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RESEARCH ARTICLE

Harnessing the benefits of combined implicit and explicit assessments for predicting risk attitudes and risky behavior: An exploratory approach

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ABSTRACT

In two studies investigating risk attitudes, we explored the benefits of combining self-reports (explicit) and automatic responses (implicit association test [IAT]). Study 1 compared MBA students (older group) and undergraduates (younger group), revealing no age differences on two explicit risk attitude measures. However, the older group had stronger negative risk attitudes on two parallel IATs. Furthermore, psychosocial maturity was a mediator in the inverse age-risk attitude relationship in the older group. Study 2 extended the utility of the two methods to finance, examining self-reported and implicitly measured financial risk attitudes among financial engineering majors. The results revealed that participants inclined toward exerting explicit control over future returns benefited from being more implicitly aggressive in stock investments, positively influencing stock return rates. Overall, these findings suggest the complementary nature of explicit and implicit assessments in understanding risk attitudes, revealing their significance across age-related and financial contexts.

Keywords: risk; attitudes; explicit measures; implicit measures; risky behavior

1. Introduction

Risk attitudes play a pivotal role in human decision-making processes and have long been studied as the main predictor of daily risk-taking behavior. Scholars have attempted to understand people's attitudes toward risk through different lenses, including economic (expected utility theory)[1], cognitive (prospect theory)[2,3], and[4] perspectives. Despite the contributions of such an eclectic approach to management research in negotiation, emotions and motivation, human resource management, organizational risk and return, and strategic risk-taking behaviors[5], most studies in these areas rely heavily on self-reporting methods. This reliance limits their potential contribution to risk research in organizational settings.

Although most self-reporting methods have robust psychometric properties with acceptable levels of

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validity and reliability, several concerns have been raised. For instance, respondents may find it difficult to report their actual values because of their introspective limits[6]. Another concern is susceptibility to response bias[7]. Respondents may be reluctant to accurately describe themselves as risk-takers or risk-haters because of their fear of being stigmatized[8]. Thus, exclusively relying on declarative measures of risk attitude may provide an incorrect overall picture of the construct and its relationship with behavioral outcomes.

This study approached these concerns from a social cognitive perspective by examining implicitly assessed attitudes toward risk as measured using the implicit association test (IAT)[9]. The IAT assesses the relative strength of associations, indexed by reaction times in sorting target stimuli with positive and negative attributes generated to represent one's implicit attitude toward a target concept. Its advantage is that it enables us to tap into an additional automatic aspect of attitude while limiting the negative impacts of self-reporting[10]. Greenwald et al.[11] and Kurdi et al.[12] supported this argument with two observations in their meta-analyses: (a) both IAT and self-reporting measures have complementary incremental validity, with each contributing a unique variance in explaining different aspects of criterion behavior, and (b) the predictive validity of self-reporting measures is more substantially influenced by a topic's social sensitivity than that of IAT measures.

Despite the IAT's merits, few studies have provided evidence of reliable methods to indirectly assess a domain-independent risk attitude. Ronay and Kim adapted the IAT to assess implicit attitudes toward risk as a global concept by measuring the strength of automatic associations between target words (i.e., RISK and [ ]) and gain- and loss-related attributes (e.g., GAIN and LOSS)[13]. The authors found that implicitly assessed attitudes toward risk played a significant role in explaining individual differences in risk-taking in the Balloon Analogue Risk Task (BART). Similarly, Traczyk and Zaleskiewicz applied an IAT that assessed the general attitude toward risk by measuring the associative strength between target words (i.e., RISKY and SAFETY) and positive and negative attributes (e.g., POSITIVE and NEGATIVE)[14]. The proposed IAT explained additional variance in self-reported risk-taking behaviors, which explicit attitudinal measures of risk cannot capture. Although the two IATs discussed so far differ in the targets and attribute stimuli used, they provided reliable evidence supporting incremental predictive validity in the field of risk attitudes. These results can be interpreted by drawing on implicit social cognition phenomena, whereby self-reported and implicitly assessed risk attitudes can be related, albeit distinctively separate, constructs[15].

Given the implicit–explicit attitude divergence, further investigation into two critical questions is needed. First, the combined use of implicit and explicit measures of risk attitudes can enrich our understanding of the determinants of risk attitudes, which in this case is age. This focus on age stems from its close relationship with psychosocial maturity, a critical factor influencing risk attitudes. Psychosocial maturity is broadly defined as the capacity to regulate one's behavior in alignment with social norms and long-term goals, developed through life experiences and social interactions over time[16,17]. These developments foster self-discipline, responsibility, and adaptability, which shape individuals' risk attitudes and influence their approach to risk-taking behaviors. Consequently, age serves as a pivotal determinant of risk attitudes, as it reflects the developmental trajectory of psychosocial maturity and its impact on risk-related behavior.

When used exclusively, traditional survey methods often yield conflicting evidence regarding the inverse relationship between age and risk attitudes[18,19]. Integrating implicit and explicit measures may provide a more comprehensive perspective on this intriguing relationship. Second, according to Perugini et al.'s findings, the multiplicative model is the least explored, wherein implicit and explicit attitudes interact synergistically to influence behavior[20]. However, despite its frequent occurrence, only a few studies have

examined this model. Similarly, few investigations have explored the conditions under which the two main aspects of risk attitudes complement each other, providing a more accurate prediction of risky behavior than considering each aspect alone. To address these issues, we conducted two studies to identify the benefits of using the IAT in studying risk attitudes. In Study 1, we tested whether age differences in risk attitudes were especially pronounced in implicit measures. Our aim was to explain the puzzling inconsistencies in the literature on age differences in directly stated risk attitudes. To delve deeper into the mechanisms driving the expected age differences in implicit risk attitudes, we also measured individual differences with an emphasis on psychosocial maturity. In Study 2, we analyzed the conditions under which implicitly assessed risk evaluations in response to stock investment complemented self-reported evaluations in predicting stock return rates.

2. Study 1

2.1. Age and risk-taking

A traditional approach to examine the relationship between age and risk attitude is to directly ask people about their risk evaluations using various types of surveys. Early studies that took this approach with a sample of managers and executives using a Likert-type scale and scenario-based questionnaire found that risk-taking decreased with age[21,22]. Rutledge et al.[23] conducted a smartphone-based experiment wherein respondents' risk attitudes were elicited using a hypothetical lottery choice task involving a risky and safe option each. They found that younger respondents chose the risky option more often than their older counterparts, at least in the domain of gains. However, other findings from gain studies are inconsistent with these results[18,19]. For instance, when asked to choose between a certain gain and a risky option, older and younger participants did not differ in the binary choice outcome[18]. Moreover, when choosing between two risky options, older adults made more risk-seeking choices than younger adults in the domain of gains[19].

