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Green ambidextrous leadership configurations and employee green innovation: a cognitive-affective processing system perspective on psychological mechanisms

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Employee green innovation behavior presents a critical yet paradoxical challenge in resource-intensive sectors. Although existing research emphasizes the importance of leadership in promoting employee environmental initiatives, it largely focuses on singular leadership approaches, neglecting the inherent tensions embedded in balancing environmental principles with innovative development. Our study particularly focuses on and conceptualizes green ambidextrous leadership, or a comprehensive leadership approach involving the flexible integration of green opening and green closing leadership behaviors. Integrating the cognitive-affective processing system framework with the literature on ambidextrous leadership, we theorize and empirically test how green ambidextrous leadership influences employee green innovation behavior. Data from 218 leader-employee dyads reveal that green ambidextrous leadership significantly enhances employee green innovation behavior via cognitive (i.e., green mindfulness) and affective (i.e., harmonious green passion) mechanisms. Furthermore, employee green innovation behavior is optimized when leaders flexibly balance higher levels of both green opening leadership and green closing leadership. The research provides theoretical insights and practical implications for motivating sustainable innovation at the grassroots level.

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Introduction

Against the urgent backdrop of the global sustainable development agenda, resource-intensive and service-oriented sectors, particularly the hospitality and tourism industry, are under unprecedented pressure to assume environmental responsibility and transform their traditional operations (García et al., 2024; Gürlek and Kılıç, 2024; Zhang et al., 2025). Meanwhile, growing expectations from customers, investors, and regulators regarding firms' environmental performance also increase the requirement for green innovation, defined as the proactive creation or adoption of novel products, processes, management practices, or business models that reduce organizational environmental damage and risks (Cocca and Ganz, 2015; Gürlek and Koseoglu, 2021; Xie and Yu, 2024; Yang et al., 2024). Once merely a peripheral corporate social responsibility gesture, green innovation has become a core strategic imperative directly tied to long-term viability and competitive advantage (Chan and Hsu, 2016; Higgins-Desbiolles et al., 2019). Critically, the scope and effectiveness of green innovation relies on the active and sustained involvement of employees (Cho and Yoo, 2021; Ruan et al., 2022). Therefore, encouraging employee green innovative behavior, or the promotion, production, and implementation of environmentally oriented, novel, and useful ideas (Aboramadan et al, 2021; Chen and Chang, 2013), has become essential for firms aiming to meet environmental challenges and seize green growth opportunities (Chen and Chang, 2013; Wang et al., 2021).

Previous studies underscore that leadership plays a vital role in stimulating employees' green behavior (Zacher et al., 2023). The same holds for green innovative behavior. For example, green transformational leadership reinforces green creativity of employees by articulating an inspiring environmental vision and further strengthening their green organizational identity (Mittal and Dhar, 2016). Similarly, environmentally specific servant leadership empowers employees to engage in green practices and innovation by equipping them with the necessary tools and resources (Aboramadan et al., 2021). Meanwhile, ethical leadership motivates employees to generate more green innovation by emphasizing environmental responsibility and modeling high ethical standards (Liu and Zhao, 2019). Collectively, this stream of research converges on a key insight: goal-oriented, environment-focused leadership provide both the impetus and the guidance for employees to participate in green innovation, laying a key foundation for understanding how leadership shapes sustainability outcomes at the grassroots level.

Although existing research provides valuable insights into how specific leadership promote employee green innovation behavior, it largely overlooks a central paradox in green such innovation. Indeed, leaders fostering employee green innovation behavior must navigate fundamental paradoxes rooted in the nature of the task itself (Duan et al., 2023). Leaders face the challenge of ensuring the synergistic integration of environmental principles with innovative development. One facet involves nurturing its distinct moral and pro-environmental characteristics (Cho and Yoo, 2021; Liu and Zhao, 2019; Lu et al., 2019). This requires leaders to act as catalysts, encouraging green experimentation, motivating green risk-taking, and using a compelling green vision to foster employees' moral resonance and pro-environmental motivation (Li et al., 2018; Rosing et al., 2011). Concurrently, leaders face the challenge of ensuring the synergistic integration of environmental principles with innovative development reflecting the alternation and change of green exploration and exploitation activities (Chen and Chang, 2013). This necessitates skillfully managing the complex dynamic interplay between green exploration and exploitation (Alghamdi, 2018; Chen and Chang, 2013; Mittal and Dhar, 2016; Ruan et al., 2022), balancing creative freedom with the need for structured execution and efficiency. Given these paradoxical demands, a singular leadership approach may be inadequate to address the "dual nature" embedded in employee green innovation behavior. Existing literature, however, offers insufficient focus on the dynamic and integrative leadership behaviors required to manage this tension. This creates a significant theoretical puzzle that we need to solve: How can leaders effectively implement integrative strategies to successfully navigate the intrinsic tension inherent in green innovation and further optimize employee green innovation behavior?

To bridge this research gap, we particularly focus on green ambidextrous leadership. Drawing upon the ambidexterity theory of leadership proposed by Rosing et al. (2011) in the general innovation domain and applying it to the context of green innovation, we define green ambidextrous leadership as a leading approach characterized by a leader's conscious and flexible switching between and integration of two complementary sets of leadership behaviors. These complementary behaviors are green opening leadership, or actions fostering independent thinking and experimentation, and green closing leadership, or actions providing oversight and structural guidance for green task implementation (Cunha et al., 2019). The inherent flexibility and integrative nature of this leadership approach may explicitly reconcile the contradictory demands associated with managing the "dual nature" of employee green innovation behavior, potentially offering more adaptable and balanced support than singular leadership. Building on this foundation, the primary purpose of our study is to examine the mechanisms by which green ambidextrous leadership impacts employee green innovation behavior. Specifically, guided by the cognitive-affective processing system framework (Chen et al., 2021; Mischel and Shoda, 1995), we propose that green ambidextrous leadership influences employee green innovation behavior by activating specific cognitive and affective responses. Cognitively, we predict that green ambidextrous leadership enhances green mindfulness, defined as deliberate attention to and processing of environmental information (Dharmesti et al., 2020; Srivastava et al., 2024). Affectively, we expect that green ambidextrous leadership helps cultivate harmonious green passion, defined as deep, coordinated emotional engagement with green work (Iftikhar et al., 2024). Ultimately, both cognitive and affective states are expected to synergistically facilitate employee green innovation behavior. We empirically test these hypothesized relationships with a survey dataset comprising 218 leader–employee dyads, as presented in Fig. 1.

This study offers significant theoretical contributions and practical implications. Theoretically, our research first advances the understanding of leadership for sustainability by introducing and validating a configurational green ambidextrous leadership approach that moves beyond singular styles. Second, we extend the literature of leadership ambidexterity (e.g., Rosing et al., 2011) by applying a nuanced configurational lens within the vital green domain. Third, our study enriches the cognitive-affective processing system framework (Mischel and Shoda, 1995) by identifying specific cognitive (i.e., green mindfulness; Srivastava et al., 2024) and affective (i.e., harmonious green passion; Iftikhar et al., 2024) mechanisms relevant to employee green behaviors. Practically, our findings underscore the importance for organizations to strategically cultivate managers' behavioral flexibility for ambidextrous green leadership (Rosing et al., 2011). They further highlight the need for managers to actively nurture employees' green mindfulness and harmonious passion supported by congruent organizational systems and a culture that values sustainability, thereby maximizing the potential for employee-driven green initiatives.
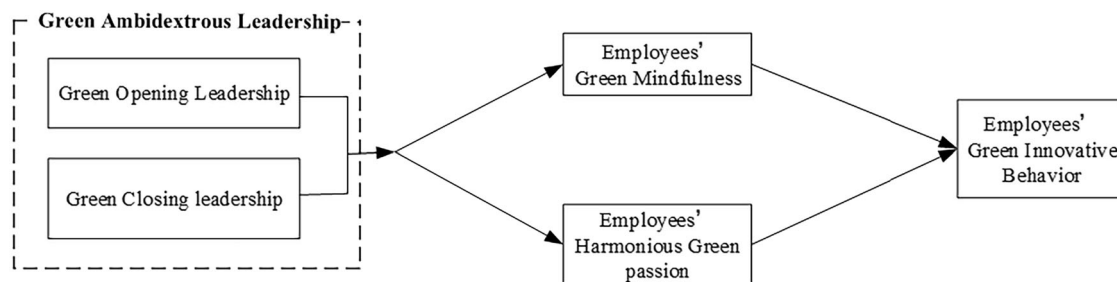
Fig. 1 Theoretical model.

