Research on the Influence of Human-AI Collaboration of R&D Personnel in Internet Enterprises on Their Innovation Performance

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Abstract. Based on self-determination theory, this study systematically explores the influence mechanism of human-AI collaboration on innovation performance. The results show that human-AI collaboration exerts a significant positive impact on innovation performance, which is realized through the mediating effects of basic psychological need satisfaction and thriving at work, as well as the combined chain mediating effect of basic psychological need satisfaction and thriving at work. Human-AI collaborative workload negatively moderates the relationship between human-AI collaboration and basic psychological need satisfaction, thereby weakening the positive impact of human-AI collaboration on innovation performance. This study not only expands the application scenarios of self-determination theory in the AI era but also provides targeted practical references for R&D personnel in internet enterprises to raise the frequency of human-AI collaboration and for enterprises to balance the labor costs of R&D positions and the human-AI collaborative workload of R&D personnel, thus helping enterprises enhance their core competitiveness.

Keywords: Human-AI Collaboration, Basic Psychological Need Satisfaction, Innovation Performance, Human-AI Collaborative Workload.

1 Introduction

Throughout the history of human civilization, the application of any new technology has always entailed both opportunities and challenges, and AI technology is no exception. Regardless of whether AI is regarded as "seemingly reasonable yet essentially one-sided", it already boasts numerous advantages that are beyond human reach. Under this trend, the government has intensively issued and gradually implemented AI-related policies, ensuring that the evolution of AI technology no longer comes at the cost of obscuring human subjectivity. R&D personnel in internet enterprises generally possess a high level of AI literacy, which has gradually fostered the development of the human-AI collaborative work mode. Human-AI collaboration is defined as the process in which employees and AI collaborate to accomplish work tasks through task coordination and complementary advantages to achieve high work efficiency[1]. With the launch

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of DeepSeek, AI technology has evolved toward open source, enabling R&D personnel in internet enterprises to independently access various AI resources to decide whether and how to conduct human-AI collaboration, thus making it a normal part of their work[2].

Reviewing existing relevant research, scholars have mostly taken generalized groups as research objects, focusing on analyzing the "double-edged sword" effect of variables such as AI usage and AI technology application on employees' work behaviors. However, systematic research on the positive effects generated by human-AI collaboration remains scarce[3]. Considering that the frequency of human-AI collaboration is measurable, whereas its depth is difficult to quantify, this study focuses on the frequency of human-AI collaboration as the research variable.

Although the innovation performance of R&D personnel in internet enterprises is not an inevitable objective of their daily work, it can boost personal development and organizational value addition, and even drive the deep integration of the internet industry and the real economy, optimize social service models, and enhance the development level of China's digital economy and its core competitiveness. Therefore, exploring the internal correlation between human-AI collaboration and the innovation performance of R&D personnel in internet enterprises carries great theoretical and practical significance. However, the internet industry is characterized by prevalent management practices such as the elimination of underperformers and a "wolf culture". Even though high-frequency human-AI collaboration can enable R&D personnel and reduce their workload, the intense involutionary competition in the industry may prompt organizations to further increase their workloads, ultimately exerting a differential impact on their innovation performance. This practical dilemma calls for empirical verification.

In summary, this study takes self-determination theory as its core theoretical foundation, aims to explore in depth the impact of human-AI collaboration on the innovation performance of R&D personnel in internet enterprises, and analyzes the mediating effects of basic psychological need satisfaction and thriving at work, the chain mediating effect of basic psychological need satisfaction and thriving at work, as well as the moderating effect of human-AI collaborative workload. This research is expected to enrich the relevant research findings on positive outcome variables in the field of human-AI collaboration, address the research gap in existing studies that focus on generalized groups while neglecting the characteristics of specific industrial positions, and provide a reference for organizations and R&D personnel in internet enterprises to better leverage the positive effects of human-AI collaboration, thereby facilitating the high-quality development of internet enterprises.

2 Theoretical Analysis and Research Hypotheses

2.1 Self-Determination Theory

In 1985, Deci et al. first proposed self-determination theory (SDT). In 2005, they integrated SDT deeply with research on work motivation, marking its formal entry into the field of organizational behavior, where it has achieved rapid development. Among its core components, the innate psychological need theory clearly states that the need for

competence, the need for autonomy, and the need for relatedness constitute the fundamental drivers of human intrinsic motivation. When these three needs are supported and facilitated by the external environment, individuals' basic psychological need satisfaction is effectively enhanced, which in turn fosters sustained and stable behavioral motivation[4].