Developmental neuroscience provides a compelling explanation for these inconsistent findings, emphasizing psychosocial factors' influence on real-life risk taking[24]. Logical reasoning abilities fully mature by 15 years of age. However, psychosocial maturity, including factors such as impulse control[25], emotion regulation[26], and delayed gratification[27], which are negatively associated with risk behaviors, develops gradually during adulthood[28]. For example, social environments help individuals develop self-discipline, responsibility (e.g., toward family and followers), and conformity to social norms as they age. Thus, older adults may possess greater psychosocial maturity from accumulated socioemotional experiences, making them more risk averse than younger adults. Given that implicit attitudes are defined as "introspectively unidentified traces of past experience" [29], the IAT should reflect risk-related associations that the two age groups acquire from their unique psychosocial maturity experiences. Consequently, older adults are expected to exhibit a stronger negative association with implicit risk than younger adults, potentially resulting in age-related differences in risk attitudes. Thus, we propose the following hypothesis:

Hypothesis 1: Implicit risk attitude measures reveal significant age differences, indicating that older adults exhibit a less favorable implicit evaluation of risk than their younger counterparts.

3. Materials and methods

3.1. Participants and procedure

A total of 62 students enrolled in an MBA program (52 males, mean age = 38.85 years, = 7.64; older group) participated in the study in exchange for course credit. Each participant was assigned to a booth equipped with a laptop. Informed consent was obtained in writing from all participants. They were then

asked to complete the Barratt Impulsiveness Scale (BIS) and NEO Five-Factor Inventory-Conscientiousness (NEO-FFI-C) as proxy variables for psychosocial maturity, with impression management as a covariate. Subsequently, they completed explicit attitudinal measures of risk before engaging in reaction time-based computer tasks using the IAT format, which are detailed later. We then assessed how aging is associated with risk attitudes and the mechanisms that can account for implicit risk attitudes among different age groups by comparing newly collected data obtained from the older group with corresponding data from a sample of 284 South Korean undergraduates (135 males, mean age = 22.73 years, = 2.20; younger group). The undergraduate data, originally reported in a previous study, followed the same procedures and measures as those used here. While some data from the younger group were utilized in the earlier research, the aforementioned study focused on group-level analyses of the discussion effect on risky decision-making.

3.2. Measures

3.2.1. Risk global-semantic differential scale

The Risk Global-Semantic Differential Scale (RG-SDS)[13] is a self-reported attitudinal measure that assesses participants' overall evaluations of the concept of risk. Participants indicated their attitudes on a 7-point scale (see supplementary material 1), with a Cronbach's α of .89. Higher scores on the RG-SDS indicate more positive attitudes toward risk.

3.2.2. Risk unique-semantic differential scale

The Risk Unique-Semantic Differential Scale (RU-SDS)[13] is a variant of the RG-SDS, wherein the target (i.e., risk) is replaced with self-relevant risk activities. The RU-SDS was used because people can display risk-taking behaviors despite having a negative perception of the overall (global) risk. Participants self-selected 10 relevant activities from 34 risky behaviors (see supplementary material 2) and reduced them to the 6 most relevant ones for each participant; these were used as evaluation categories in the same format as the RG-SDS. Higher scores on the RU-SDS indicate positive attitudes toward self-selected risk activities. The Cronbach's α of the RU-SDS was 0.95.

3.2.3. Implicit risk task-global

The Implicit Risk Task-Global (IRT) was developed by Ronay and Kim[13], who documented its utility in the form of convergent, predictive, and incremental validity. An IAT variant, the IRT-Global provides indirectly assessed implicit evaluations of risk as an "abstract" construct by measuring the relative strength of automatic associations between the attributes (i.e., GAIN and LOSS) and target concepts (e.g., RISK and [ ][13]), following the same paradigm and method used by Kim[30]. For example, if a person shows a stronger positive evaluation of risk than a negative evaluation, they will associate risk with gain more easily than with loss. Hence, they will perform the classification task more quickly and accurately when RISK is paired with GAIN attributes than when it is paired with LOSS.

In the IRT task, participants were asked to categorize the target stimuli (i.e., RISK and open square brackets; in this case, [ ]) while simultaneously discriminating between GAIN- and LOSS-related words (i.e., attribute stimuli) as fast as possible and with minimal errors. The stimuli comprised 14 items, 7 for each of the two attributes (i.e., GAIN and LOSS), which were the same as those used in the RG-SDS. IRT-Global comprises a sequence of five blocks (see supplementary material 3). In Block 1, participants practiced attribute discrimination by sorting items into "GAIN" and "LOSS" categories. In Block 2, they repeated this for the target concept discrimination by sorting stimuli into "RISK" and "[ ]" categories. In Block 3, participants classified items into two combined categories, each including the attribute and target concepts that were assigned to the same response key in the preceding two blocks (e.g., RISK + GAIN for a right ("5")

key and [ ] + LOSS for a left ("a") key). In Block 4, the key assignment for the target dimension was switched. Block 5 was complementary to Block 3 but used the reverse key assignment to the one practiced in the previous block (e.g., [ ] + GAIN for the right key and RISK + LOSS for the left key). Subsequently, an overall IRT-Global score was generated as the difference between the mean reaction times in the test trials of the combined (i.e., Block 3) and reversed combined tasks (i.e., Block 5); higher IRT-Global scores indicated faster associations of risk with gain than with loss. The Cronbach's α was 0.81.

3.2.4. Implicit risk task-unique

The Implicit Risk Task-Unique (IRT-Unique[13]) is an adaptation of the IRT-Global, which measures an individual's positive and negative associations with personally relevant risks. The only difference from the IRT-Global was that the six participant-chosen items automatically replaced the stimulus "RISK" in all blocks. The overall IRT-Unique score was calculated like the IRT-Global; higher IRT-Unique scores indicated faster associations of self-selected risk activities with gain than with loss. The Cronbach's α was 0.87.

3.2.5. Barratt impulsiveness scale

The BIS is a 23-item questionnaire that assesses impulsivity as a component of both impulse control and risk-taking behavior[31]. Higher BIS scores indicate greater impulsiveness. The Cronbach's α was 0.77.

3.2.6. Neo five factor inventory-conscientiousness

We adopted the 12-item scale from Costa and McCrae's NEO Five-Factor Inventory[32] to assess conscientiousness as a personality trait, characterized by self-discipline, industriousness, and impulse control. These factors are strongly associated with emotion regulation[26], delayed gratification[27], and age[33], which are theoretically assumed to underlie psychosocial maturity. Higher NEO-FFI-C scores indicate greater conscientiousness. The Cronbach's α was 0.80.

