Younger and older adults with high cognitive function can lead to positive bias in future imagination: Compared to near and far future

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高い認知機能を有す若齢者・高齢者は未来イメージをポジティブに変容させる――近未来と遠未来の比較――

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要約

本研究は、認知機能が自己の生活の近未来及び遠未来のイマジネーションの楽観性に影響を与えるかどうか、40 歳から 87 歳を対象に検討した。ポジティヴィティ効果と社会感情選択理論に基づく統合仮説によれば、認知機能の高者は低者と比べ、ポジティブに未来をイメージすることにつながることが予測された。さらに、認知機能の高い高齢者は近未来をポジティブに変容させる一方で、若齢者は遠未来をポジティブにイメージすることが予測された。本研究は、296 名に対し未来のイメージに関する質問紙と MMSE、LMT、ストループ課題を用いた認知課題を課した。結果として、MMSE と LMT において高い成績を示した者は、ポジティブな未来をイメージすることが分かった。さらに、60 歳以下において高い MMSE とストループ成績、LMT 得点を示した者は、10 年後といった遠未来をポジティブにイメージする一方で、60 歳以上において高い MMSE、ストループ成績、LMT 得点を示した者は、低い得点を示した者と比べて、1 年、3 年といった近未来をポジティブにイメージすることが分かった。これらの結果から、ポジティヴィティ効果と社会感情選択理論との統合仮説は、認知機能の低下が相対的に高い 60 歳以下の男性を除き、すべての参加者において支持された。

Key words

future imagination, positive bias, positivity effect, socioemotional selective theory, cognitive funtion

1. Introduction

As people grow older, the ability to regulate emotional status improves (e.g., Mather & Carstensen, 2005). Especially, adults over 60 years old appear to have increased positive affect and decreased negative affect that is, the positivity effect (e.g., Mather, 2006; Mather & Carstensen, 2005; Mother & Knight, 2005). Positive future emotional experiences are an important of aspect of mental health, well-being, and quality of life.

Evidence of a positivity effect has been obtained in studies of attention and memory, including goal-directed selective processing and memory for words, pictures, and faces (e.g., Mather, 2006). For example, compared to younger adults, older adults recalled less from slides consisting of negative pictures (Charles, Mather, & Carstensen, 2003). Also, in older adults, autobiographical memories were more likely to be distorted in a positive direction (Kennedy, Mather, & Carstensen, 2004). Thus, older adults report fewer unhappy events in their lives, and this may enhance their well-being.

Moreover, Kryla-Lighthall and Mather (2008) proposed that cognitive control may lead to the positivity effect. Specifically, they emphasized that the positivity effect must pass through the following, first is that emotional regulation goals are likely to be activated in older adults, second is that cognitive processes must be available, and third is that memory and attention tasks are likely to be influenced by available cognitive processes. They emphasized that successful emotion regulation depends on active use of cognitive control. Therefore, if cognitive function decreases in older adults, positivity bias is less likely and negativity bias is more likely.

Recent studies have hypothesized that past and future autobiographical thought is mediated by shared cognitive systems (e.g., Addis, Wong, & Schacter, 2008; Atance & O'Neill, 2001; Schacter & Addis, 2007; Suddendorf & Corballis, 1997; Tulving, 2002). For example, Addis, et al. (2008) asked young and older adults to generate past and future events to cue words (e.g., tree) and describe the event in as much detail as possible for 3 min. As results, the older adults generated fewer episode-specific details relating to the past events than the younger adults.

Importantly, the same effect occurred for future events. Addis et al. (2008) suggest that the ability of older adults to generate episode-specific details of both past and future events was correlated with their ability to integrate information and form relationships between items. Thus, Schacter and colleagues found a close relation between episodic memory and future imagining in older adults, as well as in clinical individuals and university students (e.g., Addis, Wong, & Schacter, 2008; Schacter & Addis, 2007; see also Dickson & Bates, 2006). Considered the above finding, it is possible that the emotion distorted in positive direction reported in autobiographical memory can lead to that in future imagination on older adults' lives. Furthermore, as stated before, cognitive function could influence on positivity effect. Taken together, we examined whether the future imagination of adults having high cognitive function would be more positive than the future imagination of those with low cognitive function.

Carstensen and colleagues applied Socioemotional Selective Theory (SST; Carstensen, 2006) to reveal that younger adults focus on optimizing the future, whereas older adults focus on the maximization of meaningful activities in the present (Carstensen, 2006; Fung & Carstensen, 2004; Lockenhoff & Carstensen, 2004; Charles & Carstensen, 2010). SST is a life-span theory of motivation that predicts enhanced emotion regulation with age (Carstensen, Fung, & Charles, 2003). Following SST, we predicted that imagination of the future close to the present (the near future) would be more positive for older adults, whereas younger adults would imagine the far future more positively.

