The Influence Mechanism of Mobile News Platform Information Design Elements on Visual Search Efficiency (Postprint)

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Abstract

[Purpose/Significance] To investigate the influence mechanism of interface design elements of news platforms on information visual search efficiency in the context of mobile reading, and to propose design optimization strategies. [Method/Process] By controlling three important factors in mobile news platform interfaces—information density, image-text structure, and font weight—using behavioral and eye-tracking experiments combined with subjective satisfaction questionnaires, this study examines the effects of different interface elements on users' information visual search efficiency, and explores the interaction effects of the three factors to derive their influence mechanism. [Results/Conclusion] The interaction effect among the three interface design elements—information density, image-text structure, and font weight—in mobile news information platforms is significant, and information density has a significant impact on users' subjective satisfaction. The optimal combination for visual search efficiency is text-above-image structure, low density, and light font weight.

Full Text

Preamble

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Abstract

[**Purpose/Significance**] This study investigates the influence mechanism of news platform interface design elements on information visual search efficiency in the context of mobile reading and proposes design optimization strategies. [**Method/Process**] By controlling three important factors in mobile news platform interfaces—information density, image-text structure, and font weight—this research employs behavioral and eye-tracking experiments combined with subjective satisfaction questionnaires to examine how different interface elements affect users' information visual search efficiency. The interaction effects among the three factors are explored to reveal their underlying influence mechanisms. [**Result/Conclusion**] The interaction among information density, image-text structure, and font weight is significant in mobile news information platforms, and information density has a significant impact on users' subjective satisfaction. The optimal combination for visual search efficiency is the text-above-image layout with low density and light font weight.

In the internet information era, fragmented time has made mobile reading an important way to obtain news information. When the public encounters a hot news story, they often turn to mobile news platforms to search for specific information, but frequently cannot quickly find the content they need. The cognitive process of searching for a specific target object within a certain context is known as visual search, which is not only an important method for acquiring and processing external information throughout daily life but also a crucial component of many specialized tasks. In human-computer interaction, any search task involves interface layout and control distribution. Given the particularities of mobile devices, Liu Ting and Hou Wenjun used eye-tracking experiments to study mobile interface design, which holds significant meaning for solving the aforementioned problems. Existing literature indicates that while research on webpage interfaces affecting visual search efficiency is abundant, studies specifically targeting mobile platforms remain insufficient. In recent years, mobile devices have featured various screen resolutions that differ from desktop environments, with smaller screens, more concise user operations, and more condensed interface information. Research by Liu Ting and Hou Wenjun examined three image-text layout patterns in mobile news platforms—left-text-right-image, right-text-left-image, and text-above-image—and found that the text-above-image layout yielded the highest visual search efficiency. They argued that users typically adopt a text-oriented browsing pattern in mobile reading contexts. Although this research made initial explorations into visual search behavior on mobile news platforms, mobile digital interfaces present multiple visual design elements. Single-variable discussions cannot accurately explain the visual search mechanisms of mobile news platforms, necessitating deeper analysis of the interaction effects among integrated design elements and their underlying mechanisms.

This study focuses on mobile news platform digital interfaces, exploring how information density, layout structure, and font characteristics affect visual infor-

mation search efficiency based on visual search theories. Through eye-tracking and behavioral experiments examining relevant indicators under controlled conditions, combined with questionnaire analysis of subjective satisfaction across different scenarios, this research reveals the cognitive mechanisms through which interface design elements influence users' visual search efficiency. This contributes to a more complete analysis of user visual search behavior and provides strategic guidance for optimizing mobile news platform interface design.