3.2.7. Impression management

The 20-item scale for Impression Management (IM) was based on Paulhus's Balanced Inventory of Desirable Responding[34], which seeks to negate IM's influence while responding to various risk-related attitudes and personality traits. The Cronbach's α was 0.74.

4. Results

4.1. Implicit-explicit divergence in the risk attitude construct

Table 1 presents the correlations among Study 1's measures across different age groups. Two confirmatory factor analyses were performed across age groups to directly test whether the correlational data for the explicit and implicit risk attitude measures were better suited for a model with one (**Figure 1a**) or two (**Figure 1b**) factors.

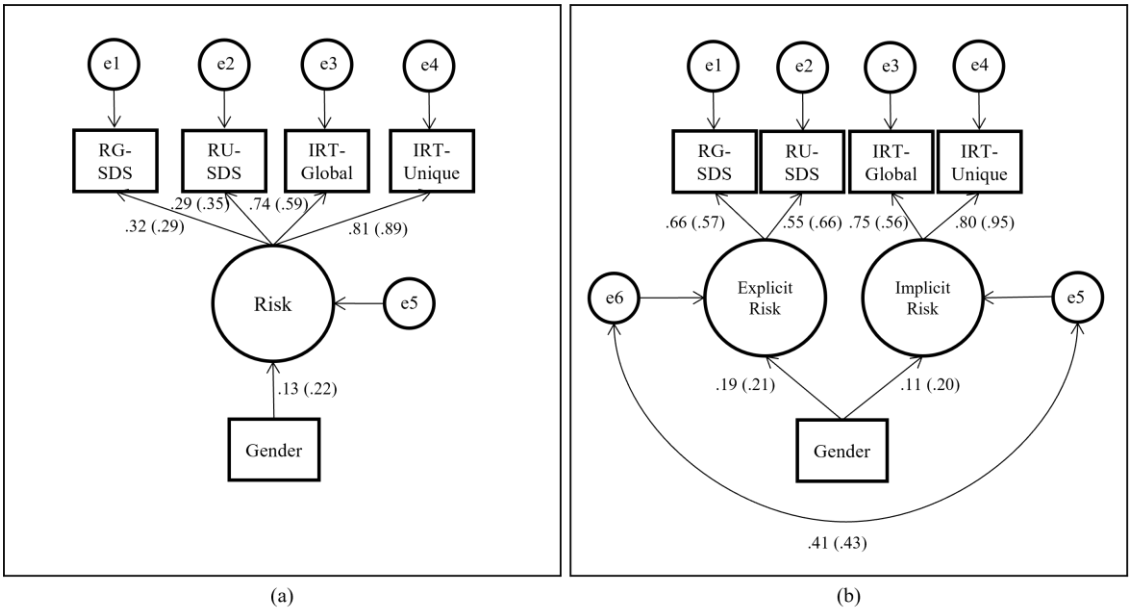

Figure 1. Confirmatory factor analysis of risk construct divergence across age groups.

Table 1. Correlation coefficients of the main variables for Study 1 across age groups.

Measure	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Demographics								
1. Age	-							
2. Gender	–.50*** (–.38***)	-						
3. IM	.41** (.06)	–.13 (.13†)	-					
Psychosocial maturity								
4. BIS	–.38* (–.29***)	–.01 (.21**)	–.42** (–.22**)	-				
5. NEO-FFI-C	.44** (.20**)	–.24 (–.18**)	.43** (.11†)	–.53*** (–.61***)	-			
Explicit risk								
6. RG-SDS	–.12 (.06)	–.12 (–.19**)	.07 (.00)	–.18 (–.12†)	.26† (.07)	-		
7. RU-SDS	.01 (.03)	–.11 (–.10)	.08 (.02)	.04 (–.11)	.24 (.09)	.36** (.38***)	-	
Implicit risk								
8. IRT-Global	–.31* (–.03)	–.08 (–.09)	–.25 (–.05)	.35* (.04)	–.24 (–.04)	.26* (.17**)	.07 (.10)	-
9. IRT-Unique	–.31* (–.09)	–.08 (–.18**)	–.50** (.00)	.38* (–.04)	–.48** (.07)	.17 (.23***)	.23† (.32***)	.60*** (.54***)

Note: *Numbers outside (inside) the parentheses indicate the correlation coefficients in the older (younger) group. Gender was coded as 1 for male and 2 for female. † p < .1; * p < .05; ** p < .01; *** p < .001.*

Clearly, the two-factor model shows a better fit, with significant chi-square differences in the older (χ^2_{diff} (2, N = 62) = 6.66 (p < .05)) and younger (χ^2_{diff} (1, N = 283) = 32.45 (p < .05)) groups (see supplementary

material 4 for further details). Thus, self-reported and implicitly assessed attitudes toward risk are conceptually divergent across both age groups.

4.2. Divergent findings for age

A univariate analysis of variance controlling for gender was performed to detect age-related differences in explicit and implicit measures. The effect of gender varied across measures (see supplementary material 5 for further details).

4.2.1. Explicit risk

A cross-age comparison test revealed similar patterns across the two explicit risk measures. The older (M = 3.60, SD = 1.38) and younger (M = 3.64, SD = 1.31) groups did not differ in the RG-SDS ($t(336) = -1.13$, $p = .26$, $d = 0.03$). These groups (M = 3.19, SD = 0.77; and M = 3.13, SD = 1.02, respectively) also did not differ in the RU-SDS ($t(341) = -0.18$, $p = .86$, $d = 0.05$).

4.2.2. Implicit risk

Greenwald et al.'s scoring algorithm[35] was used for the IRT. All statistical analyses were conducted using the scoring method (D score). While the two age groups had negative implicit attitudes toward risk globally and uniquely, the older group ($M = -0.36$, SD = 0.42) more strongly associated risk with loss than the younger group ($M = -0.18$, SD = 0.41) on the IRT-Global ($t(337) = -3.47$, $p = 10^{-3}$, $d = 0.44$). The same pattern was observed on the IRT-Unique for the older ($M = -0.42$, SD = 0.34) versus younger ($M = -0.29$, SD = 0.39) group ($t(327) = -3.08$, $p = 10^{-3}$, $d = 0.34$).

4.3. Mediating role of psychosocial maturity

Bivariate correlations supported the mediating role of psychosocial maturity in the relationship between age and implicit risk attitudes. In the older group, age was significantly correlated with the two IRTs ($r = -0.31$, $p = .03$ for the IRT-Global; $r = -0.31$, $p = .03$ for the IRT-Unique) and personality traits ($r = -0.38$, $p = .01$ for the BIS; $r = 0.44$, $p = .003$ for the NEO-FFI-C). Notably, the two implicit and personality trait measures were closely associated with an average correlation of $r = 0.36$ ($p = .02$). However, this pattern was not observed in the younger group. To examine whether implicit risk attitude decreased owing to psychosocial maturity in the older group, we compared Model 1, which constrained the two psychosocial maturity paths (age → psychosocial maturity → implicit risk) to zero, with Model 2, in which indirect path coefficients were unconstrained (**Figure 2**). Gender and impression management were included as control variables.

