Research on the Mechanism and Effectiveness of AI-assisted Creative Generation from the Perspective of Design Cognitive Theory

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Keywords: Design Cognitive Theory; AI-Assisted Creative Generation; Human-Computer Collaboration; Creative Effectiveness; Design Cognition Mechanism; User Experience; Creative Quality; Design Innovation

Abstract: Based on the perspective of design cognition theory, this paper deeply studies the internal mechanism and effectiveness of AI-assisted creative generation. Integrating core principles of design cognitive theory, assessing the current status of AI technology in creative generation, and exploring the collaborative dynamics between AI and human designers in the creative process. It builds an effectiveness evaluation system that includes efficiency, quality, user experience, and business value, and combines empirical analysis with multi-field case studies. Research has found that AI can significantly improve the efficiency of idea generation and optimize the design process. However, human designers still need to lead in creative depth and emotional expression. This study provides a theoretical basis for analyzing the role of AI in creative design. Additionally, it provides a reference for promoting the practice of human-machine collaborative innovation in the design industry. Research has confirmed that AI is an "efficiency extension tool" for design cognition rather than a substitute. Its core value lies in liberating repetitive labor and expanding the boundaries of data processing. Humans still play a crucial role in the emotional depth of creativity, cultural narratives, and value judgments. In the design industry, it is essential to broaden the use of AI for large-scale tasks while also enhancing the leadership of designers in areas like artistic creation. Future research needs to pay further attention to AI ethics, cross-domain collaborative differences, and designers' technical literacy to promote the evolution of creative design towards an innovative ecosystem.

1. Introduction

Artificial intelligence technology's rapid development is reshaping the creative industry's landscape. From poster design to product appearance innovation, from animation production to interior decoration, AI tools have become a powerful assistant for creative workers with powerful data analysis and image generation capabilities. However, existing research mostly focuses on AI creative tools' operation methods and technical principles. It rarely systematically explores the internal mechanism and effectiveness of AI-assisted creative generation from the perspective of design cognitive theory. Design cognitive theory focuses on designers completing the creative process through perception, thinking, and decision-making. Combining it with AI technology will help to deeply understand the essence of human-computer collaborative creativity and provide new directions for theoretical development and practical innovation in creative design. Therefore, this study adopts a method that combines literature research, case analysis, and empirical research to analyze the operating mechanism of AI-assisted creative generation from the perspective of design cognitive theory and evaluate its actual effectiveness [1].

At a time when digital technology is deeply reshaping the industrial ecosystem, artificial intelligence (AI) is being integrated into the creative design field at an unprecedented rate with its powerful machine learning, deep learning, and natural language processing capabilities. AI tools are widely used in the global creative industry in advertising design, interaction design, and film and television production. While this technological innovation has greatly improved the efficiency of

  DOI: 10.25236/gemmsd.2025.040

creative production, it has also triggered in-depth reflection in academia on the nature of creativity, the design cognitive process, and the human-computer collaboration model. Currently, relevant research focuses on the application level of AI technology, such as algorithm optimization of generative adversarial networks (GAN) and diffusion models in image generation, or functional analysis of specific AI tools. However, there is still a significant gap in the research on systematically exploring the mechanism and effectiveness of AI-assisted creative generation from the perspective of design cognitive theory.

As an important theoretical system integrating design and cognitive science, design cognitive theory aims to reveal the cognitive laws of information processing, concept construction, and problem solving in designers' creative activities. This theory emphasizes that designers integrate external needs, knowledge, and experience with innovative thinking through cognitive processes such as perception, memory, and imagination to complete the complex process from creative germination to solution implementation. However, existing research has not fully explored how AI technology interacts with the human design cognitive process, what challenges and supplements its algorithmic logic and data-driven model pose to the traditional design cognitive paradigm, and the allocation and integration mechanism of cognitive resources in the human-computer collaborative creative process. These theoretical gaps restrict the development of design cognitive theory in the digital age and make it difficult for the creative industry to form an efficient human-computer collaborative innovation model [2].

This study aims to fill the above-mentioned gaps in theory and practice, and through an interdisciplinary research paradigm, systematically analyze the internal mechanism and effectiveness of AI-assisted creative generation. Specifically, the study will be based on the theory of design cognition, deconstruct the mechanism of AI in the whole process of creative inspiration, concept development, and solution optimization, and construct a three-dimensional analysis framework including technology empowerment, human-computer collaboration, and cognitive interaction. At the same time, combining quantitative and qualitative research methods, an effectiveness evaluation index system is established from the four dimensions of efficiency improvement, creative quality, user experience, and commercial value, and through empirical analysis of multi-field cases, the advantages and limitations of AI in creative generation are verified. The research results will not only help to deepen the understanding of the cognitive laws of design in the digital age and improve the theoretical system of design, but also provide scientific human-computer collaboration strategies for practitioners in the creative industry and promote the transformation of the innovation paradigm of the design industry [3]. As shown below, Figure 1 illustrates the research design, and Figure 2 is the evaluation index system.

