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Temporal discounting and self-continuity: Age-dependent patterns and implications

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ABSTRACT

Intertemporal decision-making is a common aspect of everyday life. People often prefer receiving a smaller immediate reward rather than the larger one that comes later, a behaviour known as temporal discounting. Previous studies have suggested that self-continuity plays a role in temporal discounting; however, the effect of age on temporal discounting and self-continuity remains unclear. This study aimed to explore how age relates to the connection between self-continuity and temporal discounting. A total of sixty-seven younger and fifty-two older adults completed tasks assessing temporal discounting and both explicit and implicit self-continuity. The findings revealed that older adults exhibit higher discounting rates and greater self-continuity compared to their younger counterparts. Specifically, younger adults aged 23 to 29 demonstrated a negative association between explicit future self-continuity and temporal discounting, suggesting that higher explicit future self-continuity corresponds with reduced temporal discounting. Conversely, this relationship was not observed in older adults, indicating age-specific differences in how self-continuity influences intertemporal decision-making. Additionally, while previous research has linked implicit self-continuity to temporal discounting, this study found no age-related differences in implicit measures. These findings highlight the complex interplay between self-continuity and intertemporal decision-making across the lifespan, emphasising the need for further research to inform interventions for older adults.

1. Introduction

Intertemporal decision-making refers to comparing choices at different time points and making decisions (Frederick et al., 2002). For example, individuals frequently decide whether to spend money on purchases or save it for later. These decisions require weighing trade-offs between present and future outcomes. People tend to prefer smaller immediate rewards over later larger ones, as the subjective value of future outcomes would diminished over time, which is known as temporal discounting (Frederick et al., 2002). Abnormal temporal discounting has been correlated with various psychopathological disorders, and healthy and pathological ageing, manifesting as impulsive behaviours (Godefroy et al., 2023; Lempert et al., 2019).

1.1. Age differences in temporal discounting

The effect of age on temporal discounting remains a topic of debate in the existing literature. A recent meta-analysis revealed no impact of age on temporal discounting rate throughout adulthood (Seaman et al., 2022), suggesting that temporal preference remains relatively stable with age. Conversely, previous research has consistently indicated that temporal discounting varies with age, showing either a decrease or an increase as individuals get older (Liu et al., 2016; Read & Read, 2004; Richter & Mata, 2018). A subsequent meta-analysis further revealed a U-shaped relationship between age and temporal discounting (Lu, Yao, et al., 2023), indicating that younger and older individuals exhibit higher discounting rates than middle-aged adults. Meanwhile, older adults showed a decline compared to those at age 20. This complex relationship highlights the necessity of further research to reconcile these conflicting conclusions and deepen our understanding of how age impacts intertemporal decision-making. Researchers proposed that age-related differences might stem from variations in self-continuity, value and time representation, motivational processes, and self-control capabilities (Lu, Yao, et al., 2023; Trope & Liberman, 2010). Nevertheless,

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there is a lack of sufficient empirical evidence concerning the correlation between age, temporal discounting, and self-continuity.

1.2. Age differences in self-continuity

Self-continuity, conceptualised as the psychological connectedness between one's present self and past (past self-continuity) (Woike et al., 2020) and future selves (future self-continuity) (Sedikides et al., 2023), has emerged as an important factor affecting intertemporal decision-making (Ersner-Hershfield, Wimmer, & Knutson, 2009; Zhao et al., 2024). Empirical studies indicate that greater self-continuity correlates with improved well-being (Reiff et al., 2019), healthier lifestyles (Rutchick et al., 2018), and increased prosocial choices (Zhang et al., 2022).

Research on age-related differences in self-continuity has revealed intriguing patterns regarding how individuals perceive their temporal self-perception throughout the lifespan (Lockenhoff & Rutt, 2017; Lu, Gerstorf, & Lockenhoff, 2023; Rutt & Lockenhoff, 2016). Rutt and Lockenhoff (2016) examined both explicit and implicit self-continuity by assessing individuals' perceived connectedness to their past and future selves over three-month intervals. Their findings demonstrated a positive linear relationship, showing that older adults tended to have higher levels of explicit and implicit self-continuity. This pattern was later confirmed in a larger lifespan sample that explored temporal distances ranging from one month to ten years (Lu, Gerstorf, & Lockenhoff, 2023). Importantly, this consistent linear relationship in self-continuity – whether looking back at the past or ahead to the future - has been supported in various studies (Habermas & Kober, 2015; Sedikides et al., 2016). Furthermore, recent research indicated that U.S. samples of all ages reported greater consistency when considering their future selves compared to their past selves (Lu, Gerstorf, & Lockenhoff, 2023). This finding aligned with the theory of end-of-history illusion, which suggests that people, regardless of age, anticipate more stability in their future personality, values, and psychological states than their perceived past changes (Quoidbach et al., 2013).

1.3. The relationship between self-continuity and temporal discounting

Empirical research has shown that individuals with higher future self-continuity tend to report lower temporal discounting (Bartels & Urminsky, 2011; Zhao et al., 2024). While some studies have not found a correlation between future self-continuity and temporal discounting (Frederick, 2002), converging research suggests that self-continuity, reflecting psychological connectedness between temporally distinct versions of the self, affects how individuals make intertemporal decisions (Bartels & Urminsky, 2011; Ersner-Hershfield, Garton, et al., 2009; Ersner-Hershfield, Wimmer, & Knutson, 2009; Hershfield, 2019; Sun et al., 2023; Yang et al., 2024; Zhao et al., 2024). As individuals navigate their sense of self over time, the stability (or lack thereof) in this perception of self may influence how they value future rewards. Those with a higher future self-continuity often feel a stronger connection to future selves and are more likely to act in ways that may benefit them in the long term. In contrast, when future self-continuity is weak, individuals may make more impulsive choices that primarily benefit their present selves (Hershfield, 2011). The psychological connectedness perspective (Hershfield, 2019) suggests that viewing the future self as a direct continuation of the present self encourages choices favoring larger delayed rewards, thereby reducing temporal discounting. Furthermore, individuals with greater future self-continuity are more likely to focus on future consequences rather than immediate outcomes (Zhao et al., 2024). This shift in focus may enhance self-control (Adelman et al., 2017) and reduce the perceived psychological distance between the present and future selves (Ji et al., 2018).