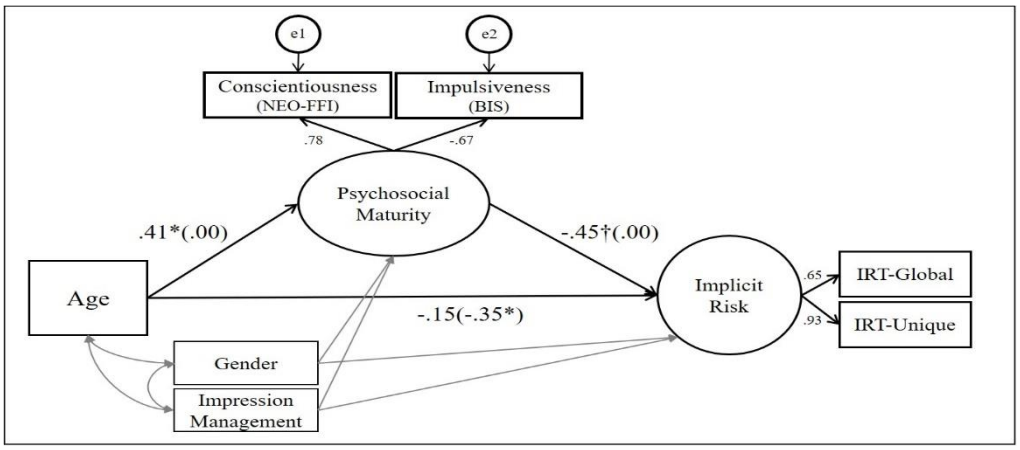

Figure 2. Mediation model for the older group

Note. *The numbers inside (outside) the parentheses indicate the standardized coefficients in Model 1 (2).* † $p < .10$, * $p < .05$.

The results revealed a better fit with Model 2 (χ^2 (7, N = 62) = 8.82 (p = .27), CFI = 0.98, TLI = 0.91, NFI = 0.92, RMSEA = 0.06) than with Model 1 (χ^2 (9, N = 62) = 17.31 (p < .05), CFI = 0.90, TLI = 0.68, NFI = 0.84, RMSEA = 0.12), with a significant χ^2_{diff} ((2, N = 62) = 8.49 (p < .05)). Further analysis using bias-corrected bootstrapping (k = 5,000) was performed to compute a 95% confidence interval (CI) and test the indirect effect's significance. The results revealed a significantly negative indirect effect of age on implicit risk (β = –0.19, 95% CI [–3.185, .000]).

5. Discussion

Study 1 revealed the underlying mechanism explaining the differences in risk attitudes, highlighting psychosocial maturity as a key mediator. Older adults' more negative implicit attitudes toward risk than those of younger adults can be interpreted by drawing an environmental association model, which suggests that exposure to an environment with different developmental opportunities may steer each age group toward heterogeneous implicit risk evaluations[36]. Our results further support this model, showing that older adults' implicit attitudes toward risk become more negative with age (i.e., through psychological maturity). Overall, these findings suggest that IAT-based measures of risk attitude may capture the strength of risk-related associations shaped by the distinct psychosocial environments experienced by each age group.

Accordingly, in Study 2, we sought to extend the utility and generality of our findings by examining whether the combined use of implicit and explicit risk evaluations can offer additional benefits in a financial context – specifically, attitudes toward stock investment. This focus on the financial domain was inspired by prior research underscoring the influence of social and cultural contexts on financial decision-making. For instance, Bault et al. [37] found that lotteries allocated to peers influence individual risk-taking and emotions. Similarly, observing others' preferred risk levels[38] or their past choices[39] has been shown to shape individuals' risk behavior. Also, Su et al.[40] demonstrated that idiocentrism (i.e., individualism at the individual level) reduces perceived financial vulnerability, while allocentrism (i.e., collectivism at the individual level) increases it, leading to financial behaviors that can negatively affect financial well-being.

These studies highlight that financial risk attitudes are not merely individual traits but are also deeply embedded in social and cultural environments. By integrating implicit measures, such as the IAT, our research aimed to capture these automatic influences that traditional self-report methods may overlook, thereby providing a more nuanced and comprehensive understanding of financial risk attitudes. This dual-method approach is particularly relevant in the context of stock investment, where companies primarily rely on self-reports to gauge customers' risk preferences. Stock investment decisions—deciding where, when, and how much to invest—require people to process substantial market information, either deliberately or spontaneously[41]. This dual processing ultimately forms the basis for developing individuals' explicit and implicit attitudes toward investment strategies, influencing how aggressively or conservatively they allocate their resources. However, respondents' self-reports of their willingness to take risks in stock investments may not fully capture automatic evaluations of their own investments because of the limitations of explicit assessment methods. To address this gap, we conducted an additional study to tap into explicit and implicit attitudes toward stock investment. Our goal was to determine whether implicitly assessed evaluations of stock investment could enhance behavioral outcome predictions. This was addressed by examining the rate of return on stock investments, highlighting the synergy between implicit and explicit measures in predicting financial behaviors.

6. Study 2

6.1. Predictive models of implicit-explicit attitudes and their utility in stock investment

Three main predictive models were derived from the literature[20]: an additive model, which appears when two types of attitudes predict a unique portion of the variance in the criterion[11,12]; a double-dissociation model, corresponding to situations where implicit and explicit attitudes are often considered particularly successful in predicting spontaneous and deliberate behaviors[42,43]; and a multiplicative model, wherein implicit and explicit attitudes synergistically interact to affect behavior. Compared with the former two, the multiplicative model is the least tested, despite its relatively frequent occurrence. However, since the mid-2000s, several studies have directly tested the predictive power of the implicit–explicit attitude interplay for diverse behaviors. In their pioneering work on health-related behavior, Perugini provided empirical insights into the interactive relationship between self-reported and implicitly assessed attitudes toward smoking[20]. Specifically, the author demonstrated how predictions about whether someone was a smoker were more accurate when the respondents had explicit and implicit positive attitudes toward smoking. Subsequently, the multiplicative effects of implicit and explicit attitudes have been replicated across different domains, such as gender bias[45] and self-construal[46].