Thus, combining the findings of SST and the positivity effect, we propose the following hypothesis. First, adults with high cognitive function would imagine their future positively, compared to those with low cognitive function. Second, adults over 60 years old with high cognitive function may exhibit a positivity bias limited to a near future span, 1 and 3 years later. Also, adults below 60 years old with high cognitive function would imagine positively the far future, 5 and 10 years later.

We examined whether a high level of cognitive function has an influence on positive future imagination. Previous studies of positivity bias in older adults have shown a direct relation between cognitive ability and positivity effect or SST. For example, older adults in previous studies of the positivity effect were restricted as an index, some degree of educational status (Kennedy et al., 2004), and recognition performance (Spaniol, Voss, & Grady, 2008), whereas the cognitive status of those in other previous studies remains unclear (see also Fung, Isaacowitz, Lu, & Li, 2010; Petrican, Mikels, & Carstensen, 2008; Sullivan, Moscovitch, Schimack, 2010). Therefore, we measure cognitive ability using the MMSE, Stroop test, and Logical Memory Test (LMT) to determine its influence on the future imagination of middle, elderly, and older adults.

Japan is a country with long-living people, and women have especially greater longevity than men (White Paper on Aging Society, 2011). If people who consider things positively, such as optimists, are able to live longer (e.g., Seligman, 1991), we may predict that women will have more positive future imagination than men. Because few studies have shown a sex difference, we examined the differences in future imagination between women and men with high and low cognitive function.

2. Method

2.1 Participants

Two hundred ninety-six adults who participated in Nagoya University's 2011 Yakumo Town Study was enrolled. They were selected according to the following criteria: those who completed a questionnaire of future imagination without a voluntary clinical examination, and who were given the MMSE (Mini-Mental State Examination; Folstein, Folstein, & McHugh, 1975), Logical Memory Test (LMT; the standardized Japanese short version of Wechsler memory scale (Hatta, Kanari, Mase, Nagano, Shirataki, & Hibino, 2009)), and Stroop test (Stroop, 1935). Participants showed no sign of serious frailty syndrome, such as metastatic neoplasm. Informed consent was obtained from participants, and the study was approved by the Ethical Committee of Nagoya University Medical School (No. 643).

2.2 Questionnaire of near and far future imagination

Future imagination of their lives was measured based on the following question. "How happy do you imagine your life will be, compared to your present life? You should assume that the present is the criterion "zero", +5 means that you will live completely happily and -5 means that you will live completely unhappily. You should circle the appropriate number for 1, 3, 5, and 10 years from the present time. Please be careful to use the present as the criterion (0). Once again, using the present ("0") as the criterion, you must imagine your life 1, 3, 5, and 10 years later. For example, you should not imagine your life after 3 years compared to 1 year later. Similarly, you should not imagine your life after 5 or 10 years compared to 3 years later." Thus, participants were asked to circle the appropriate number (-5 to +5) for each of four future times (1, 3, 5, and 10 years later). We emphasized that the criterion was the present.

2.3 The assessment of cognitive function

The MMSE, Stroop test, and Logical Memory Test (LMT) were employed to assess participants' cognitive abilities as a part of a medical examination. The tests were administered individually, and participants were given as much time as they required to complete each test.

In the LMT, the examiner twice read a short story consisting of 25 segments, and each participant was asked to recall the story immediately. Usually the LMT takes into consideration both immediate and delayed conditions, but a previous examination revealed that the correlation coefficient between the scores of immediate and delayed recall conditions was sufficiently high ($r = .92$; Hatta, Nagahara, Iwahara, & Ito, 2005); therefore we

tested only immediate recall. Each segment that was correctly recalled by the participant was assigned a score of 1 point; therefore the total score for each participant ranged from 0 to 25 points. This method was employed to examine memory function.

In the Stroop test, participants were asked to name the color of the words 'red', 'blue', 'yellow', and 'green' as fast and accurately as possible, although the words were printed in colors that differed from the name. The participants were also asked to name the color of a patch. The Stroop stimuli and color patch consisted of 40 words, and the response time (in seconds) and number of naming errors were measured by the examiner. As the error rate was too low to regard as a variable, we used only naming times in the analysis. In accordance with MacLeod and MacDonald (2000), the indices of the Stroop condition were employed to assess focused attention and executive function of working memory.

3. Results

Participants were divided into three age groups, which were 40 to 59, 60 to 69, and 70 to 87 years old. The basic characteristics of participants are shown in Table 1.