Most existing research findings have focused on exploring the relationship between leadership styles and employee behaviors[5]. With the rapid development and open-sourcing of AI technology, the work modes of R&D personnel in internet enterprises have undergone fundamental changes, and the formation process of innovation performance is closely linked to individuals' intrinsic motivation states. Based on this, this study selects SDT as its core theoretical support to explore the influence mechanism of human-AI collaboration of R&D personnel in internet enterprises on their innovation performance.

2.2 The Mediating Role of Basic Psychological Need Satisfaction

When R&D personnel increase the frequency of human-AI collaboration, they can leverage AI's superior data processing and intelligent decision-making capabilities to collaborate on completing procedural tasks, and also obtain support in certain non-procedural tasks. This allows them to exercise greater autonomy over their work rhythm, thereby enhancing their satisfaction with the need for autonomy[6]. In addition, it enables R&D personnel to solve work problems more efficiently and achieve work goals more accurately, and the sense of accomplishment derived from task completion further boosts their satisfaction with the need for competence. Moreover, this facilitates more frequent and efficient technical discussions and experience sharing between R&D personnel and organizational leaders and colleagues, promotes the flow of resources and information sharing within the organization, strengthens their perception of the alignment between personal and organizational interests, and thus enhances their satisfaction with the need for relatedness. Thus, human-AI collaboration of R&D personnel in internet enterprises exerts a positive impact on their basic psychological need satisfaction.

Sufficient work autonomy enables R&D personnel to independently plan their work directions and methods based on their own judgments, which creates a relaxed psychological environment for the development of their innovation performance. The sense of accomplishment gained by R&D personnel in overcoming challenging tasks strengthens their confidence in problem-solving and stimulates their innovation performance. A strong sense of belonging within the organization promotes communication, collaboration, and knowledge sharing among R&D personnel, helps them integrate internal and external resources, enhances their job-specific learning capabilities and cross-scenario adaptability, and provides diverse knowledge support for the generation of innovation performance. Thus, basic psychological need satisfaction of R&D personnel in internet enterprises exerts a positive impact on their innovation performance.

Based on the above analysis, this study proposes the following hypotheses:

H1: Human-AI collaboration of R&D personnel in internet enterprises positively affects their innovation performance by enhancing their basic psychological need satisfaction.

2.3 The Mediating Role of Thriving at Work

When R&D personnel increase the frequency of human-AI collaboration, they can access more timely and personalized relevant information. This feedback mechanism enables them to examine their own status, work progress, and environmental changes in a timely and comprehensive manner, effectively enriching their learning resources to facilitate more proactive learning, and supplements their psychological energy to boost their vitality, thus enhancing their thriving at work. Furthermore, as an emerging work mode, human-AI collaboration is regarded by R&D personnel as a valuable opportunity for learning and development, which increases their work interest and thus motivates them to engage in work with greater vitality[7]. Thus, human-AI collaboration of R&D personnel in internet enterprises exerts a positive impact on their thriving at work.

R&D personnel in a state of continuous learning will actively integrate internal knowledge resources and explore external learning opportunities. In the process of continuously accumulating professional knowledge and skills, they constantly attempt new work methods and problem-solving approaches, thereby improving their innovation performance. R&D personnel who maintain high vitality are more able to perceive the enjoyment of work. When faced with technical challenges and innovation demands, they are more willing to make proactive efforts to drive innovation performance[8]. Thus, thriving at work of R&D personnel in internet enterprises exerts a positive impact on their innovation performance.

Based on the above analysis, this study proposes the following hypotheses:

H2: Human-AI collaboration of R&D personnel in internet enterprises positively affects their innovation performance by enhancing their thriving at work.

2.4 The Chain Mediating Effect of Basic Psychological Need Satisfaction and Thriving at Work

The satisfaction of basic psychological needs enables R&D personnel to gain a sense of growth and well-being in their work and strengthen their self-worth recognition. This positive psychological experience further boosts their learning motivation and work vitality, prompting them to engage in work with a more proactive attitude, thus facilitating their sustained learning and high vitality—the core characteristics of thriving at work[9]. Thus, human-AI collaboration of R&D personnel in internet enterprises positively affects their innovation performance through the chain mediating effect of basic psychological need satisfaction and thriving at work.

