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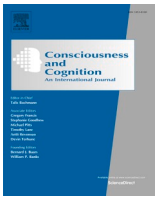

Emotional valence of self-defining memories in older adults: A longitudinal study

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ABSTRACT

The present study aimed to evaluate the pleasantness bias and fading affect bias in self-defining memories (SDMs) and to examine the relationship between their emotional valence of SDMs and cognitive function and serotonin transporter polymorphisms (5-HTTLPR) with a prospective longitudinal method. Ninety-two older adults recalled SDMs twice at an interval of one year (T1 and T2). The results showed a pleasantness bias and a fading affect bias in SDMs. The higher the working memory was, the higher the vividness of SDMs and the higher the concordance rate of SDMs between T1 and T2. Meanwhile, cognitive performance had no effect on the emotional valence of SDMs. Additionally, the repeatedly recalled SDMs in the S/S allele carriers of the 5-HTTLPR polymorphism changed with a lower negative valence at T2 than at T1. The 5-HTTLPR polymorphism may be a plasticity factor that predicts positive outcomes in positive situations.

1. Introduction

According to the theory of psychosocial development (Erikson & Erikson, 1998), integrity is a developmental task in old age. It involves the acceptance of life by reflecting on one's past life and making meaning of it. If integrity is not achieved, a sense of despair sets in because there is no time left to modify one's life. People look back at their lives based on their memories. Positive memories, such as accomplishments and events of happiness, and negative memories, such as failures and regrets, are autobiographical memories that form the self. Self-defining memories (SDMs), a subcategory of autobiographical memories, focus on enduring concerns (achievement, intimacy) or unresolved conflicts (conflict, ambivalence, dependence, etc.), which are regarded as integrative life reflections (Blagov & Singer, 2004; Blagov, Singer, Oost, & Goodman, 2022). SDMs are vivid, emotionally powerful, and frequently recalled (Singer, Rexhaj, & Baddeley, 2007; Singer, Blagov, Berry, & Oost, 2013); they are involved in pursuing long-term goals, accommodating changes over the life span (Moffitt & Singer, 1994), and creating self-esteem (Liao, Bluck, & Westerhof, 2018). Thus, SDMs are also involved in the meaning of life events (Blagov & Singer, 2004; Blagov et al., 2022). However, there are few studies of SDMs in older adults.

In this study, we focused on the emotional aspects of SDMs. Autobiographical memories are considered to have a pleasantness bias, in which positive memories are recalled approximately twice as much as negative memories (e.g., Rasmussen & Berntsen, 2009).

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Moreover, the fading affect bias (FAB), in which the intensity of negative emotions associated with autobiographical memory is more attenuated than that of positive emotions, has also been observed (Walker, Skowronski, Gibbons, Vogl, & Thompson, 2003). Studies that have examined the relationship between self-function and emotional valence in autobiographical memories have found that these two biases are adaptive in maintaining a positive sense of self (Wolf, Pociunaite, Hoehne, & Zimprich, 2021). The pleasantness bias (Martinelli, Anssens, Sperduti, & Piolino, 2013; Singer et al., 2007) and FAB (Ritchie, Skowronski, Cadogan, & Sedikides, 2014) have been observed for SDMs as well. It has been suggested that in SDMs, the pleasantness bias reflects a self-reinforcing process, and the fading affect bias reflects a self-protective process (Ritchie et al., 2014). However, these biases in SDMs have been studied less, with most studies being retrospective and recalling the emotions experienced during the event while comparing them to the current emotional valence of that event. The first purpose of this study was thus to examine whether these biases would occur by requiring older adults to recall the SDMs twice, with an interval of one year. Socioemotional selectivity theory (Carstensen, 2006), known as the life-span model of motivation, states that older adults who perceive their time as limited tend to value emotionally meaningful information and events and invest cognitive and social resources to achieve emotional satisfaction. In support of this theory, the positivity effect, in which older adults pay more attention to and remember positive information than negative information, has been observed (e.g., Reed & Carstensen, 2012). In SDMs, cross-sectional studies comparing older adults with younger adults (Singer et al., 2007) and middle-aged adults (Cuervo-Lombard, Raucher-Chéné, Linden, & Voltzenlogel, 2021) found that older adults recalled more positive SDMs than did other age groups. In this study, therefore, it would also be expected to observe pleasantness bias, in which older adults recall more positive SDMs, and FAB, in which negative emotions of SDMs are more attenuated than positive emotions.