Table 1: Basic characteristics of participants (n = 296)

		Age group		
		40-59	60-69	70-87
Number of participants	Women	60	56	56
	Men	31	52	41
Mean age (years)	Women	51.18	64.13	76.13
	Men	51.13	63.38	76.32
Educational Status (years)	Women	12.47	11.11	9.81
	Men	12.39	11.33	10.73
Educational range (years)	Women	9-16	9-14	9-14
	Men	9-16	9-16	9-16

Moreover, we divided the participants into high or low cognitive function groups for each MMSE, LMT, and Stroop tests. The score more than 29 score assigned to the high MMSE group, whereas the score less than 28 did to the low MMSE group because mean performance in 40 to 59 age group of MMSE score was 28.33. Similarly, in the LMT, the score more than 20 assigned to the high LMT group, whereas the score less than 19 did to the low LMT group because mean performance was 19.05. In turn, in Stroop task, the sec less than 33.23 assigned to the high Stroop group, whereas the sec more than 33.24 did to the low Stroop groups because mean sec was 33.23.

Mean score of participants in 60 to 69 age group was 28.42 for MMSE, 18.02 for LMT, and mean sec was 36.87 for Stroop task. Also, mean score of participants in 70 to 87 age group was 26.85 for MMSE, and 15.78 for LMT, and mean sec was 55.90 for Stroop. Thus, Table 2 shows the distribution of participants into High vs. Low cognitive function categories.

3.1 Effects of MMSE classification

A 2 (MMSE: High vs. Low) × 3 (Age: 40-59 vs. 60-69 vs. 70-87) × 2 (Sex: female vs. male) × 4 (Future span: 1, 3, 5 or 10 years later) ANOVA revealed significant main effects of MMSE (F (1, 284) = 8.25, MSe = 136.46, $p < .01$), sex (F (1, 284) = 7.27, MSe = 118.69, $p < .01$), and future span (F (3, 852) = 9.76, MSe = 8.38, $p < .001$). The future imagination score of the high MMSE group was more positive than that of the low group, and the future imagination scores of women were more positive than those of men. Moreover, all participants imagined the future more positively after 1 year (t (852) = 5.10, MSe = .86, $p < .001$), 3 years (t (852) = 4.76, MSe = .86, $p < .001$) and 5 years (t (852) = 3.18, MSe = .86, $p < .01$) than after 10 years. Future imagination scores did not differ between 3 and 5 years ($t < 1$, ns) and were marginally more positive for 1 year than for 5 years (t (852) = 1.92, MSe = .86, $p < .06$).

Table 2: Mean performance of MMSE, Stroop Test, and Logical Memory Test (LMT) in high vs. low cognitive function group for each age groups

			MMSE		Stroop		LMT	
Age groups			High	Low	High	Low	High	Low
40-59	Women	M	29.74 (38)	26.20 (22)	28.75 (35)	37.37 (25)	21.47 (32)	16.07 (28)
		SD	0.45	1.51	5.74	7.24	2.00	1.72
	Men	M	29.62 (21)	25.40 (10)	29.00 (10)	46.20 (20)	21.37 (13)	14.72 (18)
		SD	1.50	1.9	3.55	13.92	1.76	4.31
60-69	Women	M	29.63 (27)	26.17 (29)	35.08 (36)	52.35 (20)	20.33 (27)	13.72 (29)
		SD	0.49	1.37	4.70	8.66	1.78	2.85
	Men	M	29.48 (23)	25.79 (29)	36.31 (26)	55.42 (26)	20.3 (20)	13.66 (32)
		SD	0.51	1.78	4.30	7.12	1.90	3.02
70-87	Women	M	28.5 (24)	25.06 (32)	44.77 (35)	76.29 (21)	19.08 (24)	12.41 (32)
		SD	1.47	1.52	9.37	12.05	2.04	3.32
	Men	M	28.67 (18)	25.35 (23)	49.27 (24)	80.82 (17)	19.84 (19)	11.82 (22)
		SD	1.29	1.19	8.40	28.11	2.41	3.38

The MMSE × Future span interaction was significant (F (3, 852) = 7.20, MSe = 6.18, p < .001). In the high MMSE group, there was no difference among the future imagination scores for 1, 3, 5, and 10 years (F < 2, *ns*). On the other hand, in the low MMSE group, there was a significant difference in future imagination scores (F (3, 852) = 15.12, MSe = .86, p < .001).