Although the multiplicative model seems to be relatively uncommon, we conjecture that it may be useful for predicting behavioral outcomes in stock investment. Specifically, stock return performance may be better predicted by combining self-reported (explicit) and indirectly assessed (implicit) evaluations of one's own investment in stocks in a multiplicative fashion. Cheng's theoretical framework of financial decision-making reinforces our expectations by going one step further and emphasizing the synergetic interplay between conscious thought, characterized by explicit reasoning processes that require conscious attention, and unconscious thought, conceived as implicit associative mechanisms that operate automatically or with limited conscious accessibility[47]. Given the relatively small capacity of conscious thought (i.e., 40–60 bits per second) compared with that of the entire human thought system[48], Cheng proposed that unconscious thought can help reduce some judgmental heuristics (e.g., availability and representativeness) and behavioral biases (e.g., overconfidence and attraction effects) that people experience when making complex decisions on financial matters[41]. This is due to the enormous processing capacity of unconscious thought, which generally improves the quality of financial and investment decisions[47].

Nordgren et al. provided indirect evidence for this view by examining whether a sequential combination of conscious and unconscious thoughts helps make better decisions regarding complex problems[49]. The authors followed the same procedures and research design (i.e., immediate, conscious, and unconscious thought conditions; see supplementary material 6) as in the standard unconscious thought paradigm[50], except for including a newly created condition. Specifically, participants deliberated on which apartments they would be willing to rent for a given time and were then distracted in the same interval, allowing conscious and unconscious thought to occur sequentially. The results showed that participants were more likely to choose the best apartment when they engaged in periods of both conscious and unconscious thought compared with the other three conditions.

Clearly, unconscious thought is of particular value when facing complex decisions that require simultaneously processing a substantial amount of information[51], such as stock investment decisions. We argue that measuring one's automatic evaluations of stock investment with the IAT can more accurately reflect the unconscious features of indirectly assessed attitudes, which cannot be controlled by motivation and ability[52]. In their review of studies on attitudes, Gawronski et al. found that people are unaware of how their implicit attitudes can impact psychological or behavioral processes outside of conscious awareness[52].

The authors suggested that such unconscious influences can be interpreted as evidence of the unconscious features of indirectly assessed implicit attitudes. Thus, when considered simultaneously with implicitly assessed attitudes toward stock investment, their interplay with self-reported attitudes provides a valid basis for making better decisions and improving stock investment performance.

Thus, we propose the following hypothesis:

Hypothesis 1: Implicit risk attitude measures reveal significant age differences, indicating that older adults exhibit a less favorable implicit evaluation of risk than their younger counterparts.

6.2. Implicit-explicit attitudes toward investment

Other studies have attempted to apply the IAT to explore the attitude–behavior relationship in risk-related domains, such as risky flight behavior[53], internet gaming disorder[54], and entrepreneurial behavior[55]. Park et al. adapted the IAT to measure implicit attitudes toward how aggressively or conservatively one values one's own investments in stocks, terming it as the Implicit Stock Investment (ISI)[56]; this indicator measured the strength of automatic associations between the target (i.e., "My stock investment" and BLANK), and aggressive- and conservative-related attributes (e.g., AGGRESSIVE and CONSERVATIVE) via reaction times. Using a sample of students majoring in financial engineering (FE), the authors found that the ISI captures unique incremental variance beyond existing self-reported financial risk attitude measures while predicting risk-taking in a laboratory-based behavioral task (i.e., BART).

To understand implicit attitudes' influence on real life risky behavior, we explored the potential link between FE major students' attitudes toward their stock investments and their stock return performance. We expected these two variables to be negatively related—the FE major group's overall rate of return on stocks would decrease as they would respond more quickly when associating "My stock investment" with "Aggressive" than with "Conservative." A growing body of evidence supports this idea, suggesting that investors who report being more aggressive and tolerant of risk are more likely to have a higher risk portfolio[57]; thus, they hold relatively less diversified stock portfolios[58]. Indeed, investors who allocate investments to specific industries and stock characteristics perform worse in their annual rates of return than investors with well-diversified portfolios[59]. Hence, implicitly assessed attitudes toward stock investments via a bipolar IAT should negatively affect the overall rate of return in the FE major group.

Consistent with the multiplicative model of implicit–explicit attitudes, the influence of evaluative stock investment associations, measured by the ISI, on the rate of return was assumed to be conditional. We expected that the influence of implicit evaluations of one's investment in stocks on the rate of return would depend on their explicit evaluations of how much control they are willing to exert over financial risk. Lampenius and Zickar provided supporting evidence that risk control plays a crucial role in predicting investment portfolio selection[60]. In their first study, the authors provided a newly developed self-reported measure of financial risk attitudes, Financial Risk-Taking (FRT), which is elicited from two major factors: speculative risk (SR) and risk control (RC). SR is an internal force that causes individuals to accept greater risks for maximizing investment returns. RC is the driving force which leads them to prioritize the predictability of future expected returns, cash flows, and monetary status when making investment decisions. Thus, people prone to high RC levels are more likely to prefer low yield but relatively safe investment options as they want to control their returns. The authors further investigated the predictive power of these two factors on portfolio selection in their second study, which examined students majoring in finance. They found that, when asked to choose their preferred portfolio from four portfolio pairs formed by combining multiple assets (e.g., cash, stocks, options, and bonds), participants with high SR and RC scores preferred a portfolio comprising a balanced (i.e., diversified) mix of high, medium, and low risk/return on assets.

Hence, by modeling RC as a moderator, implicit attitudes toward stock investment should positively impact the rate of return when associated with a high RC. For instance, an individual harboring strong, aggressive associations with stock investment may have a better rate of return on stocks, provided that they become more explicit in controlling returns. Hence, we propose the following hypothesis:

Between explicitly assessed risk control and implicitly assessed attitudes toward stock investment explains the incremental variances in FE students' overall rate of stock returns.

7. Materials and methods

7.1. Participants and procedure

We used a convenience sample of Korean students majoring in FE by recruiting them in collaboration with a Korean university, which had established the FE department with a yearly quota of 40 students. The number of FE major students in the research participant pool was limited owing to factors such as the department's limited history of less than four years and students being on leave for mandatory military service. A total of 53 students majoring in FE (43 males, mean age = 20.53, = 0.64) participated in the study. All participants provided informed consent before participation and received course credits for completing the explicit (FRT) and implicit (ISI) financial risk attitude measures. One week after completing the surveys, they were asked to join a four-week simulated real-world stock trading competition organized by a large securities company. To encourage active participation, students were paid $5 each. At the end of the competition, participants who ranked first through sixth in the overall rate of return on their investments received additional monetary rewards ($100 for the first, $50 for the second, $30 for the third and fourth, and $20 for the fifth and sixth places).