Although many studies have explored future self-continuity and its role in temporal discounting, no direct evidence exists regarding past self-continuity and temporal discounting, and the potential impact of past self-continuity remains unclear. Previous research suggests that reduced temporal discounting correlates with underestimated time perception (Chen & Zhao, 2024) and positive autobiographical memory (Lempert et al., 2017). A greater sense of past self-continuity may indicate a decreased temporal distance (time perception) from one's objectionable past self (Sedikides et al., 2023), as well as high self-concept clarity facilitated by autobiographical memory (Jiang et al., 2020), which in turn is connected to lower temporal discounting. Therefore, further investigation into the relative stability of self-continuity could provide valuable insights into its relationship with intertemporal decision-making.

While the link between self-continuity and temporal discounting has been widely examined, there is limited research on this connection in older adults. Current evidence has revealed a robust connection between self-continuity and temporal discounting across different age groups (Bartels & Urminsky, 2011), indicating that people who experience greater self-continuity are more likely to concentrate on their expected future circumstances when outcomes occur, resulting in a preference for larger delay rewards. In older populations, research has shown that the speed of time perception (Janssen et al., 2013) tends to accelerate. This acceleration may heighten older adults' senses of past and future self-continuity by reducing the perceived temporal distance between different time points. In contrast, age-related declines in autobiographical memory and the ability to simulate future scenarios (Addis et al., 2008; Peters et al., 2019) may reduce old adults' concerns for their future selves, potentially increasing their emphasis on immediate outcomes during intertemporal decision-making (Hershfield & Bartels, 2018). Given these age-related changes in temporal perception, autobiographical memory, and future thinking, it is essential to systematically examine whether the patterns between self-continuity and temporal discounting, which are observed in younger adults, also generalise to older adults.

Moreover, the time interval is also an age-related factor that affects self-continuity. Research indicates that individuals typically experience decreased future self-continuity with longer intervals. However, older adults tend to maintain stable self-continuity approximately one year into the past and future (Bartels & Urminsky, 2011). This stability may be due to the compression of subjective time experienced by older adults (Janssen et al., 2013), which leads to a more pronounced age-related increase in self-continuity over longer intervals (Lockenhoff & Rutt, 2017). Thus, it is also worth exploring whether the age-related pattern of self-continuity and temporal discounting remains consistent across different time intervals in the past and future. Such dynamic changes could have significant practical implications for understanding how individuals of different age groups plan for their future, make decisions, and evaluate life choices throughout their lives. To our knowledge, no systematic research has investigated and compared the relationship between self-continuity and temporal discounting in younger and older adults, especially regarding how age affects temporal discounting through the perspective of self-continuity. Therefore, empirical research is necessary to examine the consistency of self-continuity over time and its association with intertemporal decision-making in older adults.

1.4. Aims and hypotheses

This study aims to investigate the relationship between self-continuity and intertemporal decision-making in younger and older adults. The hypotheses are as follows: 1) temporal discounting decreases with age; 2) older adults tend to report a greater self-continuity concerning past and future events, which correlates with a decrease in temporal discounting; 3) the relationship between self-continuity and temporal discounting exhibits a similar pattern across both younger and older adults. Understanding how self-continuity influences delay discounting could inform the development of interventions to improve intertemporal decision-making in older adults, particularly in areas such as health, financial planning, and overall well-being.

2. Method

2.1. Participants

A total of 126 participants (72 females; age range 18–86 years; Mean = 41.73, SD = 25.12) were recruited through media announcements from local communities and universities. All participants underwent the Montreal Cognitive Assessment (MoCA)-Beijing Version (Nasreddine et al., 2005) and the 21-item Depression Anxiety Stress Scales (DASS) (Henry & Crawford, 2005; Lovibond & Lovibond, 1995) to evaluate cognitive decline and emotional state issues. Four participants who scored below the MoCA cut-off score of 21 (Yang et al., 2022) and three others whose DASS scores were more than three standards above the group mean were excluded (Osborne & Overbay, 2004). The final sample included 119 participants (age range 18–85 years), which can be divided into younger ($N = 67$, age range 18–29 years) and older adults ($N = 52$, age range 60–85 years).

2.2. Temporal discounting task

Temporal discounting was assessed using the 27-item Monetary Choice Questionnaire (MCQ), where participants were required to choose between immediate smaller rewards and larger delayed rewards (Kirby et al., 1999). The individual temporal discounting rate (k) was determined through automated scoring using the hyperbolic function (Kaplan et al., 2016). To achieve normal distribution, natural log-transformed discounting rates (Lnk) were calculated, with higher values reflecting stronger preferences for immediate rewards.

2.3. Self-continuity measures

Explicit self-continuity (SC) was evaluated using a visual scale comprising seven pairs of circles with varying degrees of overlap (Fig. 1a) (Ersner-Hershfield, Garton, et al., 2009; Ersner-Hershfield, Wimmer, & Knutson, 2009). Participants rated the perceived similarity between their present self and their past or future selves across five temporal intervals: 1 day, 1 month, 6 months, 1 year, and 5 years. Participants provided a single rating for each temporal point from 1 (minimal similarity) to 7 (maximal similarity). The ratings were then averaged separately for past and future directions, with each directional score representing the mean of five temporal intervals.

Implicit self-continuity was measured using a Me/Not Me task that assessed personal trait consistency across different temporal distances (Fig. 1b) (Rutt & Lockenhoff, 2016). Participants were asked to evaluate whether specific trait words described them at present as well as at various temporal intervals in the past and future. The task employed twelve trait words, including six positive and six negative ones, which underwent a rigorous translation process. Two independent translators conducted English-to-Chinese translations, and a third researcher resolved discrepancies during the translation process. The frequency of the twelve Chinese words was controlled based on the Modern Chinese Vocabulary Frequency Thesaurus (www.cncorpus.org). The implicit SC task consisted of twelve blocks, with four trials in each block. Eleven blocks (including one present block, five past blocks, and five future blocks) required participants to evaluate whether the trait word described them at different temporal intervals (1 day, 1 month, 6 months, 1 year, and 5 years in both past and future directions). Each trait word was presented once at each temporal distance, with participants responding "Yes" or "No" by the button within a 5-s window. An additional control block requiring simple judgments of trait attributes (negative/positive) was included to ensure participants engaged in intertemporal thoughts regarding their different selves rather than merely responding to trait valence. Block order was counterbalanced across participants. Implicit SC consistency was quantified as the percentage of trait judgments that matched between the present and each temporal distance. This yielded separate consistency scores for past and future temporal directions, calculated by averaging the consistency percentages across the five intervals within each temporal direction. Higher consistency percentages indicated greater implicit self-continuity.