Specifically, future imagination for 10 years was less positive than for 5 years (t (852) = 2.26, MSe = .86, p < .05), 3 years (t (852) = 4.93, MSe = .86, p < .001), and 1 year (t (852) = 6.48, MSe = .86, p < .001), and the 5 year score was less positive than the 3 year (t (852) = 2.67, MSe = .86, p < .01) and 1 year (t (852) = 4.22, MSe = .86, p < .001) scores; scores for 1 and 3 years did not differ (t < 2, *ns*). The future imagination scores of the low MMSE group decreased gradually as a function of future span, whereas those of the high group were more consistently positive, irrespective of future span. In fact, the future imagination score of the high MMSE group did not differ from that of the low MMSE group (F < 1.52, *ns*) for the 1 year future span, but it was more positive for the future spans at 3 years (F (1, 1136) = 5.35, MSe = 25.27, p < .05), 5 years (F (1, 1136) = 12.85, MSe = 60.76, p < .001), and 10 years (F (1, 1136) = 13.07, MSe = 61.78, p < .001). Participants with a high cognitive assessment based on the MMSE showed consistent and positive far future imagination, while the low MMSE group seemed to change in the direction of more negative imagination.

The Age × Future span interaction was also significant (F (6, 852) = 10.39, MSe = 8.93, p < .001). The effect of future span was significant in the 40-59 (F (3, 852) = 3.68, MSe = 3.16, p < .05), 60-69 (F (3, 852) = 7.72, MSe = 7.72, p < .001), and 70-87 (F (3, 852) = 17.87, MSe =15.35, p < .001) groups. In the 40-59 group, more positive future imagination scores were found for 10 years (t (852) = 3.32, MSe = .86, p < .001) and 5 years (t (852) = 2.10, MSe = .86, p < .05) than for 1 year, whereas the future imagination score for 10 years was marginally more positive than that for 3 years (t (852) = 1.68, MSe = .86, p < .10). Differences were not significant between 1 and 3 years (t < 1.70, *ns*), 3 and 5 years (t < 1, *ns*), and 5 and 10 years (t < 1.30, *ns*). In the 60-69 group, future imagination scores were less positive for 10 years than for 1 year (t (852) = 5.13, MSe = .86, p < .001), 3 years (t (852) = 4.77, MSe = .86, p < .001), and 5 years (t (852) = 3.48, MSe = .86, p < .001), but there were no differences among 1, 3, and 5 years (t < 1.70, *ns*). In the 70-87 group, the future imagination score for 10 years was less positive than the scores for 1 year (t (852) = 7.32, MSe = .86, p < .001), 3 years (t (852) = 5.39, MSe = .86, p < .001), and 5 years (t (852) = 3.42, MSe = .86, p < .001), and the score for 5 years was less positive than the scores for 3 years (t (852) = 1.97, MSe = .86, p < .05) and 1 year (t (852) = 3.90, MSe = .86, p < .001). The score for 3 years was marginally less positive than that for 1 year (t (852) = 1.93, MSe = .86, p < .06). Future imagination scores for 10 years were less positive for 60-69 (t (1136) = 2.61, MSe = 4.73, p < .01) and 70-87 groups (t (1136) = 2.92, MSe = 4.73, p < .01) than for the 40-59 group (F (2, 1136) = 4.78, MSe = 22.59, p < .01), but this age difference was not found for 1, 3, and 5 years (Fs < 2, *ns*).

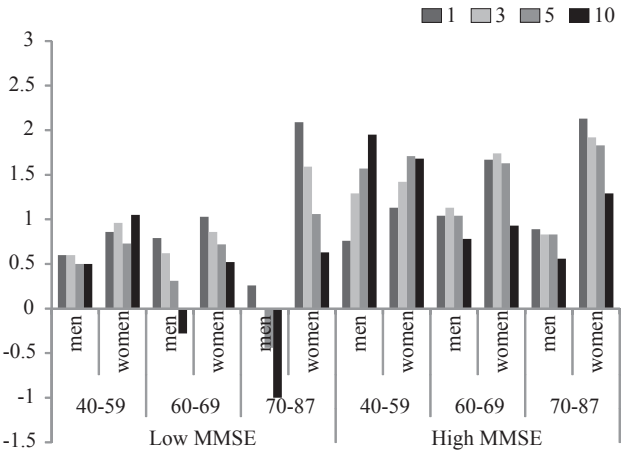

Figure 1: Mean scores of future span (1 to 10 years) in Low vs. High MMSE group as a function of age and sex. The vertical axis indicates scores for complete happiness (+5) to complete unhappiness (-5).

3.2 Combined SST and positivity effect

Originally, we predicted a non-significant interaction of Cognitive function × Age × Future span because positive future imagination superiority in the far future might not differ for the high and low cognitive functioning 40-59 groups, whereas in the near future, 60-69 and 70-87 groups might not differ with MMSE. In order to test this hypothesis of a combined SST and positivity effect, we conducted a post hoc analysis of the three-way interaction of Cognitive function (high vs. low) × Age (40-59 vs. 60-69 vs. 70-87) × Future span (1 vs. 3 vs. 5 vs. 10).