Literature review and hypothesis development

The cognitive-affective processing system perspective. The cognitive-affective processing system perspective posits that individual operates as a uniquely cognitive-affective system, continuously interacting with the social environment to generate individual-specific behavioral patterns (Mischel and Shoda, 1995). This internal system comprises an interconnected network of cognitive elements, such as encodings, expectancies, and beliefs, and affective elements, including emotions, feelings, and motivational states, which together define an individual's unique way of processing experiences. Further, the external environment the individual encounters may activate their internal cognitive-affective system. The activation process then jointly determines their psychological experiences and behavioral choices (Lavelle et al., 2007).

Within the interaction, external situational interventions, such as specific leadership approaches or organizational cues, serve as critical catalysts, prompting individuals to exhibit behavioral responses via distinct cognitive and affective reactions. In particular, cognitive reactions embody a controlled response pathway, prompting individuals to cognitively process external stimuli and further exhibit specific behavioral responses. Affective reactions, by contrast, describes an automatic affective response system that springs into actions when emotional cures activate an individual's internal processes (Mischel and Shoda, 1995). Together, the interplay between these deliberate cognitive appraisals and more automatic affective reactions critically shapes an individual's behavioral responses.

Within the innovation process, the cognitive-affective processing system perspective views employees not as passive recipients but as active agents that systematically implement self-change responses, rather than merely reacting passively to their environment (Mischel and Shoda, 1995; Farrukh et al, 2023). This understanding of employees as proactive sense-makers and goal-oriented individuals underscores the suitability of this perspective for analyzing how leadership influences discretionary behaviors like employee green innovation behaviors. Therefore, this study draws on the cognitive-affective processing system perspective to establish two pathways of cognition and emotion. Based on these pathways, we aim to investigate the mechanisms of employees' green innovation behavior formation, particularly focusing on the mechanisms that unfold in the relationship between green ambidextrous leadership and employees as they engage in efforts towards green innovation.

Green ambidextrous leadership. Ambidextrous leadership is defined as "the ability to foster both explorative and exploitative behaviors in followers by increasing or reducing variance in their behavior and flexibly switching between those behaviors" (Rosing et al., 2011). It consists of two primary components: (1) opening leadership, which promotes exploration by encouraging alternative approaches to tasks, fostering independent thinking and action, and supporting the questioning of established methods; and (2) closing leadership, which facilitates exploitation through the implementation of corrective actions, the establishment of precise protocols, and the assessment of goal attainment (Rosing et al., 2011; Zacher and Rosing, 2015). Effective ambidextrous leadership flexibly switches between and integrates opening and closing leadership behaviors as contexts change, thereby achieving a dynamic balance between exploratory and exploitative activities.

While established research supports the significant role of ambidextrous leadership in enhancing general innovation outcomes (e.g., Mueller et al., 2020; Oluwafemi et al., 2020; Kousina and Voudouris, 2023), its specific application to green innovation has remained notably underexplored. Green innovation is distinct as it inherently integrates innovation motives with profound moral considerations or environmental sustainability imperatives (Liu and Zhao, 2019; Zhang and Gong, 2024). Therefore, this study attempts to adapts the general ambidextrous framework to conceptualize green ambidextrous leadership, tailoring it to the unique paradoxical demands previously identified. Particularly, green opening leadership aims to encourage employee engagement in green experimentation and promotes behaviors that yield positive outcomes for the environment. It involves leaders acting as catalysts to stimulate green experimentation, encourage value-driven risk-taking, and foster moral resonance through a compelling green vision (Miron-Spektor and Erez, 2017; Li et al., 2018). Conversely, green closing leadership focuses on minimizing variability by providing clear guidelines and monitoring employees' progress toward achieving green goals. It may promote the exploitation of existing green knowledge through the establishment of routine processes and standardized task completion, creating a guidance-supportive environment for employees' green exploitation activities (Miron-Spektor and Erez, 2017).

Effective green ambidextrous leadership thus highlights the importance of a "both/and/complementary" approach (Mom et al., 2009; Rosing et al., 2011), supporting the entire cycle of employee green innovation from initial ideation to sustained implementation. However, fully understanding the impact of ambidexterity requires more than treating it as a single, aggregated score, as some previous studies have done, for instance, by using multiplication or subtraction methods to calculate a combined index (Asiaei et al., 2023). Viewing it solely as an overall balance risk overlooking how different configurations of opening and closing green leadership produce unique effects. Instead, we should examine precisely how these distinct leadership configurations interact and operate in green practice. We contend that different configurations, that is, specific configurations of high and low levels of green opening and closing leadership, may create qualitatively distinct leadership contexts for employees. Therefore, this study adopts a configurational approach (Tsai et al., 2022) to explore the differential impacts of various congruent (e.g., "high-high", "low-low") of these leadership behaviors, positing they uniquely shape

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employee cognitive and affective reactions and subsequent innovative actions in the pursuit of environmental objectives.

Green ambidextrous leadership, green mindfulness, and employees' green innovation behavior. Based the cognitive-affective processing system perspective, green ambidextrous leadership function as salient situational cues that may activate employees' internal processes of thinking and feeling, shaping their cognitive states such as their green mindfulness. Drawing from broader conceptualizations of mindfulness as conscious and non-judgmental awareness of the present moment (Kabat-Zinn, 2005; Langer and Moldoveanu, 2000), we define green mindfulness as a distinct mental state characterized by a sustained pattern of attention directed toward environmental matters. This involves individuals' particular cognitive engagement with sustainability and its related information (Dharmesti et al., 2020; Murillo-Ramos et al., 2024). Crucially for our argument, key aspects of green mindfulness include: (1) heightened sensitivity to the environment, (2) receptivity to novel information, (3) consciousness of multiple viewpoints, (4) vigilance towards a specific environment, and (5) an engaged awakeness concerning the present moment related to environment (Dharmesti et al., 2020).

Green ambidextrous leadership, as a fusion of two distinct leadership approaches, can through its carious configurations and the situational cues these generate, differentially activate employees' internal cognitive processes, influencing the formation and intensity of their green mindfulness. Specifically, high green opening leadership cultivate an autonomy-supportive environment. This leadership approach encourages employees to reframe environmental issues as opportunities for innovation, prompts them to undertake greater green risks supported by compelling green visions (Ray et al., 2011; Kardoyo et al., 2020). This further stimulates their cognitive systems to more readily process and respond to green-related information. Thus, employees under strong green opening leadership tend to view green issues from broader and more diverse perspectives, exhibit increased receptivity to novel green information, all of which contribute to activating and enhancing their overall green mindfulness (Dharmesti et al., 2020). While high green opening leadership may effectively foster the breadth in environmental awareness and divergent thinking, an exclusive reliance on this approach may not fully cultivate employees' sustained and focused attention on current environmental issues or specific the present-moment green tasks. Such a singular focus on exploration and experimentation might lead to over-stimulation or a diffusion of effort.

