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Trapped by Algorithms, Empowered by Leaders: Uncovering the Cognitive-Affective Costs of Algorithmic Management and the Buffering Role of Leader's Digital Empathy

Anqi Zhai*

School of Huazhong Agricultural University, Wuhan 430070, China

Anqi_zhai@163.com

Abstract. Based on the cognitive-affective system theory, this study explores the mechanism of employee performance erosion in algorithmic management contexts and the moderating role of leader's digital empathy. Through tracking surveys of frontline employees in digital enterprises in Beijing, Shanghai, and other regions, 424 valid samples were collected for empirical analysis. The findings indicate that employees' perceived algorithmic control significantly negatively impacts job performance through the chained mediation path of "subjective liminality → emotional exhaustion."Leader's digital empathy moderates the process by which algorithmic control influences subjective liminality and emotional exhaustion.

Keywords: algorithmic management; perceived algorithmic control; subjective liminality; emotional exhaustion; leader's digital empathy.

1. Introduction

Amid the wave of digital transformation, algorithmic management is reshaping corporate governance models while exerting complex psychological and behavioral impacts on employees (Langer et al., 2021). On one hand, its high-control nature may undermine employee autonomy and trigger role ambiguity (Pei Jialiang et al., 2021). On the other hand, its "cold" characteristics lack humanized emotional support, potentially exacerbating psychological resource depletion and impairing job performance (Zhan Xiaojun et al., 2023). Existing research predominantly focuses on gig economy contexts (Duggan et al., 2020; Goods et al., 2019), with insufficient attention to formal employees (Sun Rui et al., 2024). Moreover, systematic frameworks for cognitive-affective interaction mechanisms and leadership roles remain understudied (Chen Ruijun et al., 2011; Zhan Xiaojun et al., 2023). Thus, clarifying the deep mechanisms of algorithmic management's impact on employee performance and leadership intervention pathways holds significant importance.

Accordingly, this paper proposes: First, perceived algorithmic control negatively affects employee performance through a two-stage mechanism of "subjective liminality" (cognitive unit) and "emotional exhaustion" (affective unit). Second, leaders with strong digital ethical empathy can mitigate this negative chain effect by providing emotional support. This study offers three theoretical contributions: First, it expands algorithmic management research boundaries by focusing on formal employees, addressing sample limitations in existing studies. Second, it constructs a chained mediation path integrating cognitive-affective interactions, deepening theoretical explanations of perceived algorithmic control mechanisms. Third, it fills a gap in leadership research within technology-driven management contexts.

2. Theoretical Foundation and Core Concepts

This study is grounded in the cognitive-affective system theory. This theory emphasizes that individual behavior is influenced by the dynamic processing of situational stimuli by cognitive and affective systems. During periods of drastic environmental changes, the interactive responses between cognition and emotion determine an individual's adaptive behavior. Algorithmic management environments significantly alter employees' work cognition patterns and emotional experiences, constituting a persistent external stimulus. In this context, employees' perception of algorithm-

dominated workflows and performance evaluations forms perceived algorithmic control, triggering uncertainty about work roles and future development—termed subjective liminality, manifested as role ambiguity and weakened organizational identification (Dhar et al., 2023). When the cognitive system fails to establish stable meaning structures, the affective system becomes activated, generating negative emotions such as anxiety and tension. Long-term accumulation may lead to emotional exhaustion and impaired performance. subjective liminality mediates between perceived algorithmic control and performance, presenting a chain pathway of "external context → cognitive appraisal → emotional response → behavioral outcome."

However, the cognitive-affective system theory not only focuses on the internal dynamics of cognitive-affective mechanisms but also highlights how external resources facilitating individual adaptation influence their responses. When employees face high-intensity algorithmic control, whether managers can recognize their psychological states and provide appropriate responses determines whether employees will fall into maladaptive cognitive-affective reaction cycles. Based on this, this study introduces digital ethical empathy as a moderating variable. This capability encompasses three dimensions—cognitive, affective, and behavioral tendencies—manifested as awareness, understanding, and responsiveness to employees' psychological states. It concretely embodies the situational adaptive mechanisms emphasized by the cognitive-affective system theory.