7.2. Measures

7.2.1. Financial risk-taking

The FRT measure has two five-item subscales assessing speculative risk (FRT-SR) and risk control (FRT-RC) (see supplementary material 6)[60]. FRT-SR and FRT-RC were rated on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Their Cronbach's α were 0.65 and 0.57, respectively. FRT-RC's reliability coefficient was re-estimated using McDonald's Omega (ω) index[61], a newly recommended indicator that is less biased than Cronbach's α. This value was 0.62, with values above 0.6 indicating adequate internal consistency.

7.2.2. Implicit stock investment

We used the ISI to assess implicit attitudes toward stock investment by estimating the relative strength of automatic associations between the attributes ("AGGRESSIVE" and "CONSERVATIVE") and target concepts ("My STOCK INVESTMENT" and "[ ]")[56].

As with the IRT task, the ISI procedure included a sequence of five blocks, each involving a categorization task wherein the participants were instructed to sort the target stimuli (i.e., MY STOCK INVESTMENT and [ ]) while simultaneously discriminating between aggressive- and conservative-related words (i.e., attribute stimuli) (see **Figure 3**).

In Block 1, the participants practiced attribute discrimination by sorting the items into "AGGRESSIVE" and "CONSERVATIVE" categories. In Block 2, the same was done for discrimination by sorting the stimuli into "MY STOCK INVESTMENT" and "[ ]" categories. In Block 3, they sorted the items into two combined categories, each including the target concept and attribute that shared the same response key in the preceding two blocks (e.g., "MY STOCK INVESTMENT" + "AGGRESSIVE" for the right ("5") key and

"[ ]" + "CONSERVATIVE" for the left ("a") key). In Block 4, the stimulus items for the target dimension used in Block 2 were illustrated again but with their assignment keys switched. In Block 5, the participants repeated Block 3 actions with switched pairings (e.g., "[ ]" + "AGGRESSIVE" for the right key and "MY STOCK INVESTMENT" + "CONSERVATIVE" for the left key). The overall ISI score (D) was the difference between the mean reaction times in test trials of the combined (i.e., Block 3) and reversed combined (i.e., Block 5) tasks. Higher ISI scores indicate faster associations of stock investment with aggressive rather than with conservative behavior. The Cronbach's α was 0.78.

	Response Key on the Keyboard		
Block Sequence	Left		Right
1. Attribute Discrimination Practice	CONSERVATIVE		AGGRESSIVE
	•	CONSERVATIVE	
		AGGRESSIVE	•
2. Target Discrimination Practice	BLANK		MY STOCK INVESTMENT
	•		
		MY STOCK INVESTMENT	•
3. Initial Combined Task	BLANK CONSERVATIVE		MY STOCK INVESTMENT AGGRESSIVE
	•	CONSERVATIVE	
		AGGRESSIVE	•
	•		
		MY STOCK INVESTMENT	•
4. Reversed Target Discrimination Practice	MY STOCK INVESTMENT		BLANK
	•	MY STOCK INVESTMENT	
			•
5. Reversed Combined Task	MY STOCK INVESTMENT CONSERVATIVE		BLANK AGGRESSIVE
	•	CONSERVATIVE	
		AGGRESSIVE	•
	•	MY STOCK INVESTMENT	
			•

Figure 3. Implicit stock investment measure.

Note: *Black dots indicate the correct response.*

7.2.3. Control variables

A brief survey was conducted to gather participants' demographic information and their perceptions of external factors that could affect trading decisions, such as investment information, stock market forecasting, international and domestic economic fluctuations, and time spent on stock trading. These factors were rated on a 5-point scale from 1 (not at all influential) to 5 (extremely influential), reflecting their perceived influence on participants' trading decisions during the competition. The control variables included these

factors along with the year of study (ranging from one to three years), gender (female = 0; male = 1), and the average number of stocks in portfolios.

8. Results

8.1. Enhanced interaction of implicit stock investment with financial risk-taking control

Table 2 presents the correlations between the variables. ISI was negatively correlated with the overall rate of stock return (r = –0.24, p = .079), but this correlation was marginally significant. However, this pattern did not hold for FRT-RC (r = –0.16, p = .26) and FRT-SR (r = –0.11, p = .43).

Table 2. Correlation coefficients among the main variables for Study 2.

Variables	1	2	3	4	5	6	7	8	9	10
Individual demographics										
1. Gender	-									
2. Year of study	–.21	-								
3. Investment information	–.10	.05	-							
4. Market forecasting	–.40**	.05	.17	-						
5. Economic condition	–.20	.002	.27†	.16	-					
6. Time spent investing in stocks	.12	.05	.47**	.07	.15	-				
7. Number of stocks in the portfolio	.29*	.02	.19	–.21	–.28†	.25	-			
Explicit risk										
8. FRT-RC	–.04	–.03	–.15	.06	–.07	–.32*	.14	-		
9. FRT-SR	–.05	.09	–.01	–.07	.11	.24	–.01	–.24†	-	
Implicit risk										
10. ISI	–.15	.14	–.21	–.004	–.05	–.25	–.26†	–.16	–.11	-
Performance										
11. Rate of return	–.18	.05	–.13	–.04	.04	.13	.14	.15	–.03	–.24†

Note: *† p < .10, * p < .05, ** p < .01.*

To explain the additional variance owing to the interaction between ISI and FRT-RC, we employed a moderated multiple regression analysis. Here, control variables were added in step 1, a set of predictors (i.e., FRT-RC, FRT-SR, and ISI) in step 2, the other two interactions (i.e., ISI × FRT-SR and FRT-RC × FRT-SR) in step 3, and the ISI–FRT-RC interaction in step 4. As shown in **Table 3** (Model 2), the three main predictors were non-significant (b = 0.58, se = 0.65, p = .38 for FRT-RC; b = –0.15, se = 0.57, p = .80 for FRT-SR; b = –6.15, se = 4.04, p = .14 for ISI). However, critically and as theoretically expected, only ISI × FRT-RC had a significant two-way interaction effect (Model 4; β = 0.53, t = 2.63, p = .01). In addition, we conducted a bias-corrected bootstrap test with 5,000 samples to verify the moderating effect, revealing a significantly positive interaction effect of ISI × FRT-RC on the rate of return (b = 4.17, se = 2.31, 95% CI [0.16, 8.82]).

Table 3. Moderating analysis of ISI on the rates of return.