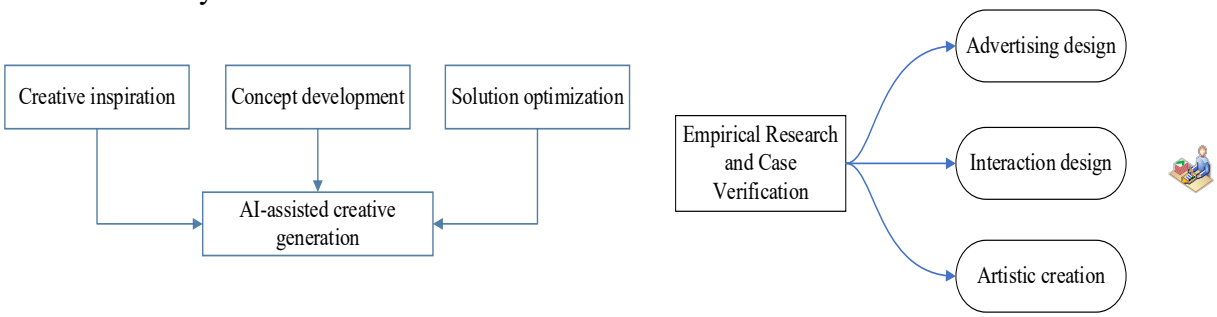

Fig. 1 Research design

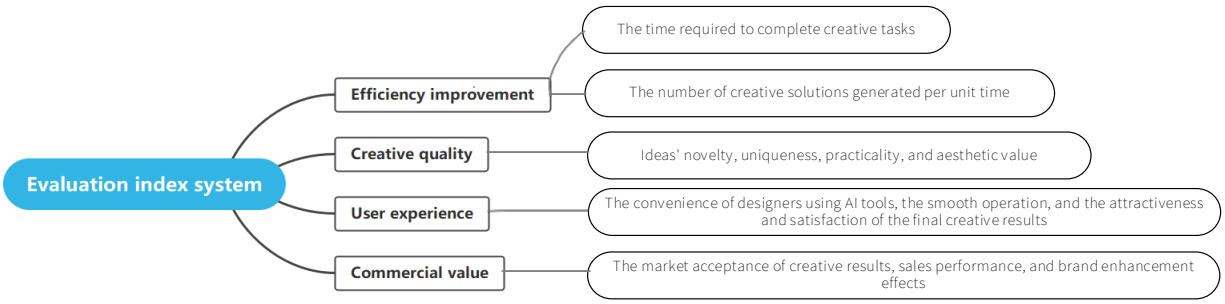

Fig. 2 Evaluation index system

2. Design Cognition and the Foundation of AI-Assisted Creative Generation

2.1 The Core of Design Cognition

Design cognition focuses on designers' thinking activities and cognitive patterns in the creative process. It believes that design is a complex problem-solving process. Designers use divergent and convergent thinking to gradually form creative concepts and transform them into design solutions by understanding and analyzing design tasks, mobilizing their knowledge reserves and experience. In this process, the designer's cognitive abilities, such as perception, memory, and imagination, play a key role. For example, when facing the design task of a smartwatch, the designer will first perceive information such as market demand and user preferences, then combine their understanding of smart products and design experience to build a preliminary concept of the watch's appearance, function, etc. in their mind. Finally, the design solution is completed through continuous optimization and adjustment. Design cognition provides a theoretical framework for understanding the human creative process and a reference for analyzing the role of AI in creative generation.

2.2 Technological Evolution and Application Status of AI-assisted Creative Generation

The development of AI in the field of creative generation has gone through a process from simple rule application to deep learning driven. In the early days, AI used preset algorithms and rules to achieve the generation of simple graphics and the arrangement and combination of design elements. With the development of deep learning technology, AI has powerful image recognition, natural language processing and generation capabilities. For example, AI tools based on generative adversarial networks (GANs) can generate realistic images and design solutions by learning a large amount of image data; language models based on Transformer architectures can generate creative copy based on text descriptions. At present, many AI-creative generation tools have emerged in the market, such as Midjourney, Stable Diffusion, DALL-E, etc., which are widely used in advertising design, game development, industrial design and other fields. In advertising design, designers use AI tools to quickly generate multiple drafts of advertising posters, greatly shortening the design cycle; in game development, AI assists in generating game scenes and character images, improving development efficiency and visual effects [4].