Although cognitive functions, such as processing speed, episodic memory, and working memory, decline with age (Park et al., 2002), the importance of executive functions has been highlighted in the retrieval of autobiographical memories at each stage of elaboration regarding retrieval cues, strategic retrieval, and verification of retrieval results (Conway & Pleydell-Pearce, 2000). People with higher working memory, inhibitory control and cognitive flexibility recall more specific autobiographical memories and fewer general autobiographical memories (Guler & Mackovichova, 2019). Age-related declines in working memory and executive function are associated with a decrease in specific memories and an increase in general autobiographical memory (Piolino et al., 2010; Ros et al., 2009, 2017). Studies on SDMs have reported that the higher the updating ability of executive functions, the more SDMs are generated (El Haj & Gallouj, 2019). Meanwhile, it has been reported that SDMs can be retrieved by older adults and youths (Martinelli et al., 2013). As a second purpose, we measured a wide range of general cognitive functions to examine the relationship between functions that decline with age (perceptual reasoning, working memory, processing speed) and functions without age-related decline (verbal comprehension) and SDMs. To the best of our knowledge, no study has directly examined the relationship between the emotional valence of SDMs and cognitive function in older adults. Positive experiences are frequently rehearsed to strengthen the self or be shared with others (Wolf et al., 2021). Thus, the recall of positive SDM requires little effort and would be predicted to be less affected by memory functions that decline with age, such as working memory. Conversely, negative events are rehearsed less frequently and thus have lower intensity (Wolf et al., 2021). Therefore, if recall of negative SDMs requires more effort, it is expected that the lower the cognitive functioning, the less negative SDMs will be recalled.

In addition to age and cognitive processes, physiological factors also involve emotional processes. Emotional responses are, at least in part, genetically regulated (Canli, Ferri, & Duman, 2009). In the current study, we focus on serotonin, which has been widely studied as a neurotransmitter related to the processing of emotional information (Canli & Lesch, 2007), the interaction of emotion and memory (Mammarella, Di Domenico, & Fairfield, 2016; Meneses & Liy-Salmeron, 2012), and the generation and control of emotions such as subjective satisfaction (Lachmann et al., 2021). The serotonin transporter gene SLC6A4 has been studied more than any other candidate gene in neurobiology (Jonassen & Landrø, 2014). Brain imaging studies have shown an association between serotonin genes and networks in the amygdala and prefrontal cortex that are involved in the interaction between emotion and memory (Mammarella et al., 2016; Todd, Palombo, Levine, & Anderson, 2011). The pleasantness bias and fading affect bias are robust effects resulting from the interaction of memory and emotion, and these effects may be influenced by serotonin. However, we have not found any studies examining the association between genes and the emotional valence of SDM.

The serotonin transporter (5-HTT) is a key regulator that removes serotonin released into the synaptic cleft. The 5-HTT protein is encoded by a single gene, SLC6A4, and its expression is modulated by 5-HTTLPR. The short ('S') allele of 5-HTTLPR is less efficient at transcribing 5-HTT than the long ('L') allele, resulting in higher concentrations of serotonin in the synaptic cleft (Canli & Lesch, 2007). In particular, relationships between two short allele (S/S) carriers and negative emotions, such as anxiety (Lesch et al., 1996) and depression (Caspi et al., 2003), have been reported. It has also been suggested that the nervous system, which enhances fear and arousal and sustains the emotional salience of a threat, is preferentially activated under stress (Drabant et al., 2012). In addition, a study examining the association between brain activity and 5-HTTLPR, while considering personality traits and friends, revealed that S/S carriers experienced strong distress during negative reflection, with increased activity in the dorsal anterior cingulate cortex, dorsal medial prefrontal cortex, and right anterior insula (Ma et al., 2014). Although depressed individuals often recall negative memories (Gaddy & Ingram, 2014), studies examining the association between the 5-HTTLPR polymorphism and emotional memories have shown that children with the S/S allele recall more negative memories (Hayden et al., 2008), and those with the S/S allele who have experienced interpersonal childhood trauma events are less likely to recall positive memories (Vrijsen et al., 2015). Thus, the 5-HTTLPR polymorphism has been suggested to be involved in negative emotions and memories, predicting that the S/S genotype is associated with negative SDM recall.