As predicted, the three-way interaction was not significant (F < 1, *ns*). In the 40-59 group, greater positive imagination for the far future over the near future was limited to the high MMSE group (F (3, 852) = 7.48, MSe = 6.42, p < .001) and was not found for the low MMSE group (F < 1). In the 60-69 and 70-87 groups, those with low and high MMSE scores showed the same pattern of greater positive imagination for the near future than for the far future (60-69 low: F (3, 852) = 6.07, MSe = 5.21, p < .001; 60-69 high: F (3, 852) = 3.61, MSe = 3.10, p < .05; 70-87 low: F (3, 852) = 18.11, MSe = 15.56, p < .001; 70-87 high: F (3, 852) = 3.28, MSe = 2.81, p < .05).

3.3 Effects of Stroop classification

A 2 (Stroop: high vs. low) × 3 (Age: 40-59 vs. 60-69 vs. 70-87) × 2 (Sex: female vs. male) × 4 (Future Span: 1, 3, 5 or 10 years) ANOVA revealed significant main effects of sex (F (1, 284) = 6.67, MSe = 109.42, p < .05), and future span (F (3, 852) = 9.38, MSe = 8.25, p < .001). Future imagination scores were more positive for femen than for men. Moreover, femen imagined the future more positively after 1 year (t (852) = 4.96, MSe = .88,

$p < .001$), 3 years (t (852) = 4.72, MSe = .88, $p < .001$), and 5 years (t (852) = 3.09, MSe = .88, $p < .01$), than after 10 years; no differences were found between 1 and 3 years ($t < 1$, *ns*), 1 and 5 years ($t < 1.86$, *ns*), or 3 and 5 years ($t < 1.63$, *ns*).

The Stroop × Age interaction was marginally significant (F (2, 284) = 2.37, MSe = 38.96, $p < .10$). In the 70-87 group, the future imagination score of the high Stroop group was marginally more positive than that of the low Stroop group (F = 3.08, MSe = 50.60, $p < .09$); there was no such difference for the 40-59 ($F < 2.20$, *ns*) and 60-69 ($F < 1.08$, *ns*) groups.

The Age × Sex interaction was also marginally significant (F (2, 284) = 2.36, MSe = 38.96, $p < .10$). With increasing age, the future imagination of male participants was less positive (F (2, 284) = 3.25, MSe = 53.40, $p < .05$); this was not the case for female participants (F (2, 284) = 3.25, MSe = 53.40, $p < .05$). The future imagination of the 70-87 group was less positive than that of the 40-59 group (t (284) = 2.28, MSe = 16.41, $p < .05$), but not for the 60-69 group ($t < 1$, *ns*). Moreover, in the 70-87 group, the future imagination of female participants was more positive than that of male participants (F (1, 284) = 9.47, MSe =155.46, $p < .01$); this was not the case for the 40-59-aged (F = .00, *ns*) and 60-69 ($F < 1.91$, *ns*) groups.

The Age × Future span interaction was significant (F (6, 852) = 12.67, MSe = 11.13, $p < .001$). In each age group, the effect of future span was significant (40-59: F (3, 852) = 5.39, MSe = 4.74, $p < .01$; 60-69: F (3, 852) = 8.41, MSe = 7.40, $p < .001$; 70-87: F (3, 852) = 20.91, MSe = 18.38, $p < .001$). In the 40-59 group, future imagination was more positive for 10 years (t (852) = 3.97, MSe = .88, $p < .001$), 5 years (t (852) = 2.74, MSe = .88, $p < .01$), and 3 years (t (852) = 2.01, MSe = .88, $p < .05$) than for 1 year, and future imagination was marginally more positive for 10 years than for 5 years (t (852) = 1.95, MSe = .88, $p < .06$). In the 60-69 group, future imagination was less positive for 10 years than for 1 year (t (852) = 5.00, MSe = .88, $p < .001$), 3 years (t (852) = 4.57, MSe = .88, $p < .001$), and 5 years (t (852) = 3.56, MSe = .88, $p < .001$). Also, in the 70-87 group, future imagination was less positive for 10 years than for 1 year (t (852) = 3.97, MSe = .88, $p < .001$), 3 years (t (852) = 3.97, MSe = .88, $p < .001$), and 5 years (t (852) = 3.97, MSe = .88, $p < .001$). Moreover, future imagination was less positive for 5 years than for 3 years (t (852) = 2.40, MSe = .88, $p < .05$) and 1 year (t (852) = 4.47, MSe = .88, $p < .05$), and it was less positive for 3 years than for 1 year (t (852) = 2.07, MSe = .88, $p < .05$). Thus, future imagination for 10 years was more positive for the 40-59 group than for the 60-69 (t (852) = 3.00, MSe = 4.76, $p < .01$) and 70-87 (t (852) = 3.96, MSe = 4.76, $p < .001$) groups.