Based on the above analysis, this study proposes the following hypotheses:

H3: Human-AI collaboration of R&D personnel in internet enterprises enhances their basic psychological need satisfaction, which in turn boosts their thriving at work, and ultimately exerts a positive impact on their innovation performance.

2.5 The Moderating Role of Human-AI Collaborative Workload

The management logic of the internet industry is characterized by efficiency-oriented high pressure. Although human-AI collaboration can improve the work efficiency of

R&D personnel, it may easily trigger efficiency-driven demands from organizations, thus giving rise to human-AI collaborative workload. Specifically, after R&D personnel conduct human-AI collaboration at work, organizations may raise their work requirements and increase their work intensity, leading to their subjective perception of time pressure, which prevents human-AI collaboration from fully reducing their work burden. Based on this, this study takes the positive enablement of human-AI collaboration as the starting point, and centers on the core characteristic that human-AI collaborative workload arises from human-AI collaboration, revealing a progressive relationship where human-AI collaboration generates positive effects while human-AI collaborative workload attenuates such effects.

When the human-AI collaborative workload is at a low level, R&D personnel can fully leverage the technical advantages of AI to satisfy their basic psychological needs. However, when human-AI collaborative workload is at a high level, R&D personnel have to invest more emotional and mental resources to cope with excessive tasks and tight deadlines, making it difficult for their need for autonomy to be fully satisfied. At the same time, high human-AI collaborative workload imposes heavy work pressure on R&D personnel, leading to a decline in task completion quality or even errors, thus hindering the satisfaction of their need for competence. Furthermore, to concentrate their energy and emotions on coping with the additional workload, R&D personnel reduce active communication and interaction with colleagues, making their need for relatedness difficult to be fully satisfied. In addition, R&D personnel facing high human-AI collaborative workload often set higher standards for basic psychological need satisfaction, which further makes it harder to meet such needs[10]. Thus, human-AI collaborative workload of R&D personnel in internet enterprises negatively moderates the relationship between human-AI collaboration and basic psychological need satisfaction, thereby not only negatively moderating the mediating effect of basic psychological need satisfaction between human-AI collaboration and innovation performance, but also negatively moderating the chain mediating effect of basic psychological need satisfaction and thriving at work between human-AI collaboration and innovation performance.

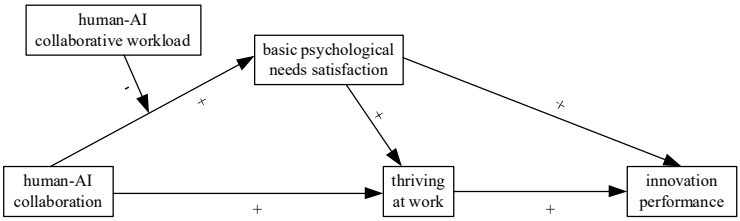

Fig. 1. The theoretical model

Based on the above analysis, this study proposes the following hypotheses:

H4: Human-AI collaborative workload of R&D personnel in internet enterprises negatively moderates the relationship between human-AI collaboration and basic psychological need satisfaction, and consequently negatively moderates the mediating effect of basic psychological need satisfaction between human-AI collaboration and

innovation performance, as well as the chain mediating effect of basic psychological need satisfaction and thriving at work between human-AI collaboration and innovation performance.

The theoretical model of this study is shown in Figure 1.

3 Research Design

3.1 Research Sample and Data Collection

This study conducted the survey under the premise that participants had engaged in human-AI collaboration at work but had not completed all task links through this mode consistently since their employment. The measurement items covered demographic variables, human-AI collaboration, human-AI collaborative workload, basic psychological need satisfaction, thriving at work, and innovation performance.

3.2 Variable Measurement

The scales of human-AI collaboration, basic psychological need satisfaction, thriving at work, innovation performance, and human-AI collaborative workload in this study were all adopted and referenced from mature scales published in authoritative domestic and international journals. Demographic variables were controlled: gender, age, highest educational attainment, working years, duration of human-AI collaboration experience, enterprise type, and job type.

4 Empirical Analysis

4.1 Reliability, Validity, and Common Method Bias Test

The Cronbach'sα coefficients and KMO values for human-AI collaboration, basic psychological need satisfaction, thriving at work, innovation performance, and human-AI collaborative workload all meet the required standards. The χ^2/df, RMSEA, CFI, TLI, and SRMR of both the five-factor model and the model with an added common method factor also meet the criteria. The variance explained by the first unrotated principal component is lower than the 40% critical value and half of the total cumulative explained variance ratio.