3. Research Hypotheses

3.1 Employee Perceived Algorithmic Control and Job Performance

Algorithmic control implements high-level management over employees through precise task matching and comprehensive supervision measures (Guo Tongmei et al., 2024). According to the cognitive-affective system theory (Mischel et al., 1995), an individual's cognitive and affective systems are influenced by environmental factors (e.g., algorithmic management) and generate specific behavioral responses. Multiple studies indicate that algorithmic task allocation overlooks employee traits (Duggan et al., 2020; Lehdonvirta, 2018; Zhan Xiaojun et al., 2023), reduces job autonomy (Goods et al., 2019; Langer et al., 2021), limits flexibility, and leads to career development uncertainty (Pei Jialiang et al., 2021). Additionally, algorithmic performance evaluation overly relies on data metrics while neglecting dimensions of complex problem-solving ability, simplifying employees' perceived work value and thereby diminishing motivation (van Doorn, 2017). Meanwhile, adaptation pressure from algorithmic updates negatively impacts job performance (Zhang Yunli et al., 2009). Based on the above analysis, the following hypothesis is proposed:

H1: Employees' perceived algorithmic control negatively affects job performance.

3.2 The Mediating Role of subjective liminality

The cognitive-affective system theory posits that the cognitive system reacts first to environmental stimuli and guides individual behavioral responses (Mischel et al., 1995). Perceived algorithmic control, through rigid data-driven task allocation and performance evaluation models, significantly restricts employees' autonomous decision-making, obscuring role definition and future development paths (Dhar et al., 2023; Kellogg et al., 2019), triggering subjective liminality in individual cognition (Hafi et al., 2014). subjective liminality disperses psychological resources, making it difficult for employees to focus on core job tasks (Jarrahi et al., 2021). In summary, the independent variable of perceived algorithmic control negatively affects the dependent variable of job performance by reinforcing the cognitive response of subjective liminality. Thus, the following hypotheses are proposed:

H2a: Employees' perceived algorithmic control positively influences subjective liminality;

H2b: subjective liminality negatively affects employee job performance;

H2c: subjective liminality mediates the relationship between employees' perceived algorithmic control and job performance.

3.3 The Mediating Role of Emotional Exhaustion

According to the cognitive-affective system theory, an individual's cognitive appraisal of environmental factors can further trigger emotional responses and influence behavior (Mischel et al., 1995). Algorithmic technology places employees under high pressure and continuous monitoring (Guo Tongmei et al., 2024; Shevchuk et al., 2019). This persistent cognitive stress can induce anxiety in employees, and as negative emotions accumulate, they gradually fall into a state of emotional exhaustion (Schörpf et al., 2017). Emotional exhaustion diminishes employees' work enthusiasm, initiative, and creativity (Yang Boning, 2014) and can also lead to undesirable behaviors such as absenteeism and turnover (Chen Ruijun et al., 2011), significantly negatively impacting job performance (Maslach et al., 2001). Therefore, the following hypotheses are proposed:

H3a: Employees' perceived algorithmic control positively influences emotional exhaustion;

H3b: Emotional exhaustion negatively affects employees' job performance;

H3c: Emotional exhaustion mediates the relationship between employees' perceived algorithmic control and job performance.

