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# The Asymmetric Effect of Strategic Digital Games on Managers' Cognitive Biases: The Moderating Role of Gender

## ABSTRACT

Despite the growing use of digital games as cognitive intervention tools in the financial domain, evidence regarding their effects on the cognitive biases of financial managers remains inconsistent, and the moderating role of gender in this relationship remains unclear. This study aimed to examine the direct effect of engagement with strategic management-oriented digital games on cognitive biases and to investigate the moderating role of gender, using data from 321 managers and financial professionals across industries in Iran. Data were collected using a researcher-developed questionnaire to assess gaming patterns, adapted from the Game Experience Questionnaire (GEQ) and the Cognitive Absorption Experience Scale (CAES) and culturally adapted with a Content Validity Index (CVI) of 0.92 and Content Validity Ratio (CVR) values greater than 0.65, together with the standardized Cognitive Bias Questionnaire developed by Ritika and Kishore (2021). The data were analyzed using partial least squares structural equation modeling (PLS-SEM). The moderating role of gender was examined through multigroup analysis using a permutation test with 5,000 repetitions in SmartPLS 4. Analysis of the full sample showed that the direct path from gaming patterns to cognitive bias was not statistically significant ($\beta = 0.003$, $p = .967$); however, the multigroup analysis revealed an asymmetric gender pattern. Among women, engagement with these games was significantly associated with reduced cognitive bias ($\beta = -0.264$, $p = .024$), whereas no significant relationship was observed among men ($\beta = 0.125$, $p = .089$), and the difference between the coefficients for the two groups was statistically significant (difference = 0.389, $p = .004$). Moreover, in the subsidiary models, gaming had a significant positive effect on loss aversion ($\beta = 0.143$, $p = .031$), an effect observed predominantly among men. The findings indicate that the relationship between engagement with strategic digital games and cognitive biases is neither uniform nor universal but is substantially contingent on gender. Women, despite exhibiting higher baseline levels of certain biases such as loss aversion, appear to derive greater bias-reducing benefits from these tools, whereas men show no appreciable change. In addition to extending the theoretical literature on behavioral finance, this gender gap highlights the need to design gender-sensitive cognitive interventions within management development programs and financial literacy education.

**Keywords:** strategic digital games, cognitive biases, gender, multigroup analysis, behavioral finance.

## Introduction

Managerial decision-making is increasingly conducted in environments characterized by uncertainty, information overload, time pressure, strategic interdependence, and rapidly changing market conditions. Under such circumstances, managers are rarely able to process all available information through fully rational and analytically exhaustive procedures. Instead, they frequently rely on heuristics, simplified judgment strategies, prior expectations, salient cues, and affective responses. Although such cognitive shortcuts may increase decision speed, they can also systematically distort judgment and produce cognitive biases that affect investment selection, risk assessment, resource allocation, forecasting, financing, and strategic planning. In behavioral finance, these systematic deviations from normative rationality have become central to explaining why financial decision-makers may persistently depart from models based on complete information and utility maximization. Recent evidence indicates that biases such as overconfidence, loss aversion, anchoring, confirmation bias, herding, and optimism continue to shape financial judgments across different organizational and investment contexts [1, 2]. For managers, these biases are particularly consequential because individual cognitive distortions can be amplified through organizational authority, affecting not only personal investment outcomes but also corporate capital allocation, risk exposure, and long-term strategic performance.

The importance of cognitive bias in managerial finance is especially apparent when decisions involve ambiguity and risk. Managers are expected to integrate financial indicators, market information, strategic forecasts, and organizational priorities while simultaneously responding to uncertain and sometimes conflicting signals. Under these conditions, cognitive tendencies can influence how evidence is selected, weighted, and interpreted. Research in the Iranian context has similarly demonstrated that cognitive factors play a substantial role in strategic financial decision-making and that managers may be influenced by psychological mechanisms that deviate from formal rationality [3]. Chamani et al. further showed that cognitive biases are closely related to the rationality of economic decision-making under risk, reinforcing the proposition that behavioral tendencies are not peripheral anomalies but central determinants of financial judgment [4]. Moreover, distorted perceptions of financial competence may themselves become a source of bias. Inflated perceptions of financial literacy can encourage individuals to rely excessively on their own judgment, potentially weakening information search, calibration, and corrective learning [5]. These findings indicate that improving managerial decisions requires more than increasing access to financial information; it also requires mechanisms capable of modifying how decision-makers process, interpret, and respond to that information.

One of the most prominent manifestations of biased managerial judgment is excessive confidence in one's own beliefs, forecasts, or abilities. Overconfidence can cause managers to underestimate uncertainty, underweight contradictory evidence, and overestimate the precision of their predictions. Closely related patterns may arise from optimism, whereby favorable expectations lead decision-makers to assign excessive probability to desirable outcomes. Recent evidence demonstrates that managerial optimism can be economically costly when expectations become detached from realistic assessments, contributing to inefficient investment behavior [6]. Such results are important because they illustrate how cognitive tendencies that appear motivationally beneficial at moderate levels can become maladaptive when they distort investment appraisal. In similar fashion, confirmation bias may induce managers to selectively attend to evidence that supports prior assumptions while discounting disconfirming information, whereas anchoring can lead initial values or reference points to exert disproportionate influence on subsequent judgments. These biases may interact with organizational incentives, professional experience, and social information, producing complex patterns that cannot be adequately understood through purely rational financial models.

Loss aversion constitutes another particularly important cognitive mechanism in financial and managerial decision-making. Decision-makers often experience potential losses more intensely than equivalent gains, producing asymmetrical responses to risk and influencing choices involving investment, portfolio adjustment, financing, and strategic commitment. Such asymmetry can result in excessive conservatism in some circumstances and maladaptive persistence in others. Meta-analytic and comparative behavioral finance research indicates that loss aversion remains one of the most persistent behavioral biases affecting investor and financial decision-making [1]. At the same time, biases are unlikely to operate independently. Overconfidence, herding, anchoring, confirmation seeking, and loss aversion may coexist within the same individual and can be activated differently according to the structure of the decision environment. Bayesian game-based analyses have further emphasized that cognitive biases may emerge strategically when decision-makers act under uncertainty while anticipating the actions of other agents [7]. This is especially relevant to managerial finance, where decisions are often interactive rather than isolated and where competitors, investors, colleagues, and markets respond dynamically to organizational actions.

The recognition that cognitive biases are partly shaped by experience and decision environments has increased interest in interventions that can strengthen adaptive reasoning. Traditional approaches have typically relied on financial education, decision aids, structured analytic techniques, or explicit debiasing instructions. However, the growing digitalization of organizational learning has introduced game-based and gamified environments as alternative tools for developing managerial competencies. Digital games can create simulated contexts in which individuals repeatedly make decisions, receive immediate feedback, experience the consequences of choices, and adjust their strategies. Unlike conventional didactic training, strategic games provide an interactive system in which decision-making unfolds dynamically across multiple trials. This creates opportunities for experiential learning, iterative feedback, cognitive engagement, and emotional involvement. In managerial education, simulation gaming is particularly attractive because it can approximate the uncertainty, competition, resource constraints, and feedback structures found in actual organizational environments.

Research on business simulation gaming indicates that well-designed simulations may contribute to the development of future managers by strengthening cognitive realism and providing opportunities to connect decision-making processes with performance consequences [8]. Cognitive realism is especially important because the educational value of a simulation depends not only on its surface resemblance to a business environment but also on whether it reproduces the psychological and informational demands of real managerial decisions. When players must prioritize competing goals, manage limited resources, interpret incomplete information, and adapt to dynamic feedback, the simulation may exercise many of the same cognitive processes involved in professional judgment. Consequently, strategic digital games may function not merely as motivational technologies but as structured cognitive environments capable of influencing how users perceive risk, process uncertainty, respond to feedback, and revise prior beliefs.

The effectiveness of game-based environments, however, is strongly related to the quality of player engagement. Flow, immersion, and sustained cognitive involvement are among the mechanisms through which digital games may affect learning and decision performance. A meta-analysis of 87 empirical studies found that flow experience constitutes an important component of digital game-based learning, suggesting that the psychological state generated by active engagement can shape educational outcomes [9]. Flow is generally associated with focused attention, an appropriate balance between challenge and skill, clear goals, and immediate feedback. These properties are also relevant to strategic decision-making because they can encourage individuals to remain cognitively engaged with complex problems rather than relying exclusively on habitual or superficial responses. Strategic games that calibrate challenge appropriately may therefore provide repeated opportunities for users to test assumptions, recognize consequences, and refine decision strategies.

At the same time, game mechanics can influence cognition in different ways. Immediate rewards, competitive structures, progress indicators, constraints, and forced-choice mechanisms shape how players interpret options and respond to uncertainty. Research on player agency under constraint suggests that forced-choice structures can meaningfully alter the subjective experience of decision-making by limiting perceived autonomy while intensifying attention to available alternatives [10]. Such mechanisms are relevant to management-oriented games because many strategic decisions involve constrained choice sets rather than unlimited freedom. Similarly, game mechanics may affect users' psychological needs and financial attitudes, particularly when learning activities are accompanied by structured debriefing [11]. These findings imply that the effects of games are not attributable simply to "playing" as a generic activity. Rather, the cognitive consequences of gaming depend on specific features such as challenge, feedback, reward, competition, progression, agency, and post-decision reflection.