However, some studies suggest that short alleles are associated with positive emotional expression. A study examining the association of 5-HTTLPR with positive emotional expression while reading still cartoons and viewing thematically ambiguous but subtly amusing films showed that short alleles were associated with heightened positive emotional expression, such as laughter and smiling behavior (Haase et al., 2015). Another study revealed that S/S carriers report more anger and amusement and exhibit more

emotionally expressive behaviors in response to embarrassing situations (Gyurak et al., 2013). Additionally, a study examining the association between the serotonin gene and sensory processing sensitivity, which is a personality trait that is sensitive to subtle stimuli and exhibits strong positive and negative emotional reactions, reported that 5-HTTLPR S-allele carriers showed increases in both negative and positive emotional responses (Homberg, Schubert, Asan, & Aron, 2016). It has also been suggested that S-allele carriers have higher and lower emotions over a wide range (negative and positive) in response to various emotion-inducing situations encountered in daily life than long-allele carriers (Haase et al., 2015). Several studies have reported that the S allele is not a vulnerability factor that predicts negative outcomes but rather as a plasticity factor that predicts negative outcomes in negative situations and positive outcomes in positive situations (Belsky & Pluess, 2009). For example, the S/S 5-HTTLPR genotype is associated with lower memory specificity in individuals with a history of major depressive disorder. Meanwhile, the S/S 5-HTTLPR genotype was associated with greater memory specificity in individuals without a history of major depressive disorder (Sumner et al., 2014). Thus, if the S allele is a plasticity factor, we would expect S/S carriers to exhibit more pleasantness bias and FAB than L allele carriers.

2. Methods

2.1. Participants

Five hundred Japanese older adults aged 65 years or older, selected from the pool of older adults who had participated in previous studies, were asked to participate by mail, and recruitment was closed upon obtaining the consent of 100 participants. A total of 69 males and 31 females participated in the first experiment (T1). The second experiment was conducted one year after T1. Data from 92 participants (63 males and 29 females, mean age = 71.87 years, SD = 4.10) who participated at both T1 and T2 were used for analysis. The mean education years was 13.87 (SD = 2.23). None of the participants had a history of neurological or psychiatric illness. The study measured the WAIS-IV as a measure of cognitive function, and none of the participants had extremely low intelligence with a full scale intelligence quotient below 70. Informed consent for participation was obtained from all the participants. They were paid 5000 yen for T1 and 3000 yen for T2 as rewards.

The sample size validity was examined using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). In this study, to examine the difference between SDM recalled only at T1 and SDM recalled repeatedly at T1 and T2, we conducted a repeated one-way analysis of variance (ANOVA) for each SDM index. Assuming a moderate effect size (0.25), the sample required to obtain a power of 0.8 was 34 participants (Faul et al., 2007). Ninety-two participants participated in both T1 and T2, which allowed us to detect a small-to-moderate effect (f = 0.15) with a power of 0.8. In addition, ANOVA was used to compare the 5-HTTLPR genotypes for the SDM index. Since the genotypes of the participants were measured at T1, the number of participants could not be determined by the genotype beforehand. Therefore, a post hoc power analysis was conducted, and the power is described in the Results section.

2.2. Measures

2.2.1. Self-Defining memory task

To measure SDMs, an SDM task and memory rating sheet were used (Singer & Blagov, 2000). In this task, the participants were asked to recall five SDMs after explaining the characteristics of SDMs to them: they are clearly remembered and still important; they are related to important enduring themes from your life and help explain yourself, leading to strong emotions; and they are recalled many times. The participants were asked to recall their memories in as much detail as possible. Then, using a memory rating sheet, they rated vividness and importance of each SDM and their emotions when recalling each SDM on the basis of 12 emotions (“happy,” “sad,” “angry,” “fearful,” “surprised,” “ashamed,” “disgusted,” “guilty,” “interested,” “embarrassed,” “contempt,” and “proud”) with a seven-point Likert scale ranging from 0 (Not at all) to 6 (Extremely). For the emotional valence of SDMs, positive valence (additive mean of happy, proud, and interested) and negative valence (additive mean of sad, angry, fearful, ashamed, disgusted, guilty, embarrassed, and contempt) were calculated according to a previous study (Singer et al., 2007). The SDM indices listed in Table 1 were used for the analysis.

Table 1
Indices of self-dfining memory in this study.