3.4 The Chain Mediating Role of subjective liminality and Emotional Exhaustion

The cognitive-affective system theory further posits that there is a dynamic and progressive interaction mechanism between an individual's cognitive appraisal and affective responses (Mischel et al., 1995). Under algorithmic control, the mechanization of task allocation and performance evaluation creates role ambiguity and uncertainty at the cognitive level for employees (Dhar et al., 2023), leading to subjective liminality. Prolonged exposure to this cognitive state can induce negative emotions, and their continuous accumulation depletes employees' psychological resources, resulting in emotional exhaustion (Hellgren et al., 2003; Hans, 2005). This process reflects the dynamic progressive logic from cognition to affect, where subjective liminality serves as the cognitive antecedent of emotional exhaustion (Hafi et al., 2014). Finally, emotional exhaustion reduces task execution efficiency and job performance (Yang Boning, 2014). In summary, subjective liminality and emotional exhaustion form a chain mediating relationship between perceived algorithmic control and employee performance. Thus, this study proposes:

H4a: subjective liminality positively influences emotional exhaustion;

H4b: subjective liminality and emotional exhaustion play a chain mediating role, meaning that employees' perceived algorithmic control negatively affects job performance through subjective liminality and emotional exhaustion.

3.5 The Moderating Role of Leaders' digital Empathy

According to the cognitive-affective system theory, external environmental stimuli are subjectively interpreted through an individual's cognitive system, and this interpretation depends not only on the situation itself but also on external factors. In algorithmic management environments, employees' negative cognitive and affective responses may be moderated by a key factor:Leader's Digital Empathy (Lemoine et al., 2023; George, 2000).

First, in the pathway where algorithmic control affects employees' subjective liminality, when leaders possess high digital ethical empathy capabilities, they proactively address and enhance algorithmic transparency. For instance, they actively inform employees about algorithmic task allocation and performance evaluation criteria, reducing cognitive ambiguity (Edmondson, 1999). They are also adept at recognizing employees' role anxiety (Zheng Xiaoming et al., 2020) and providing timely psychological support to alleviate cognitive burden (Lemoine et al., 2023). Second, in the pathway where algorithmic control influences emotional exhaustion, leaders with strong digital ethical empathy mitigate cognitive pressure caused by algorithmic monitoring and control by explaining the decision-making logic of algorithmic management, thereby fostering employees' understanding and trust (Lemoine et al., 2023). Additionally, they promptly address and actively alleviate negative emotions stemming from algorithmic control through necessary emotional support,

preventing cumulative emotional strain (Wang Bei, 2022), which significantly reduces the risk of emotional exhaustion (George, 2000). Thus, this study proposes the following hypotheses:

H5a:Leader's digital empathy weakens the positive effect of algorithmic control on subjective liminality.

H5b:Leader's digital empathy weakens the positive effect of algorithmic control on employees' emotional exhaustion.

4. Empirical Testing

4.1 Research Design

This study collected data from digital enterprise clusters such as Beijing Zhongguancun Science Park and Shanghai Zhangjiang AI Demonstration Zone using Credamo's precision sampling and cross-level matching function. Screening criteria included: sample enterprises must have experience deploying algorithmic management systems (e.g., intelligent scheduling, automated evaluation, or AI decision-making systems); study subjects were frontline employees directly using algorithmic management tools; industries were narrowed to internet platform operations, e-commerce, and smart manufacturing—three sectors with over 70% algorithmic penetration (per the 2024 China Digital Economy Development White Paper standard).

To avoid common method bias, a two-wave longitudinal design was adopted with all variables self-reported by employees. The first wave measured relatively stable variables, including demographic variables, employee-perceived algorithmic control, subjective liminality, and leader's digital empathy. A total of 832 questionnaires were distributed, and after excluding invalid responses with patterned answers, logical inconsistencies, or completion times under 120 seconds, 712 valid questionnaires were collected. The second wave, conducted 14 days later, tracked context-sensitive variables (including emotional exhaustion and employee job performance) among the same 712 employees identified by the last four digits of their mobile numbers. This phase yielded 588 valid responses, with 424 complete matched samples (72.11% matching rate) obtained after data cleaning. Anonymous encryption technology was employed throughout the survey, with participants receiving CNY 15 remuneration and signing confidentiality agreements upon completion.