Gamified training has also received increasing attention in organizational research. Evidence suggests that gamified training may improve performance through multiple psychological pathways rather than through a single motivational effect [12]. The mechanisms involved may include engagement, perceived challenge, persistence, feedback responsiveness, and enhanced involvement with the learning task. From a managerial development perspective, this is significant because strategic digital games can expose participants to decision cycles that would be difficult, costly, or risky to reproduce in real organizational contexts. A manager can experience simulated losses, failed strategies, competitive pressures, and uncertain outcomes without exposing an actual organization to financial harm. Consequently, simulation environments may facilitate learning from errors and help users develop more adaptive responses to ambiguity.

Neuroscientific evidence provides additional support for the possibility that sustained gaming experience is associated with changes in cognitive processing. Research involving experienced gamers has identified increased neural connectivity in regions associated with visual attention and executive function, suggesting that intensive engagement with strategic games may be associated with neural adaptations relevant to complex information processing [13]. Whole-brain modeling research similarly indicates that gaming expertise is associated with meso-scale brain plasticity and neural efficiency mechanisms, providing evidence that repeated digital gaming can influence functional organization beyond simple behavioral familiarity [14]. These findings do not establish that gaming necessarily reduces cognitive biases, but they strengthen the theoretical plausibility that repeated exposure to strategic digital environments can alter attentional control, executive processing, and response regulation—processes that are directly relevant to biased judgment.

More recent neuroimaging research has specifically connected strategic decision-making in financial simulation games with neural correlates of flow, thereby linking game engagement to decision processes closely related to the financial domain [15]. This emerging evidence suggests that strategic simulations may activate cognitive systems involved in sustained attention, decision evaluation, and adaptive engagement. Such findings are particularly relevant to managerial finance because strategic financial decisions rarely depend on a single isolated judgment. Instead, managers must repeatedly revise expectations, interpret feedback, and adapt to dynamic market or organizational conditions. Digital simulations may therefore provide a cognitively rich context in which these adaptive processes are repeatedly exercised.

Nevertheless, it should not be assumed that game-based environments uniformly improve judgment. Digital games may also reproduce or even exploit cognitive biases. Research on dark design patterns in casual mobile games illustrates how interface structures and reward mechanisms can capitalize on cognitive tendencies to shape player behavior [16]. In this sense, gaming environments can function as both potential debiasing tools and potential bias-amplifying systems. Immediate rewards may strengthen short-term decision orientation, competition may increase overconfidence or social comparison, and repeated exposure to gains and losses may alter loss sensitivity. Therefore, the relationship between gaming and cognitive bias is theoretically ambiguous. The same features that promote engagement and experiential learning may, under different conditions, reinforce heuristic processing or create new biases.

This ambiguity underscores the importance of examining specific patterns of engagement rather than treating digital gaming as a homogeneous behavior. Challenge orientation, immediate reward, social competition, and level-based progression represent distinct experiential characteristics that may influence cognition differently. Challenge may stimulate analytical engagement and cognitive persistence, whereas immediate reward may heighten responsiveness to short-term outcomes. Social competition may increase attention to relative performance and possibly strengthen social comparison or herding tendencies. Progression systems may reinforce persistence but may also encourage commitment to previously selected strategies. Because these mechanisms can produce opposing effects, the aggregate relationship between strategic gaming and cognitive bias may appear weak or nonsignificant even when meaningful effects exist within specific subgroups or bias dimensions.

Decision-making style is another important contextual consideration. Individuals differ systematically in the extent to which they prefer analytical, dependent, emotional, risk-oriented, or programmed approaches to decisions. Cross-context evidence has demonstrated meaningful variation in decision-making styles and trust across professional groups, including bankers and other occupational populations [17]. Furthermore, methodological work on decision-making style analysis has emphasized that influence is not merely categorical but can vary in intensity across decision contexts [18]. These findings suggest that the impact of digital strategic games on cognitive outcomes may partly depend on how individuals normally approach decisions. A game that encourages experimentation and rapid feedback may benefit an overly rigid decision-maker differently from an individual who already relies heavily on intuitive or risk-taking styles. Even where decision-making style is not the primary moderator under investigation, its conceptual relevance illustrates why the relationship between gaming experience and cognitive bias should not be assumed to be universal.

A particularly underexplored source of heterogeneity is gender. Behavioral finance research has long suggested that men and women may differ in risk perception, confidence, sensitivity to losses, competitive orientation, and information processing, although the direction and magnitude of such differences vary across contexts. If strategic games influence cognitive biases through repeated exposure to risk, feedback, competition, and simulated loss, their effects may plausibly differ between male and female managers. For example, one group may respond to repeated simulated losses by developing greater calibration and caution, whereas another may interpret the same experience primarily through competition or performance reinforcement. Accordingly, gender may not simply predict baseline bias levels but may moderate the relationship between gaming engagement and subsequent cognitive tendencies.

Evidence from serious games also supports the broader proposition that cognitive bias can be modified through interactive digital interventions. A recent study using three-dimensional animated serious games demonstrated the feasibility of addressing cognitive biases in adolescents with neurodevelopmental disorders, suggesting that game-based interventions can target biased processing rather than merely teach factual content [19]. Although the population and clinical context differ substantially from managerial finance, the study is important because it demonstrates that cognitive bias itself can serve as an intervention target within a game-based environment. Extending this logic to management raises the possibility that strategically designed games may alter cognitive responses relevant to financial decision-making, particularly when repeated feedback allows participants to encounter and revise maladaptive patterns.

However, the empirical evaluation of these relationships requires careful methodological design. Studies examining gaming, cognition, and managerial behavior commonly rely on self-report measures, creating potential vulnerability to common method bias arising from response tendencies, item characteristics, measurement context, and shared data sources. Methodological research emphasizes that common method bias should be addressed through both procedural and statistical safeguards rather than assumed to be absent [20]. In addition, the complex relationships among latent psychological constructs require analytical techniques capable of estimating measurement properties and structural paths simultaneously. Partial least squares structural equation modeling has become widely used for prediction-oriented models and exploratory theory development, although its assumptions and interpretation require careful scrutiny [21]. For research examining gaming patterns, cognitive biases, and moderating mechanisms, rigorous assessment of construct validity, reliability, collinearity, and group differences is therefore essential.

Despite the growth of behavioral finance, serious gaming, business simulation, and gamified training research, several gaps remain. First, most studies examining digital games focus on learning performance, engagement, flow, or training outcomes rather than cognitive biases among professional managers [8, 9, 12]. Second, behavioral finance research has extensively documented cognitive biases in investment and managerial decision-making but has devoted comparatively less attention to digital experiential mechanisms that might attenuate or intensify these biases [1, 2]. Third, neuroscientific studies provide evidence that gaming expertise is associated with executive-function-related neural adaptation, but the behavioral implications of such adaptation for managerial cognitive biases remain insufficiently tested [13, 14]. Fourth, the possibility that gaming effects are asymmetric across gender groups has received little direct empirical examination in managerial and financial populations. Finally, the Iranian managerial context remains particularly underrepresented despite evidence that cognitive biases play an important role in economic and strategic financial decisions within this setting [3-5].

Accordingly, rather than assuming that strategic digital games exert a uniform beneficial or detrimental effect, it is necessary to examine whether their relationship with cognitive bias is contingent on individual characteristics and whether apparently weak aggregate effects conceal meaningful subgroup differences. This perspective is consistent with contemporary behavioral approaches that treat managerial judgment as context-dependent and interactive rather than governed by stable, universally expressed biases. It also recognizes that gaming environments can simultaneously provide cognitively demanding practice, immediate performance feedback, social comparison, constrained agency, and emotionally salient exposure to gains and losses [10, 11, 16]. These mechanisms may have different psychological consequences for different users, making moderation analysis particularly important.

Understanding such asymmetry also has practical implications for managerial development. If strategic digital games reduce certain biases among some managers but have negligible or even bias-enhancing effects among others, uniform implementation of game-based financial training may be inefficient. Organizations may instead need to design differentiated learning systems in which game mechanics, challenge levels, feedback, debriefing, and competitive structures are calibrated to participant characteristics. Such an approach would align with emerging evidence that gamified training performance depends on interacting psychological mechanisms rather than a simple direct effect of gamification [12]. It would also extend research on simulation-based managerial learning by shifting attention from performance improvement alone to the quality of the cognitive processes through which managers interpret risk and make strategic financial decisions [8].

Therefore, the aim of the present study was to examine the direct effect of engagement with strategic management-oriented digital games on managers' cognitive biases and to determine whether gender moderates this relationship among managers and financial professionals in Iran.

## Methodology

This study was conducted within a pragmatic critical realist paradigm, which assumes that cognitive biases and patterns of engagement with digital games represent phenomena that have an objective basis independent of the researcher's subjective interpretation, while acknowledging that their empirical assessment is necessarily mediated through observable indicators and contextual conditions (Bhaskar, 2016). In terms of purpose, the study was applied and developmental, and with respect to the method of data collection, it employed a descriptive-survey design with correlational and causal-comparative components (Creswell & Creswell, 2018). A cross-sectional survey strategy was adopted because of its ethical and practical feasibility, its efficiency for collecting data from a relatively large and geographically dispersed population, and its suitability for simultaneously examining direct relationships and moderating effects among latent constructs (Hair et al., 2022). The primary analytical objective was to determine whether engagement with strategic management-oriented digital games was associated with managers' cognitive biases and whether the magnitude and direction of this relationship differed according to gender.