To complement the exploratory impetus triggered by green opening leadership, green closing leadership address other facets critical for a comprehensive development of green mindfulness. Such leadership emphasizes establishing clear and specific green guidelines, closely monitoring the achievement of green goals, and systematically rectifying green-related errors (Klonek et al., 2023). Although such directive and structured approach might narrow the scope of employees' attention away from the most multiple or broadest perspectives when initially encoding information (Hafenbrack and Vohs, 2018), it critically fosters their sustained focus on the current environmental issues and deepens their vigilant engagement with the present-moment green task and responsibilities. By providing clear environmental expectations and guidances, green closing leadership promotes a deliberate and meticulous processing of information relevant to achieving specific green purposes.

However, while both green opening leadership and green closing leadership may independently increase certain aspects of green mindfulness, neither approach in isolation is likely to achieve its maximum or most well-rounded cultivation, suggesting the necessities for their effective integration. Thus, when leaders flexibly integrate and shift between both approaches to deploy high-level green opening leadership and high-level green closing leadership concurrently, they can unlock the complementary advantages and foster synergistic effects (Guo et al., 2020; Rus et al., 2024). According to cognitive-affective processing system perspective (Mischel and Shoda, 1995), the "high-high" combination of green ambidextrous leadership constitutes strong and multifaceted situational information for employees. Such enriched informational environment is expected to concurrently activate distinct but complementary internal cognitive pathways: those associated with high green opening leadership stimulate broad environmental awareness to novelty, and consideration of diverse perspectives, while those linked to high green closing leadership promote sustained attention, focused processing of current green objectives, and diligent engagement with specific environmental tasks. This comprehensive stimulation and clear direction enable employees to more effectively interpret environmental cues, process green-related information from multiple yet pertinent angles, and maintain a deep, conscious engagement with their environmental responsibilities, thereby maximizing their green mindfulness. In contrast, when in a "low-low" combination, employees experience neither significant exploratory impetus nor structured focus. This absence of distinct and alternative leadership cues likely hinders their environmental sensitivity(Alghamdi, 2018; Rosing et al., 2011), their openness to new green information, and their sustained attention to current environmental issues, thus significantly impeding the development of green mindfulness (Dharmesti et al., 2020). Thus, we proposed:

H1: The level of employees' green mindfulness is higher when green opening leadership and green closing leadership are both high than when they are both low.

When green opening leadership and green closing leadership are incongruent, leaders typically manifest a primary style. This leads to either a "high green opening leadership and low green closing leadership" approach, or vice versa. From the cognitive-affective processing system perspective (Mischel and Shoda, 1995), these incongruent configurations present employees with imbalanced or incomplete sets of situational cues compared to a congruent "high-high" approach. We argue that both of these imbalanced configurations are less effective than the "high-high" configurations in maximizing employee green mindfulness because they sub-optimally activate the necessary internal cognitive processes.

For instance, a "high green opening and low green closing" approach strongly signals the importance of experimentation and flexible information seeking; its cues may effectively activate cognitive processes related to heightened environmental sensitivity and receptivity to novel ideas (Chen et al., 2023). However, the corresponding lack of strong green closing cues means there is often insufficient situational input to concurrently activate or sustain cognitive processes needed for clear and structured green objectives or focused monitoring, potentially leading to diffuse cognitive efforts rather than applied green mindfulness. Conversely, a "low green opening and high green closing" scenario predominantly provides situational cues emphasizing adherence and diligent monitoring. While these cues may activate cognitive processes that foster sustained attention to current green task, the lack of green opening cues in this configuration likely fails to adequately stimulate cognitive processes for broader environmental awareness or receptivity to novel solutions beyond prescribed routines. Thus, both incongruent patterns, due to their one-sided emphasis in situational signaling, are expected to

cultivate a less comprehensive and less potent form of green mindfulness.

Both incongruent leadership configurations present imbalanced situational cues, resulting in a partial activation of cognitive processes relevant to green mindfulness. These approaches contrast with the "high-high" configuration, which comprehensively supports expansive awareness and focused processing. Thus, we propose the following hypothesis.

H2: The level of employees' green mindfulness is higher when the congruence combination of green opening leadership and green closing leadership is "high-high" than when the incongruence configurations are "high-low" and "low-high".

Based on cognitive-affective processing system perspective, once employees' internal cognitive processes (e.g., green mindfulness) are formed and activated by situational cues, they subsequently organize and guide their observable, individual-specific behavioral patterns (Mischel and Shoda, 1995). Thus, green mindfulness, when cultivated by green ambidextrous leadership, acts as a unique cognitive resource that serves as a significant drive for employees' engagement in green innovation activities (Dharmesti et al., 2020; Murillo et al., 2024). Specifically, employees with high green mindfulness excel at capturing various green information and environmental cues. The ready influx of information allows them to continuously encode, integrate, and refine cognitive processes related to green innovation activities, thereby enhancing their information overall information processing capacity. Additionally, the deliberate and non-judgmental processes inherent in mindfulness enable employees to avoid automatic biased responses towards green tasks. Instead, they can make more rational choices when combining and processing useful environmental information, which further facilitates the generation and implementation of new ideas (Hwang and Lee, 2018). Furthermore, the openness and curiosity associated with mindfulness enable employees to increase their insights and reflect on their internal experiences, thus enhancing their sense of efficacy in green activities and autonomously promoting the creative initiatives that constitute employee green innovation behavior. Integrating hypothesis 1 and 2, we proposed:

H3: Green mindfulness mediates the relationship between green ambidextrous leadership and employees' green innovative behavior.

Green ambidextrous leadership, harmonious green passion, and employees' green innovation behavior. Based the cognitive-affective processing system perspective, green ambidextrous leadership supplies employees with rich environmental affective cues. These cues can trigger employees' intrinsic affective reactions toward green issues, activating their internal emotional processes, such as green harmonious passion. Building on the research on "harmonious passion" by Vallerand et al. (2003; 2007), Robertson and Barling (2013) further defined harmonious green passion as a positive emotion that drives individuals to engage in green behaviors. Crucially for our research argument, the core characteristics of green harmonious passion include: (1) a strong "liking" tendency to engage in green activities; (2) the belief that engaging in green activities is highly "important"; (3) the willingness to devote time and effort to green "behavior"; and (4) the perception that green activities are "controllable".

Green ambidextrous leadership plays an important role in improving employees' harmonious green passion. Specifically, as mentioned above, high-level green opening leadership creates an autonomy-supportive work environment for employees, which stimulates their intrinsic enthusiasm towards green initiatives. On this basis, employees develop a strong emotional inclination to "like" and consider these activities as "important," thereby being willing to spend more time on green activities, which further formed and enhanced their harmonious green passion (Mageau et al., 2009; Liu et al., 2011; Murillo-Ramos et al., 2024). However, high-level green opening leadership may also lead employees to doubt the perceived controllability of their work due to its lack of clear rules and guiding constraints (Klonek et al., 2023). In fact, employees' perceived controllability plays a crucial role in fostering harmonious green passion. When individuals realize that a green idea cannot be implemented, their perceived controllability declines significantly, which in turn diminishes their harmonious green passion (Collewaert et al., 2016). Conversely, high-level green closing leadership, with its established conventions and constraints (Zacher and Rosing, 2015), helping employees perceive a strong sense of controllability. Nevertheless, as employees become increasingly proficient in task execution, they may fall into a monotonous emotional state(Wihler et al., 2022; Murillo-Ramos et al., 2024), losing the intrinsic enjoyment of solving green problems, which may negatively affect their harmonious green passion.

