approx -1.00$) further reinforce this interpretation. Such values indicate that the superiority of the structured condition is not marginal or context-dependent, but robust and widely shared among participants. This convergence between statistical significance and perceptual agreement strengthens the validity of the findings and underscores the importance of designing for collective perception rather than individual preference.
Another important implication of the study is the need to critically reconsider the role of simplicity in design. Minimalism is often assumed to enhance usability by reducing visual clutter; however, the findings demonstrate that reduction alone is insufficient. The minimal condition, although visually cleaner, failed to achieve the same level of clarity and consistency as the structured design. This suggests that simplicity, when not supported by clear organizational logic, may result in perceptual ambiguity rather than efficiency.

Accordingly, the study supports a paradigm shift from a quantity-based model of design (more vs. less) toward a structure-based model (organized vs. unorganized). Within this framework, visual organization becomes the central determinant of how information is perceived, processed, and understood. Effective design is therefore not achieved by minimizing elements, but by structuring their relationships in a way that aligns with perceptual and cognitive processes.

Finally, the strong alignment between the empirical findings and the conceptual framework proposed in Figure 1 confirms the validity of the theoretical model. Visual organization operates through two interdependent mechanisms—attentional guidance and cognitive load regulation—which together shape perceptual efficiency. These mechanisms do not function independently; rather, they form a dynamic system in which structured attention reduces cognitive demand, and reduced cognitive demand stabilizes attention.
In this sense, perceptual efficiency can be understood as an emergent property of well-organized visual systems—systems in which structure, attention, and cognition are tightly integrated to produce both effective and consistent user experience.

6. Conclusion
This study investigated the role of visual organization in shaping perceptual efficiency in product design through a controlled experimental approach. By isolating visual organization as the primary variable while maintaining all other design attributes constant, the findings provide clear evidence that perceptual performance is fundamentally determined by the structure of visual information rather than its quantity.
Across all analytical levels, the structured design condition consistently outperformed both dense and minimal configurations. It achieved higher levels of clarity, ease of understanding, and attention capture, while also demonstrating greater consistency in participant responses. This indicates that perceptual efficiency is not only a matter of performance, but also of stability in how users interpret visual information.
The results further reveal that neither increasing nor reducing the number of visual elements guarantees improved perception. Dense configurations introduce competition and cognitive overload, while minimal configurations may remove essential cues required for interpretation. In contrast, structured organization enables users to process visual information as coherent units, reducing cognitive effort and enhancing interpretability.
A key contribution of this study is the identification of perceptual consistency as an essential dimension of effective design. The findings suggest that successful product design should not only aim to improve user performance, but also to minimize variability in perception across users, thereby promoting shared understanding.
From a theoretical perspective, the study supports the integration of Gestalt principles and Cognitive Load Theory in explaining how visual structure influences perception. From a practical standpoint, it highlights the

importance of organizing visual elements hierarchically and relationally, rather than focusing solely on simplification or visual reduction.

In conclusion, perceptual efficiency in product design emerges not from how much information is presented, but from how effectively that information is structured. By aligning visual organization with perceptual and cognitive processes, designers can create products that are not only more effective, but also more consistent, intuitive, and user-centered.

7. Recommendations

Based on the findings of this study, several design-oriented and research-oriented recommendations can be proposed to enhance perceptual efficiency in product design.

7.1 Design Recommendations

The results clearly demonstrate that structured visual organization significantly improves both perceptual performance and response consistency. Accordingly, designers are encouraged to:

- Prioritize visual hierarchy as a fundamental design principle, ensuring that elements are clearly organized according to importance and function
- Use grouping, alignment, and spacing to establish meaningful relationships between visual elements
- Avoid excessive visual density, as it introduces competing stimuli that increase cognitive load and reduce clarity
- Avoid over-reduction of elements, which may eliminate critical perceptual cues required for interpretation
- Design interfaces that guide user attention sequentially, rather than relying on unstructured or scattered layouts

These recommendations emphasize that effective design depends on organizing visual relationships rather than simply reducing or increasing the number of elements.

7.2 Cognitive and Perceptual Recommendations

From a cognitive perspective, the study highlights the importance of aligning visual structure with perceptual processing mechanisms. Therefore, it is recommended that:

- Designers explicitly consider cognitive load when organizing visual information, aiming to minimize unnecessary mental effort
- Design evaluation should include consistency of user responses, not only average performance measures
- Principles of perceptual grouping (Gestalt principles) should be systematically integrated into design decision-making
- Interfaces should be tested for their ability to produce stable and predictable interpretations across different users

These recommendations extend the evaluation of design beyond usability toward perceptual coherence.

7.3 Methodological Recommendations

The study demonstrates the value of controlled experimental approaches in design research. Accordingly, future studies are encouraged to:

- Adopt controlled comparative designs that isolate visual organization as an independent variable
- Combine quantitative measures (e.g., Likert scales, statistical tests) with distributional analysis to assess response consistency
- Incorporate additional methods such as eye-tracking to analyze attentional flow and visual navigation
- Expand sample size and diversity to improve the generalizability of findings

7.4 Recommendations for Design Practice

In professional design contexts, it is recommended that:

- Design decisions move beyond aesthetic preference toward evidence-based evaluation
- Interface testing should include perceptual metrics, not only functional usability measures
- Design teams adopt frameworks that focus on structuring visual information, rather than simply adding or removing elements
- Existing product interfaces should be reviewed and refined based on principles of visual organization and perceptual clarity

7.5 Future Research Directions

Future research can build on the findings of this study by:

- Investigating the role of visual organization across different product categories and interaction contexts
- Exploring cultural and demographic influences on perceptual interpretation
- Examining the relationship between perceptual efficiency and long-term user experience
- Developing predictive models that link visual structure to perceptual outcomes

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