2.4. Procedures

Participants completed 60-min sessions in either laboratory or home settings using PsychoPy v2023.2.0 (Peirce, 2007). After providing informed consent and completing preliminary assessments, including demographics, substance use, cognitive status, and emotional state, participants performed the Monetary Choice Questionnaire (MCQ). This was followed by counterbalanced self-continuity tasks with randomized temporal intervals. Each self-continuity task began with the instruction. Finally, participants were compensated with MOP 100 for their participation. This study has been approved by the University ethics committee. Written informed consent, along with consent to publish, was obtained from all participants.

2.5. Statistical analyses

Statistical analyses were performed using R v4.4.1 and SPSS v26.0. First, descriptive statistics were calculated for demographic variables and task performance measures, including discounting rates, explicit self-continuity (SC) ratings, implicit SC consistency, and reaction times (RT). All SC-related measures, both explicit and implicit (including ratings, consistency, and RT), were calculated separately for the past and future time intervals of each group (younger and older). Next, mean scores from these intervals were computed to establish an overall SC performance for each participant and group. These overall scores, together with the individual past and future ratings, were included in the subsequent analysis between groups analyses. For between-group

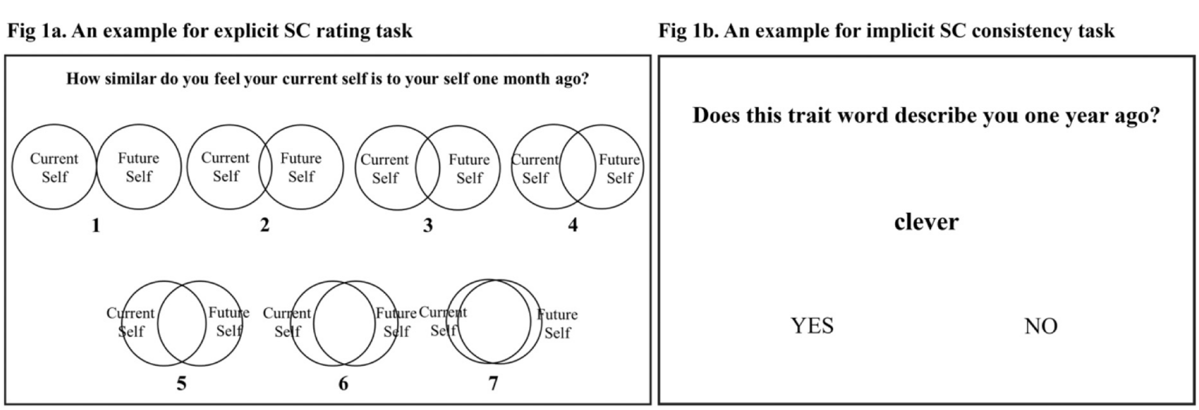

Fig. 1. Examples of explicit self-continuity rating task and implicit consistency task.

comparisons, independent t-tests or ANCOVA with age-related demographics adjusted as covariates were used, following confirmation of normality through Levene's test. Welch's ANOVA was applied for data that exhibited heteroscedasticity.

To examine temporal effects (time direction and intervals) on self-continuity and their age-dependent modulation, we employed two multilevel models, with explicit SC ratings and implicit SC consistency as the dependent variables. Both models incorporated fixed effects for temporal direction (past = −1, future = 1), and natural log-transformed time intervals (1 day = 0; 30 days = 3.401; 180 days = 5.193; 365 days = 5.900; 1825 days = 7.509). We specifically assessed three models: the first includes only main effects (age group, time directions, time intervals), the second combines main effects with two-way interactions (age group × time directions, age group × time intervals, time directions × time intervals), and the third integrates main effects and a three-way interaction (age group × time directions × time intervals), all with random intercepts for participants. The most suitable model identified was determined through likelihood ratio tests (LRT) and the Akaike Information Criterion (AIC) (Burnham & Anderson, 2004; Matuschek et al., 2017). Age-specific temporal patterns were then analysed by fitting comparable models separately for younger and older cohorts, using age as a continuous predictor. Additionally, zero-order models were applied to each dependent variable to calculate the intraclass correlation coefficients (ICCs). The ICCs found were 0.126 for explicit SC ratings and 0.285 for implicit SC consistency. This means that 12.6 % of the total variance in explicit SC ratings and 28.5 % in implicit SC consistency can be attributed to interindividual differences. Also, ICCs were computed for multilevel models to assess the suitability of multilevel modelling further. Specifics can be found in Supplementary Table S1.

Furthermore, the age-dependent relationship between self-continuity and temporal discounting was investigated using multiple regression analyses. Two models examined the effects of implicit SC consistency and explicit SC ratings on temporal discounting separately. The same modelling strategy was conducted using the criteria of LRT and residual sum of squares (RSS) (Furnival & Wilson, 2000). Stratified analyses for younger and older adults included age and SC-related measures as predictors for age-specific patterns. Age (18–85 years), explicit SC ratings (1–7), and implicit SC consistency (0–1) were standardized by Z-score for comparability. Parameter estimates were reported alongside standard errors and two-tailed tests of significance ($\alpha = 0.05$).

To further validate the robustness of all models, age-associated covariances were included after confirming the absence of multicollinearity. Additionally, nonsignificant results were examined further using Bayesian multilevel models (BMMs) with Gaussian distributions (McElreath, 2018). Parameter estimation utilized Markov Chain Monte Carlo sampling (4 chains, 2000 iterations per chain, 1000 warm-ups), with convergence assessed through the Gelman-Rubin diagnostic and effective sample size. Evidence strength was evaluated using posterior distributions and 95 % credible intervals.