Literature Review and Research Hypotheses

Different visual presentation methods of information density have inherent connections with objective performance and subjective evaluation in digital interface visual search. Early research by P. Kolers et al. defined text information density as character crowding, controlling density through character spacing and line spacing. Their eye-tracking experiments found that in black-background-white-text screens, smaller character spacing improved reading efficiency; when information volume was constant, single line spacing required more fixations and time than double line spacing, resulting in lower recognition efficiency. This result differs significantly from P. Muter et al.'s proposal that horizontal spacing ratios have no effect on reading speed and comprehension. Research on line spacing also shows considerable variation. On one hand, T. Halverson et al. found in studies of word groups with different line spacing that sparse word groups yielded higher search efficiency than dense groups in text-based interface layouts. On the other hand, Yan Yuming et al. discovered that line spacing had no significant effect on keyword search time in Chinese webpages.

As digital interface information volume increases and information structures become more complex, D. Weller proposed defining information density in digital interfaces as the ratio of information volume to area within a given region. Weller conducted experimental studies on both overall and local information density in webpage text, finding that greater overall density in desktop webpage interfaces led to longer search times, while high, medium, and low local density levels showed no significant differences in search time—meaning local density had no impact on search efficiency. Similarly, Liu Jie et al. examined rich and concise webpage information density designs and their effects on Chinese and English users' visual search abilities, confirming that Chinese users' search time increased significantly when searching for high-density, high-visual-impact webpage content. These studies demonstrate that information density is a crucial factor affecting visual search efficiency. Regarding its mechanism, M. Beck et al. argued that webpage information density affects task difficulty, thereby influencing visual search efficiency—higher page density and more frequent density changes increase search difficulty. Furthermore, researchers propose that under different information volumes causing varying cognitive loads, users' visual search in digital interfaces differs significantly: more interface elements lead to higher cognitive load and lower search efficiency. In summary, information density in digital interfaces substantially impacts users' visual search efficiency.

The layout structure of digital interfaces themselves significantly influences users' information visual search efficiency. Layout structure can be defined as the arrangement and positioning of text, images, and other elements in an interface according to certain principles. K. Snowberry et al. studied simple horizontal and vertical text layout structures, finding that vertical page layouts reduced visual search time by 25% compared to horizontal arrangements. However, Lei Jing's research reached a different conclusion, discovering that when searching for specific targets in text-heavy digital interfaces, horizontal structures for category vocabulary columns and information entry columns were more conducive to visual search than vertical structures, explained by users' habit of sequentially searching from left to right and top to bottom. R. Goonetilleke et al. further conducted visual search experiments on three different layout patterns—horizontal, vertical, and evenly distributed—in Chinese webpages, proving that different text layout methods change users' search strategies and thus affect visual search efficiency. Based on text layout positions in digital interfaces, M. Russell compared eye movement patterns across three e-commerce websites, finding that placing information on the right side of the interface resulted in the longest search time and lowest efficiency. Compared to text-only interfaces, visual processing is more complex in image-text combination interfaces. Numerous studies indicate that image recognition is superior to text recognition, but extensive advertising images in digital interfaces can distract users and increase cognitive load, affecting visual behavior. Further research by Li Cheng on illustration effects in digital interfaces found that placing illustrations on the left side of text yielded the best browsing results. Regarding the reasons why digital interface layout affects visual search, researchers argue that it relates to both human search habits and visual field perception asymmetry—the upper visual field has advantages in local information processing over the lower visual field but requires more attentional resource allocation, while the right visual field shows more significant advantages in language and cognitive processing than the left visual field, with better attention distribution. For mobile news platform digital interfaces, given the constraints of small screen size and fragmented reading contexts, layout structures generally manifest as image-text combinations. Therefore, this study selects image-text structure as an independent variable for mobile news platform interfaces.

As a fundamental interface design element, font characteristics significantly impact users' visual search efficiency. Inappropriate font choices in interface design affect effective information transmission. J. Ling and P. Schaik studied font types for English letters in digital interfaces, finding that although font type had no significant effect on visual search tasks, users showed subjective preference for Arial font. In Chinese font research for digital interfaces, Gong Diankun et al. used visual search programs to record reaction times, finding that when font size was identical, Song typeface yielded significantly shorter visual search reaction times than Kai typeface; with the same font type, 22-point characters showed significantly shorter reaction times than 15-point characters. However, different results emerged from Yan Yuming et al.'s study of Chinese webpage

searches, which found font type had no effect on keyword search time, consistent with the aforementioned English letter search results. In search research where targets and backgrounds differed in multiple font attributes, H.F. Wang used five font display features—bold, underline, character border, italic, and shadow—to explore highlighting effects on Chinese character visual search, finding that bold target display yielded the fastest and most accurate visual search. In mobile news platform interfaces, where screens are significantly smaller than desktop versions and font sizes and types tend toward standardization across platforms, font weight lacks consistent specification. Therefore, this study investigates the impact of font weight on visual search efficiency.