Index	Measurement
Positive valence	Mean of positive factors of SDMs recalled at T1
Negative valence	Mean of negative factors of SDMs recalled at T1
Vividness	Mean of vividness of SDMs recalled at T1
Importance	Mean of importance of SDMs recalled at T1
Age score	Mean of age at event of SDMs experienced
Concordance rate	Proportion of SDMs recalled at T1 that were also repeated at T2 (%)
Change in positive valence	Positive valence at T2 minus positive valence at T1 for repeatedly recalled SDMs
Change in negative valence	Negative valence at T2 minus negative valence at T1 for repeatedly recalled SDMs
Change in vividness	Vividness at T2 minus vividness at T1 for repeatedly recalled SDMs
Change in importance	Importance at T2 minus importance at T1 for repeatedly recalled SDMs

2.2.2. Cognitive function

Cognitive function was measured using the Japanese version of the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV; Wechsler, 2018). The Full Scale Intelligence Quotient (FSIQ), Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI) were calculated from the scores of the 10 core subtests.

2.2.3. Mood

The mood congruency effect makes autobiographical memories that are congruent with the current mood more likely to be recalled than those that are incongruent (Holland & Kensinger, 2010). To adjust for the effect of mood on recalled SDMs, we measured psychological well-being as positive mood and psychological distress as negative mood. Psychological well-being was measured using a simplified Japanese version of the World Health Organization Five Well-Being Index (WHO-5-J; Inagaki et al., 2013). Each item was measured on a four-point scale, with higher scores indicating higher psychological well-being. Psychological distress was measured using the Japanese version (Furukawa et al., 2008) of the Kessler Psychological Distress Scale (K6; Kessler et al., 2002). The participants were asked to respond to six items measuring the frequency with which they experienced symptoms of psychological distress (e.g., feeling so sad that nothing could cheer them) during the past 30 days. The participants rated their responses on a five-point scale. At T1, the mean of WHO-5 was 3.27 (SD = 0.82), and the mean of K6 was 0.54 (SD = 0.45); at T2, the mean of WHO-5 was 3.52 (SD = 0.95), and the mean of K6 was 0.39 (SD = 0.42).

2.2.4. Genotyping to generate the S- and L-Fragments

DNA was isolated from saliva (Oragene, DNA Genotek Inc., Ottawa, Canada), and polymerase chain reaction (PCR) amplification was conducted with the following primers: 5′-GGCGTTGCCGCTCTGAATTGC-3′ (stpr5-2) and 5′-GAGGGACTGAGCTGGACAACCAC-3′ (stpr3-2) in a total volume of 12.5 μL, consisting of 100 ng genomic DNA, 10 mM Tris-HCl (pH 8.3), 50 mM KCl, 1 mM MgCl2, 200 μM dNTPs, 5% dimethyl sulfoxide, 0.2 μM of each primer, and 0.5 U of Taq polymerase (Thermo Fisher Scientific, Waltham, MA, USA) for 35 cycles (94 °C for 30 s, 61 °C for 30 s, and 72 °C for 1 min). The PCR products were analyzed on a 3% agarose gel stained with ethidium bromide according to a previous study (Heils et al., 1996).

2.3. Procedure

The experiments were conducted individually. At T1, the experiment was divided into two days. On the first day, the experimenter explained the purpose of the study to the participants and obtained their written informed consent, following which their cognitive function was measured. On the second day, mood, SDMs, emotion regulation scale, and saliva sampling were examined in that order. The participants wrote down the SDMs on the record sheets.

Since T2 occurred during the COVID-19 pandemic, it was conducted as a telephone interview. All conversations were recorded with the participants' consent. Measurements of mood and SDM tasks were conducted in this order. After the SDM task, the five SDMs recalled in T1 were presented to the participants orally and individually. The participants were asked to report whether they were consistent with the SDMs recalled at T2.

The SDM recall procedure differed between T1, which was written, and T2, which was verbal. To confirm whether the difference in procedure affected the emotional valence of the SDMs recalled, the comparison was made between T1 and T2 for each of the positive (T1, Mean = 3.36, SD = 1.21; T2 = 3.39, SD = 1.11) and negative scores (T1, Mean = 1.55, SD = 1.05; T2 = 1.36, SD = 0.84) of the SDMs. The results showed no significant difference in each emotional valence of SDMs between T1 and T2 (positive score, t (91) = -0.261, p = .80, Cohen's d = 1.22; negative score, t (91) = 1.46, p = .15, Cohen's d = 1.23).