3. Results

3.1. Demographic information

Table 1 presents demographic information for all participants, including both younger and older adults. The two groups were matched in terms of sex, income level, and alcohol use (all $ps > 0.05$), but they differed in age ($t(117) = -50.55$, $p < .001$), education ($t(117) = 5.12$, $p < .001$), MoCA ($t(117) = 9.87$, $p < .001$), DASS (depression: $t(117) = 4.30$, $p < .001$; anxiety: $t(117) = 3.66$, $p = .001$; stress: $t(117) = 4.83$, $p < .001$), and smoking frequency ($t(117) = 2.52$, $p = .025$). Therefore, education and smoking frequency were included as covariates in the subsequent analyses.

3.2. Temporal discounting and explicit/implicit self-continuity performance

Group differences are summarised in Table 2. The normality testing and Levene's test confirmed that the temporal discounting rate, explicit SC ratings and implicit SC RT followed a normal distribution and equal variances, while implicit SC consistency did not. Therefore, we used ANCOVA (with education and smoking status as covariates) for the normally distributed measures and Welch's ANOVA for implicit SC consistency. The results showed that older adults exhibited higher temporal discounting (F (1,117) = 13.59, $p < .001$, $\eta^2 = 0.104$) and higher explicit SC ratings for both past (F (1,117) = 19.88, $p < .001$, $\eta^2 = 0.139$) and future (F (1,117) = 10.00, $p = .002$, $\eta^2 = 0.079$) directions. Additionally, older adults had greater implicit consistency measures for both past (F (1,96) = 47.21, $p < .001$, $\eta^2 = 0.330$) and future (F (1,96) = 24.03, $p < .001$, $\eta^2 = 0.200$) conditions. Younger and older adults reported no significant differences in implicit SC RT (all $ps > 0.05$).

3.3. Age differences in explicit self-continuity

Among the tested models (see Supplementary Table S2 for details), the suitable multilevel model included age group, natural log-transformed time intervals, time directions (past vs. future), and two-way interactions among these variables (see Table 3). There were no significant main effects for age group ($b = 0.043$, $SE = 0.205$, $p = .835$) or time directions ($b = 0.038$, $SE = 0.156$, $p = .807$). However, time intervals significantly predicted lower ratings ($b = -0.552$, $SE = 0.023$, $p < .001$). An interaction was found between age group and time intervals ($b = 0.172$, $SE = 0.028$, $p < .001$). Simple slope analyses revealed that explicit SC ratings decreased with longer temporal intervals, but this decline was less pronounced in older adults ($b = -0.50$, $SE = 0.02$, p

Table 1
Demographics features and group comparison.

Variables	Overall (N = 119)	Younger (N = 67)	Older (N = 52)	Test statistic	*p-value*
Demographics					
Age	41.09 ± 24.71	19.90 ± 2.52	68.40 ± 7.32	$t_{(117)} = -50.55$	*<0.001*
Sex (female)	67	39	28	$\chi^2_{(1,\ N=119)} = 0.23$	*0.634*
Education years	12.60 ± 3.30	13.84 ± 2.31	11.00 ± 3.70	$t_{(117)} = 5.12$	*<0.001*
Perceived socioeconomic status	2.54 ± 0.70	2.58 ± 0.68	2.48 ± 0.73	$t_{(117)} = 0.78$	*0.435*
Cognition					
MoCA	27.07 ± 1.78	28.12 ± 1.12	25.71 ± 1.54	$t_{(117)} = 9.87$	*<0.001*
Emotion (DASS)					
Depression	6.02 ± 5.75	7.88 ± 6.23	3.62 ± 3.90	$t_{(117)} = 4.30$	*<0.001*
Anxiety	6.54 ± 5.52	8.09 ± 6.06	4.54 ± 3.96	$t_{(117)} = 3.66$	*0.001*
Stress	9.87 ± 7.14	12.42 ± 7.55	6.58 ± 4.95	$t_{(117)} = 4.83$	*<0.001*
Substance Use					
Alcohol	5.69 ± 1.57	5.57 ± 1.48	5.85 ± 1.67	$t_{(117)} = -0.96$	*0.337*
Cigarette	4.68 ± 0.85	4.85 ± 0.44	4.46 ± 1.16	$t_{(117)} = 2.52$	*0.025*

Table 2
Descriptions and between-group comparations of temporal discounting and self-continuity tasks.

Variables	Overall	Younger	Older	*F*-test	*p*	η^2
Temporal discounting rate						
Ln k	−3.85 (1.85)	−4.38 (0.23)	−3.18 (0.22)	$F_{(1,117)} = 13.59$	*<0.001*	0.104
Explicit SC rating						
Overall	5.42 (0.85)	5.14 (0.09)	5.77 (0.11)	$F_{(1,117)} = 18.84$	*<0.001*	*0.039*
Past	5.24 (1.06)	4.89 (0.12)	5.69 (0.14)	$F_{(1,117)} = 19.88$	*<0.001*	*0.139*
Future	5.59 (0.86)	5.39 (0.10)	5.85 (0.11)	$F_{(1,117)} = 10.00$	*0.002*	*0.079*
Implicit SC consistency						
Overall	0.83 (0.16)	0.75 (0.02)	0.97 (0.01)	$F_{(1,96)} = 46.33$	*<0.001*	*0.326*
Past	0.82 (0.17)	0.75 (0.02)	0.97 (0.01)	$F_{(1,96)} = 47.21$	*<0.001*	*0.330*
Future	0.82 (0.20)	0.76 (0.03)	0.97 (0.01)	$F_{(1,96)} = 24.03$	*<0.001*	*0.200*
Implicit SC RT						
Overall	1.84 (0.43)	1.80 (0.05)	1.92 (0.08)	$F_{(1,96)} = 2.25$	*0.137*	*0.023*
Past	1.87 (0.49)	1.84 (0.06)	1.95 (0.09)	$F_{(1,96)} = 1.28$	*0.228*	*0.015*
Future	1.81 (0.49)	1.77 (0.06)	1.89 (0.10)	$F_{(1,96)} = 2.09$	*0.151*	*0.021*

Note. Values are presented as mean (standard deviation). For explicit SC ratings, one younger participant was excluded due to ratings exceeding three SDs above the group mean (younger: 66, older: 52). For implicit SC analyses, 23 older adults were excluded due to missing response data (responses not recorded when exceeding time constraint), and one younger adult was excluded due to consistency scores exceeding three SDs above the group mean (younger: 66; older: 29).