4.2 Data Quality Tests

This study used Cronbach's alpha to assess scale reliability, while AVE and CR values evaluated convergent validity. Discriminant validity was examined through Fornell-Larcker criterion (comparing AVE square roots with inter-construct correlations) and HTMT method. Endogeneity and statistical analysis results are presented in Tables 1 and 2. All constructs demonstrated good internal consistency with reliability coefficients exceeding 0.8. Convergent validity was supported by AVE values above 0.6 and CR values exceeding 0.9. Table 2 shows each construct's AVE square root exceeded its maximum absolute correlation with other variables, with all HTMT ratios below the 0.85 threshold, confirming strong discriminant validity.

4.3 Common Method Bias and Multicollinearity Tests

First, Harman's single-factor test revealed the first factor accounted for 48.509% of total variance (below the 50% threshold), indicating insignificant common method bias. Second, confirmatory factor analysis demonstrated the baseline model's fit indices outperformed alternative models, confirming good discriminant validity among constructs (see Table 1). Finally, variance inflation factor (VIF) analysis showed all values below 10, proving no severe multicollinearity issues and verifying variable independence.

Table 1 Confirmatory factor analysis results

Factor Model	χ2	df	χ2/ df	CFI	RMSEA	IFI	TLI
Judgment criteria	-	-	<3	>0.9	<0.10	>0.9	>0.9
Five factors: A; B ; C; D ; E	1830.546	1070	1.711	0.952	0.041	0.952	0.949
Four factors: A;B ;C+ D;E	2422.880	1074	2.256	0.914	0.054	0.915	0.910
Three factors: A;B +C+ D;E	3257.571	1077	3.025	0.862	0.069	0.862	0.855
Two factors: A+B+C+ D; E	4504.886	1079	4.175	0.783	0.087	0.783	0.773
Single factor: A+B+C+D+E	5082.803	1080	4.706	0.746	0.094	0.747	0.735

Note: A: Perceived algorithmic control ; B: subjective liminality ; C: Emotional exhaustion ; D:Leader's Digital Empathy ; E: Job performance ;

4.4 Correlation Test and Confirmatory Factor Analysis

Table 2 presents the correlation coefficients and descriptive statistical analysis results among variables. The table shows that the means and standard deviations of all variables are within normal ranges, and there are significant correlations between variables, consistent with the hypotheses.

Table 2 Correlation test and descriptive statistical analysis

	PAC	SL	EE	DEEL	JP
PAC	0.780	0.726	0.823	0.708	0.751
SL	0.682 **	0.766	0.729	0.687	0.71
EE	0.7 51 **	0.694 **	0.785	0.708	0.691
DEEL	- 0.639 **	- 0.623 **	- 0.647 **	0.800	0.657
JP	-0.691 **	-0.656 **	-0.644 **	0.584 **	0.788
Average value	2.551243568	2.496658805	2.54827044	3.5324	3.488600629
Standard deviation	0.944064849	0.889039571	0.955724404	0.96296	0.947430147

Note: ** : p<0.01; the bold italic font on the diagonal line is the AVE square root value, the value below the diagonal line is the correlation coefficient, and the value above the diagonal line is the HTMT value

4.5 Hypothesis Testing Results

First, testing the direct effects. As shown in Table 3, perceived algorithmic control negatively impacts job performance (B=-0.680, $p < 0.001$), supporting Hypothesis 1. Perceived algorithmic control positively affects subjective liminality and emotional exhaustion (B=0.635, p<0.001; B=0.792, p<0.001), validating Hypotheses 2a and 3a. Both subjective liminality and emotional exhaustion negatively influence job performance (B=-0.667, p<0.001; B=-0.617, p<0.001), confirming Hypotheses 2 b and 3 b . Second, examining indirect effects. Hierarchical regression results further indicate that when both perceived algorithmic control and subjective liminality are included in the model, they significantly affect job performance (B=-0.461, p<0.001; B=-0.344, p<0.001), demonstrating that subjective liminality mediates the negative impact of perceived algorithmic control on job performance. Similarly, emotional exhaustion mediates this negative effect.