3. Analysis of the Mechanism of AI-assisted Creative Generation

3.1 AI Empowerment Mechanism in the Process of Creative Generation

In the creative inspiration acquisition stage, AI provides designers with a rich source of inspiration with its huge database and efficient data analysis capabilities. For example, when a designer enters the keyword "future city theme poster", the AI tool can instantly retrieve a large number of related images, design cases and popular trend information to help designers develop ideas. In the concept expansion and deepening stage, AI can analyze and expand the initial creative concept. Taking furniture design as an example, after the designer proposes the concept of "modular sofa", AI can generate a variety of module combination solutions and appearance design styles based on ergonomic data, material properties and spatial layout knowledge to assist designers in improving their creativity.

In the solution improvement and optimization stage, AI uses algorithms to evaluate and improve the design solution [5]. By simulating user usage scenarios and analyzing the coordination between design elements, AI can point out the problems in the solution and provide optimization suggestions, such as adjusting color matching and improving product structure. Generative AI profoundly impacts creativity by expanding possibilities and challenging traditional norms. For example, AI-driven tools can produce novel music compositions or visual art, inspiring humans to explore uncharted artistic territories. However, concerns arise about originality, as AI-generated content may mimic human styles, sparking debates over authorship and authenticity. Yet, rather than replacing human creativity, generative AI often serves as a catalyst, pushing creators to rethink processes, blending human intuition with machine-generated insights, and redefining the boundaries of imaginative expression in the digital age.

3.2 Collaborative Operation Mechanism between AI and Designers

AI and designers have formed a unique collaborative operation mode in the creative generation process. Regarding information transmission, designers can easily input design requirements and instructions to the AI through a friendly human-computer interaction interface. AI can also visually feedback the generated results to designers. The two sides complement each other. AI is good at processing large-scale data and quickly generating various possible solutions, while designers have unique aesthetic judgment, emotional understanding, and innovative thinking. For example, AI can quickly generate hundreds of logo drafts in different styles for brand logo design. Designers can select solutions that meet the brand tone and cultural connotation, and further optimize the details to give the logo emotion and soul. It is crucial to clarify the role positioning of both parties. AI is an auxiliary tool for creative generation, providing designers with creative inspiration and efficiency support; designers are the leaders of creativity, controlling the design direction and quality [6]. Conceptual ambiguity in design cognition often leads to high communication costs, and AI transforms abstract thinking into concrete solutions through algorithms. For example, the collaborative model between AI and designers is typical for graphic design. In an image design of environmental protection brands, designers use AI tools to input keywords and brand core values. AI generates over 200 LOGO drafts in minutes, covering multiple styles such as geometry and plant bionics. The designer selects five schemes that align with the brand concept, integrate eco-friendly materials, and consider the aesthetic preferences of the target audience while manually adjusting color saturation and symbolic metaphors. Finally, a recognizable brand logo is created to integrate data efficiency and human warmth.

4. Effectiveness Evaluation of AI-Assisted Creative Generation

4.1 Construction of Performance Evaluation Index System

This study constructed an evaluation index system with multiple dimensions to scientifically evaluate the effectiveness of AI-assisted creative generation. In terms of creative generation efficiency, the time required to complete creative tasks and the number of creative solutions generated per unit time are used to measure AI's speed-up effect on the design process. Creative quality indicators cover ideas' novelty, uniqueness, practicality, and aesthetic value and are evaluated through expert review and user scoring [7]. User experience indicators include the convenience of designers using AI tools, the smooth operation, and the attractiveness and satisfaction of the final creative results to the target users. Commercial value conversion indicators focus on the market acceptance of creative results, sales performance, and brand enhancement effects.

4.2 Empirical Research and Case Verification

In order to deeply understand the actual role of AI in creative generation, this study selected three typical fields: advertising design, interaction design, and artistic creation for case analysis, and explored the synergistic effect of AI and human designers in combination with actual application scenarios.

4.2.1 Advertising Design: Efficiency-First Large-Scale Creation

In the field of advertising design, the core value of AI is reflected in the rapid response to batch demands. For example, when an e-commerce platform conducts a promotion, the designer inputs keywords such as "festive atmosphere" and "promotional information prominence" through AI tools. The system can generate dozens of poster drafts in different styles in a short period of time, covering a variety of visual styles such as retro, technological, and fresh. Although these drafts are not final products, they can provide designers with a rich creative starting point and avoid inefficient trial and error from scratch. Designers only need to focus on the precise expression of the brand tone, such as adjusting the color matching to match the brand visual identification system, or optimizing the copywriting layout to enhance the efficiency of information communication. This model significantly shortens the design cycle and is particularly suitable for marketing scenarios that require high-frequency output. It frees designers from repetitive work and allows them to turn to more strategic creative ideas.