Variables	Rate of return on stock			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Control variables				
Gender	–.30	–.30	–.29	–.33†
Year of study	.06	.07	.04	.17
Investment information	–.35†	–.37†	–.41†	–.47*
Market forecasting	–.08	–.12	–.12	–.26
Economic fluctuations	.13	.10	.14	.16
Time spent investing in stocks	.24	.29	.31	.31
Number of stocks in the portfolio	.28	.15	.17	.24
Main effects				
FRT-RC		.17	.13	.22
FRT-SR		–.05	–.06	.07
ISI		–.25	–.16	–.12
Interaction 1				
FRT-RC*FRT-SR			.12	.05
FRT-SR*ISI			–.14	.13
Interaction 2				
FRT-RC*ISI				.53*
R^2	.18	.28	.30	.44
ΔR^2		.10	.02	.14
ΔF		1.34	.44	6.91

Note. *Standardized coefficients are presented. † $p < .10$; * $p < .05$.*

To better understand this interaction, we plotted and tested simple slopes using values one standard deviation above and below the mean of the FRT-RC. **Figure 4** shows a positive relationship between ISI and return performance under a high FRT-RC value ($b = 8.25$, $se = 3.54$, $p = .03$). Thus, FE students who were implicitly more aggressive about stock investments had better rates of return when they were explicitly predisposed to pursue control over their expected future returns. Meanwhile, the relationship was significantly negative in a low FRT-RC level ($b = –13.81$, $se = 2.34$, $p = 10^{–7}$).

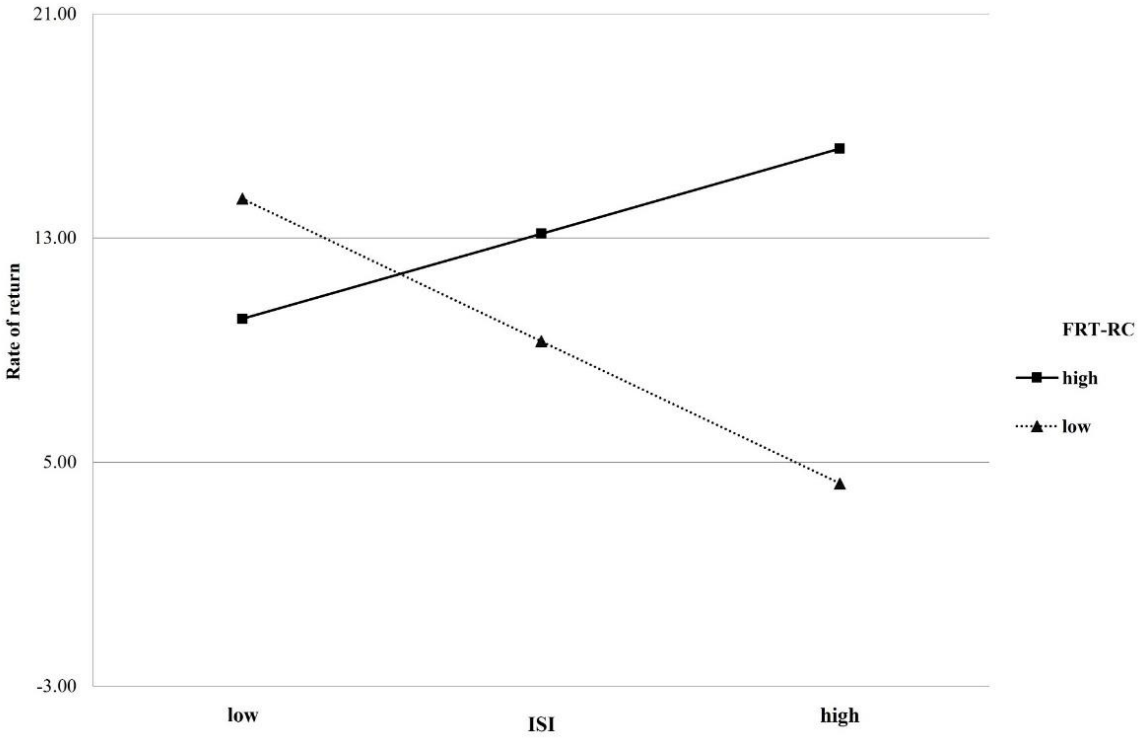

Figure 4. Interaction effect of ISI and FRT-RC on the rates of return.

Thus, implicitly aggressive FE students had lower rates of return on stocks when they were less explicitly predisposed to pursuing control over expected future returns.

9. Discussion

Study 2 provided evidence for the additional benefits of the combined use of financial risk attitudes, demonstrating a complex link moderated by the FRT-RC between ISI and stock return performance. The interaction was fully crossed, suggesting that stock return performance depends on both implicit and explicit attitudes toward financial risk; that is, being implicitly more aggressive about stock investment improved rates of return on stocks when participants were more predisposed to exercising conscious control over expected future returns and lowered return rates when they stated being less explicit in controlling financial risk. Thus, self-reported and implicitly assessed attitudes toward financial risk, as measured by the FRT-RC and ISI, respectively, complement each other in predicting overall rates of return. These findings are consistent with extant research that reveals the explanatory power of the interaction between explicit and implicit measures in predicting various behaviors, including defensive reactions to social feedback[62], aggression under the influence of alcohol[63], and bullying behavior[64].

10. General discussion

10.1. Implicit risk attitudes as complementary assets

Study 1 demonstrated the utility of using implicit risk measures to provide new insights into age differences in risk attitudes. Specifically, compared with younger adults, older adults have more negative implicit attitudes toward risk as a global concept (IRT-Global) and as a response to personally relevant risk activities (IRT-Unique). Furthermore, we revealed the reasons why the older group had strong risk–loss associations in the IRTs, demonstrating that they became implicitly more negative about risk as they aged (via gradual increasing psychological maturity levels, represented by conscientiousness and impulsiveness).

Thus, IAT-based measures of risk attitude may reflect the strength of the risk-related associations to which each age group has been exposed in their psychosocial environments.

Notably, the mediation effect observed in older adults was not replicated in the younger group because of the lack of correlations between psychosocial maturity and implicit risk attitudes. This may be due to their development in terms of psychosocial maturity. Compared with older adults, younger adults tend to have unstable psychosocial maturity and are more vulnerable to external forces[65]. Thus, psychosocial maturity's influence on risk judgment may not be salient enough to become internalized and automatized in the younger group compared with the older group. Younger adults' transitional, flexible, and formative nature during psychosocial maturity makes it difficult for them to foster strong associations of risk with their developmental experiences in maturity, thereby resulting in non-significant correlations between IRT measures and psychosocial maturity.

Despite inconsistent mediation effects across the two age groups, the findings reflecting the marked age differences for the IRTs are consistent with our suggestion that the implicit measurement approach is a useful complement to the more traditional, explicit ones. We propose a new perspective that offers a basis for interpreting the mixed findings in the literature, which uses age as a determinant of self-reported risk attitudes.