Table 3 Hierarchical regression analysis results

Variable	subjective liminality		Emotional exhaustion			Job performance						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Control variable												

Gender	-0.168	-0.115	-0.087	-0.022	0.036	0.209	0.154	0.098	0.114	0.156	0.148	0.116
Age	-0.008	-0.005	0.017	0.020	0.023	0.031	0.029	0.026	0.027	0.042	0.034	0.030
Education	-0.169	-0.009	-0.194	0.006	-0.069	0.197	0.026	0.085	0.023	0.077	0.027	0.024
Enterprise scale	-0.091	-0.087	0.005	0.010	0.072	0.126	0.122	0.065	0.092	0.129	0.125	0.098
Nature of enterprise	0.064	0.045	0.008	-0.015	-0.039	-0.016	0.004	0.027	0.019	-0.011	0.000	0.015
Position type	0.055	0.052	-0.052	-0.056	-0.093	-0.111	-0.107	-0.074	-0.090	-0.143	-0.123	-0.101
Marital status	-0.157	-0.227	0.143	0.056	0.259	0.344	0.419	0.239	0.341	0.433	0.434	0.361
Independent variable												
PAC		0.635***		0.792***			-0.680***		-0.461***		-0.466***	-0.369***
Mediating variable												
SL					0.738***			-0.667***	-0.344***			-0.292***
EE										-0.617***	-0.270***	-0.158**
R 2	0.063	0.479	0.052	0.611	0.052	0.082	0.501	0.448	0.555	0.449	0.530	0.564
Adj R 2	0.047	0.469	0.036	0.603	0.036	0.066	0.491	0.437	0.546	0.438	0.520	0.553
F	4.003***	330.879***	3.268**	595.652***	3.268**	5.276***	348.661***	275.559***	50.716***	276.620***	25.453***	29.870***

Note: * indicates p<0.050, ** indicates p<0.010 (two-tailed test).PAC: Perceived algorithmic control ;
SL: subjective liminality ; EE: Emotional exhaustion ;

Further examination of the mediating effects of subjective liminality and emotional exhaustion on the relationship between perceived algorithmic control and job performance was conducted using the bootstrap method, with results shown in Table 4. The table reveals that perceived algorithmic control negatively affects job performance through subjective liminality, and similarly through emotional exhaustion. In conclusion, the mediating effects of subjective liminality and emotional exhaustion were further validated, supporting hypotheses 2c and 3c .

Table 4 Bootstrap test results of mediation effect

Impact Path	illustrate	Effect	SE	BootLLCI	BootULCI	p
PAC ⇒ JP	Direct Effect	-0.369	0.056	-0.479	-0.260	0.000
PAC ⇒ JP	Total effect	-0.680	0.036	-0.752	-0.609	0.000
PAC ⇒ SL ⇒ JP	Indirect effects	-0.186	0.035	-0.253	-0.116	0.000
PAC⇒EE⇒JP		-0.092	0.033	-0.156	-0.029	0.005
PAC⇒SL⇒EE⇒JP		-0.033	0.013	-0.060	-0.010	0.009

Third, testing the moderating effect. As shown in Tables 5 and 6, the interaction term between perceived algorithmic control and leader's digital empathy negatively and significantly affects subjective liminality $(B = -0.090, P < 0.05)$, indicating that leader's digital empathy mitigates the positive impact of perceived algorithmic control on subjective liminality. Simultaneously, the interaction term between perceived algorithmic control and leader's digital empathy negatively and significantly affects emotional exhaustion $(B = -0.117, P < 0.01)$, demonstrating that leader's digital empathy alleviates the positive influence of perceived algorithmic control on emotional exhaustion.