Therefore, similar to the pathway through which green mindfulness is influenced, a single leadership style, whether green opening or green closing, may prove inadequate for fully stimulating employees' harmonious green passion. Instead, it remains necessary to effectively integrate and flexibly switch between these two leadership approaches in order to unlock the unique complementary and synergistic advantages of green ambidextrous leadership (Guo et al., 2020). According to the cognitive–affective processing system perspective (Mischel and Shoda, 1995), the "high–high" combination of green ambidextrous leadership not only enables employees to experience a strong sense of autonomy, liking, and importance when participating in green activities (Rosing et al., 2011), but also strengthens their perception of controllability over these tasks (Collewaert et al., 2016). This dual impact motivates employees to devote more time and effort to green tasks (Ma et al., 2019), thereby maximizing their harmonious green passion. Moreover, green ambidextrous leadership prevents employees from falling into unrealistic fantasies or becoming trapped in monotonous tasks during the implementation of green initiatives, by flexibly switching between different leadership styles (Ma et al., 2019). This effectively avoids the negative affective tendencies such as dislike or burnout that employees may experience when facing a single leadership approach(Stein and Vincent-Höper, 2020). In contrast, under the "low-low" combination, leaders lack openness and guidance, making it difficult to motivate employees to maintain a long-lasting harmonious passion (Robertson and Barling, 2013; Vallerand et al., 2003). It can be seen that the "high–high" combination provides balanced and comprehensive emotional cues, through which employees' green harmonious passion can be more effectively activated. Therefore, we proposed:

H4: The level of employees' harmonious green passion is higher when green opening leadership and green closing leadership are both high than when they are both low.

When green opening leadership and closing leadership are incongruence, as mentioned above, regardless of which style is dominant, an imbalance between openness and closure within green leadership is revealed. Similar to the mechanism discussed above regarding the influence on green mindfulness, we argue that both imbalanced configurations deliver context cues with their own biases to employees. Neither approach is as effective as the "high-high" combination in maximizing employees' harmonious green passion, because they fail to fully trigger the necessary internal emotional processes.

Specially, a "high green opening and low green closing" approach may convey contextual cues that over-encourage employees to engage in green experimentation and risk-taking, while excessively neglecting aspects such as rule clarity or

deviation correction (Rosing et al., 2011; Kousina and Voudouris, 2023). This imbalance fails to fully supply the key elements required to activate the emotional process through perception of controllability, potentially preventing employees from sufficiently generating or sustaining harmonious green outcomes.

By contrast, a "low green opening and high green closing" approach may overly emphasize task completion and deviation correction (Rosing et al., 2011; Kousina and Voudouris, 2023), thereby limiting employees' autonomy and impeding the development of a positive emotional orientation towards green activities (Robertson and Barling, 2013; Vallerand et al., 2003). Employees may become trapped in repetitive, monotonous tasks, which is detrimental to fostering harmonious green passion. Therefore, compared to situations where green opening and closing leadership are incongruent, green ambidextrous green leadership is most effective only when both styles are in a "high–high" combination. This allows for leveraging the complementary strengths of both approaches, achieving a balance between diverging and converging approaches, and effectively enhancing employees' harmonious green passion.

Hence, we propose:

H5: The level of employees' harmonious green passion is higher when the green opening and closing leadership are at "high-high" congruence than when they are incongruent.

Furthermore, the stimulation of harmonious green passion can foster employees' green innovative behavior. Specifically, green innovative behavior requires employees to engage in more autonomous and ethical considerations compared to other innovative behavior (Chen et al., 2021). Harmonious green passion represents an internalized state of autonomous emotion, characterized by strong intrinsic motivation and emotional resources towards green behaviors, which can better facilitate green innovative behavior (Dai et al., 2021). On one hand, employees with harmonious green passion perceive their work as valuable and meaningful, investing more time and effort into engaging in challenging and demanding green innovative activities, thereby experiencing a sense of achievement (Robertson and Barling, 2013; Luu, 2021). On the other hand, harmonious green passion sustains employees' passion for green work and effectively stimulates their novel ideas (Liu et al., 2011), thereby providing a continuous source of positive emotional resources for green innovation. The current research proposes the following hypothesis:

H6: Harmonious green passion mediates the relationship between green ambidextrous leadership and employees' green innovative behavior.

Methodology
Participants and procedures. To test the proposed hypotheses, a questionnaire survey was conducted in China, targeting managers and employees from over 20 tourism companies and hotels in Jiangsu Province and Beijing. Both regions are characterized by high economic development levels and mature tourism industries, providing a representative context for examining the practices of Chinese tourism and hotel companies. This selection was based on their stronger emphasis on employee-driven green behaviors, which allows for a more accurate reflection of how leadership influences employees' psychology and behavior.

To avoid common method bias and homogeneity, we collected sample data from two groups, team leaders and team members. After obtaining written informed consent from all participants and official endorsements from participating companies, the data collection process unfolded in three phases. Firstly, 60 managers provided demographic information and evaluated their team members' green innovative behavior. Managers then distributed surveys to their direct subordinates, ensuring dyadic matching through unique participant IDs that preserved anonymity. Employees were assured of confidential data handling, with explicit guarantees that responses would not be linked to individual identities or be used solely for academic purposes. Employees further completed surveys in two phases. The first-phase survey included employees' personal demographic variables and ratings of their direct leaders' green leadership (both opening and closing). Three weeks later, the second-phase survey was conducted, covering green mindfulness, harmonious green passion, and the presence of green innovative coworkers. The second phase tracked the same employees from the first phase to maintain data consistency across stages. A total of 300 leader-employee dyadic matched responses were collected, and after verifying the authenticity of the responses and eliminating invalid questionnaires, 218 valid questionnaires were obtained, with 4 to 6 people in each team. The overall response rate was 72.67%.

This comprehensive data collection process provides a robust foundation for analyzing the impact of leadership on green innovation behavior within the context of the study. The high response rate further enhances the reliability of the findings.

Among the leaders, 60.30% were male and 39.40% were female. In terms of age, 1.40% were below the age of 25, 52.50% were between 25 and 35, 33.80% were between 36 and 45, 11.50% were between 45 and 55, and 0.50% were above the age of 55.

Among the employees, gender distribution showed a relatively balanced ratio, with male employees accounting for 42.90% and female employees accounting for 57.10%. In terms of age, employees below the age of 25 accounted for 38.40%, those between 25 and 35 accounted for 49.80%, those between 36 and 45 accounted for 9.10%, those between 45 and 55 accounted for 1.40%, and employees above the age of 55 accounted for 1.00%.

Measures. Employees provided ratings for their direct leaders' green leadership (both opening and closing), green mindfulness, harmonious green passion, and the presence of green innovative coworkers, measured using a 5-point Likert scale ranging from 1 (the worst) to 5 (the best). All surveys were translated into Chinese from English.

Employees' Green Innovative Behavior (GIB) was measured with a six-item scale developed by Scott and Bruce (1994) and adapted by Aboramadan et al. (2021). An example item was "I search out new environmentally-related technologies, processes, techniques, and/or product ideas." The Cronbach's alpha coefficient for this assessment was 0.95.

Green Ambidextrous Leadership (GAL) was assessed using two sub-scales: green opening leadership (GOL) and green closing leadership (GCL). The seven-item scales for GOL and GCL were adapted from Rosing et al. (2011). Employees rated their leaders' behaviors. An example item for green opening leadership was "My leader allows us to accomplish tasks in various ways that are beneficial for green practices". An example item for green closing leadership was "My leader monitors and controls our attainment of green and low carbon goals". The Cronbach's alpha coefficient for this assessment was 0.94.