Table 3
Estimates for explicit self-continuity ratings.

Effect	Estimate	*SE*	*t*-value	*p*
Fixed Effects				
Intercept	7.317	0.149	49.064	*<0.001*
Age group	0.043	0.205	0.208	*0.835*
Time directions	0.038	0.156	0.245	*0.807*
Time intervals	−0.552	0.023	−23.685	*<0.001*
Age group × Time directions	−0.335	0.144	−2.320	*0.021*
Age group × Time intervals	0.172	0.028	6.126	*<0.001*
Time directions × Time intervals	0.105	0.028	3.759	*<0.001*
Random Effects				
Individual intercept	0.471	0.686		
Residual variance	1.513	1.230		

$< .001$) compared to younger adults ($b = -0.33$, $SE = 0.02$, $p < .001$), as shown in Fig. 2a. Interaction between time intervals and time direction was also significant ($b = 0.105$, $SE = 0.028$, $p < .001$), and simple slopes indicated that SC ratings decreased more steeply for past selves ($b = -0.48$, $SE = 0.02$, $p < .001$) than future ($b = -0.37$, $SE = 0.02$, $p < .001$) with the increased time intervals (Fig. 2b). Additionally, a significant interaction emerged between age group and time directions ($b = -0.335$, $SE = 0.144$, $p = .021$). Post-hoc comparison revealed that younger adults reported higher self-continuity ratings for the future compared to past selves ($b = 0.500$, $SE = 0.140$, $p < .001$), whereas the older showed comparable ratings across temporal directions ($b = 0.165$, $SE = 0.158$, $p = .294$) (Fig. 2c).

In younger adults, significant main effects were observed in both time direction ($b = 1.942$, $SE = 0.711$, $p = .006$) and time intervals ($b = -0.434$, $SE = 0.136$, $p = .002$). This indicated that younger adults rated explicit SC ratings higher for the future and lower as temporal intervals increased (see Table 4). There was also a significant interaction between age and time direction ($b = -0.100$, $SE = 0.035$, $p = .004$). Simple slope analyses showed that the age-related effect of time direction was significant for individuals aged 18 to 22. However, this effect was not significant for those older than 22 (all $ps > 0.03$; Fig. 3a, Supplementary Table S3 for specific coefficients). Additionally, the interaction between time direction and time intervals was significant ($b = 0.123$, $SE = 0.034$, $p < .001$; Fig. 3b). The decline in explicit SC ratings was steeper for the past ($b = -0.56$, $SE = 0.03$, $p < .001$) compared to the future ($b = -0.44$, $SE = 0.03$, $p < .001$).

In contrast, no significant main effects or interactions were found in older adults (all $ps > 0.05$; see Supplementary Table S4 for details). Moreover, a BMMs analysis corroborated the nonsignificant results of explicit self-continuity in older adults (Supplementary Table S5).

3.4. *Age differences in implicit self-continuity*

Among the models tested (see Supplementary Table S6 for details), the model with only main effects was the most appropriate model. Results revealed a significant main effect of age group ($b = 0.218$, $SE = 0.028$, $p < .001$), indicating an increase in implicit consistency from younger to older adults, while other effects were not significant (all $ps > 0.05$; Supplementary Table S7). Meanwhile, no significant main effects were found in further stratified analyses for older and younger adults (all $ps > 0.05$; Supplementary Table S8, S9). The BMMs results supported the nonsignificant results regarding age differences in implicit self-continuity (Supplementary Table S10, S11).

3.5. *Age-dependent relationship between temporal discounting and self-continuity*

In multiple regression analyses, the effects of explicit SC ratings and implicit SC consistency (past and future) on temporal discounting were separately examined. The model, including main effects and three-way interaction, was selected for both explicit and implicit SC (Supplementary Table S12, S13). The model that estimated the effect of explicit SC on temporal discounting only revealed a significant main effect of age group ($b = 1.424$, $SE = 0.386$, $p < .001$), suggesting a higher discounting rate observed in older adults than younger ones, while no significant interaction was observed. Neither significant main effects nor interactions were reported for implicit SC (see Supplementary Table S14, S15 for details). All non-significant results were confirmed through BMMs analyses (Supplementary Tables S16 and S17).

In younger adults, while the main effects were not significant (all $ps > 0.05$, see Table 5), age played a moderating role in the relationship between explicit future SC and temporal discounting ($b = -0.748$, $SE = 0.331$, $p = .028$). A significant negative association emerged starting at age 23 ($b = -0.86$, $SE = 0.40$, $p = .030$), suggesting that higher explicit future SC led to lower temporal discounting in this age range (see Fig. 4). However, no similar patterns were observed in older adults or with implicit SC (Supplementary Table S18, S20, S21). BMMs analyses confirmed the nonsignificant results of the effect of explicit past/future self-continuity on temporal discounting in older adults, as well as the nonsignificant effects of implicit past/future consistency on discounting in both age groups (Supplementary Table S19, S22, S23), suggesting explicit future SC ratings and implicit consistency have limited effects on temporal discounting rates, particularly in older adults.