4.2.2 Interaction Design: Balancing Usability and Emotional Engagement

In interaction design, AI is a "usability optimizer," while designers focus on emotional resonance and contextual understanding. For example, when developing a mental health app, AI analyzes user behavior data—such as tap patterns, session durations, and feedback responses—to generate wireframes with optimized navigation flows. It might simulate 50+ interface layouts, prioritizing those with the lowest predicted user error rates or fastest task completion times based on machine learning models trained on millions of interaction logs. Designers play a crucial role in enhancing emotional elements within the interface. They refine micro-interactions and ensure the design aligns with the brand's empathetic tone. Meanwhile, AI provides data-driven insights that validate usability improvements—such as reducing click paths by 30%. At the same time, human creativity addresses intangible needs, like building trust through the use of visual metaphors. This collaboration highlights AI's strength in optimizing functional logic and designers' irreplaceable role in translating data into meaningful user experiences.

4.2.3 Artistic Creation: Exploration of Boundaries and Breakthroughs

In the field of artistic creation that emphasizes personalized expression, the role of AI is more controversial, but it also shows unique value. For example, when illustrators create science fiction-themed works, they can use AI to generate complex future city backgrounds or mechanical device details, quickly build a visual framework, and save a lot of basic drawing time. However, AI-generated images often lack deep narrative-a mechanical forest scene completed by AI may be realistic in details, but it is difficult to convey the theme of "conflict between technology and nature." At this time, artists need to intervene, inject personal ideas into the work by adding symbolic elements or adjusting the color tone, and realize the integration of technical materials and artistic ideas. Such cases show that AI can be used as an efficient "material production tool", but the core of artistic creation-emotional expression and concept transmission-still relies on human subjective initiative.

4.2.4 Research Implications

Empirical research shows that AI is not a substitute for designers, but a "catalyst" to promote changes in creative production models. Its value lies not in completing creativity independently, but in forming a collaborative system of "efficient division of labor and complementary advantages" with human designers: AI expands the "possibility boundary" of creativity, while humans choose, deepen and give meaning to it. For the design industry, this means that the core capabilities of designers need to be redefined - in addition to traditional aesthetic literacy and design skills, understanding the advantages and limitations of AI technology and mastering effective methods of human-computer collaboration will become essential qualities in the digital age. Future creative innovations will be more reflected in the depth and breadth of human-computer collaboration, unlocking more groundbreaking design solutions through the integration of technical rationality and humanistic sensibility.

5. Conclusion

This study systematically analyzes the mechanism and effectiveness of AI-assisted idea generation from the perspective of design cognition theory. Research shows that AI plays an important auxiliary role in the entire process of creative generation. By collaborating with designers, it significantly improves the efficiency of creative generation and optimizes the design process. The constructed performance evaluation system and empirical analysis of cases in multiple fields provide a basis for objectively evaluating the role of AI in creative design. However, this study also has some limitations, such as the limited scope of case selection and the lack of follow-up research on the long-term effects of collaboration between AI and designers. Future research can further expand the case sample, explore in depth the optimal model of collaboration between AI and designers in different creative fields, pay attention to the impact of AI technology development on design cognition, and promote the in-depth development of human-computer collaborative innovation in the field of creative design.

On the theoretical level, this study expands the digital application scenarios of design cognition, proving that AI technology can assist designers in completing low-creativity tasks such as information processing and rule-based operations, while human-specific emotional cognition, cross-domain association and other abilities are still irreplaceable "creative cores". On the practical level, the "efficiency-oriented cognitive assistant + creative cognitive subject" collaborative model revealed by the study provides an operational human-machine division of labor strategy for the creative industry - for example, the depth of AI use can be increased in large-scale design tasks, while in scenarios that require uniqueness such as brand narratives and cultural expressions, the dominant position of designers needs to be strengthened. In addition, gender difference research shows that female designers have more advantages in emotional expression, suggesting that companies can improve the effectiveness of human-machine collaboration by optimizing the team's cognitive structure.

Although this study has constructed a relatively complete analytical framework, it still has the following limitations: First, the cases are mainly concentrated in visual design and product design, and the coverage of non-visual creative scenes such as film and television screenwriting and music creation is insufficient. Second, the empirical data are mostly based on short-term tasks, and there is a lack of tracking and analysis of the long-term effects of human-computer collaboration. Third, the impact of AI ethics on design cognition has not been explored in depth. Future research can be deepened from the following aspects. It is necessary to expand the scope of cases to explore the specificity of human-computer collaboration in different creative fields. Additionally, longitudinal research is suggested to analyze the long-term impact of AI intervention on designers' cognitive habits. Finally, it is also vital to introduce ethical dimensions to provide more comprehensive theoretical support for creative design in the AI era.

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