Employees' Green Mindfulness (GM) was assessed using six items adapted from Kalyar et al. (2021). An example item was "I feel free to discuss environmental issues and problems". The Cronbach's alpha coefficient for this assessment was 0.89.

Employees' Harmonious Green Passion (HGP) was measured using a ten-item scale developed by Robertson and Barling (2013). An example item was "I am passionate about the environment". The Cronbach's alpha for this scale was 0.96.

Table 1 Confirmatory Factor Analysis.

	χ^2	df	χ^2/df	RMSEA	CFI	TLI	SRMR
Five-factor model (GIB, GOB, GCB, GM, HGP)	1241.88	584	2.13	0.07	0.93	0.92	0.05
Four-factor model (GIB, GOB, GCB, GM + HGP)	2692.90	591	4.56	0.12	0.77	0.76	0.09
Three-factor model (GIB, GOB + GCB, GM + HGP)	3196.95	591	5.41	0.14	0.72	0.70	0.18
Two-factor model (GIB + GOB + GCB, GM + HGP)	4333.99	593	7.31	0.17	0.59	0.57	0.21
One-factor model (GIB + GOB + GCB + GM + HGP)	5302.10	594	8.93	0.19	0.49	0.46	0.15

Control variables were also added in the survey. According to previous research, GIB may be related to the demographics of employees and leaders (e.g., Aboramadan et al., 2021; Wang et al., 2021). This study collected the employees' and leader' gender, age, marriage, years of work experience, and education level as control variables.

Data analysis. Data analysis for this study was conducted using SPSS 26.0 and Mplus 8.0 software. We adopt polynomial regression and surface analysis to investigate the inner mechanisms of green ambidextrous leadership congruence or incongruence. To mitigate the impact of multicollinearity, the independent variables were first centered before conducting polynomial regression. Subsequently, squared terms and interaction terms were calculated using the centered data to construct the following models:

$$GM = b_0 + b_1(GOB) + b_2(GCB) + b_3(GOB^2) + b_4(GCB^2) + b_5(GOB*GCB) + e$$
(1)

$$HGP = b_0 + b_1(GOB) + b_2(GCB) + b_3(GOB^2) + b_4(GCB^2) + b_5(GOB*GCB) + e$$
(2)

In Eqs. (1) and (2), GIB represents Green Innovative Behavior, GOB represents Green Opening Leadership Behavior, GCB represents Green Closing Behavior, GGM represents Green Mindfulness, HGP represents Harmonious Green Passion. By analyzing the slope and curvature of the congruent curve (GOB = GCB) and incongruent curve (GOB = −GCB), the state of the response surface was examined to analyze the differentiated effects of different combinations of leadership on employees' Green Mindfulness and Harmonious Green Passion. The comparison between congruent and incongruent combinations can be determined by the curvature of the incongruent line, which should have a significantly negative value. Testing for the "high-high" and "low-low" combinations under congruence and the two "high-low" combinations under incongruence can be conducted using the slopes of the congruent and incongruent lines. To test for mediation, the five terms in the polynomial regression were multiplied by their respective regression coefficients and summed to create composite variables. Bootstrap analysis was then used to examine the mediating effects of Green Mindfulness and Harmonious Green Passion.

Result

Validation of questionnaire and common method bias test. The internal consistency coefficients were used to assess the reliability of the main variables in this study. The analysis results indicated that the Cronbach's alpha coefficients was GIB = 0.91, GOB = 0.95, GCB = 0.84, GM = 0.85, HGP = 0.91, indicating satisfactory reliability of the variables.

Subsequently, the measurement model was tested using confirmatory factor analysis. The results are presented in Table 1. The six-factor model showed a good fit (χ^2/df = 2.13, RMSEA = 0.07, CFI = 0.93, TLI = 0.92, SRMR = 0.05), outperforming alternative models, which indicates good discriminant validity among the variables.

To mitigate the issues of multicollinearity and common method bias (CMB), this study conducted a Harman's single-factor analysis using SPSS 26.0 software on the complete data of the questionnaire variables. If the first principal component factor accounts for more than 50% of the total variance, it indicates a severe presence of method bias. The results of the analysis revealed the extraction of five factors, with the unrotated factor explaining a variance contribution of 23.10%, which is below the 50% threshold. Moreover, this value is significantly lower than the total explained variance (79.67%). These findings indicate that the common method bias in this study is not a serious concern.

Correlation analysis. Correlation analysis was conducted using SPSS 26.0 to examine the collinearity issues among the variables. Table 2 presents the means, standard deviations, and correlation coefficients of the variables, providing the basis for hypothesis testing.

Hypothesis test

Response surface analysis of green ambidextrous leadership. According to Edwards (1993, 2002), two matching measurement indicators should be measured using the same scale. To avoid multicollinearity, it is necessary to centralize the predictor variables before the analysis (Shanock et al., 2010). Then we calculate GOB^2 and GCB^2, and GOB*GCB, and then conduct hierarchical regression analysis as follows: Firstly, control variables, GOB, and GCB are included in the regression equation to test their linear relationship with the dependent variable (M1, M3). Secondly, GOB^2, GCB^2, and GOB*GCB are added to the equation to test the nonlinear relations and interaction effects (M2, M4). If the inclusion of higher-order terms results in a significant increase in R-squared or significant coefficients for the higher-order terms, it indicates a significant relationship between the predictor variable and the outcome variable. Thus, further analysis is needed to calculate the slopes and curvatures on the GOB = GCB line and the GOB = -GCB line (i.e., a1, a2, a3, a4) and test their significance. Then, we use Excel software to create a three-dimensional response surface for result interpretation. The results are as follows.

As shown in Table 3, in the results of the second-order polynomial regression, significant effects were observed. Specifically, in models M2 and M4, the adjusted R-squared values showed a significant increase. This indicates that there is a nonlinear relationship between the congruence/incongruence of green opening and closing leadership and employees' green

Table 2 Pearson Correlation Coefficient ($N = 218$).

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
L-GENDER	1.39	0.49	1.00													
L-AGE	2.57	0.73	0.03	1.00												
L-Marriage	1.24	0.48	0.08	-0.17*	1.00											
L-Working age	1.89	1.18	0.11	0.70	-0.06	1.00										
L-Education	3.70	1.05	0.41**	-0.06	0.01	0.22**	1.00									
E-GENDER	1.57	0.50	0.04	-0.01	-0.02	0.09	0.13	1.00								
E-AGE	1.76	0.75	-0.16*	0.04	-0.03	-0.03	-0.13*	-0.13	1.00							
E-Marriage	1.51	0.51	0.08	-0.00	0.02	0.09	0.20**	0.18*	-0.43**	1.00						
E-Working age	1.32	0.68	-0.11	0.05	-0.01	0.07	0.48**	-0.12	0.52**	-0.30**	1.00					
E-Education	2.74	0.79	0.26**	-0.03	0.16	0.10	0.17*	0.02	-0.27**	0.12	-0.14*	1.00				
GIB	3.24	0.93	0.04	-0.18**	0.09	-0.01	-0.00	-0.01	-0.14*	0.09	0.03	0.20**	1.00			
GOB	3.66	0.99	-0.04	0.02	-0.03	0.01	0.01	0.02	-0.04	-0.00	0.14*	0.09	0.33*	1.00		
GCB	3.23	0.99	-0.04	-0.05	-0.04	-0.01	0.05	-0.03	-0.06	-0.01	0.05	0.02	0.35*	0.33*	1.00	
GM	3.52	0.79	-0.03	-0.08	-0.00	0.02	-0.01	-0.02	-0.04	0.03	0.05	0.16*	0.52**	0.60**	0.55**	1.00
HGP	3.61	0.82	0.02	0.02	-0.05	0.04			-0.06	0.03	0.06	0.03	0.43**	0.55*	0.55**	0.60**