The theoretical population consisted of professional decision-makers working in finance, investment, and risk management across Iranian industries and the capital market who routinely encounter complex information environments, uncertainty, and potentially game-like decision stimuli. The accessible population was defined according to relatively stringent professional eligibility criteria. Eligible participants included chief financial officers, chief executive officers, members of boards of directors, investment managers, risk managers, senior financial analysts, professional capital-market and cryptocurrency traders, and middle-level financial managers who were directly involved in investment or financing decisions. Participants were recruited from medium-sized and large organizations operating in major Iranian industries, including petrochemicals, automotive manufacturing, basic metals, information technology, banking and insurance, food industries, and knowledge-based start-ups. Inclusion criteria required at least three years of organizational or professional financial decision-making experience for chief executive officers and board members and at least five years of relevant experience for participants in the other occupational categories. In addition, participation was restricted to individuals who voluntarily provided informed consent to take part in the study.

Because no comprehensive sampling frame or national registry of financial managers and professional financial decision-makers was available, probability sampling from the entire theoretical population was not feasible. Accordingly, a combined non-probability sampling strategy was implemented through complementary criterion-based purposive sampling, theoretically informed snowball sampling, and venue- and event-based recruitment. This approach was intended to increase access to specialized professional groups while maintaining the predefined eligibility criteria and improving occupational and industrial heterogeneity within the sample (Palinkas et al., 2015). Criterion-based purposive sampling was initially used to identify individuals whose professional responsibilities directly involved financial, investment, or risk-related decision-making. Snowball recruitment subsequently enabled access to other qualified professionals through referrals within managerial and financial networks, while venue- and event-based recruitment was used to reach eligible participants through professional meetings, financial and managerial events, and relevant organizational settings.

The required sample size was determined using a multi-criterion approach rather than relying on a single rule of thumb. First, application of the 10-times rule based on the largest number of indicators associated with a focal construct, namely the 24 indicators used to assess cognitive bias, suggested a minimum sample of 240 participants. Second, an a priori statistical power analysis conducted using G*Power, assuming statistical power of .95, a medium effect size of ($f^2 = .15$), and five predictors, indicated a minimum sample size of 172 participants (Faul et al., 2020). Third, the minimum sample size estimation procedure proposed by Kock and Hadaya (2018), using a standard error criterion of .05, suggested a minimum of 247 cases. Consideration was also given to multigroup analysis requirements, for which approximately 100 observations per subgroup were considered necessary to obtain sufficiently stable group-specific estimates. Finally, the target recruitment size was increased to account for an anticipated questionnaire return rate of approximately 35%–45% and an expected exclusion rate of approximately 10%–15% due to incomplete, careless, duplicate, or otherwise invalid responses. On this basis, the target number of raw responses was established at approximately 350–400 cases.

The questionnaire was distributed to 680 eligible managers and financial professionals, from whom 410 raw responses were obtained. The dataset was subsequently subjected to a rigorous data-screening procedure. Twenty-four questionnaires were excluded because of substantial missing information, 22 because of evident straight-lining or random response patterns, 18 because the questionnaire had been completed in less than eight minutes, 12 because they were identified as multivariate outliers, and 13 because they represented duplicate submissions identified on the basis of Internet Protocol information. Following these exclusions, the final analytical sample consisted of 321 participants, corresponding to an effective response rate of 47.2%. This sample size exceeded the minimum requirements derived from all sample-size determination procedures and provided statistical power greater than .95 for detecting small-to-medium effects within the specified model (Hair et al., 2022). The final sample consisted of 220 men (68.5%) and 101 women (31.5%). Participants generally had substantial professional experience, with 83.4% reporting more than five years of work experience, while 72.9% held postgraduate qualifications at the master's or doctoral level. These characteristics were considered broadly consistent with the professional profile of the accessible population of managerial and financial decision-makers targeted by the study.

Data were collected using a structured questionnaire comprising measures of strategic digital gaming patterns and preferences, cognitive biases, and demographic and professional characteristics. The independent variable, gaming patterns and digital preferences, was assessed using a researcher-developed instrument consisting of 16 items distributed across four dimensions: challenge orientation, immediate reward, social competition, and level-based progression. Item development was informed by internationally established measures of digital game experience and engagement, particularly the Game Experience Questionnaire and related measures of cognitive-affective involvement in digital environments. The selected theoretical domains reflected cognitive-emotional engagement, immersion, challenge, perceived agency, cognitive realism, and dynamic decision-making characteristics that are particularly relevant to strategic and management-oriented digital games. The purpose of developing a context-specific measure was to capture forms of gaming engagement that were conceptually relevant to managerial decision-making rather than merely assessing general gaming frequency or recreational use.

Development of the researcher-made gaming-pattern instrument followed a systematic scale-development procedure consistent with established recommendations for instrument construction and validation (Boateng et al., 2018; DeVellis & Thorpe, 2022). The initial phase involved a systematic examination of the relevant literature to identify constructs associated with engagement in strategic, managerial, and decision-oriented digital games. In the subsequent phase, conceptually relevant content was adapted from established international gaming and cognitive-affective engagement measures and used to construct an initial pool of items. The items then underwent a structured translation and cultural adaptation procedure. Two independent translators with relevant expertise first translated the source material into Persian. Conceptual adaptation was then performed to ensure that the wording and scenarios reflected financial and managerial contexts familiar to professionals operating within the Iranian economy. A back-translation was subsequently conducted by a translator who had not been exposed to the original version, allowing conceptual inconsistencies between the source and adapted versions to be identified and corrected.

Content validation of the researcher-developed measure was conducted by two independent expert panels. The first panel consisted of nine university-based experts with expertise in management and research methodology, whereas the second panel consisted of nine senior financial managers with more than ten years of professional experience. The experts independently evaluated the relevance, clarity, necessity, and contextual appropriateness of the proposed items. The Content Validity Ratio (CVR) and Content Validity Index (CVI) were calculated to quantify expert agreement. Items with CVR values below .56 or CVI values below .79 were revised or removed in accordance with established content-validation criteria (Lawshe, 1975; Polit & Beck, 2006). The final instrument demonstrated an overall CVI of .92, while the CVR for every retained item exceeded .65, indicating satisfactory content validity. Responses were recorded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The internal consistency and construct reliability of the gaming-pattern measure were also examined. Cronbach's alpha coefficients for its four dimensions ranged from .67 to .72, while composite reliability coefficients ranged from .80 to .83. These coefficients were considered acceptable given the multidimensional and developmental nature of the instrument. Within the complete measurement model, standardized indicator loadings for the gaming-related constructs ranged from .626 to .760, and average variance extracted values were approximately .50–.55, providing further support for the reliability and convergent validity of the measure.

Managers' cognitive biases, representing the dependent construct, were assessed using the standardized investor-behavior questionnaire developed and validated by Ritika and Kishore (2021). The instrument contained 24 items operationalizing seven dimensions of cognitive bias relevant to financial and investment decision-making. These dimensions included loss aversion, assessed with five items; anchoring, assessed with three items; confirmation bias, assessed with five items; overconfidence, assessed with three items; the halo effect, assessed with three items; herding behavior, assessed with three items; and decision haste or impulsive decision-making, assessed with two items. Because the original measure had been designed for investment-related contexts outside Iran, it was culturally adapted to the Iranian managerial and financial environment. The substantive meaning of the original constructs was retained, while the wording and situational references were adjusted where necessary to reflect financial scenarios and decision-making conditions commonly encountered within Iranian industries and financial markets.

Psychometric evaluation was conducted for all constructs incorporated into the final model. Internal consistency was assessed using Cronbach's alpha and composite reliability. Across all dimensions, Cronbach's alpha coefficients ranged from .59 to .81, while composite reliability coefficients ranged from .76 to .92. Although several alpha coefficients were relatively modest, composite reliability values remained above the recommended threshold and were considered acceptable in conjunction with the other measurement-model criteria. Convergent validity was supported by average variance extracted values ranging from .503 to .769 and standardized factor loadings greater than .57, with most indicators exceeding .70. Discriminant validity was examined using both the Fornell–Larcker criterion and the heterotrait-monotrait ratio of correlations. All HTMT values were below .85, supporting adequate empirical distinction among the measured constructs (Hair et al., 2022; Henseler et al., 2015).

The questionnaire also contained 11 demographic and contextual items designed to characterize the respondents and support descriptive and moderation analyses. These items addressed gender, length of professional experience in finance, educational attainment, occupational position, whether the respondent engaged in digital gaming, average number of hours spent playing digital games per week, familiarity with gamified systems in the workplace, and other relevant professional and behavioral characteristics. Gender was specifically retained as the grouping variable for the multigroup analysis used to examine whether the structural relationship between strategic digital gaming engagement and cognitive biases differed between male and female respondents.

Procedural and statistical precautions were implemented to reduce the potential influence of common method bias because both the predictor and outcome variables were obtained through self-report measures within the same survey. Respondent anonymity was emphasized, and reverse-worded items were incorporated where appropriate to reduce acquiescence and consistency motives. Common method variance was subsequently examined using Harman's single-factor test. The first unrotated factor accounted for 32.4% of the total variance, substantially below the conventional 50% threshold, suggesting that a single general method factor did not dominate the covariance structure and that common method bias was unlikely to constitute a major threat to the interpretation of the results.

Data analysis was performed using partial least squares structural equation modeling (PLS-SEM) in SmartPLS 4. PLS-SEM was selected because the study had a predominantly predictive and explanatory orientation, involved simultaneous estimation of relationships among latent variables, incorporated gender-based moderation through multigroup comparisons, and did not require multivariate normality to the same extent as covariance-based structural equation modeling (Hair et al., 2022; Sarstedt et al., 2022). The analytical procedure consisted of sequential assessment of the measurement model and structural model, followed by gender-based multigroup analysis. Preliminary data screening was undertaken before estimation to identify incomplete cases, duplicate responses, implausibly short completion times, careless response patterns, and multivariate outliers. Only the 321 responses satisfying all data-quality criteria were retained for the final analysis.