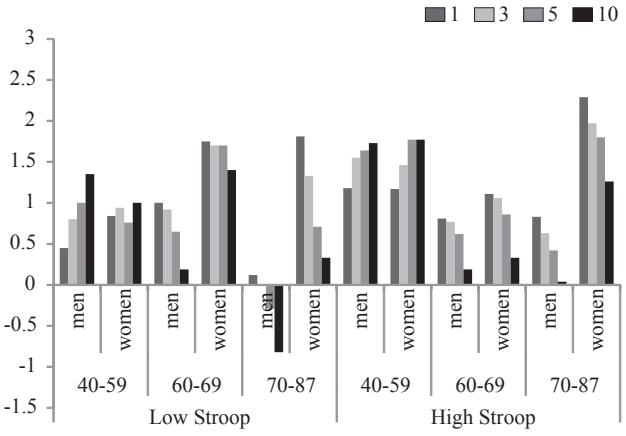

Figure 2: Mean scores of future span (1 to 10 years) in Low vs. High Stroop groups as a function of age and sex. The vertical axis indicates scores for complete happiness (+5) to complete unhappiness (-5).

3.4 Combined SST and positivity effect

Similar to the MMSE, we predicted a non-significant interaction of Cognitive function × Age × Future span. As predicted, the three-way interaction was not significant ($F < 1$, *ns*). In the 40-59-aged group, greater positive imagination for the far future over the near future was limited to the high Stroop group (F (3, 852) = 3.43, MSe = 3.02, $p < .05$), and was not found in the low Stroop group (F (3, 852) = 2.38, MSe = 2.09, $p < .10$). In the 60-69 and 70-87 groups, those with low and high Stroop scores showed the same pattern of greater positive imagination for the near future than for the far future (60-69 low: F (3, 852) = 3.40, MSe = 2.98, $p < .05$; 60-69 high: F (3, 852) = 5.11, MSe = 4.49, $p < .01$; 70-87 low: F (3, 852) = 14.15, MSe = 12.44, $p < .001$; 70-87 high: F (3, 852) = 7.44, MSe = 6.54, $p < .001$).

3.5 Effects of LMT classification

A 2 (LMT: high vs. low) × 3 (Age: 40-59 vs. 60-69 vs. 70-87) × 2 (Sex: female vs. male) × 4 (Future Span: 1, 3, 5, or 10 years) ANOVA revealed a significant main effect of LMT (F (1, 284) = 5.90, MSe = 96.11, $p < .05$). Future imagination scores were more positive for the high LMT group than for the low LMT group. A significant main effect of sex (F (3, 852) = 7.48, MSe = 121.88, $p < .01$) revealed more positive future imagination scores for femen than for men. The main effect of future span was also significant (F (3, 852) = 8.22, MSe = 7.18, $p < .001$). Future imagination scores were less positive for 10 years than for 1 year (t (852) = 4.46, MSe = .87, $p < .001$), 3 years (t (852) = 4.46, MSe = .87, $p < .001$), and 5 years (t (852) = 3.08, MSe = .87, $p < .01$), but there were no differences among 1, 3, and 5 years ($ts < 1.4$, *ns*).

The LMT × Future Span interaction was also significant (F (3, 852) = 3.53, MSe = 2.93, $p < .05$). The effect of future span was significant for the low LMT group (F (3, 852) = 9.67, MSe = 8.45, $p < .001$), but not for the high LMT group (F (3, 852) =1.90, *ns*). For the low LMT group, future imagination scores were less positive for 10 years than for 1 year (t (852) = 5.52, MSe = .87, $p < .001$), 3 years (t (852) = 4.21, MSe = .87, $p < .001$), and 5 years (t (852) = 2.57, MSe = .87, $p < .05$). Also, scores were lower for 5 years than for 1 year and marginally

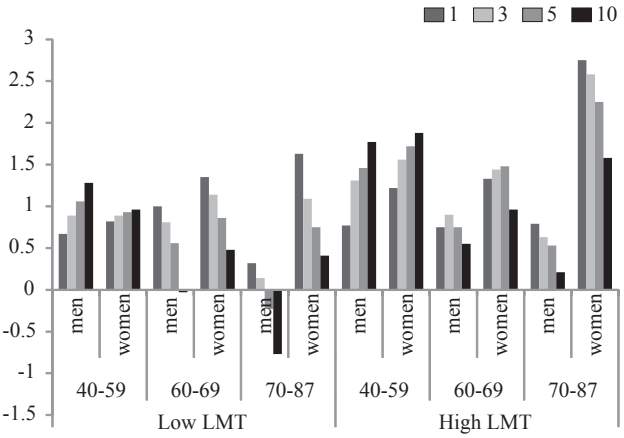

Figure 3: Mean scores of future span (1 to 10 years) in Low vs. High LMT groups as a function of age and sex. The vertical axis indicates scores for complete happiness (+5) to complete unhappiness (-5).

lower for 5 years than for 3 years; no differences were found between 1 and 3 years (t (852) = 1.30, *ns*). Moreover, future imagination scores were less positive in the low LMT group than that in the high LMT group for 3 years (F (1, 1136) = 4.86, MSe = .22, p < .05), 5 years (F (3, 852) = 7.32, MSe = 34.63, p < .01), and 10 years (F (3, 852) = 8.64, MSe = 40.86, p < .01), but not for 1 year (F = 1.36, *ns*).