*Note. $N = 218$. ** $p < 0.01$, * $p < 0.05$, two-sided test.*

innovative behavior, green mindfulness, and harmonious green passion. To present the corresponding findings clearly, response surface plots were created as follows:

As shown in Fig. 2, the response surface results indicate an "arch bridge" pattern. Differences in green mindfulness under matched conditions can be assessed based on the slope (a1) and curvature (a2) of the matching curve ($X = Y$). As presented in Table 3 and Fig. 2, the curvature of the matching curve is not significant (a2 $= -0.01$, $p = 0.85$), indicating that the response surface along the matching curve closely approximates a straight line. The slope is significantly positive (a1 $= 0.65$, $p < 0.01$), suggesting that green mindfulness increases with a higher level of congruence between green opening and closing leadership (as shown in Fig. 2). In other words, employees' green mindfulness is higher when green opening and closing leadership are both high than when they are both low, supporting H1.

Differences in green mindfulness under matched and mismatched conditions can be assessed by examining the slope (a3) and curvature (a4) of the incongruent matching curve ($X = -Y$). As demonstrated in Table 3 and Fig. 2, the slope of the mismatched curve is not statistically significant (a3 $= -0.01$, $p = 0.87$), while the curvature is significantly negative (a4 $= -0.37$, $p < 0.01$). The non-significant slope suggests that the vertex of the mismatched curve is very close to the point where the matching and mismatched curves intersect. The significant negative curvature implies that the surface descends gradually to both sides from the matching curve (see Fig. 2). This result indicates that the green mindfulness exhibits larger values under matched conditions than under mismatched conditions. In other words, the level of employees' green mindfulness is higher when there is "high-high" congruence between the levels of green opening and closing leadership compared to when they are incongruent, therefore, supporting H2.

As indicated in Table 3 and Fig. 3, concerning the prediction of employees' harmonious green passion by the congruence of green opening and closing leadership, it is evident that the curvature of the matching curve is not statistically significant (a2 $= -0.01$, $p = 0.85$). However, the slope is significantly positive (a1 $= 0.70$, $p < 0.01$), indicating that the response surface approximates a straight line along the matching curve. Furthermore, harmonious green passion increases as the congruence between green opening and closing leadership intensifies. In other words, employees' harmonious green passion is higher when green opening and closing leadership are both high than when they are both low, thus supporting H4.

Whether there are differences in harmonious green passion between matched and unmatched conditions can be assessed by examining the slope and curvature of the incongruent matching curve. As shown in Table 3, the slope of the incongruent matching curve is not statistically significant (a3 $= -0.09$, $p = 0.20$), while the curvature is significantly negative (a4 $= -0.36$, $p < 0.01$). The non-significant slope indicates that the vertex of the incongruent matching curve is very close to the intersection of the matching and incongruent curves. The significant negative curvature suggests that the surface descends gradually to both sides from the matching curve, as illustrated in Fig. 3. This outcome implies that the dependent variable exhibits a higher value under matched conditions compared to unmatched conditions. In other words, the level of employees' green mindfulness is higher when there is a "high-high" congruence in the levels of green opening and closing leadership compared to when they are incongruent, supporting H5.
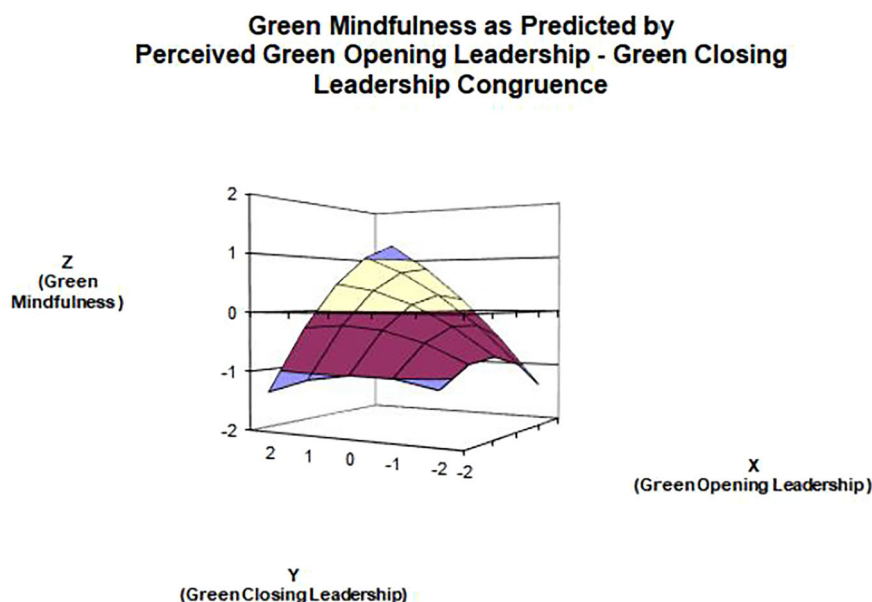
The mediating role of green mindfulness and harmonious green passion. Following the approach proposed by Edwards and Cable (2009), a block variable was calculated by summing the products

Table 3 Main effect regression analysis.

Variable	GM				HGP			
	M1		M2		M3		M4	
	B	P	B	P	B	P	B	P
Constant	0.32	0.38	0.33	0.33	0.33	0.40	0.31	0.40
L-GENDER	−0.02	0.86	0.01	0.93	0.11	0.24	0.14	0.11
L-AGE	−0.19**	0.01	−0.18**	0.01	0.00	0.99	0.02	0.80
L-Marriage	−0.02	0.86	0.00	0.98	−0.03	0.75	−0.02	0.82
L-Working age	0.10*	0.05	0.08	0.08	0.03	0.56	0.01	0.90
L-Education	−0.04	0.47	−0.06	0.17	−0.03	0.51	−0.06	0.23
E-GENDER	−0.07	0.38	−0.08	0.29	−0.07	0.43	−0.08	0.34
E-AGE	0.08	0.22	0.13*	0.04	0.00	0.97	0.04	0.54
E-Marriage	0.06	0.50	0.04	0.61	0.06	0.49	0.04	0.63
E-Working age	−0.07	0.32	−0.09	0.16	−0.01	0.88	−0.03	0.65
E-Education	0.12*	0.04	0.19***	0.00	−0.02	0.78	0.06	0.36
GOB	0.38***	0.00	**0.30*****	0.00	0.33***	0.00	**0.40*****	0.00
GCB	0.32***	0.00	**0.31*****	0.00	0.39***	0.00	**0.30*****	0.00
GOB*GOB			**−0.13*****	0.00			**−0.17*****	0.00
GOB*GCB			**0.18*****	0.00			**0.18*****	0.00
GCB*GCB			**−0.06**	0.14			**−0.01**	0.81
△R^2	0.48***		0.07***		0.49***		0.07***	
F	106.73		12.28		101.45		10.91	
Surface tests	**B**		**P**		**B**		**P**	
a1: Slope along x = y	**0.61*****		**0.00**		**0.70*****		**0.00**	
a2: Curvature on x = y	−0.01		0.85		−0.01		0.85	
a3: Slope along x = −y	0.01		0.87		0.09		0.20	
a4: Curvature on x = −y	**−0.37*****		**0.00**		**−0.36*****		**0.00**	

Bold values indicate regression coefficients and test results that are statistically significant at the corresponding **p**-value levels. N= 218. ***p < 0.001; **p < 0.01; *p < 0.05, two-sided test.