The measurement model was first evaluated to determine whether the observed indicators adequately represented the latent constructs before interpreting structural relationships. Indicator reliability was assessed using standardized outer loadings, with values above .50 considered minimally acceptable and values above .70 preferred. Internal consistency reliability was examined through both Cronbach's alpha and composite reliability, with values exceeding approximately .60 and .70, respectively, regarded as acceptable depending on the developmental status of the measure. Convergent validity was evaluated using the average variance extracted, with AVE values greater than .50 indicating that a construct explained more than half of the variance in its indicators. Discriminant validity was evaluated using the Fornell–Larcker criterion and the heterotrait-monotrait ratio, with HTMT values below .85 interpreted as evidence that the constructs were empirically distinguishable (Hair et al., 2022; Henseler et al., 2015). The measurement model met these criteria, with AVE values ranging from .503 to .769 and composite reliability coefficients ranging from .76 to .92.

Potential collinearity was examined before interpreting the structural coefficients. Variance inflation factor values were calculated at the indicator and predictor levels. All VIF values ranged from 1.09 to 2.22 and therefore remained below the conservative threshold of 3.00, providing no evidence of problematic multicollinearity. This assessment was particularly important because inflated collinearity may distort estimated path coefficients and interfere with the interpretation of individual predictor effects in PLS-SEM models.

The structural model was subsequently evaluated to test the hypothesized direct relationship between strategic digital gaming patterns and cognitive biases. Statistical significance of the path coefficients was determined using a nonparametric bootstrapping procedure with 5,000 resamples and 95% confidence intervals (Hair et al., 2022). Standardized path coefficients were used to determine the direction and magnitude of the associations, while corresponding p values and bootstrapped confidence intervals were used for statistical inference. In addition to statistical significance, practical magnitude was evaluated using Cohen's ($f^2$) effect-size index, with values of approximately .02, .15, and .35 interpreted as small, medium, and large effects, respectively (Cohen, 1988). Model predictive relevance was further examined using the blindfolding procedure and Stone–Geisser's ($Q^2$) statistic, with positive ($Q^2$) values interpreted as evidence that the model possessed out-of-sample predictive relevance for the endogenous constructs (Sarstedt et al., 2022; Shmueli et al., 2019).

Approximate overall model fit was examined using several complementary indices. The standardized root mean square residual was .068, which was below the commonly recommended threshold of .08 and therefore indicated an acceptable discrepancy between the observed and model-implied correlation matrices. The normed fit index was .91, exceeding the conventional criterion of .90. The global goodness-of-fit index was .38, which was interpreted as reflecting moderate-to-strong overall fit according to the criterion applied in the study. Because global fit indices have a more limited role in variance-based SEM than in covariance-based SEM, these indices were interpreted as supplementary diagnostics rather than as the principal basis for model acceptance; emphasis was placed primarily on measurement quality, explained variance, effect sizes, predictive relevance, and the statistical significance of the structural paths.

The moderating role of gender was examined through PLS multigroup analysis by comparing the structural path coefficients obtained for the male and female subsamples. The final dataset comprised 220 men and 101 women, providing more than 100 observations in each group and therefore permitting stable group-specific estimation. A permutation-based multigroup procedure with 5,000 permutations was used to test whether the path coefficient linking strategic digital gaming patterns to cognitive bias differed significantly between the two gender groups. The permutation approach was selected because it is well suited to comparisons involving unequal group sizes and does not rely on the stringent assumptions of multivariate normality and homogeneity of variances required by conventional parametric comparison procedures. Statistical significance was assessed on the basis of the empirical permutation distribution of between-group differences in path coefficients. This procedure made it possible to determine not only whether the direct relationship was significant within each gender group but also whether the magnitude and direction of the relationship differed significantly between men and women. The same analytical logic was applied in supplementary models examining individual dimensions of cognitive bias, including loss aversion, in order to identify whether gender-specific patterns were concentrated in particular forms of managerial cognitive bias.

## Findings and Results

The final sample consisted of 321 managers and financial professionals, including 220 men (68.5%) and 101 women (31.5%). In terms of work experience in the financial field, the majority of participants had substantial professional experience: 14.6% had between 5 and 10 years of experience, 38.3% had between 10 and 20 years, and 35.8% had more than 20 years of experience, whereas only 11.2% had less than 5 years of experience. Educational attainment was predominantly at the postgraduate level, with 45.2% holding a master's degree and 27.7% holding a doctoral degree. Regarding occupational position, chief executive officers (41.4%) and board members (24.9%) represented the most frequent occupational groups.

Findings related to gaming behavior indicated that 86.0% of the managers in the sample engaged in digital gaming; however, the amount of time devoted to this activity was generally limited. Specifically, 43.0% played for less than 1 hour per week, while 33.3% played between 1 and 5 hours per week. The mean score for gaming patterns and preferences was 3.90 out of 5 (SD = 0.53). The overall mean score for cognitive biases was 2.81 out of 5 (SD = 0.66). Among the seven dimensions of cognitive bias, loss aversion had the highest mean score (M = 3.06), which was substantially higher than the reported global average of approximately 2.25 and was consistent with the findings of Chamani et al. (2024), who estimated the loss-aversion coefficient (λ) in Iran at approximately 3.2.

**Table 1**

*Frequency Distribution of Sample Demographic Characteristics*

| Variable | Subgroup | Frequency | Percentage |
|---|---|---|---|
| Gender | Men | 220 | 68.5 |
| | Women | 101 | 31.5 |
| Work experience | Less than 5 years | 36 | 11.2 |
| | 5–10 years | 47 | 14.6 |
| | 10–20 years | 123 | 38.3 |
| | More than 20 years | 115 | 35.8 |
| Education | Diploma and associate degree | 11 | 3.4 |
| | Bachelor's degree | 76 | 23.7 |
| | Master's degree | 145 | 45.2 |
| | Doctoral degree | 89 | 27.7 |
| Digital gaming | Yes | 276 | 86.0 |
| | No | 45 | 14.0 |

Skewness and kurtosis values for all variables fell within the acceptable range of −1 to +2, indicating that the data were suitable for advanced PLS-SEM analyses.

To evaluate convergent validity and collinearity, confirmatory factor analysis was performed. The results presented in Table 2 showed that all standardized factor loadings were statistically significant at a high level ($p < .001$), while variance inflation factor (VIF) values for all indicators ranged from 1.09 to 2.22, indicating the absence of problematic collinearity within the model.

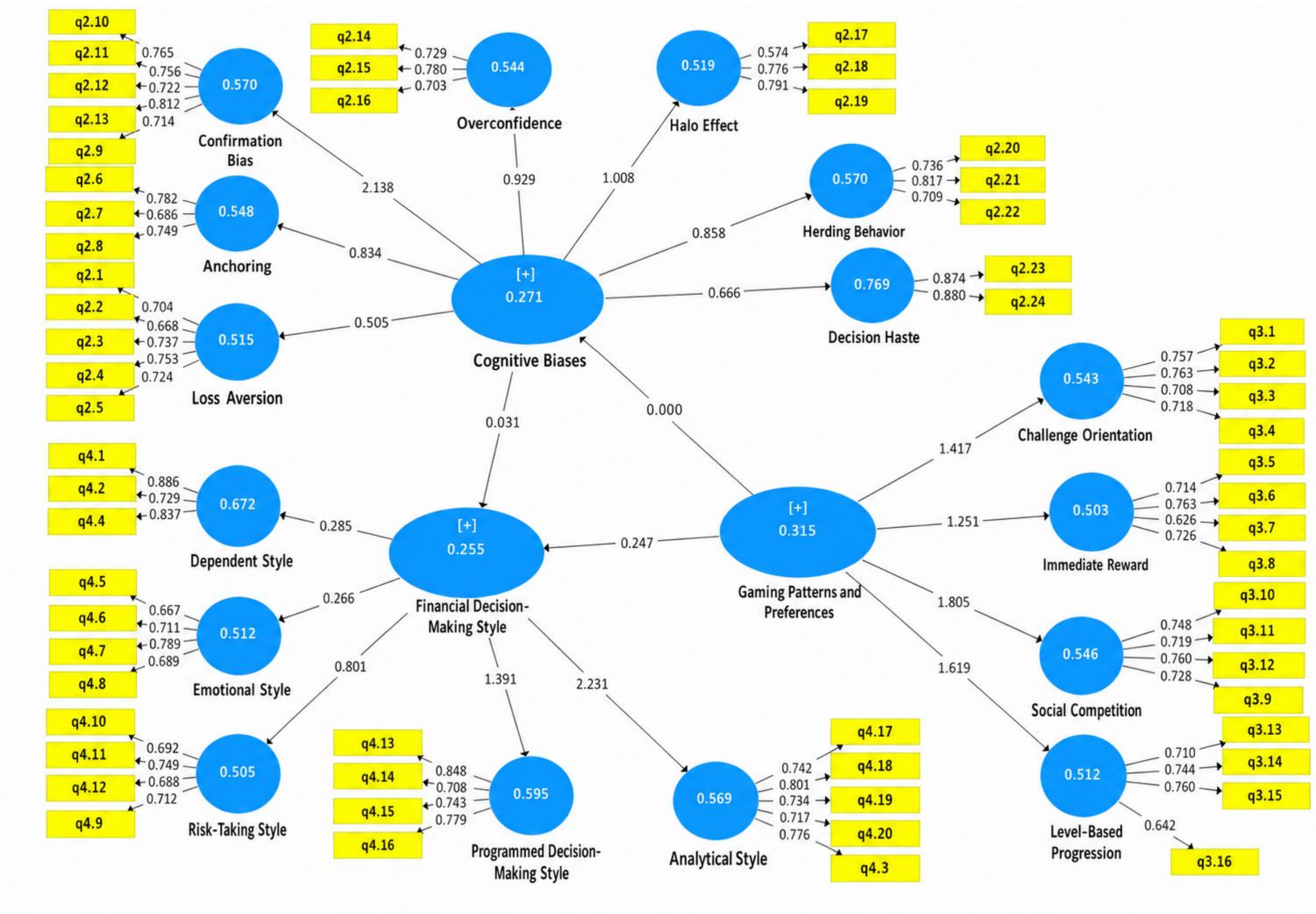
**Table 2**

*Summary of Confirmatory Factor Analysis*

| Construct | Range of Standardized Factor Loadings | VIF Range | Status |
|---|---|---|---|
| Gaming patterns and preferences | .626–.760 | 1.22–1.43 | Supported |
| Cognitive bias (overall) | .574–.874 | 1.09–1.77 | Supported |