4. Discussion

This study investigated how age affects the relationship between self-

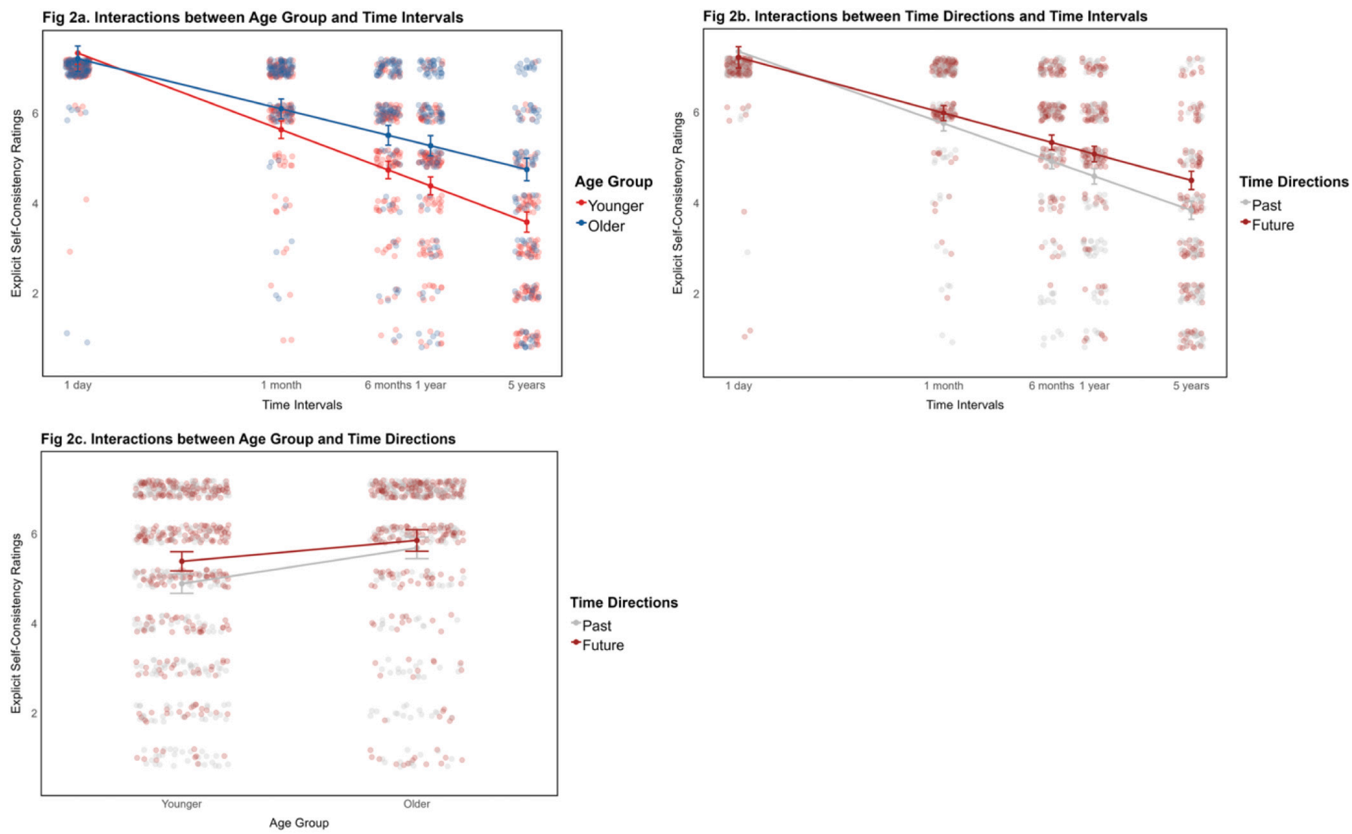

Fig. 2. Interactions between time intervals, age group, and time directions.

Table 4
Estimates for explicit self-continuity in younger adults.

Effect	Estimate	*SE*	*t*-value	*p*
Fixed Effects				
Intercept	5.764	1.023	5.632	<0.001
Age	0.080	0.051	1.574	0.117
Time directions	1.942	0.711	2.732	0.006
Time intervals	−0.434	0.136	−3.179	0.002
Age × Time directions	−0.100	0.035	−2.879	0.004
Age × Time intervals	−0.006	0.007	−0.949	0.343
Time directions × Time intervals	0.123	0.034	3.614	<0.001
Random Effects				
Individual intercept	0.466	0.682		
Residual variance	1.260	1.123		

Table 5
Estimates of explicit past and future self-continuity for temporal discounting in younger adults.

Coefficients	Estimate	*SE*	*t*-value	*p*
Intercept	−4.726	2.265	−17.85	<0.001
Age	−0.022	0.264	−0.082	0.935
Explicit past SC	−0.027	0.363	−0.075	0.940
Explicit future SC	−0.182	0.284	−0.641	0.524
Age × Explicit past SC	0.724	0.477	1.519	0.134
Age × Explicit future SC	−0.748	0.331	−2.261	0.028
Explicit past SC × Explicit future SC	0.138	0.310	0.444	0.659
Age × Explicit past SC × Explicit future SC	0.058	0.423	0.138	0.891

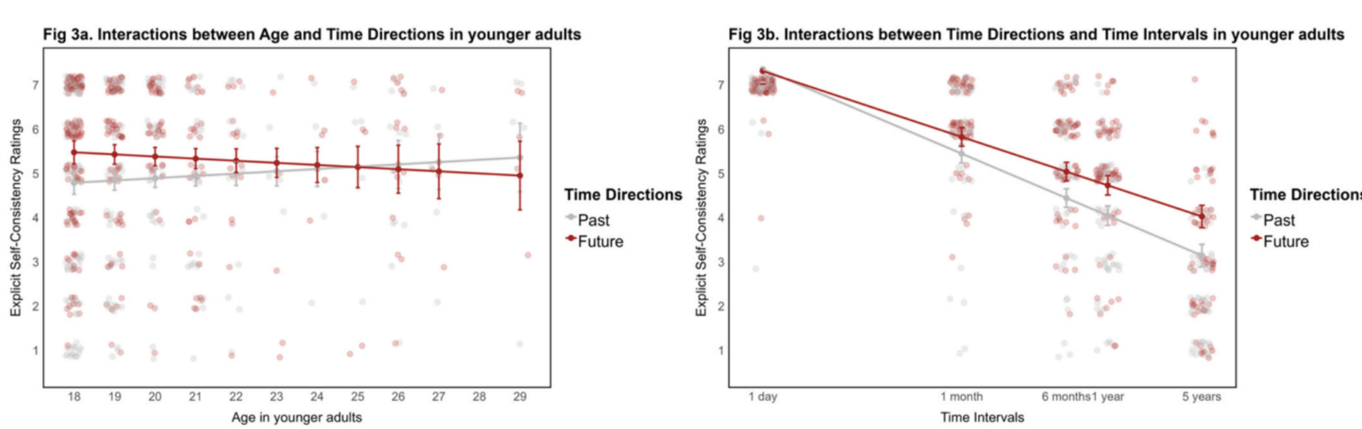

Fig. 3. Interactions between time intervals, age, and time directions in younger adults.