Green Mindfulness as Predicted by Perceived Green Opening Leadership - Green Closing Leadership Congruence
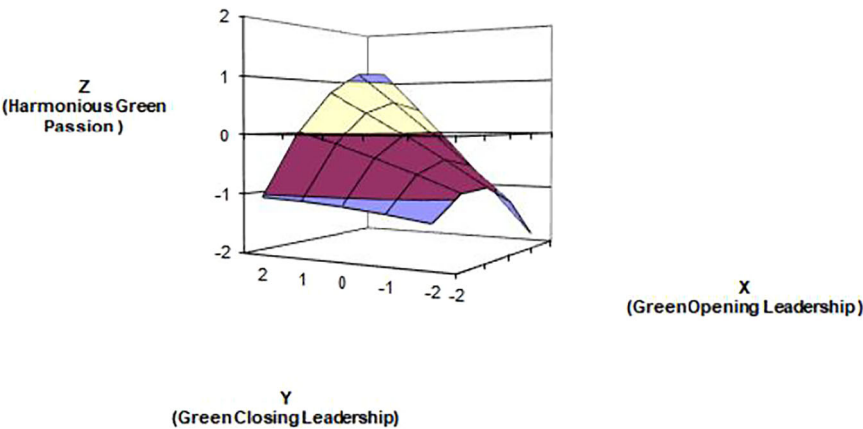
Fig. 2 Response Surface Relating GM to GOB and GM. (x axis: green opening leadership; y axis: green closing leadership; z axis: green mindfulness).

of the original values of GOB, GCB, GOB², GOB × GCB, and GCB² with the corresponding polynomial regression coefficients of the dependent variables. This block variable represents the matching of green opening and closing leadership. To test the mediation effects, a Bootstrap confidence interval approach was used. Specifically, 5000 Bootstrap samples were generated using the process module in SPSS process model 4, with a confidence interval set at 95%. If the confidence interval of the indirect effect does not include zero, the mediation effect is considered

significant. The results of the regression analysis are presented in Table 4.

As shown in Table 4, controlled with both leader and employee's gender, age, marriage, years of work experience and education level, the indirect effect of green mindfulness between the block variable of ambidextrous leadership and employees' green innovative behavior is 0.38, with a 95% confidence interval of [0.239, 0.533], which does not include zero. Hence, H3 is supported.

Fig. 3 Response Surface Relating HGP to OB and CB. (x axis: green opening leadership; y axis: green closing leadership; z axis: harmonious green passion).

Table 4 Mediation analysis regression results.				
Path	Effect	BootSE	BootLLCI	BootULCI
Direct effect (block variable -GIB)	0.26	0.11	0.043	0.470
Indirect effect (block variable -GM-GIB)	0.38	0.08	0.239	0.533
Indirect effect (block variable -HGP-GIB)	0.26	0.08	0.113	0.420
Total effect	0.63	0.09	0.455	0.812

Similarly, the indirect effect of harmonious green passion between the block variable of ambidextrous leadership and employees' green innovative behavior is 0.26, with a 95% confidence interval of [0.113, 0.420], which does not include zero. Therefore, H6 is supported.

Discussion
Drawing on the perspective of cognitive-affective processing system (Rosing et al., 2011; Mischel and Shoda, 1995), we investigated how specific green ambidextrous leadership configurations relate to employee green innovation behavior. Our findings indicate that among the configurations examined, leaders employing a congruent "high-high" configuration are most effective in fostering both green mindfulness and harmonious green passion in their employees. Further analysis suggests that the cognitive (i.e., green mindfulness) and affective (i.e., harmonious green passion) states are key psychological mechanisms through which the "high-high" leadership configuration positively associated with employee green innovation behavior. Taken together, these results suggest that leaders may achieve greater success in driving green innovation when they actively and flexibly integrate opening behaviors that support exploration and closing behaviors that support ensure structured execution. In doing so, they may effectively nurture the crucial psychological conditions necessary for sustained employee engagement in green initiatives.

Theoretical contributions. Our study offers three significant theoretical contributions. First, our research advances the understanding of leadership's influence on employee green innovation by challenging the prevailing focus on singular leadership styles. While prior studies offer valuable insights (e.g.,

Mittal and Dhar, 2016; Liu and Zhao, 2019), their narrow focus on singular leadership styles provides an incomplete theoretical picture. Such approaches fall short in explaining how leaders can effectively navigate the deeply embedded paradoxical demands inherent in sustainability initiatives. On one hand, leaders must foster creative experimentation to generate new green ideas (Cho and Yoo, 2021; Li et al., 2018). On the other hand, they must ensure these ideas are executed in a disciplined and structured manner (Chen and Chang, 2013; Ruan et al., 2022).

Moving beyond the theoretical limitations imposed by the singular leadership styles focus, our study specifically conceptualizes and empirically investigates the influence of green ambidextrous leadership on employee green innovation. Critically, our findings suggest that the congruent "high-high" configuration, where leaders demonstrate high levels of both closing leadership behaviors and opening leadership behaviors, is particularly effective in fostering the psychological precursors to employee green innovation behavior. Supplementing the literature on the relationship between singular leadership styles and employee green innovation (Mittal and Dhar, 2016; Liu and Zhao, 2019), our finding substantiates the theoretical value of an ambidextrous perspective (Rosing et al., 2011) by highlighting how managing the duality of green innovation can be effectively addressed through the skillful combination of these distinct leadership functions. In essence, this work calls for a shift in the theoretical conversation from a focus on investigating a single leadership style to an emphasis on understanding which leadership configurations create the necessary synergy for employee green innovation.

Second, our research makes a significant contribution by extending the literature on ambidextrous leadership, particularly its opening-closing behavioral dimension (Rosing et al., 2011),

into the vital yet underexplored domain of green innovation. While prior work has established the relevance of leader ambidexterity for general innovation (e.g., Alghamdi, 2018; Rosing and Zacher, 2023; Zacher et al., 2016; Zacher and Rosing, 2015), as Tho et al. (2025) confirmed, ambidextrous leadership enhances exploratory-exploitative innovation agility by integrating opening-closing behaviors, its specific manifestation in the unique context of promoting employee pro-environmental conduct remained unclear. Our study addresses this omission by not only adapting the core concepts to define green ambidextrous leadership, but more importantly, by advancing this line of inquiry via a configurational perspective. Our empirical results suggest that specific combinations of green opening and closing leadership create qualitatively distinct contexts for employees. Specifically, our findings indicate that the congruent "high-high" configuration has a significantly stronger positive association with the psychological precursors of green innovation compared to other patterns. Critically, our work moves beyond simplistic notions of "balance" to champion this more precise configurational approach. This focus provides a more granular and nuanced understanding than analyzing overall balance alone, highlighting a synergistic effect where the flexible interplay between opening and closing leadership behaviors operates effectively when leaders simultaneously deploy high levels of both.