Table 5 Regression model and results of the moderating effect of Leader's Digital Empathy

Variable	Dependent variable: subjective liminality				Dependent variable: Emotional exhaustion			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Control variable								
Gender	-0.168	-0.115	-0.127	-0.124	-0.087	-0.022	-0.032	-0.029
Age	-0.008	-0.005	-0.003	-0.006	0.017	0.020	0.022	0.018
Education	-0.169	-0.009	-0.003	-0.007	-0.194	0.006	0.011	0.005
Enterprise scale	-0.091	-0.087	-0.080	-0.074	0.005	0.010	0.016	0.024
Nature of enterprise	0.064	0.045	0.023	0.033	0.008	-0.015	-0.035	-0.021
Position type	0.055	0.052	0.040	0.031	-0.052	-0.056	-0.067	-0.078
Marital status	-0.157	-0.227	-0.122	-0.106	0.143	0.056	0.150	0.170
Independent variable								
PAC		0.635***	0.449***	0.403***		0.792***	0.626***	0.566***
Moderating variable								
DEEL			-0.290***	-0.264***			-0.258***	-0.224***
Interaction term								
PAC*DEEL				-0.090*				-0.117**
R 2	0.063	0.479	0.536	0.541	0.052	0.611	0.650	0.658
ΔR 2	0.047	0.469	0.526	0.530	0.036	0.603	0.643	0.650
F	4.003***	330.879***	53. 354***	4.721 *	3.268**	595.652***	46.689***	9.230**

Note: PAC：Perceived algorithmic control ; DEEL：Leader's digital empathy；

Table 6 Simple slope analysis of Leader's Digital Empathy

Dependent variable	Levels of moderating variables	Regression coefficient	Standard error	t	p	95% CI	
subjective liminality	Low level (-1SD)	0.490	0.046	10.679	0.000	0.400	0.580
	average value	0.403	0.047	8.597	0.000	0.311	0.495
	High level (+1SD)	0.316	0.074	4.261	0.000	0.171	0.461
Emotional exhaustion	Low level (-1SD)	0.679	0.043	15.928	0.000	0.595	0.7633
	average value	0.566	0.044	13.005	0.000	0.481	0.652
	High level (+1SD)	0.454	0.069	6.586	0.000	0.319	0.589

Note: BootLLCI refers to the lower limit of the 95% interval of Bootstrap sampling, and BootULCI refers to the upper limit of the 95% interval of Bootstrap sampling

This study examined the moderating effect of leader's digital empathy through simple slope analysis. Results (see Table 6) showed significant differences in the impact of employees' perceived algorithmic control on subjective liminality and emotional exhaustion. Regression coefficients gradually decreased across low, medium, and high moderation levels. Figure 2 demonstrates that higher levels of leader's digital empathy weaken the effect of perceived algorithmic control on subjective liminality. The same pattern is shown in Figure 3.