The Age × Sex interaction, was marginally significant (F (2, 284) = 2.65, MSe = 43.24, p < .10). With age, the future imagination of male participants became marginally less positive (F (2, 284) = 2.53, MSe = 41.24, p < .09); this was not the case for female participants (F (2, 284) = .77, *ns*). The future imagination scores of male participants were less positive in the 70-87 group than in the 40-59 group (t (284) = 1.97, MSe = 16.30, p < .05), but not for the difference between 60-69 and 70-87 group (t < 1.1, *ns*). Moreover, in the 70-87 group, future imagination scores were more positive for femen than for men (F (1, 284) = 11.49, MSe =187.25, p < .001); this was not the case in the 40-59 (F < 1, *ns*) and 60-69 (F < 1.25, *ns*) groups.

The Age × Future span interaction was significant (F (6, 852) = 13.37, MSe = 11.69, p < .001). In each age group, the effect of future span was significant (40-59: F (3, 852) = 6.75, MSe = 5.90, p < .001; 60-69: F (3, 852) = 8.41, MSe = 7.35, p < .001; 70-87: F (3, 852) = 19.79, MSe = 17.30, p < .001). In the 40-59 group, future imagination was more positive for 10 years than for 1 year (t (852) = 3.97, MSe = .87, p < .001) and 3 years (t (852) = 3.97, MSe = .87, p < .001), but not for 5 years (t < 1.30, *ns*). Also, future imagination was more positive for 3 years (t (852) = 2.12, MSe = .87, p < .05) and 5 years (t (852) = 3.05, MSe = .87, p < .01) than for 1 year; there was no difference between 5 and 10 years (t < 1.30, *ns*) or 3 and 5 years (t < 1, *ns*). In the 60-69 group, future imagination was less positive for 10 years than for 1 year (t (852) = 4.84, MSe = .87, p < .001), 3 years (t (852) = 4.58, MSe = .87, p < .001), and 5 years (t (852) = 3.32, MSe = .87, p < .001). In the 70-87 group, future imagination was less positive for 10 years than for 1 year (t (852) = 7.55, MSe = .87, p < .001), 3 years (t (852) = 5.62, MSe = .87, p < .001), and 5 years (t (852) = 3.49, MSe = .87, p < .001). Future imagination was less positive for 5 years than for 3 years (t (852) = 2.13, MSe = .87, p < .05) and 1 year (t (852) = 4.07, MSe = .87, p < .001), and scores for 3 years were marginally less positive than those for 1 year (t (852) = 1.93, MSe = .87, p < .06). Thus, future imagination for 10 years was more positive for the 40-59 group than for the 60-69 (t (852) = 3.17, MSe = 4.73, p < .01) and 70-87 (t (852) = 3.51, MSe = 4.73, p < .001) groups, but there was no difference between the 60-69 and 70-87 groups (t < 1, *ns*).

3.6 Combined SST and positivity effect

Similar to the MMSE and Stroop, For the LMT, as predicted, the three-way interaction was not significant (F < 1, *ns*). In the 40-59 group, greater positive imagination for the far future over near future was limited to the high LMT group (F (3, 852) = 6.40, MSe = 5.59, p < .001) and was not found in the low LMT group (F < 1.33, *ns*). In the 60-69 group, greater positive imagination for the far future over the near future was limited to the high LMT group (F (3, 852) = 6.07, MSe = 5.21, p < .001) and was not found for the low LMT group (F < 1.33, *ns*). In the 70-87 group, those with low and high LMT scores showed the same pattern of greater positive imagination for the near future than for the far future (low: F (3, 852) = 12.79, MSe = 11.18, p < .001; high: F (3, 852) = 7.56, MSe = 6.61, p < .001).