**Figure 1**

*Initial Measurement Model*




**Convergent validity and reliability:** As shown in Table 3, standardized factor loadings for all indicators exceeded .50, with most exceeding .70, and were statistically significant at $p < .001$. Cronbach's alpha coefficients ranged from .59 to .81. Composite reliability (CR) coefficients for all constructs ranged from .76 to .92 and therefore exceeded the recommended threshold of .70. In addition, average variance extracted (AVE) values for all constructs were greater than .50, indicating acceptable to good convergent validity.

**Table 3**

*Reliability and Convergent Validity Indices*

| Construct | Cronbach's Alpha | Composite Reliability (CR) | AVE | Factor Loading Range |
|---|---|---|---|---|
| Gaming patterns and preferences | .67–.72 | .80–.83 | .50–.55 | .626–.760 |
| Cognitive bias (overall) | .59–.77 | .76–.84 | .52–.57 | .574–.874 |

**Discriminant validity:** Discriminant validity was assessed using the heterotrait-monotrait ratio of correlations (HTMT). The results indicated that all HTMT values for construct pairs were below the threshold of .85 (Henseler et al., 2015). HTMT values ranged from .08 to .79, clearly indicating satisfactory discriminant validity and adequate empirical distinction among the conceptual constructs.

Following confirmation of the quality of the measurement model, the structural model was evaluated to test the research hypotheses. Path coefficients were estimated using a bootstrapping procedure with 5,000 resamples, and the results are summarized in Table 4.

**Table 4**

*Results of Direct and Moderating Hypothesis Tests for the Structural Paths*

| Hypothesis | Path | Standardized Coefficient (β) | SD | t | p | Test Method | Result |
|---|---|---|---|---|---|---|---|
| H1 | Gaming → Cognitive bias | .003 | .065 | .041 | .967 | Bootstrapping, 5,000 resamples | Rejected |
| H2 | Gender moderation of Gaming → Cognitive bias | Difference = .389 | — | — | .004 | Permutation test, 5,000 permutations | Supported |

As shown in Table 4 and Figures 2 and 3, Hypothesis H1, which proposed a direct effect of gaming on cognitive biases in the total sample, was rejected. The coefficient of determination ($R^2$) for cognitive bias was .000, indicating that gaming patterns explained virtually none of the variance in cognitive bias in the total sample.

**Figure 2**

*Structural Model Showing Path Coefficients and t Statistics*

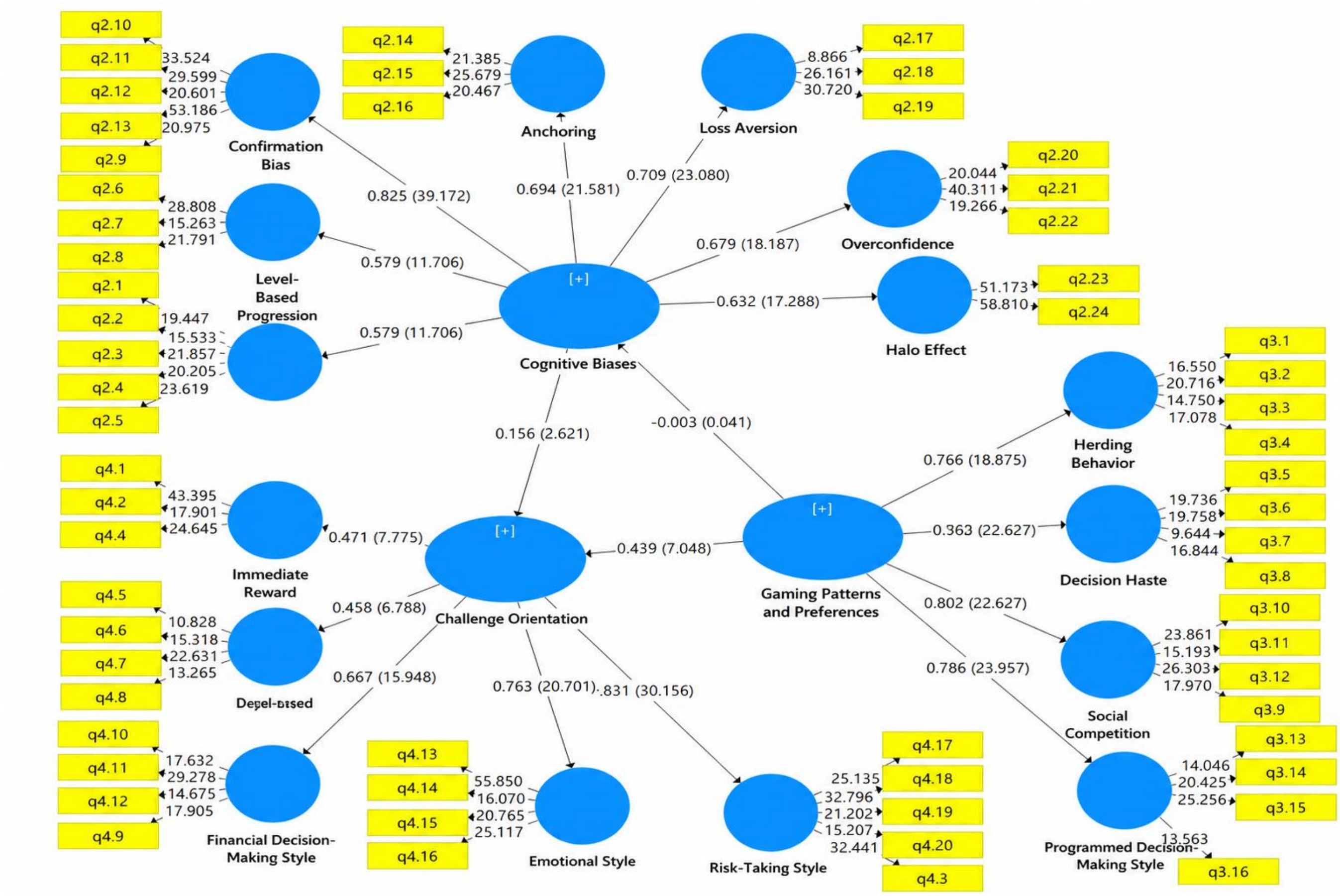
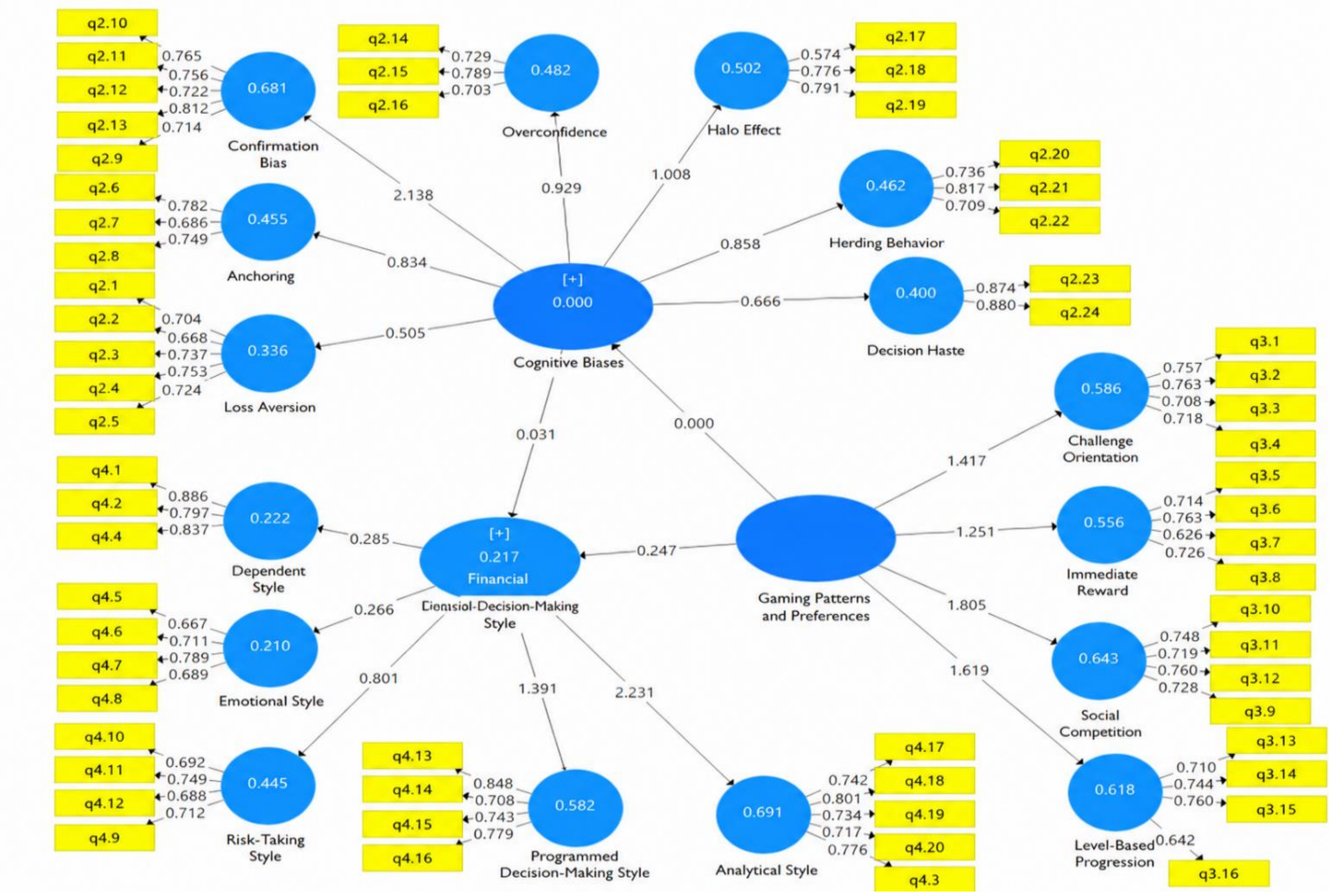