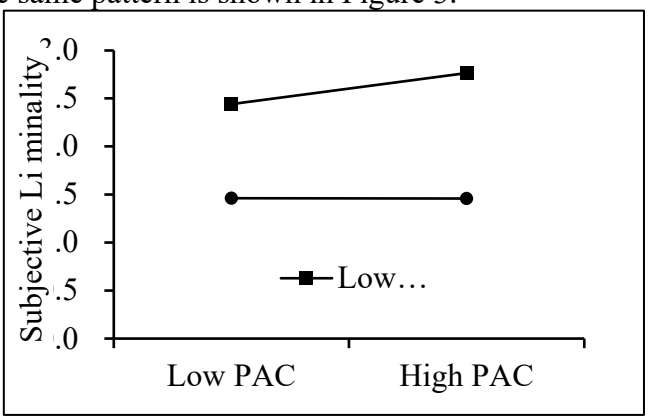

Figure 2 Simple slope graph of Leader's Digital Empathy

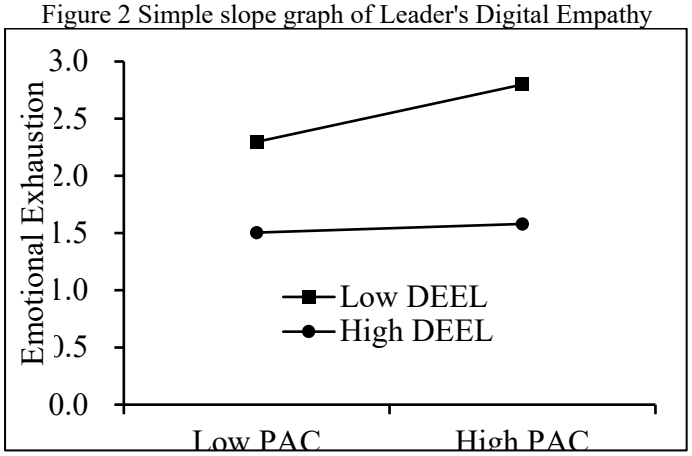

Figure 3 Simple slope graph of Leader's Digital Empathy

5. Discussion

Based on cognitive-affective system theory, this study reveals the internal mechanism through which employees' perceived algorithmic control negatively impacts job performance via the chained mediation path of subjective liminality → emotional exhaustion, while verifying the crucial

moderating role of leader's digital empathy in weakening this indirect effect. It expands the theoretical boundaries of technostressors from a cognitive-affective interaction perspective.

5.1 Theoretical Contributions

First, it expands the population boundary of algorithmic management research by focusing on regular employees, extending the applicability of algorithmic management theory to traditional organizational contexts. Second, it reveals the chained depletion mechanism of algorithmic control's impact on performance: the progressive dual-path of cognitive anchoring and emotional erosion. Grounded in cognitive-affective system theory, this study constructs a chained mediation model of "subjective liminality → emotional exhaustion," transcending the single-dimensional limitations of existing research (Tarafdar et al., 2019) and clarifying the unique depletion transmission pattern of algorithmic stressors. Third, it elucidates the dynamic balance between algorithmic rigidity and leadership flexibility by proposing the moderating role of leader's digital empathy. Current research pays limited attention to how leadership behaviors mitigate negative effects of algorithmic management. This study finds that leaders with high digital ethical empathy can both enhance algorithmic transparency to assist employees' cognitive restructuring and reduce role uncertainty, while precisely responding to emotional needs to decrease emotional depletion and strengthen psychological resilience. This challenges the technological determinism perspective of algorithmic management (Burrell, 2016) and expands the research perspective of leadership theory.

5.2 Practical Implications

This study offers practical guidance for enhancing managerial effectiveness and improving employee experiences in algorithmic management contexts. First, organizations should establish a development mechanism for leaders' digital ethical empathy. This includes creating standardized evaluation systems integrated into performance appraisals, implementing tool-based training programs, and linking empathy capabilities to incentive structures. Second, an "employee–algorithm" co-design mechanism should be implemented. Employees can set preference parameters, participate in algorithm improvement committees, help optimize evaluation metrics, and benefit from early-warning systems that monitor emotional exhaustion. Third, organizations should develop a dual-channel "cognitive–affective" communication system to improve algorithm transparency. Measures include providing decision traceability platforms, deploying AI-based emotional assistants, and implementing designated "algorithm-free days" to f

5.3 Limitations and Future Directions

This study has several limitations. Key variables were measured using self-reported data, which may be subject to social desirability bias, memory distortion, and subjective interpretation. Future research could incorporate behavioral observations and physiological indicators to enhance measurement accuracy. Although a longitudinal design was adopted, the relatively short intervals between data collection waves may limit the ability to capture long-term effects. Additionally, the sample was concentrated in specific industries or regions, which may restrict the generalizability of the findings. Future studies should consider extending the study period and diversifying the sample to improve external validity. Finally, this study did not account for contextual variables such as organizational culture and industry competition, nor for individual characteristics like digital literacy and psychological resilience. Future research may consider integrating alternative theoretical perspectives to examine more complex mechanisms.

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