10.2. Extension of the implicit-explicit interplay to financial risk attitudes

Study 2 examined the influence of stock investment-related associations, as measured by the ISI, and their interplay with explicit evaluations of financial risk, measured by the FRT-RC and FRT-SR, on the overall rate of return on stocks in an FE student sample. Although the FRTs were considered predictors along with the ISI, we only found the FRT-RC × ISI interaction to have a significantly positive relationship with the rate of return. Thus, the FRT-RC acts as a dispositional boundary condition under which the negative ISI–stock return rate relationship is positive. Specifically, compared with their low FRT-RC counterparts, FE students who were strongly inclined to exercise explicit control over future expected returns benefited from becoming more implicitly aggressive about their investments in terms of the stock return rate.

These findings provide clear support for the fact that among the three predictive models of implicit–explicit attitudes, the multiplicative model works even in the prediction of risky financial behavior. This interactive pattern can be explained by two independent but interactive systems of information processing—one thoughtful (a reflective system) and the other more automatic (an impulsive system)—that jointly determine social behavior[66]. The reflective–impulsive model's (RIM) key message is that human behavior is not categorized to be purely reflective or impulsive; rather, it is guided by a joint function of self-reported and implicitly assessed attitudes that consider the consequences of reflective (effortful, intended, and controlled) and impulsive (effortless, spontaneous, and automatic) processes, respectively. Consistent with the RIM's prediction, Niemand and Mai found that counterfeit-buying behavior was better explained when an individual's attitudes toward pirated products, measured both explicitly and implicitly, were congruent in a positive direction[67]. Our results provide further evidence supporting the RIM by demonstrating that individual differences in stock return performance can be better predicted when self-reported and implicitly assessed attitudes toward financial risk-related concepts—risk control and stock investment—operate in a multiplicative manner.

11. Implications

Theoretically, integrating the implicit cognition framework into a risk analysis helps provide corroborating evidence to support the explicit–implicit divergence in the risk attitude construct. Thus, a more

comprehensive assessment of the multifaceted risk attitude construct is required to determine if the findings observed for both explicit and implicit risk measures converge. This would also help ensure generalizability to obtain a more nuanced understanding of findings that cannot be explained by existing self-reported risk measures. Study 1 had the additional benefit of adopting implicit risk measures, documenting profound age differences in implicitly assessed attitudes toward risk and the underlying mechanism for why implicit risk attitudes become negative with age. Meanwhile, extant research has largely focused on the incremental predictive power of IAT-based measures of risk attitude compared with explicit measures in determining risky behaviors. Study 2 expands on this literature by demonstrating what happens when implicit and explicit aspects of attitudes toward financial risk-related concepts interact complementarily in financial investment behavior. These results align with previous research by Kim et al.[68], which underscored the value of an implicit psychological approach in studying culture and ethnic minorities. In their study, an ethnic attitude IAT was developed to assess identity among first- and second-generation Korean-Americans. The findings revealed that while first-generation participants exhibited a strong Korean self-identity and national identity on both explicit and implicit measures, second-generation participants explicitly identified with the U.S. yet implicitly preferred a Korean self-identity and a connection to Korea. Notably, implicit psychological acculturation—measured by the IAT as a preference for Korean self-identity and association with Korea—significantly predicted psychological distress in second-generation participants, whereas explicit psychological acculturation, assessed through self-reported ethnic attitudes, did not.

This study also has practical implications for decision-makers and policymakers seeking to develop new diversity management standards to connect with a multigenerational workforce. Understanding age differences in risk attitudes from a multifaceted perspective can help in precisely predicting the willingness of individuals from different generations to take risks. Eventually, this can improve organizational decision-making quality under risk by smoothing generational conflicts that impede group consensus on specific issues. We also demonstrated the potential for using the ISI as a useful tool for selecting and placing investment managers in financial investment companies because it may help distinguish managerial position candidates' financial investment performance.

12. Limitations and future directions

Several limitations must be considered. First, the samples in both studies were predominantly male (82% of all participants), and the overall sample size was relatively small. While gender was included as a control variable in the analyses across both studies to rule out its impact on risk attitudes, this imbalance, along with the limited sample size, may still constrain the generalizability of our findings. Future research should replicate our findings with a larger sample with a more balanced gender distribution to enhance statistical power, improve the reliability of the results, and better capture potential gender differences in risk attitudes, ultimately strengthening the broader applicability of the findings. Second, our sample comprised FE students, who tend to pursue careers closely associated with finance[56]. While this provides useful insights into the perspectives of future finance professionals, it may limit the generalizability of our findings to those already engaged in financial decision-making. Future research should include a broader range of field samples, such as institutional investors and individual investors who actively participate in financial decision-making. Including these diverse groups would enhance the external validity of the findings. Given that professionals and individual investors often rely on experiential knowledge and market-driven heuristics[69], analyzing their implicit attitudes toward financial risk, in relation to their decision-making process, could offer deeper insights into how financial choices are made in practice. Third, further investigation is needed to uncover the underlying mechanisms—the black box—linking the ISI–FRT-RC interaction to stock investment

performance. For instance, it would be valuable to explore how individuals who exhibit implicit aggressiveness toward stock investments while explicitly striving for control over their expected future returns construct their portfolios. Specifically, examining their decision-making processes when selecting from portfolio pairs composed of diverse assets (e.g., cash, stocks, options, and bonds) could provide deeper insights into how these dual tendencies shape investment behavior.

Fourth, the absence of significant correlations between IRT measures and psychosocial maturity in the younger group underscores the need to explore whether automatic evaluations of risk could be malleable and influenced by environmental factors. Recent studies have provided further evidence of the malleability of implicit attitudes. A meta-analysis by Forscher et al. [70] examined various procedures aimed at changing implicit measures and found that while implicit attitudes can indeed be altered, these changes do not necessarily lead to corresponding shifts in explicit attitudes or behavior. In another study, Charlesworth and Banaji[71] discovered that implicit biases related to race, skin tone, and sexuality have been decreasing over time, suggesting that societal changes and increased awareness may contribute to the reduction of these biases. Building on these findings, further research – particularly longitudinal studies – is needed to explore how younger individuals' automatic associations with risk evolve over time. As they gain more life experience and mature psychosocially, their implicit risk attitudes may gradually shift, reshaping their relationships with key psychological factors associated with maturity, such as conscientiousness and impulsiveness. Additionally, understanding how implicit and explicit risk attitudes interact over time is crucial, as their dynamic interplay may shape long-term behavioral outcomes across different domains. While implicit attitudes can influence behavior independently, their alignment with explicit attitudes across developmental stages remains unclear. Maturation may either bring them into closer alignment or highlight their differences. Investigating these interactions longitudinally could deepen our understanding of implicit attitudes' role in environmental risk-taking, financial decisions, and health behaviors, offering valuable insights into behavioral regulation.

Author contributions

Junsu Park reviewed the literature, conducted the analysis, and wrote the manuscript. Do-Yeong Kim interpreted the findings and edited and revised the manuscript. Both authors critically reviewed and approved the final manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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