Figure 2 presents the structural model, including the path coefficient and corresponding t statistic for the total sample. The path from gaming patterns to cognitive bias was not statistically significant, with β = .003 and t = .041, which was below the critical value of 1.96 (p = .967). This result indicates that, in the total sample, the direct effect of gaming patterns on cognitive bias was not statistically significant.

**Figure 3**

*Structural Model Showing Coefficients of Determination Within the Endogenous Construct and Cohen's Effect Sizes on the Structural Paths*




To examine the asymmetric moderating effect of gender on the relationship between gaming and cognitive bias, the sample was divided into men (n = 220) and women (n = 101), and the structural model was estimated separately for each group. The results of the multigroup analysis (MGA), conducted using a permutation test with 5,000 permutations, are reported in Table 5.

**Figure 4**

*Structural Model Showing Path Coefficients and t Statistics for the Male Group*

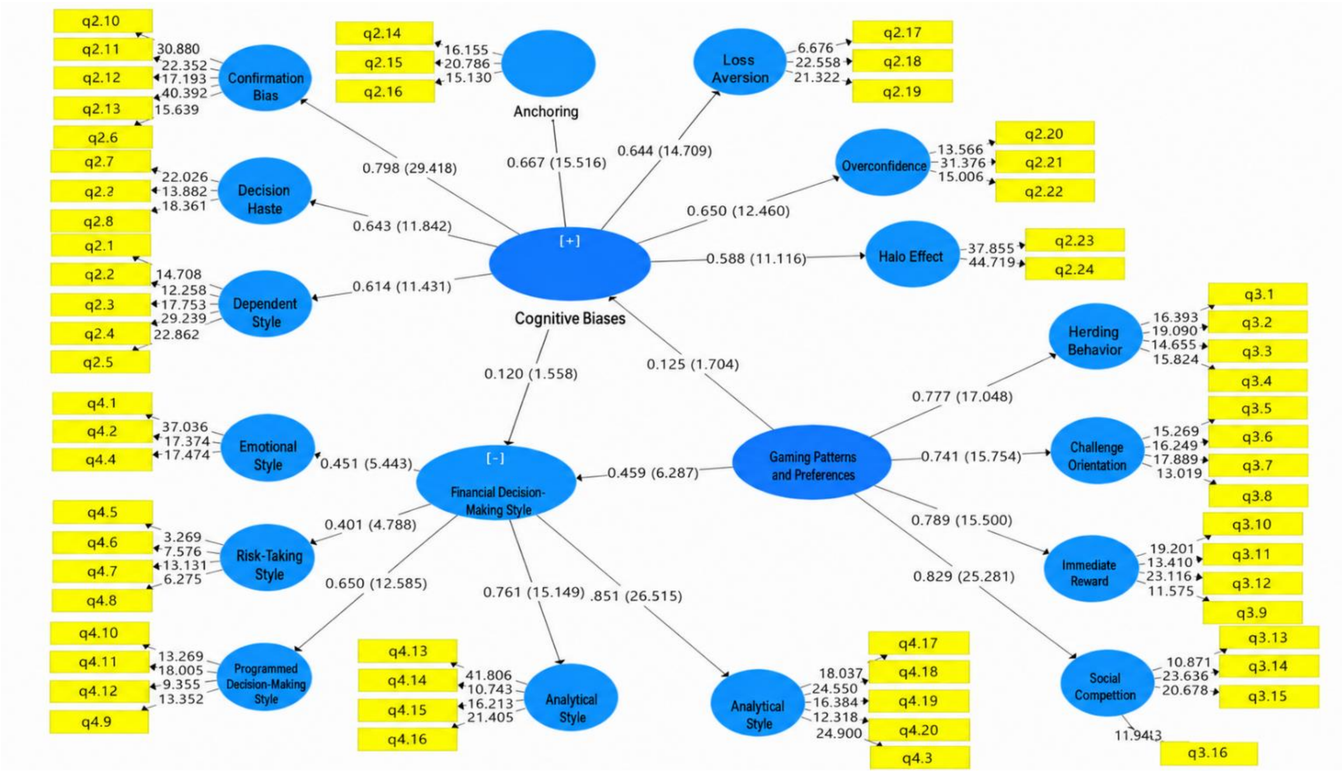
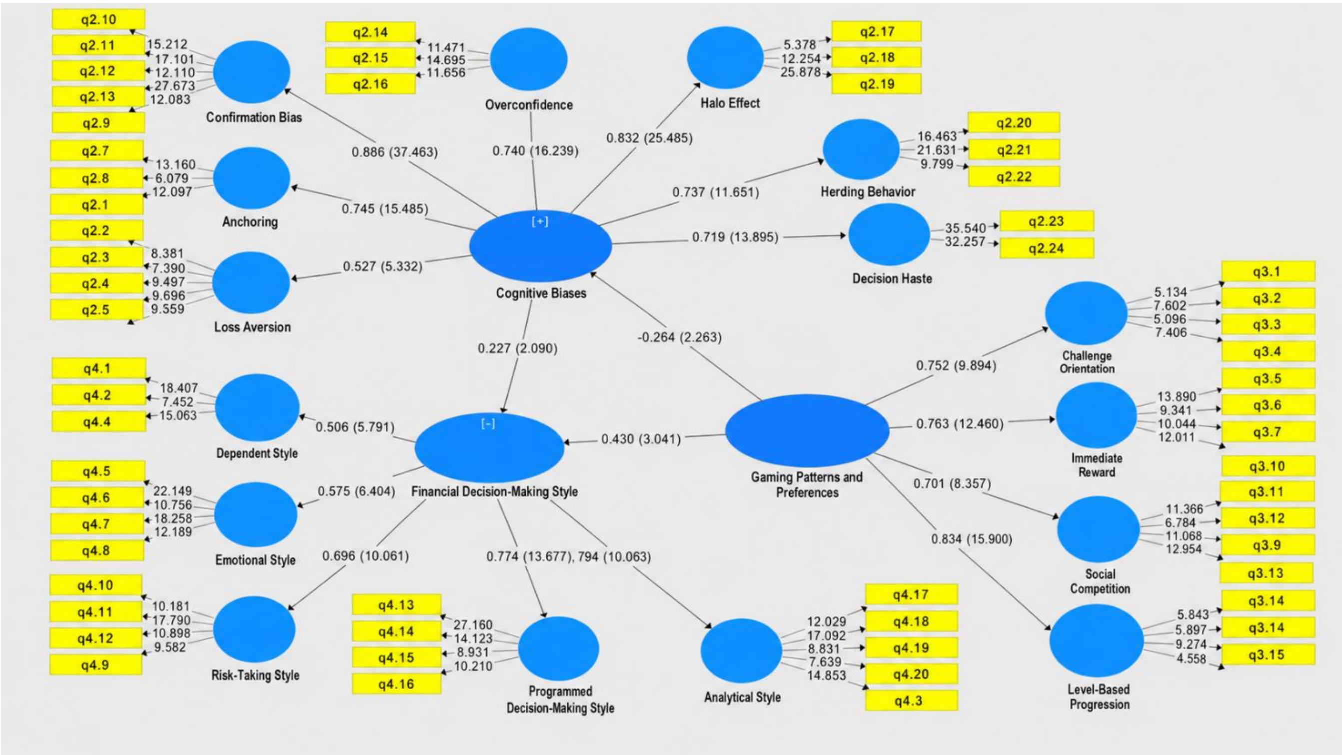



**Figure 5**

*Structural Model Showing Path Coefficients and t Statistics for the Female Group*




Figures 4 and 5 present the structural models separately for men and women. In the male group, the path from gaming patterns to cognitive bias was positive but statistically nonsignificant, with β = .125 and t = 1.704, which was below the critical value of 1.96 ($p = .089$). In contrast, among women, the same path was negative and statistically significant, with $\beta = -.264$ and $t = 2.263$, which exceeded the critical value of 1.96 ($p = .024$). This marked difference indicates that women experience a greater reduction in cognitive bias for each unit increase in engagement with strategic digital games than men, a finding that is consistent with documented gender differences in risk processing and loss aversion (Dawson, 2023; Rahnama Rudposhti & Zandi, 2021).