Research on the influence of interface design elements on visual search efficiency is common, but due to substantial internal correlations among various design elements, deeper analysis of their interaction effects is needed to uncover the mechanisms affecting visual search efficiency in real interfaces with multiple design elements present.

Based on this, the following research hypotheses are proposed:

H1: Information density, image-text structure, and font weight in mobile news platform interfaces have interactive effects on visual search efficiency.

H2: Information density, image-text structure, and font weight in mobile news platform interfaces significantly affect users' subjective satisfaction.

Research Methods

3.1 Participants

Forty students from China University of Geosciences (Wuhan) participated in this study. Participants had a mean age of 23.45 ± 2.65 years, diverse academic backgrounds, normal or corrected-to-normal vision of 5.0 or above, no color blindness, and were all right-handed. None had previously participated in eye-tracking experiments. To avoid familiarity effects, participants were required to have at least six months of experience using mobile news information platforms such as Tencent News, Sohu News, NetEase News, and Toutiao.

3.2 Independent Variable Levels

Analysis of 100 randomly selected news items from each of the six most downloaded news platforms in the Android app market (Toutiao, Sohu News, Yidian Zixun, NetEase News, Tencent News, and Baidu News) informed the operationalization of variables.

Information density was defined as the number of news information items presented within the same interface, with the number of items varying proportionally with line spacing. Content analysis of selected mobile news platforms revealed that high-density interfaces displayed up to 6.5 news items per standard page, while low-density interfaces displayed as few as 3.5 items. Therefore,

three levels were selected: high density (6 news items), medium density (5 news items), and low density (4 news items) per standard page, as shown in [Figure 1: see original paper].

Content analysis of image-text structures in sampled mobile news platforms revealed five layout patterns: text-above-image, left-text-right-image, right-text-left-image, large-image, and text-only. The three most common layouts were text-above-image (28.6%), left-text-right-image (34.9%), and right-text-left-image (23.4%). Therefore, this study selected left-text-right-image, text-above-image, and right-text-left-image as the three levels of image-text structure, as shown in [Figure 2: see original paper].

Font analysis of sampled news materials showed that mobile platforms generally use Microsoft YaHei and Founder Lanting typefaces, with three font weight levels: bold, regular, and light. Zhang Li et al. demonstrated that the Founder Lanting typeface, with its slightly flat and full shape and simple, extended strokes, facilitates Chinese character recognition and processing. Therefore, this experiment uniformly used the Founder Lanting typeface: Founder Lanting Zhonghei for bold, Founder Lanting-GBK regular for normal weight, and Founder Lanting Xihei for light weight, as shown in [Figure 3: see original paper].

3.3 Experimental Design

The experiment employed a 3 (news information density: high, medium, low) × 3 (image-text structure: left-text-right-image, text-above-image, right-text-left-image) × 3 (font weight: bold, regular, light) within-subjects design to examine participants' visual search efficiency, eye-tracking patterns, and post-experiment subjective satisfaction during mobile news information searches.

Dependent variables: Visual search efficiency was measured using first-click time, total fixation time, and fixation count. **First-click time** refers to the time from task onset to clicking on the target, representing search duration. **Total fixation time**, also called total dwell time, refers to the sum of all fixation durations within an area of interest, sensitive to slower and longer cognitive processing—longer fixation times indicate more difficult information extraction. **Fixation count** refers to the number of fixations within an area of interest; high fixation rates indicate either greater interest in a region or that the region contains complex information requiring difficult encoding. More fixations suggest more saccades and greater uncertainty about the target, indicating a longer search process. **Subjective satisfaction** was measured through scores on a post-experiment questionnaire referencing J. Cook's satisfaction scale, assessing participants' satisfaction with their search behavior on each page using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Higher scores indicated greater satisfaction with the page type.