The ethics committee of our research institution provided approval for the present study.

Table 2
Comparison of SDM Indices Between SDMs With and Without Repeated Recall at T1.

Self-defining memory		Mean	SD	ANOVA		
				F	*P value*	partial η^2
Positive valence	recalled only at T1	3.32	1.53	0.47	0.50	0.01
	recalled at both T1 and T2	3.44	1.51			
Negative valence	recalled only at T1	1.54	1.18	0.20	0.66	0.00
	recalled at both T1 and T2	1.48	1.31			
Vividness	recalled only at T1	4.92	1.36	3.80	0.05†	0.04
	recalled at both T1 and T2	5.09	1.18			
Importance	recalled only at T1	4.52	1.51	11.47	0.001*	0.12
	recalled at both T1 and T2	4.97	1.15			
Age score	recalled only at T1	33.24	12.73	0.08	0.78	0.00
	recalled at both T1 and T2	33.79	16.33			

Note. †p. < 0.10; *p. < 0.001.

3. Results

3.1. The pleasantness bias and fading affect bias

Although the participants were asked to recall five SDMs, three participants recalled only four SDMs at T1. Therefore, 457 SDMs were recalled at T1, and 183 were repeated at T2.

Comparing the degree of emotional valence between positive (mean = 3.36, SD = 1.21) and negative (mean = 1.55, SD = 1.05) emotions at T1, positive valence was significantly higher, and the participants recalled more SDMs with positive emotions (F (1, 91) = 80.51, p = . 000, η_p^2 = .47). This result implies a pleasantness bias.

To evaluate the FAB on the changes in positive (T1, Mean = 3.44, SD = 1.51; T2, Mean = 3.42, SD = 1.38) and negative (T1, Mean = 1.48, SD = 1.31; T2, Mean = 1.37, SD = 1.03) emotional valence of repeatedly recalled SDMs, we compared T1 and T2 for each emotional valence by ANCOVA with the positive and negative moods (T1 and T2) as covariates. In this analysis, 88 participants, excluding the four participants who recalled completely different SDMs at T1 and T2, were analyzed. As a result, the FAB showed that the negative emotional valence was attenuated (T1, F (1, 83) = 5.11, p = . 03, η_p^2 = .06), although the positive emotional valence of SDM did not attenuate (F (1, 83) = 0.37, p = . 54, η_p^2 = .01).

Additionally, to examine the characteristics of SDMs recalled repeatedly, we compared SDMs recalled only at T1 and SDMs recalled at both T1 and T2 for each emotional valence, vividness, importance at T1, and age score using one-way repeated-measures ANOVA (Table 2). The analysis results showed that the SDMs that were recalled repeatedly were significantly more important (F(1, 87) = 11.47, p = .001, η_p^2 = .12) and tended to be more vivid (F(1, 87) = 3.80, p = .05, η_p^2 = .04) than the SDMs that were not recalled repeatedly. No significant differences were found for emotional valence (positive, F(1, 87) = 0.47, p = .50, η_p^2 = .01; negative, F(1, 87) = 0.20, p = .66, η_p^2 = .00) or age (F(1, 87) = 0.01, p = .78, η_p^2 = .00).

3.1.1. Relationship between SDMs and cognitive function

Zero-order correlation analyses were conducted to examine the relationships among each index of the SDMs and cognitive functioning (Table 3). The results showed that the higher the WMI was, the greater the vividness of the SDMs (r = 0.24, p = .02) and the higher the concordance rate (r = 0.31, p = .003). No significant correlation was found between emotional valence and cognitive

Table 3
Means and Correlation Coefficients for SDMs, Age, and Cognitive Function.