**Table 5**

*Results of Multigroup Analysis for the Moderating Role of Gender*

| Path | Men (β / p) | Women (β / p) | Difference Between Coefficients | p for Between-Group Comparison | Moderating Effect Size ($f^2$) | Test Method | Result |
|---|---|---|---|---|---|---|---|
| Gaming → Cognitive bias | .125 / .089 | −.264 / .024 | .389 | .004 | Small (.045) | Permutation test, 5,000 permutations | Supported |

To test the moderating role of gender, the structural model was estimated separately for the male ($n = 220$) and female ($n = 101$) subgroups. Subsequently, a permutation test with 5,000 permutations was used to generate the empirical distribution of the between-group difference in path coefficients under the null hypothesis of no difference between the groups. The coefficient difference of .389 was obtained by subtracting the female path coefficient from the male path coefficient [$.125 - (-.264) = .389$]. The resulting p value of .004 indicates that the between-group difference was statistically significant. Therefore, gender played a statistically significant moderating role in the relationship between gaming patterns and cognitive bias.

The findings presented in Table 5 and Figures 4 and 5 reveal a clearly asymmetric pattern.

In the male group (Figure 4), the relationship between engagement with digital games and cognitive biases was positive but statistically nonsignificant ($\beta = .125$, $t = 1.704$, $p = .089$).

In the female group (Figure 5), the same relationship was negative and statistically significant ($\beta = -.264$, $t = 2.263$, $p = .024$). The magnitude of this effect was considered small to moderate ($f^2 \approx .04$).

The permutation test with 5,000 permutations demonstrated that the difference between the coefficients of the two groups was statistically significant (difference = .389, $p = .004$). Accordingly, the main research hypothesis (H2), proposing a moderating role of gender, was strongly supported.

To obtain a more detailed understanding of the relationships between the underlying dimensions of the constructs, supplementary submodels were also estimated. The most important findings from these analyses are summarized in Table 6.

**Table 6**

*Summary of Results From the Supplementary Models: Effects of Gaming Patterns on Cognitive Bias Dimensions*

| Path Examined | β | t | p | Interpretation |
|---|---|---|---|---|
| Gaming patterns → Loss aversion | .143 | 2.158 | .027 | Strategic games may increase short-term sensitivity to losses by repeatedly exposing players to loss-related outcomes. |
| Gaming patterns → Overconfidence | .116 | 1.763 | .079 | The effect of gaming on overconfidence approached statistical significance but requires further investigation. |
| Gaming patterns → Herding behavior | .003 | .035 | .972 | Gaming patterns had no statistically significant effect on herding behavior. |
| Gaming patterns → Anchoring | .000 | .004 | .996 | Gaming patterns had no statistically significant effect on anchoring bias. |
| Gaming patterns → Confirmation bias | .083 | .923 | .356 | The effect of gaming patterns on confirmation bias was not statistically significant. |
| Gaming patterns → Halo effect | .025 | .251 | .802 | The effect of gaming patterns on the halo effect was not statistically significant. |
| Gaming patterns → Decision haste | .031 | .397 | .691 | The effect of gaming patterns on decision haste was not statistically significant. |

The findings from the supplementary models indicate that only the effect of gaming patterns on loss aversion was statistically significant (β = .143, p = .027). This finding suggests that strategic digital games may increase short-term sensitivity to risk and potential losses, an interpretation that is also consistent with the concept of response inhibition in the neuroscience literature (Bavelier et al., 2020; Coronel-Oliveros et al., 2024).

However, none of the other dimensions of cognitive bias, including overconfidence, anchoring, confirmation bias, herding behavior, the halo effect, and decision haste, were directly and significantly influenced by gaming patterns.

## Discussion and Conclusion

The present study investigated the relationship between engagement with strategic management-oriented digital games and cognitive biases among managers and financial professionals, with particular attention to the moderating role of gender. The findings revealed a notably asymmetric pattern. At the aggregate level, gaming patterns and preferences had virtually no direct relationship with overall cognitive bias (β = .003, t = .041, p = .967), and the explained variance in cognitive bias was effectively zero. Therefore, the first hypothesis proposing a direct effect of strategic digital gaming engagement on managers' cognitive biases was not supported. However, this null result concealed substantial heterogeneity between male and female participants. Among men, the relationship between gaming engagement and cognitive bias was positive but nonsignificant (β = .125, t = 1.704, p = .089), whereas among women, the relationship was negative and statistically significant (β = −.264, t = 2.263, p = .024). The difference between the two coefficients was statistically significant (difference = .389, p = .004), confirming gender as a meaningful moderator. Supplementary analyses further showed that gaming patterns were positively associated with loss aversion (β = .143, t = 2.158, p = .027), whereas their relationships with overconfidence, anchoring, confirmation bias, herding behavior, the halo effect, and decision haste were not statistically significant.

The absence of a significant direct relationship in the total sample is theoretically important because it challenges the assumption that strategic digital gaming produces uniform cognitive benefits among managerial decision-makers. Research on game-based learning has demonstrated that games can generate high levels of engagement, flow, cognitive involvement, and experiential learning, but these processes do not necessarily translate into identical cognitive outcomes across all users [9]. Similarly, research on business simulation gaming indicates that cognitive realism and decision-making experience may enhance managerial development, but the impact of simulation depends on how individuals interact with and cognitively process the simulated environment [8]. Thus, strategic games should not be conceptualized as intrinsically debiasing interventions. Rather, their effects appear to depend on the characteristics of the participant, the mechanics of the game, and the particular cognitive process under consideration.

The null aggregate effect is also consistent with the broader behavioral-finance literature, which conceptualizes cognitive biases as relatively heterogeneous and context-dependent tendencies rather than as a single unified psychological deficiency. Managers and investors may simultaneously exhibit loss aversion, overconfidence, anchoring, confirmation bias, herding, and other judgment tendencies, but the strength and direction of these biases vary according to decision context and individual characteristics [1, 2]. Consequently, an intervention that weakens one cognitive bias may leave another unchanged or may even strengthen a different bias. This interpretation is supported by the supplementary results of the present study, in which gaming engagement was significantly related to loss aversion but showed no significant association with most other bias dimensions. The lack of an aggregate effect may therefore reflect the cancellation of different underlying responses rather than the complete absence of cognitive consequences.

This interpretation is particularly plausible in light of evidence showing that digital games contain psychological mechanisms capable of producing both adaptive and maladaptive effects. Strategic games frequently combine immediate feedback, constrained choices, competition, rewards, repeated losses, progression systems, and uncertain outcomes. These mechanisms can encourage cognitive flexibility and learning, but they can also activate or reinforce pre-existing heuristics. Research on dark design patterns has demonstrated that gaming systems can deliberately or inadvertently exploit users' cognitive biases, illustrating that digital environments are not inherently cognitively corrective [16]. Similarly, research on player agency under constrained choice conditions indicates that the structure of available options itself can alter how decisions are experienced and processed [10]. Therefore, the absence of a universal debiasing effect in the present study is compatible with the view that the cognitive impact of games depends on the interaction between game mechanics and player characteristics.

The most important finding was the significant moderating role of gender. Among women, greater engagement with strategic digital games was associated with lower overall cognitive bias, whereas no statistically significant effect was detected among men. This finding suggests that the same digital strategic environment may produce different cognitive consequences across gender groups. One explanation concerns differential responses to uncertainty, competitive feedback, simulated losses, and decision consequences. Strategic games repeatedly require players to revise choices in response to feedback and to learn from unsuccessful strategies. If female participants engage more cautiously with risk-related feedback or assign greater informational value to adverse outcomes, repeated exposure may facilitate calibration and weaken reliance on automatic cognitive responses. In this interpretation, gaming becomes a form of experiential debiasing because it repeatedly confronts decision-makers with the consequences of inaccurate judgments.

The result is also compatible with behavioral-finance research demonstrating meaningful variation in bias-related financial decision-making across individuals and contexts. Cognitive biases play an important role in the rationality of economic decisions under risk, and their effects can vary according to psychological and situational characteristics [4]. Similarly, managerial financial decisions in the Iranian context have been shown to be influenced by multiple cognitive factors, emphasizing that professional expertise alone does not eliminate psychologically driven distortions [3]. The present study extends this literature by suggesting that exposure to strategic digital environments may interact with individual characteristics to alter these biases rather than exerting a simple direct effect.

The observed gender asymmetry may also be interpreted through the framework of decision-making styles. Decision makers differ in their reliance on analytical reasoning, dependence on others, emotional responses, programmed decision procedures, and willingness to accept risk. Research has demonstrated systematic variation in decision-making styles and trust across professional groups, including populations engaged in financial decisions [17]. Furthermore, decision-making style should not be viewed as merely categorical because the intensity of different influences can vary considerably across contexts [18]. Accordingly, male and female managers may engage with the same strategic game mechanics through different decision-processing tendencies. If the female participants used feedback more analytically or engaged more intensively in corrective learning, strategic game experience could reduce cognitive distortions even if the same exposure produced little change among male participants.

The finding for women is also consistent with the broader proposition that serious games can be used to modify biased cognitive processing. Research using three-dimensional animated serious games has demonstrated that cognitive biases can be deliberately targeted and modified through interactive digital interventions [19]. Although that study involved a different population and application context, it provides evidence for the fundamental mechanism underlying the present result: repeated interaction with structured game environments can potentially alter how individuals interpret information and respond to cognitively challenging situations. The current findings extend this possibility to managerial and financial decision-making, while simultaneously showing that such effects should not be assumed to occur equally across all participants.