3.4 Experimental Materials and Procedure

The experiment used a Tobii X2-60 eye tracker with a 60 Hz sampling rate, 0.4° accuracy, and 0.2° precision. Eye movement data were recorded via the eye tracker's companion software and exported for statistical analysis using Tobii Studio.

To ensure balanced interest and familiarity with experimental materials, news items were randomly selected according to independent variable levels and screened for medium familiarity and medium interest using a 5-point Likert scale. Target words were uniformly two-character nouns positioned within the first four news items. To eliminate position and order effects, experimental materials were displayed randomly. Familiar, commonly used neutral vocabulary was selected as target words, with word frequency statistics ensuring each target appeared only once per page.

Due to experimental design limitations preventing direct assessment of mobile phone interfaces, the study used desktop computers to simulate mobile contexts, with mouse operation substituting for touch gestures—an approach validated as effective for usability evaluation of mobile prototype pages. Throughout the experiment, each participant completed 27 visual search tasks across all combinations of independent variable levels ($3 \times 3 \times 3$). To separate visual search time from mouse click time, participants were instructed not to move the mouse until locating the target. The experiment lasted 20 minutes, with 10-second breaks after every three trials to prevent fatigue. Break duration was adjusted based on visual fatigue, after which the eye tracker was recalibrated before continuing.

Each trial proceeded as follows: (1) The search target was displayed centrally for 2 seconds; (2) The target disappeared; (3) Participants performed visual search to locate the target word; (4) Participants quickly moved the mouse to the target and clicked; (5) Participants completed the subjective satisfaction questionnaire; (6) The process repeated.

Experimental Results

Multivariate analysis of variance examined the effects of news information density, image-text structure, and font weight on users' visual search processes.

4.1 First-Click Time

Analysis of first-click time revealed a significant three-way interaction among image-text structure, information density, and font weight, $F(8, 312) = 2.741$, $p < 0.05$. Simple effects tests showed that in text-above-image layouts, light font weight yielded significantly higher search efficiency than regular and bold at low and medium density levels. In right-text-left-image layouts, bold font showed significantly higher efficiency than light weight at low density, while light weight was significantly more efficient than bold and regular at medium density. In

left-text-right-image layouts, light weight was significantly more efficient than bold and regular at low density, while regular weight was significantly more efficient than bold at high density. Combinations with optimal visual search efficiency revealed that the text-above-image, low-density, light-weight combination required the shortest first-click time.

Significant two-way interactions emerged between information density and font weight, image-text structure and font weight, and image-text structure and information density. Main effects were significant for image-text structure, information density, and font weight. Post-hoc tests showed that right-text-left-image layouts required significantly more time than text-above-image layouts, which in turn required significantly more time than left-text-right-image layouts. High density required significantly more time than low and medium densities, and bold font required significantly more time than light weight (all $p < 0.05$), as shown in .

4.2 Total Fixation Time

Multivariate analysis of total fixation time revealed a significant three-way interaction among image-text structure, information density, and font weight, $F(8, 312) = 4.648$, $p < 0.05$. Simple effects tests showed that in text-above-image, high-density layouts, bold font required significantly more fixation time than regular weight. In right-text-left-image, low-density layouts, regular weight required significantly more fixation time than light and bold weights. In right-text-left-image, medium-density layouts, bold required significantly more fixation time than light and regular weights. In right-text-left-image, high-density layouts, light weight required significantly less fixation time than bold and regular weights, as shown in .

Two-way interactions were significant between information density and font weight, image-text structure and font weight, and image-text structure and information density. At low density, regular weight required significantly more fixation time than light weight. In right-text-left-image layouts, bold required significantly less fixation time than light and regular weights, while medium density required significantly more time than high density.