Variables		Age	WAIS-IV				
			FSIQ	VCI	PRI	WMI	PSI
SDM	Mean (SD)	71.87 (4.10)	110.88 (15.39)	112.73 (14.80)	105.15 (15.75)	108.70 (14.68)	107.17 (15.91)
Positive valence	3.36 (1.21)	−0.01	−0.09	−0.05	−0.05	−0.05	−0.11
Negative valence	1.55 (1.05)	0.03	0.03	0.00	0.10	−0.11	0.04
Vividness	4.97 (1.19)	−0.01	0.16	0.07	0.10	0.24*	0.13
Importance	4.69 (1.19)	−0.08	0.08	0.07	0.00	0.18†	0.07
Age score	33.39 (10.60)	0.11	−0.10	−0.02	−0.07	−0.13	−0.15
Concordance rate	40.00 (18.75)	0.03	0.13	0.06	0.19†	0.31**	−0.05
Change in positive valence	−0.02 (1.31)	−0.01	0.01	0.08	−0.01	0.02	−0.12
Change in negative valence	−0.11 (1.50)	−0.12	−0.01	0.00	−0.05	0.15	0.03
Change in vividness	0.22 (1.24)	0.02	−0.09	−0.09	−0.07	−0.10	0.01
Change in importance	−0.09 (1.71)	−0.14	−0.07	0.04	−0.11	0.00	−0.05

Note. SDM = self-defining memory; WAIS-IV = Wechsler Adult Intelligence Scale-Fourth Edition; FSIQ = Full Scale Intelligence Quotient; VCI = Verbal Comprehension Index; WMI = Working Memory Index; PSI = Processing Speed Index; † p < .10, * p. < 0.05; **p. < 0.01.

function.

3.2. Comparison between serotonin polymorphisms for each SDM Index

The results of PCR analysis showed that the genotypes were S/S in 43, S/L in 49, and L/L in 4 individuals. It has been suggested that S allele homozygotes (S/S) exhibit greater emotional reactivity than heterozygotes (S/L) or L allele homozygotes (L/L) (Harrington et al., 2019). Additionally, since the L/L genotype is uncommon in Japanese individuals, the participants were divided into two groups according to previous studies: the S/S allele group and the L allele group with one or two L alleles (e.g., Katsuyama et al., 2008).

ANOVA was conducted to compare each SDM measure among serotonin gene polymorphisms (Table 4). The results showed no main effect of genotype polymorphism on the emotional valence, importance, vividness, or age scores of SDMs recalled at T1. A main effect of genotype was found, however, for the temporal change in emotional valence between T1 and T2. The results revealed that the positive emotional valence of the repeatedly recalled SDMs tended to increase more at T2 than at T1 ($F(1, 86) = 3.36$, $p = .07$, $\eta_p^2 = .04$), and the negative emotional valence decreased significantly more at T2 than at T1 ($F(1, 86) = 4.51$, $p = .04$, $\eta_p^2 = .05$) for the S/S allele carriers. The powers for these analyses were.49 (effect size (f) = 0.20, α = 0.05) for the change in positive valence and.59 (effect size (f) = 0.23, α = 0.05) for the change in negative valence. ANCOVA was also conducted to confirm whether these differences were still found after adjusting for changes in mood from T1 to T2 and working memory, which was significantly associated with the SDM index in the correlation analysis above. The results showed a significant main effect of genotype polymorphism on the change in negative valence ($F(1, 83) = 3.83$, $p = .05$, $\eta_p^2 = .04$), although no significant main effect of genotype was found for the change in positive valence ($F(1, 83) = 3.32$, $p = .07$, $\eta_p^2 = .04$). These results suggest that older adults with the S/S allele show more FABs with decreasing negative valence over time than L carriers.

4. Discussion

This study aimed to elucidate the features of repeated recall of SDMs by asking participants to recall SDMs twice (T1 and T2) with an interval of one year and to examine the relationship between the emotional valence of SDMs and cognitive function and serotonin genotype.

4.1. Features of Self-Defined memory and their relationship to cognitive function

The results showed a pleasantness bias in recalling positive SDMs rather than negative SDMs and FAB, in which the negative emotional valence of SDMs was more attenuated than the positive emotional valence. The pleasantness bias reflects a self-reinforcing process, while the FAB reflects a self-protective process (Ritchie et al., 2014). An example of positive SDMs that related the self-reinforcing process was the following.

> *I started swimming for the first time at the age of 65 and learned to swim crawl. Now I belong to a master class, my times are getting a little faster, and I enjoy practicing.*

Table 4
Comparison of SDM Indices Between S/S Alleles and the L Allele Groups.