Neuroscientific research provides another plausible explanation for the observed association. Strategic gaming has been linked with neural adaptations in regions involved in visual attention, executive functioning, cognitive control, and efficient information processing [13]. Whole-brain modeling has likewise shown that gaming expertise is associated with meso-scale brain plasticity and efficiency mechanisms, suggesting that repeated gaming experience can influence the neural organization underlying complex cognition [14]. More specifically, research on financial simulation games has identified neural correlates of flow during strategic decision-making, connecting intensive game engagement with attention and decision-processing mechanisms directly relevant to financial judgment [15]. These studies do not establish that gaming directly eliminates managerial biases, but they provide biological plausibility for the idea that repeated strategic gaming may modify cognitive processes involved in attention, monitoring, inhibition, and adaptive response selection.

The fact that this apparent bias-reducing relationship emerged only among women suggests, however, that neural or cognitive adaptation alone cannot fully explain the results. Game-related cognitive effects are probably moderated by motivational engagement, perceived competence, responsiveness to feedback, and the meaning assigned to game outcomes. Gamified training research indicates that performance improvements operate through multiple psychological pathways and depend on moderating conditions rather than arising from exposure to gamification alone [12]. Similarly, the effects of game-based learning on financial attitudes and psychological needs depend on specific mechanics and the incorporation of debriefing and reflective processes [11]. The present gender-specific pattern may therefore reflect differences in how participants engage with game feedback and translate simulated experiences into cognitive adjustment.

The nonsignificant positive relationship observed among men also deserves attention. Although the coefficient did not reach statistical significance, its direction was opposite to that observed among women. This pattern suggests that gaming should not automatically be interpreted as cognitively protective for male managers. Competitive game environments may reinforce confidence, performance orientation, and rapid response tendencies in some players. If repeated success strengthens beliefs in one's own judgment, gaming could potentially preserve or even intensify certain cognitive tendencies rather than reduce them. This interpretation is particularly relevant to overconfidence, given evidence that overly favorable managerial expectations can contribute to inefficient investment decisions [6]. Moreover, inflated perceptions of financial competence have been associated with financial decision-making problems, suggesting that subjective confidence may diverge from actual decision quality [5]. Thus, strategic games that strongly emphasize competition or achievement could theoretically produce different effects depending on whether players interpret performance feedback as corrective information or as confirmation of their competence.

The supplementary finding concerning loss aversion further illustrates the complexity of game-related cognitive effects. Strategic gaming was positively associated with loss aversion, indicating that greater engagement corresponded to increased sensitivity to potential losses. Although this might initially appear inconsistent with the possibility of debiasing, the result can be understood as increased vigilance toward negative outcomes. Strategic games repeatedly expose players to failure, resource depletion, lost opportunities, and the consequences of erroneous decisions. Such repeated experience may heighten the salience of losses and increase attention to adverse outcomes. Behavioral-finance studies have consistently identified loss aversion as a central determinant of financial decision-making under risk [1, 4]. The present results suggest that strategic gaming may not simply suppress this mechanism; instead, it may increase awareness of potential losses while simultaneously affecting broader cognitive regulation differently across groups.

This heightened loss sensitivity may also reflect response-monitoring and inhibitory processes developed through repeated strategic gameplay. Strategic games frequently punish impulsive choices and require players to delay action, monitor evolving conditions, and inhibit responses that have previously produced unfavorable outcomes. Evidence concerning gaming expertise and neural efficiency supports the proposition that repeated game engagement can strengthen cognitive-control mechanisms [14]. Such adaptation could make negative outcomes more behaviorally salient without necessarily producing maladaptive avoidance. Accordingly, the positive association with loss aversion should not automatically be interpreted as detrimental; in professional financial settings, greater sensitivity to downside risk may sometimes promote prudent decision-making, although excessive loss aversion can also discourage potentially beneficial investments.

The absence of significant effects on anchoring, confirmation bias, herding behavior, the halo effect, and decision haste suggests that these biases may be more resistant to incidental gaming experience and may require explicitly designed debiasing mechanisms. General engagement with strategic games may provide practice in problem solving, feedback utilization, and risk management, but it does not necessarily force users to identify their own anchoring points, seek disconfirming evidence, resist social influence, or reconsider first impressions. This distinction is consistent with research showing that cognitive bias can be modified through serious games when the intervention specifically targets biased processing [19]. It also suggests that future managerial games should incorporate explicit cognitive challenges if debiasing is the intended training outcome.

The findings additionally support a more nuanced conceptualization of gamification in managerial development. Business simulation games have demonstrated value for strengthening managerial learning by connecting cognitive realism, decision-making, and performance [8], and flow has been identified as an important mechanism in digital game-based learning [9]. However, the present study indicates that engagement alone should not be equated with universally improved cognition. Game environments may produce different outcomes across users, and the same game mechanics may reduce some biases while increasing sensitivity to others. Bayesian perspectives further suggest that cognitive biases emerge in interactive strategic settings where individuals form beliefs about uncertain outcomes and the behavior of other agents [7]. Strategic digital games reproduce precisely these interactive conditions, which may explain why their effects are multidimensional rather than uniformly corrective.

From a theoretical standpoint, the findings contribute to behavioral finance by linking cognitive bias research with digital game-based managerial development. Existing research has largely examined the existence and consequences of cognitive biases in financial decision-making [1, 2], whereas gaming research has concentrated more strongly on engagement, learning, simulation performance, and flow [8, 9]. The present findings connect these literatures by demonstrating that strategic gaming may be associated with cognitive bias, but that this association is conditional rather than universal. The significant gender moderation further demonstrates why aggregate estimates can be misleading: an almost exactly zero coefficient in the total sample concealed a meaningful negative association among women and a nonsignificant positive association among men. This pattern highlights the importance of examining heterogeneity in behavioral-finance models rather than assuming that average effects adequately represent all managerial subgroups.

The results should also be interpreted within the methodological context of latent-variable modeling. Because cognitive bias and gaming engagement are multidimensional constructs measured through self-report indicators, careful attention to measurement quality and method effects is essential. Contemporary methodological research emphasizes that common method bias can arise from numerous features of the measurement process and should be addressed using both procedural and statistical safeguards [20]. Furthermore, although PLS-SEM is useful for prediction-oriented and exploratory structural models, its estimates require cautious interpretation and should not be treated as automatically establishing causality [21]. Therefore, the present findings are most appropriately viewed as evidence of statistically differentiated relationships that provide a basis for stronger longitudinal and experimental tests.

Several limitations should be considered when interpreting the findings. First, the cross-sectional design does not permit firm causal conclusions regarding whether strategic gaming changes cognitive biases or whether individuals with particular cognitive profiles are more likely to engage with certain types of games. Second, the study relied primarily on self-report instruments, and participants' reported gaming engagement and cognitive tendencies may differ from their actual behavior in real financial decisions. Third, the sample was obtained using non-probability recruitment procedures and was limited to managers and financial professionals in Iran; therefore, generalization to other national, cultural, occupational, or institutional contexts should be approached cautiously. Fourth, the gender groups were unequal in size, with considerably more male than female participants, although the analytical approach was selected to accommodate this imbalance. Fifth, the study examined broad patterns of strategic digital gaming rather than specific commercial or simulation games, and differences in game genre, difficulty, reward schedules, competitive structure, and duration of exposure may produce different cognitive effects. Finally, potentially important variables such as age, personality, gaming expertise, organizational level, financial literacy, risk tolerance, and actual decision performance were not modeled as additional moderators or mediators.

Future studies should employ longitudinal and experimental designs in which managers are randomly assigned to clearly specified strategic game interventions and control conditions, with cognitive biases measured before training, immediately afterward, and at follow-up intervals. Such designs would provide stronger evidence concerning causality and the durability of observed effects. Researchers should also examine different game mechanics separately, including challenge, competition, immediate reward, loss feedback, progression systems, constrained choice, and debriefing, to identify which components are responsible for beneficial or adverse effects. Larger and more gender-balanced samples should be recruited across industries and countries to determine whether the observed asymmetric pattern can be replicated across cultural and organizational settings. Future research should additionally incorporate behavioral decision tasks, simulated investment performance, eye-tracking, response-time measures, or neurocognitive indicators alongside questionnaires. Moderated mediation models could examine whether flow, cognitive engagement, risk perception, decision-making style, confidence calibration, or response inhibition explain gender differences in gaming-related cognitive outcomes. Particular attention should also be given to whether increased loss aversion represents maladaptive avoidance or more accurate sensitivity to downside risk.

Organizations should avoid implementing strategic digital games as uniform, one-size-fits-all debiasing interventions. Instead, managerial development programs should first assess participants' cognitive tendencies, decision-making styles, gaming familiarity, and responses to risk before selecting or designing game-based training. Strategic simulations intended to improve financial judgment should incorporate explicit feedback about biased decisions, opportunities to reconsider initial judgments, exposure to disconfirming evidence, structured reflection after gains and losses, and post-game debriefing that connects simulated experiences to real managerial decisions. Because the present findings indicate different patterns among men and women, training designers should monitor subgroup responses rather than assuming equivalent effects and should adapt difficulty, competitive intensity, feedback, and loss exposure when necessary. Organizations should also evaluate game-based interventions using actual decision-quality indicators rather than relying solely on participant enjoyment or engagement. In practice, strategic gaming is likely to be most valuable when integrated with financial literacy education, behavioral-finance training, reflective decision protocols, and structured managerial coaching rather than used as a stand-alone intervention.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## Authors' Contributions

All authors equally contributed to this study.

## Declaration of Interest

The authors of this article declared no conflict of interest.

## Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

## Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.


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