3.7 Summary of the statistic analyses

First, a difference in cognitive function as measured by the MMSE and LMT, but not by the Stroop test, produced differences in future imagination, such that high MMSE and LMT groups imagined their future more positively than the low MMSE and LMT groups. This is evidence of a positivity effect. Second, the 40-59-aged group imagined the far future (10 years from the present) as more positive than the near future, whereas the 60-69 and 70-87 groups imagined the near future (1 and 3 years from the present) more positively. This is the evidence of the SST. Third, the low cognitive function group (as measured by the MMSE and LMT) showed gradually less positive future imagination from near to far future, whereas the high cognitive function group did not change. Fourth, for all indices, a significant sex difference was found. Furthermore, in the high Stroop and high LMT groups, men in the 60-69 and 70-87groups showed less positive future imagination than those in the 40-59-aged group, but this was not true for women.

Finally, most importantly, the post hoc analysis showed that adults in 40-59 years old with high cognitive performer had greater positive imagination for the far future than for the near future, but this was not true for those with low cognitive performer. By contrast, the adults of 60-69 and 70-87 years old

with low and high cognitive performers had greater positive imagination for the near future than for the far future, except for 60-69 years old in the high LMT group. Overall, this supports the hypothesis of a combined SST and positivity effect, with the exception of the near future positive imagination of the adults of 40-59 in the low cognitive ability group.

4. Discussion

This study examined whether cognitive function of younger and older adults influences the near and far future imagining of their lives. This study was based on three premises. The first was a close relation between episodic memory and future imagining in younger and older adults (e.g., Addis, et al., 2008; Schacter & Addis, 2007) and therefore, the positivity effect in autobiographical memory could lead to that in future imagination on adults' lives. The second was that the positivity effect influences cognitive control (Kryla-Lighthall & Mather, 2008). The third drew on the SST (Carstensen, 2006) to suggest that younger adults focus on the future and older adults focus on the maximization of meaningful activities in the present, because the perception of limited time lead to changes in priorities.

The results showed a consistent relationship between positive future imagination and cognitive indices. Therefore, as predicted, adults with high cognitive function could positively imagine their futures. Thus, in accordance with the positivity effect, cognitive control had an influence on positive imagination of the future. Moreover, as predicted by the SST, younger adults such as 40's imagined positively a distant future, as much as 10 years later, whereas adults over 60 years old imagined positively near future times, 1 and 3 years later. According to the SST, adults over 60 years old focus on the meaningfulness of the present, whereas younger adults focus on the far future.

Therefore, the near future, rather than the far future, should be imagined positively, irrespective of cognitive function; however, this was not so for younger adults with low cognitive performer. That is, the adults of 40 to 59 years old with low cognitive performer may not shift near to far future imagination in a positive direction, as shown in Table 3. These new findings suggest that the SST can be mediated by cognitive function. Future research should therefore examine the relation between cognitive function and SST.

According to Mather (2006), a positivity bias is related to the updating of negative information to positive information, which requires the inhibition of negative information. Therefore, of the three indices used in this study, positive future imagination appears to have a robust relation to the Stroop test, because the Stroop test requires sustained attention and response inhibition. Adults over 70 years old with high Stroop test scores had more positive scores than those with low Stroop test scores, but this pattern was not seen with 40's to 60's groups. Future work should examine the direct relation between measures of other forms of inhibitory control and imagination over a future time span, in order to specify the relationship between cognitive function and future imagination.

We found that a sex difference had a robust influence on future imagination, with women imagining their future more posi-

Table 3: Correspondences between present results and hypothesized combination of SST and positivity effect

Cognitive function	Age groups	Indices	Hypothesis	Present results	Future span			
					1	3	5	10
Low	40-59	MMSE	near < far	-	.73	.78	.62	.78
		Stroop Test		-	.65	.87	.88	1.18
		LMT		-	.75	.89	1.00	1.12
	60-69	MMSE	far < near	+	.91	.74	.52	.12
		Stroop Test		+	1.38	1.31	1.18	.80
		LMT		+	1.18	.98	.71	.23
	70-87	MMSE	far < near	+	1.51	1.38	1.33	.93
		Stroop Test		+	.97	.67	.21	-.25
		LMT		+	.98	.62	.26	-.18
High	40-59	MMSE	near < far	+	.95	1.36	1.64	1.82
		Stroop Test		+	1.18	1.51	1.71	1.75
		LMT		+	1.00	1.44	1.59	1.83
	60-69	MMSE	far < near	+	1.36	1.44	1.34	.86
		Stroop Test		-	.96	.92	.74	.26
		LMT		+	1.04	1.17	1.12	.76
	70-87	MMSE	far < near	+	1.51	1.38	1.33	.93
		Stroop Test		+	1.56	1.30	1.11	.65
		LMT		+	1.77	1.61	1.39	.90

tively than men. Also, men, but not women, in the adults over 60 years old showed less positive future imagination than those in the adults below 60 years old. To our knowledge, no previous studies have focused on sex differences in future imagination. In Japan, women live longer than men. It is possible that the relationship between longevity and positive future imagination is driven by cognitive control. Future research should consider sex differences in future imagination.

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