The main effect of font weight was significant, $F(2, 78) = 7.626$, $p < 0.05$. Post-hoc tests revealed significant differences between light and bold weights, with light weight showing shorter total fixation times, indicating participants spent less time fixating on test materials in this condition.

4.3 Fixation Count

Analysis of fixation count showed a significant three-way interaction among image-text structure, information density, and font weight, $F(8, 312) = 3.401$, $p < 0.05$. Simple effects tests revealed that in right-text-left-image layouts at medium and high density levels, light weight produced significantly fewer fixations than bold weight, as shown in .

Two-way interactions were significant between image-text structure and information density, image-text structure and font weight, and information density and font weight. In right-text-left-image layouts, light weight yielded significantly fewer fixations than bold and regular weights, and low density produced significantly fewer fixations than medium density. In left-text-right-image layouts, medium density resulted in significantly fewer fixations than low and high densities. At medium density, light weight produced significantly fewer fixations than bold weight.

Main effects were significant for image-text structure and font weight. Post-hoc tests showed that right-text-left-image layouts generated significantly more fixations than text-above-image layouts, and light weight produced significantly fewer fixations than bold and regular weights (all $p < 0.05$).

4.4 Subjective Satisfaction Analysis

Multivariate analysis of subjective satisfaction revealed non-significant main effects for image-text structure and font weight, but a significant main effect for information density, $F(2,\ 78) = 9.632,\ p < 0.05$. Post-hoc tests showed that subjective satisfaction at high density was significantly lower than at medium and low densities. Lower information density corresponded to higher subjective satisfaction. No significant interactions existed among the three factors, as shown in [Figure 11: see original paper].

Discussion

In mobile news information platforms, behavioral and eye-tracking data combined with subjective evaluation can effectively analyze users' visual search behavior and cognitive processing. Results indicate that information density, image-text structure, and font weight interact significantly, with information density significantly affecting subjective satisfaction. This discussion addresses the interactive effects of the three independent variables on visual search efficiency, search patterns, and user satisfaction.

5.1 Effects on Visual Search Efficiency

Visual search efficiency was measured by first-click time (target mouse click time). Analysis shows significant interactive effects among information density, image-text structure, and font weight on task completion time.

In text-above-image layouts, light font weight yielded higher visual search efficiency at low and medium densities. This is primarily explained by visual field perception asymmetry. Although the upper visual field shows advantages in local information processing and visual search over the lower visual field, He et al. found that the upper visual field requires more attentional resources than the lower visual field when completing the same task. Research indicates that light font weight can enlarge inter-stroke gaps to prevent character adhesion and

maintain clarity, thereby reducing attentional resource demands. Low-density information capacity does not create high identification load, and light weight makes character structures clearer, facilitating visual processing efficiency. In left-text-right-image layouts at high density, regular weight showed significantly higher efficiency than bold. This can be explained by the left visual field's disadvantage in written language processing, combined with high information density concentrating excessive text on the left side, requiring excessive cognitive resources. Bold weight further increases character adhesion, creating higher cognitive load and longer search times.

In right-text-left-image layouts, bold weight showed higher search efficiency than light weight at low density. From a search habit perspective, users habitually search from left to right, causing images to consume attentional resources through semantic and imaginal encoding, increasing cognitive load compared to left-text-right-image layouts. However, low density appropriately reduces information capacity, and bold weight increases visual weight by thickening strokes and reducing negative space, making characters more conspicuous and improving search efficiency. At medium density, light weight was significantly more efficient than bold. With moderate information volume, light weight enables rapid and effective information identification, reducing task completion time.

5.2 Effects on Visual Search Patterns

Visual search patterns refer to users' eye movement behaviors captured by the eye tracker, measured by fixation count and total fixation time. Eye-tracking data show significant interactive effects among information density, image-text structure, and font weight on both measures.