Third, our study advances the cognitive-affective processing system framework (Mischel and Shoda, 1995) by moving it from a general theoretical framework to a specific context to explore the domain of green leadership and innovation and specifying the underlying cognitive and affective mechanisms. While the original cognitive-affective processing system framework (Mischel and Shoda, 1995) provides a powerful but abstract architecture for understanding person-situation interactions, a persistent question in the literature has been the identification of the specific cognitive and affective units that are salient in different contexts. Existing research on the impact of ambidextrous leadership on employee innovation has indeed explored certain cognitive and affective dimensions (Tho et al., 2025; Kousina and Voudouris, 2023; Usman et al., 2022). However, these studies have largely remained fragmented, and the current research perspectives, though valuable, lack comprehensiveness. Our research provides empirical support for the idea that, in the context of green innovation, green mindfulness operates as a key cognitive unit (Srivastava et al., 2024) and harmonious green passion functions as a key affective unit (Iftikhar et al., 2024). More importantly, we show how these states are linked to distinct green ambidextrous leadership configurations, which function as potent situational features, and subsequently mediate the pathway to green innovation behavior. By specifying and empirically testing this entire psychological pathway, our research offers concrete support for the processes outlined by the cognitive-affective processing system operating within the sustainability field. Moving beyond a simple application, our research leverages the context of leader ambidexterity to provide a vivid organizational instantiation of the cognitive-affective processing system framework's core logics, thus enriching the theory's own explanatory power and scope.

Practical implications. First, given the complexity and inherently dual nature of green innovation, organizations, particularly those in the hotel and tourism sector, should treat the cultivation of managers' green ambidextrous leadership as a strategic priority. This involves more than encouraging leaders to adopt a balanced view of the paradoxes embedded in green innovation; even more important is enhancing their behavioral flexibility. Through targeted training and development programs, firms can help leaders acquire an acute ability to diagnose shifting work contexts and employee states, and to move deliberately and timely between green opening leadership behaviors, such as encouraging experimentation and granting autonomy, and green "closing" leadership behaviors, such as clarifying goals and standardizing procedures. Such context-sensitive, dynamic adjustment is crucial for sustaining employees' engagement across the entire green innovation process.

Second, our findings highlight the important role of employees' green mindfulness and harmonious green passion in shaping green innovation behavior. Managers, therefore, need to look beyond behavioral outputs and actively cultivate these pivotal psychological experiences. Leaders can enhance employee green mindfulness by purposefully employing green opening leadership behaviors. Such behaviors include sharing environmental knowledge, inviting critical questioning of existing routines, and providing slack or resources for green experimentation. Meanwhile, to spark and sustain harmonious green passion, leaders should leverage the synergy between both leadership approaches. Opening behaviors can ignite intrinsic interest and a sense of purpose, while the structure and support from closing behaviors can ensure the passion is channeled toward concrete outcomes, guarding against overload or aimlessness. Attending to employees' cognitive and affective needs is thus a vital pathway to promoting employee green innovation.

Third, the impact of any single leader is necessarily constrained; maximizing the effectiveness of green ambidextrous leadership demands more support from organization. When a firm's systems, processes, and culture align with the ambidextrous signals sent by its leaders, leaders and employees may receive clear and reinforcing cues. Consequently, organizations should examine and adjust human resource practices to ensure that performance appraisals and reward systems value contributions to both green exploration and green exploitation. Moreover, cultivating a culture that embeds environmental responsibility as a core value, prizes learning from exploratory failures, and publicly celebrates green achievements will provide fertile ground for ambidextrous leadership to flourish. Under such conditions, employees are more likely to channel their mindfulness and passion toward the shared objective of sustainable organizational development.

Limitations and future research directions. While this study offers valuable insights, several limitations warrant attention and provide significant opportunities for future research. First, although we employed a multi-wave, paired questionnaire design involving leaders and employees to mitigate common method bias, our reliance on self-report data, despite mitigation efforts, means the influence of common method bias cannot be entirely precluded (Podsakoff et al., 2003). Therefore, future research should aim to enhance the robustness of our findings through more rigorous design. A primary approach for strengthening the causal inference and mitigating common method bias would be to integrate objective data rather than relying solely on self-reports. For instance, metrics such as green patent submissions or verified energy-saving records would provide more tangible evidence for the practical benefits of green ambidextrous leadership. Furthermore, adopting more sophisticated research designs is also valuable. Employing longitudinal or quasi-experimental designs would allow for a more rigorous examination of the causal pathways proposed in our research (Antonakis et al., 2010).

Second, our sample was drawn exclusively from the hospitality and tourism industry within China. This specific context, potentially characterized by relatively high external

environmental expectations and industry green certification pressures, might influence the observed strength of the relationship between green ambidextrous leadership and employee green innovation behavior. Therefore, the external validity of our findings to other settings requires further examination. For example, future research should seek to replicate and extend these findings across different industrial sectors (e.g., manufacturing, information technology) and diverse cultural or institutional contexts. At the same time, investigating the potential moderating role of key contextual variables, such as the intensity of industry environmental regulations (Cole et al., 2005) or prevailing national green norms (Razzaq et al., 2023), would be particularly valuable for understanding the boundary conditions under which green ambidextrous leadership is most impactful.

Third, on a theoretical level, our study conceptualized and investigated green ambidextrous leadership primarily through the lens of the "opening-closing" behavioral classification (Rosing et al., 2011). While this provides valuable insights, leader ambidexterity can also be conceptualized through other important theoretical dualities, such as balancing transformational and transactional approaches (Bass et al., 1996) or navigating empowering versus directive power orientations (Yukl, 2012). This opens up several promising avenues for future research. A key direction is to explore whether these alternative paradigms of green ambidextrous leadership operate through different mechanisms or under different boundary conditions. Meanwhile, future studies could compare the relative effectiveness of these models on a wider spectrum of outcomes, from employee green innovation to firm-level sustainable performance (Yan and Zhang, 2021). Moreover, integrating insights from additional theoretical perspectives, such as social information processing theory (Salancik and Pfeffer, 1978) or self-determination theory (Deci and Ryan, 1985), holds promise for further deepening our complex understanding of green ambidextrous leadership.

Conclusion. Drawing upon the cognitive-affective processing system framework and ambidextrous leadership theory, we investigated how specific configurations of leaders' green opening and green closing behaviors are associated with employee green innovation behavior. We found that leaders employing a congruent "high-high" configuration are particularly effective, simultaneously fostering employee green mindfulness (i.e., cognitive pathway) and harmonious green passion (i.e., affective pathway), which in turn mediate the positive relationship with green innovation behavior. These findings hold significant theoretical implications for advancing our understanding of effective leadership in complex sustainability contexts by highlighting the value of a configurational, ambidextrous approach over singular styles, and they offer important practical guidance for organizations aiming to nurture the important psychological conditions conducive to promoting sustained employee engagement in crucial green innovation initiatives.

Data availability
No datasets were generated or analysed during the current study.

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Author contributions

HL and SX wrote the main manuscript text. They contributed equally to this work and are co-first authors. As the corresponding author, CZH made substantial contributions during the revision process, including restructuring the introduction and theoretical framework, enhancing the empirical analysis, and revising the discussion section. HMP completed data curation and formal analysis, and SXC contributed to the investigation. CXW focused on revising the section regarding the impact of green ambidextrous leadership on employees' harmonious green passion. HL also provided funding acquisition. All authors reviewed and approved the final manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This research was conducted in accordance with the ethical principles outlined in the 1964 Declaration of Helsinki, including its subsequent amendments and other relevant ethical guidelines. It received approval from the Ethics Committee of Nanjing University of Science and Technology (NJUST) on July 20, 2022, with the approval number NJUST-20220720. The approval covered the project's research content, design, methods, and participant types, ensuring full compliance with ethical standards for studies involving human participants.

Informed consent

Informed consent was obtained in writing from all participants from August to September 2022. The consent form clearly outlined the study's purpose, the scope of data collection, and the agreement to the publication of the research results. Participants were assured that their anonymity and confidentiality would be maintained, and that the collected data would be used exclusively for research analysis and not disclosed to third parties. They were informed that participation was voluntary and that they could withdraw at any time without any consequences. As the study involved non-interventional research, participants were assured that there were no foreseeable risks associated with their participation.

Additional information

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