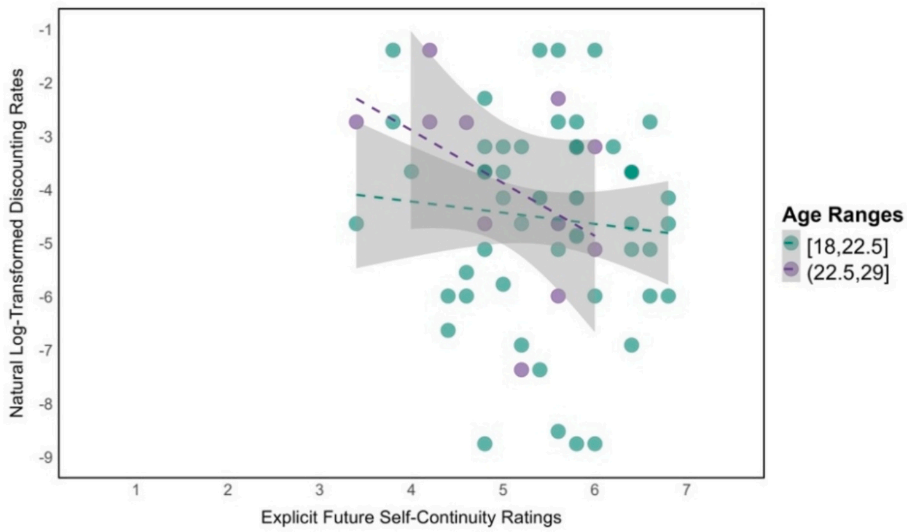

Fig. 4. Age-moderated effect on the relationship between explicit future self-continuity and temporal discounting in younger adults.

continuity and temporal discounting. The current results did not support the first hypothesis that temporal discounting decreases with age, which instead showed that older adults displayed higher temporal discounting than younger adults. This aligned with the socioemotional selectivity theory (Carstensen, 2006), which posits that older adults, in contrast to younger ones, steeply discount future rewards due to their perception of time as limited. Additionally, explicit self-continuity for the past and future also increased with age. The study revealed an age-dependent pattern in the relationship between explicit self-continuity and temporal discounting. Specifically, while higher explicit self-continuity was linked to lower temporal discounting in younger adults aged 23 to 29, this relationship was not observed in the early stage of younger adults (18–22 years old) and older adults.

4.1. Age-dependent patterns in the relationship between self-continuity and temporal discounting

Previous research identified negative relationships between both explicit and implicit future self-continuity and temporal discounting in young adults (Ersner-Hershfield, Garton, et al., 2009). The current study reaffirmed the negative association between explicit self-continuity and temporal discounting among younger adults aged 23–29 but not those aged 18–22. Additionally, this study expanded the population from younger to older adults and found that the relationship between self-continuity and temporal discounting was not present in older adults, indicating age-dependent patterns in younger and older adults.

4.1.1. Variations in young adults

In line with previous studies (Ersner-Hershfield, Wimmer, & Knutson, 2009; Hershfield & Bartels, 2018; Sun et al., 2023; Zhao et al., 2024), explicit future self-continuity showed a negative association with temporal discounting in the later phase of young adulthood. Specifically, individuals who reported higher levels of future self-continuity demonstrate lower temporal discounting, suggesting a greater willingness to postpone immediate gratification in favour of larger rewards in the future. This relationship indicates that younger adults with a strong sense of future self-continuity are more likely to engage in future self-projection, allowing them to assess the long-term benefits of their decisions more effectively (Hershfield, 2011). In contrast, those who perceived a greater psychological distance between their present and future selves tend to be less inclined to consider delayed rewards. This may reflect a reduced capacity to integrate future outcomes into their present decision-making processes (Bartels & Rips, 2010).

Our findings revealed a notable age-dependent pattern among younger adults. Specifically, the relationship between self-continuity and temporal discounting was more pronounced among individuals aged 23 to 29 years compared to those aged 18 to 22 years. This variation suggests the developmental differences in the maturation of intertemporal decision-making process. Our findings may highlight a critical developmental transition point into early adulthood. Younger adults aged 23 and older begin to exhibit more sophisticated, future-oriented cognitive schemas that are closely linked to the evolution of personal identity and changing life goals during this period (Hershfield & Bartels, 2018). These cognitive advancements enhance their consideration of future consequences during intertemporal decision-making. In contrast, individuals aged 18 to 22 are often in a period of identity exploration and self-concept formation. This stage is characterised by more abstract and less integrated representations of their future selves, resembling those of others (Pronin et al., 2008). As a result, they tend to focus more on present outcomes rather than future ones.

4.1.2. Stability in older adults

In contrast, explicit self-continuity did not show a significant correlation with temporal discounting in older adults. These individuals exhibited increased temporal discounting, regardless of their level of explicit self-continuity (Frederick, 2002). Compared to younger adults, older adults consistently demonstrated higher explicit self-continuity, irrespective of their intertemporal choices. This finding suggests that their preference for immediate rewards may reflect an adaptive response influenced by age-specific cognitive and emotional processes in how they evaluate rewards. The socioemotional selectivity theory (Carstensen, 2006) posits that this preference for the present may stem from factors unique to ageing, such as health concerns, financial stability, and a heightened awareness of mortality when faced with time constraints (Carstensen & Reynolds, 2023). As a result, older adults tend to place greater emphasis on immediate rewards rather than delayed outcomes. Additionally, the weak link between explicit self-continuity and temporal discounting in older adults might stem from their minimal variations in discounting rates. In the present study, the delays in the MCQ questionnaire were from one week to six months, which may not provide sufficient delays to detect changes in temporal discounting among older adults. Future research should consider employing longer delays (e.g., 1 year, 5 years) when assessing temporal discounting, potentially revealing the relationship between self-continuity and temporal discounting in older adults.