In text-above-image, high-density layouts, bold font required significantly more fixation time than regular weight, indicating more difficult search. High-density interfaces demand more attentional resources, and the text-above-image layout creates horizontally distributed text exceeding normal visual span, creating substantial cognitive load. Bold weight increases character adhesion, negatively impacting visual search and increasing fixation time.

In right-text-left-image layouts: (1) At low density, regular weight required significantly more fixation time than bold. Regular weight exhibits some character adhesion without strong conspicuousness, resulting in lower recognizability and longer fixation times. However, users' left-to-right search habits cause images to consume attentional resources, while low density reduces cognitive load. Bold weight improves overall character recognizability, reducing dwell time. (2) At medium density, bold required significantly more fixation time and fixations than light weight. With moderate information volume and attentional resource allocation, bold weight's character adhesion imposed substantial burden, increasing processing time and fixation count, indicating complex information and difficult encoding. (3) At high density, light weight required significantly less fixation time and fewer fixations than bold. With excessive text concen-

trated on the right side requiring substantial cognitive resources, light weight effectively improved character clarity, reducing task difficulty and resulting in shorter dwell times and fewer fixations.

5.3 Effects on Subjective Satisfaction

Subjective satisfaction analysis shows that information density significantly affects satisfaction, but no significant interaction exists among the three factors, indicating that only information density independently influences satisfaction. Lower interface density yields higher subjective satisfaction. According to cognitive load theory, low-density interfaces require less search content, consume fewer cognitive resources, and make task completion easier, resulting in higher satisfaction.

Information density not only independently affects users' subjective experience during visual search but also interacts with image-text structure and font weight to influence search efficiency and eye movement behavior. Different image-text layouts create visual field perception asymmetry and differential visual processing. Text-above-image and left-text-right-image layouts better conform to users' visual search habits, while right-text-left-image layouts align with right visual field cognitive processing advantages. Font weight significantly affects cognitive processing time, with light weight offering higher recognizability and improved visual identification efficiency. Information density dominates subjective experience, with low-density pages creating smaller cognitive load and significantly higher user satisfaction. Combinations and variations of the three variables produce different effects on users' visual search behavior.

This study yields the following conclusions: The interaction among information density, image-text structure, and font weight is significant in mobile news platforms, and information density significantly impacts subjective satisfaction. The optimal combination for visual search efficiency is text-above-image layout with low density and light font weight.

This research identified interactive effects among multiple design elements in mobile news platforms and explicated the mechanisms of different element combinations, holding important significance for further research on human information behavior in digital interfaces. Results also provide theoretical foundations for mobile news platform interface design, leading to the following design strategies: When considering only visual search efficiency, prioritize light weight in text-above-image layouts at low and medium densities; use bold weight in right-text-left-image layouts at low density; employ light weight in right-text-left-image medium-density and left-text-right-image low-density layouts; and choose regular weight for left-text-right-image high-density layouts. When aiming to enhance user satisfaction, focus on adjusting information density, as low-density interfaces provide better subjective experiences. When considering visual behavior effects, use light weight for text information in text-above-image high-density layouts to reduce search time; use light weight in right-text-left-image

low-density layouts to facilitate faster information search; and use light weight rather than bold in right-text-left-image medium- and high-density layouts to reduce cognitive load and achieve better reading effects.

This study has limitations. First, using desktop computers to simulate mobile interfaces with mouse operation, while accurately recording data, differs from real contexts. Future research should use more flexible equipment to collect data in authentic mobile scenarios. Second, visual search research could incorporate more physiological and psychological indicators; studies show that cognitive load, emotional experience, and user motivation are important for evaluating interface usage. Future research should consider measuring more psychological and behavioral indicators for more comprehensive investigation. Finally, as all participants were university students, sample representativeness is somewhat limited; subsequent research should expand sampling for more robust validation.

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Author Contributions

Fang Hao: Topic selection and paper writing; Chen Yinchao: Conceptualization and paper writing; Zhao Ying: Data analysis and paper revision; Li Xiaohuan: Experiment and data collection; Wei Qiang: Conceptualization and data analysis.

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