Self-defining memory	5HTT polymorphisms	Mean	SD	ANOVA		
				F-statics	*P value*	partial η^2
Positive valence	S/S	3.23	1.27	0.90	0.35	0.01
	L allele group	3.47	1.16			
Negative valence	S/S	1.72	1.13	2.16	0.14	0.02
	L allele group	1.40	0.97			
Vividness	S/S	4.94	1.24	0.07	0.80	0.00
	L allele group	5.00	1.17			
Importance	S/S	4.61	1.20	0.36	0.55	0.00
	L allele group	4.76	1.19			
Age score	S/S	33.94	12.05	0.21	0.65	0.00
	L allele group	32.91	9.24			
Concordance rate	S/S	37.67	17.57	1.25	0.27	0.01
	L allele group	42.04	19.68			
Change in positive valence	S/S	0.26	1.35	3.36	0.07†	0.04
	L allele group	−0.25	1.23			
Change in negative valence	S/S	−0.47	1.41	4.51	0.04*	0.05
	L allele group	0.20	1.54			
Change in vividness	S/S	0.09	1.15	0.78	0.38	0.01
	L allele group	0.33	1.34			
Change in importance	S/S	−0.11	1.66	0.02	0.89	0.00
	L allele group	−0.07	1.77			

Note. † $p < .10$, * $p < .05$.

An example of SDMs that could be considered the self-protection process included the following.

> *I was bullied in elementary school. I could not even talk to my mother about it. As an adult, I told my friends at a class reunion that I had been bullied, and they apologized for not being able to help me. I felt like I was saved.*

The present study suggests that self-reinforcing and self-protection processes are maintained in older adults via SDMs. In addition, the SDMs that were recalled repeatedly were of higher importance and tended to be more vivid. These results support that older adults can identify significant experiences that help determine their sense of enduring identity (Singer et al., 2007). Examples of repeatedly recalled SDMs are as follows.

> *When I was approximately 40 years old, I often traveled with my wife and three children. It was a very busy time at work, but the smiles on my children's faces encouraged me to do my best at work, and it was a very fulfilling time. It is a precious memory that I will never forget for the rest of my life.*
> *Twenty-six years ago on October 21, I lost my oldest son, age 16, in a motorcycle accident. I was off work that day and my second son and I were playing baseball at a nearby park. Then, my wife came and told me that my eldest son had been rushed to the hospital. I hurried to the hospital, but he was already dead. I will never forget it for a day.*

Regarding the association between cognitive function and SDM, higher WMI was associated with higher SDM vividness and a higher concordance rate. When asked to recall important autobiographical memories such as SDMs, an individual needs to access the target information from a variety of sources. The strategic search process, including identification of the context for retrieving the target information, retrieval of information from the context, and verification of the retrieved information, is thought to be regulated by working memory in the frontal cortical network (Conway & Pleydell-Pearce, 2000). A study that examined the relationship between autobiographical memory retrieval and working memory found that individuals with high working memory capacity were better at generating contextual information as cues for retrieval than those with low working memory capacity and were also better at retrieving the desired information from the context (Unsworth, Spillers, & Brewer, 2012). In addition, the higher the working memory is, the more specific autobiographical memories recalled and the less overgeneral categoric memories recalled (Piolino et al., 2010; Ros, Latorre, & Serrano, 2009). In the present study, the participants with high working memory were able to recall not only the contents of SDMs but also their contextual information, thus being able to recall SDMs more vividly and improve the concordance rate. Meanwhile, cognitive functioning was not associated with the emotional valence of SDMs. A study (El Haj & Allain, 2020) of patients with mild Alzheimer's disease (AD) reported that although AD showed fewer specific SDMs than healthy older adults (controls), no significant differences in the number of neutral, positive, and negative SDMs recalled were found between AD participants and controls. They also found both AD participants and controls recalled mainly positive SDM (pleasantness bias). Positive events are frequently rehearsed to strengthen the self or to share them with others (Wolf et al., 2021). Since recalling positive SDMs does not require an effortful process dependent on cognitive functioning, it is possible that an association with cognitive functioning was not found.

4.2. The serotonin transporter 5-HTTLPR polymorphism and Self-defined memory

Regarding the association with the serotonin transporter 5-HTTLPR polymorphism, the repeatedly recalled SDMs in the S/S group changed to have a lower negative valence at T2 than at T1. Serotonin is a neurotransmitter involved in emotional function, and the serotonin transporter (5-HTT) is an important regulator that removes serotonin released into the synaptic cleft. Short allele variants of 5-HTTLPR reduce the expression of the serotonin transporter, resulting in lower levels of serotonin uptake from the synaptic cleft (for review, see Canli & Lesch, 2007).