Moreover, previous studies indicate that older adults tend to engage in future-oriented behaviour after future simulation, but this behaviour is not correlated with their future self-continuity (Engle-Friedman et al., 2022). Also, while future vividness can predict temporal discounting (Sokol & Serper, 2020), future similarity does not have this predictive power. This suggests that future self-continuity operates independently of the imagination of the future self, as indicated by future simulation (Hershfield & Bartels, 2018). Consistent with the finding that future thinking may not be an effective intervention for temporal discounting in older adults (Mok et al., 2020; Sasse et al., 2017), we may also need to be cautious of using future self-continuity as the intervention for optimising intertemporal choices in older adults (Seaman et al., 2022) or populations affected by conditions like Alzheimer's disease and Parkinson's disease (Godefroy et al., 2023).

4.2. Age differences in self-continuity

Furthermore, our study broadens the current understanding of the multifaceted effects of ageing on self-continuity.

4.2.1. Effects of time direction: Past vs. future

The end-of-history illusion suggests that people of all ages perceive their self-continuity as more stable in the future than in the past, as they anticipate fewer changes in their future values and preferences (Quoidbach et al., 2013). However, our findings indicated a more nuanced pattern across different age groups. Younger adults exhibited the classic end-of-history illusion, reporting a greater sense of future self-continuity compared to past self-continuity. In contrast, older adults displayed comparable levels of explicit self-continuity for both the past and future (Rutt & Lockenhoff, 2016). Interestingly, similar patterns of age-related self-continuity were observed in German populations but not in the U.S. context (Lu, Gerstorf, & Lockenhoff, 2023), suggesting potential cross-cultural variations in how temporal identity is constructed. Specifically, older adults from societies with stronger holistic values (e.g., China) or structured social systems, like Germany, tended to maintain a more integrated view of identity (Ji et al., 2018) compared to their U.S. counterparts, who are predominantly in an individualistic context (De Oliveira & Nisbett, 2017; Zhang et al., 2014). This enhanced integration of self-identity over time may help older adults incorporate past experiences into their decision-making and promote choices aligned with long-term goals.

Our results indicated that the end-of-illusion effect was most pronounced among younger adults aged 18 to 20. This group demonstrated a stronger future self-continuity compared to past self-continuity, reflecting past and future asymmetries in identity formation (Pronin & Ross, 2006). The notable past and future asymmetry in 18–20 year olds may result from their recent experience of the critical developmental transition from childhood to adulthood. They have not yet constructed an elaborate past self-continuity, while the heightened future orientation during early adulthood may represent a critical developmental period. This developmental transition coincides with the onset of adult responsibilities in areas such as career development, intertemporal relationships, and financial stability, which require individuals to integrate past experiences with future aspirations (Ibarra, 2005).

4.2.2. Effects of time intervals: Near vs. distant

Moreover, our findings are consistent with prior research (Hershfield, 2011), showing variations in explicit self-continuity across time intervals among younger adults. Participants exhibited higher self-continuity for temporally proximal points than distal ones, regardless of time directions. This pattern supported the construal level theory (Trope & Liberman, 2010), which suggests that as time distance increases, psychological abstraction in self-representation also rises, leading to a decreased sense of familiarity with distant selves. Understanding this dynamic could inform the development of interventions to enhance reflection on past experiences. This, in turn, may encourage young adults to consider their past more deeply, fostering a more integrated self and enhancing decision-making and personal growth.

4.2.3. Explicit vs. implicit self-continuity

Previous research has demonstrated associations between implicit self-continuity and temporal discounting across multiple time intervals in relation to ageing (Rutt & Lockenhoff, 2016). However, the current study did not find any age-related differences in implicit self-continuity or its relationship with temporal discounting. Earlier studies have shown that explicit and implicit self-continuity represent distinct aspects of self-perception and involve different cognitive mechanisms (Rutt & Lockenhoff, 2016). Additionally, our findings suggest that automatic responses related to temporal self-perception remain relatively stable throughout adulthood, regardless of broader cognitive developmental changes. Alternatively, current implicit measurement approaches may not be sensitive enough to detect subtle age-related variations in how older adults process self-continuity with future rewards. A recent study also indicated that self-reports could be more effective tools than implicit measures in psychological science (Corneille & Gawronski, 2024). Future research should employ diverse methodological approaches to explore further the developmental trajectories of self-continuity and their implications for intertemporal decision-making across the lifespan.

5. Limitations and future directions

This study employed a cross-sectional design, which cannot eliminate the confounding of the cohort effect when examining age differences. Although the meta-analysis did not find that the birth cohort confounds the age effect on temporal discounting (Lu, Yao, et al., 2023), future research using longitudinal designs should continue to investigate the age effect throughout the lifespan. Meanwhile, this study assessed temporal discounting using the MCQ questionnaire, examining timeframes from 7 to 186 days, while also evaluating self-continuity over a span of 1 day to 5 years. The differing timeframes between the two assessments may lead to a lack of association between self-continuity and temporal discounting in older adults compared to younger adults. Future research should use longer delays for temporal discounting to further confirm the generalization of the current findings. Moreover, this study did not include middle-aged adults. To further investigate the lifespan pattern in the relationship between self-continuity and temporal discounting, it is important to recruit more participants across a broader age range, including teenagers and middle-aged individuals.

6. Conclusion

This study highlighted the importance of understanding the complex relationship between explicit self-continuity and temporal discounting among different age groups. While explicit self-continuity acts as a protective factor against impulsive decision-making in younger adults, our findings suggested that this association weakens in older adults. This age-dependent pattern warrants further investigation into the cognitive and emotional mechanisms influencing the relationship between temporal discounting and self-continuity. Understanding these developmental dynamics is crucial for designing targeted interventions that can enhance decision-making strategies at various life stages, particularly in contexts involving long-term planning and health-related choices in later life.

CRediT authorship contribution statement

Lulu Liu: Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Yongle Lin:** Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Formal analysis, Data curation. **Menghan Sun:** Writing – review & editing, Project administration, Investigation, Data curation. **Zejian Chen:** Writing – review & editing, Validation, Project administration, Investigation, Data curation.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used Grammarly in order to improve the readability and language of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Declaration of competing interest

Lulu Liu reports financial support was provided by National Natural Science Foundation of China. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2025.104970.

Data availability

Data will be made available on request.

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