4.2 Correlation Analysis

The maximum correlation coefficient among all non-demographic variables in this study is less than 0.7, and the maximum VIF value is less than 3. Human-AI collaboration is significantly positively correlated with basic psychological need satisfaction and thriving at work. Basic psychological need satisfaction is significantly positively correlated with thriving at work and innovation performance. Thriving at work is significantly positively correlated with innovation performance.

4.3 Hypothesis Testing

Test of Mediating Effects.

This study tested the hypotheses using hierarchical regression analysis and Bootstrap analysis. The effect of human-AI collaboration on innovation performance through basic psychological need satisfaction was significant. The effect of human-AI collaboration on innovation performance through thriving at work was significant. The effect of human-AI collaboration on innovation performance through the chain mediation of basic psychological need satisfaction and thriving at work was significant. Therefore, Hypotheses H1, H2, and H3 are supported.

Test of Moderating Effects.

This study tested the hypotheses using hierarchical regression analysis and Bootstrap analysis. The interaction term between human-AI collaboration and human-AI collaborative workload significantly reduced basic psychological need satisfaction. Specifically, the effect of human-AI collaboration on basic psychological need satisfaction under low human-AI collaborative workload (M−1SD) was significant, whereas the effect under high human-AI collaborative workload (M+1SD) was not significant.

Test of Moderated Mediating Effects.

This study further conducted Bootstrap analysis to verify the moderated mediating effects. The inter-group difference in the effect of human-AI collaboration on innovation performance through basic psychological need satisfaction was significant. The inter-group difference in the effect of human-AI collaboration on innovation performance through basic psychological need satisfaction and thriving at work was significant. Specifically, under low human-AI collaborative workload, the effect of human-AI collaboration on innovation performance through basic psychological need satisfaction was significant, and the effect through basic psychological need satisfaction and thriving at work was also significant. Under high human-AI collaborative workload, the effect of human-AI collaboration on innovation performance through basic psychological need satisfaction was not significant, and the effect through basic psychological need satisfaction and thriving at work was also not significant. Therefore, Hypothesis H4 is supported.

5 Conclusions and Discussion

5.1 Research Conclusions

This study finds that human-AI collaboration exerts a significant positive impact on innovation performance, which is realized through the mediating effects of basic psychological need satisfaction and thriving at work, as well as the chain mediating effect of basic psychological need satisfaction and thriving at work. Human-AI collaborative workload negatively moderates the relationship between human-AI collaboration and basic psychological need satisfaction.

5.2 Theoretical Contributions and Practical Implications

First, this study provides a reference paradigm for research on similar sub-groups. Second, this study offers a new direction for understanding human-AI collaboration in the AI era. Furthermore, this study improves the antecedent research of self-determination theory. Finally, this study promotes the refined development of the relationship between human-AI collaboration and basic psychological need satisfaction.

For R&D personnel in internet enterprises: instead of passively responding to the impact of AI, they should proactively raise the frequency of human-AI collaboration in work, which can provide a sustained driving force for the improvement of innovation performance. For organizations of internet enterprises: although many enterprises are faced with survival pressures and R&D personnel can independently obtain AI resources, organizations still need to develop or introduce a complete set of AI systems adapted to R&D scenarios to meet the needs of R&D personnel to conduct human-AI collaboration at work. Excessively high human-AI collaborative workload will inhibit the positive effects of human-AI collaboration, so organizations need to control it within a reasonable range. If the current human-AI collaborative workload of R&D personnel is generally high, organizations can recruit new R&D personnel appropriately to reduce the overall level of human-AI collaborative workload. The communication and collision between new and existing employees can also help enhance internal organizational cohesion, thus forging a better corporate reputation and attracting the public to sustain consumption and usage of corporate products.

5.3 Research Limitations and Future Prospects

This study still has some deficiencies. First, as AI technology develops to a more mature and stable stage, it remains to be further verified whether human-AI collaboration still presents an enabling effect. Second, a specialized human-AI collaboration scale adapted to the work scenarios of specific groups can be developed. Finally, the conceptual definition and measurement dimensions of innovation performance can be further expanded to reflect innovation performance in a comprehensive manner.

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Disclosure of Interests

The authors declare no competing interests that are relevant to the content of this article.

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