Previous studies have shown an association between S/S allele carriers and negative emotions such as anxiety (Lesch et al., 1996) and depression (Caspi et al., 2003). Meanwhile, some studies suggest that short alleles are associated with positive emotional expression. S/S carriers show higher sensitivity to both negative and positive life event influences, with higher neuroticism, when subjects are exposed to negative environments but show lower neuroticism in positive environments than L allele carriers (Pluess, Belsky, Way, & Taylor, 2010). Several studies suggest that 5-HTTLPR is not a vulnerability factor that predicts negative outcomes in negative situations but a plasticity factor that predicts positive outcomes in positive situations (Belsky & Pluess, 2009; Sumner et al., 2014) and that the S allele functions as an emotional amplifier (Haase et al., 2015). These features of the 5-HTTLPR polymorphism may promote emotional aspects of SDMs. Even after adjusting for mood as a covariate, we observed a main effect of the 5-HTTLPR polymorphism in FAB. Our results support the idea that candidate genes such as 5-HTTLPR, along with age, ethnicity, depressive symptoms, and other genetic factors, are small but robust factors contributing to individual differences in emotional expression (Haase et al., 2015).

4.3. Limitations and future directions

Although the present study focused on temporal changes in emotional valence, we did not examine changes in the content of the recalled memories. Studies constructing life stories (McAdams, Reynolds, Lewis, Patten, & Bowman, 2001) that examine how people narratively situate personal experiences with emotion report that a bad, affectively negative life scene could be subsequently transformed and redeemed into a positive life scene (redemption sequence). A longitudinal study over a longer time span with detailed data on the content of SDMs is required to determine whether the change in emotional valence reflects changes in emotional valence only or in the redemption sequence.

In the present study, there were no relationships between the emotional valence of SDMs and cognitive function. This suggests that

age-related decline in cognitive function in the normal range does not affect the increase or decrease in negative or positive memories. Then, what influences the recall of positive or negative SDMs? Autobiographical memories play a role in regulating emotions and improving mood by maintaining self-relevant positive emotions and minimizing negative emotions (Rasmussen & Berntsen, 2009; Ritchie et al., 2014). Emotion regulation strategies are promising candidate variables to examine individual differences in retrieving emotional autobiographical memories (Wolf et al., 2021). Especially since older adults are motivated by emotion regulation (Carstensen, 2006), future research should examine the relationship between the emotion regulation strategies used by individuals and the characteristics of SDMs, such as pleasure bias and FAB.

To date, no studies have been reported examining the association between SDMs and genetic polymorphisms. Therefore, the finding that SDMs in S/S carriers amplified the FAB is interesting when considering the effect of serotonin transporter polymorphism (5-HTTLPR) on emotional responses. However, associations between other genetic polymorphisms and emotional memory have been reported (for review, Todd et al., 2011), and the candidate gene approach, which focuses on specific genes, also has limitations. Although it is difficult to obtain a sufficient sample size to conduct genome-wide association studies in longitudinal studies of SDMs, further studies on the emotional valence of SDMs and genetic factors need to be conducted.

This study showed that emotional valence affects recall of SDMs, that the attenuation over time varies by emotional valence, and that 60% of SDMs are replaced within one year. Studies of episodic memory in the older adults often focus on performance, such as memory capacity and accuracy. However, previous studies on SDMs have shown that features such as forgetting and transformation involve self-reinforcement and self-protection, and our results suggest that these functions are maintained in old age. There are few studies of SDMs in older adults. In achieving integrity, which is a developmental task in old age, it is necessary to advance research on SDMs associated with making sense of life (Blagov et al., 2022).

CRediT authorship contribution statement

Kouhei Masumoto: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing – original draft, Visualization, Supervision, Project administration, Funding acquisition. **Koji Sato:** Validation, Formal analysis, Resources, Writing – original draft, Funding acquisition. **Kazuhiro Harada:** Methodology, Resources, Data curation, Writing – review & editing, Funding acquisition. **Kenta Yamamoto:** Validation, Investigation, Writing – review & editing. **Mariko Shiozaki:** Conceptualization, Data curation, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Research data for this article

The data analyzed during the current study are available from the corresponding author on reasonable request.

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