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Relationships between Age, Subjective Memory, Metacognition and Thought-Action Fusion

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Abstract

It is unclear how the relationships between age and metacognitive beliefs are affected by beliefs about memory. To examine this question, we measured beliefs about memory (reliability of memory and retrospective changes in memory), metacognitive beliefs (using the Metacognitions Questionnaire-30 [MCQ-30]) and Thought-Action Fusion (TAF) in a large sample of participants (n = 812) over a wide age range (17-64 years) using a cross-sectional design. Participants who reported positive beliefs regarding memory reliability and retrospective changes in memory had more positive MCQ-30 scores. Among late middle-aged adults, holding negative beliefs about memory appears to be associated with an increased need to control and focus on cognitive processes, and increased worry. In addition, discrepancies in the results, especially for the late middle-aged group, may reflect efforts to cope with feelings of worry. Our results indicated that beliefs about memory and metacognitive beliefs are important considerations for understanding the relationship between age and memory.

Keywords

Beliefs about memory, Metacognition, Thought action fusion, Age

Introduction

Evidence suggests that relationships between age and metacognitive beliefs are affected by subjective evaluation of cognitive functioning. Questionnaires which measure metacognitive beliefs, intrusive beliefs, beliefs about cognitive functions (e.g. memory, attention) and thoughts consist of subfactors which may also be influenced by age. Previous research has shown that metacognitive beliefs are negatively related to subjective evaluation about cognitive functions and cognitive failures [1]; the thought control [2] and thought action fusion (TAF) [3-5]. However, how these relationships change with age is unclear. To clarify these issues, in a cross-sectional study over a wide age range, we examined how the relationships between metacognitive beliefs, thought-action fusion, and beliefs about memory vary by age.

'Metacognition' is a high-level cognitive process which includes the awareness of and ability to control, evaluate and monitor one's own cognition [6-8]. Metacognition is also an important factor in the development and maintenance of various psychological disorders [1,9-15], especially social anxiety, generalized anxiety disorder, and obsessive compulsive disorder (OCD).

Overestimation of the importance of intrusive thoughts and beliefs is called "fusion beliefs" [16]. Thought-Action Fusion (TAF), a type of fusion belief, is defined as the belief that thoughts alone can lead to unwanted actions or have moral consequences. TAF is considered a metacognitive belief and cognitive bias that leads to the incorrect assumption of a causal relationship between thoughts and reality [17]. There are two forms of TAF [18,19] *moral* and *probability*. The *moral* form is the belief that merely thinking about doing something immoral or unethical is as bad as actually doing it; for example, thinking about stealing someone's money is equal to stealing it. The *probability* form is the belief that thinking about unwanted situations increases their likelihood; e.g. thinking about an earthquake will cause one to occur.

Studies suggest that middle-aged adults have more negative beliefs about their cognitive performance (e,g, memory) than younger adults [20,21] and they report more negative beliefs about their ability to control their own memory processes, compared to younger adults [22-24]. However, it has been claimed that middle-aged adults

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show enhanced self-understanding and self-management strategies than younger adult [25,26]. While the increased experience and awareness of our own thinking processes can be seen as a positive outcome of aging, negative beliefs about the ability to control memory functioning can be seen as an unfortunate feature of aging.

Metacognitive beliefs extend beyond beliefs about subjective cognitive performance to assumptions about the cognitive abilities of others. For example, younger adults are presumed to have better memory performance than middle-aged and older adults, and memory performance is presumed to increase with level of education. Also, older adults are considered to be better at handling worrying thoughts due to experience, unlike younger adults who struggle to control worry [27] stated that these kinds of stereotypes are learned and internalized from childhood and sustained into adulthood. Further research is needed to understand the relationship between actual memory performance and metacognitive beliefs, and particularly, whether age-related differences in metacognitive beliefs stem from actual beliefs about memory performance or negative aspects of metacognitive beliefs [28-30]. Therefore, it is important to investigate the relationship between age and various metacognitive beliefs to understand the extent and directionality (positive or negative) of change in metacognitive beliefs that occurs with age. Moreover, the findings could be used to guide strategies for middle-aged and older adults to compensate for cognitive decline through awareness of metacognitive beliefs. It has been shown that age-related decline in cognitive performance affects older adults' quality of life [31,32]. Previous studies suggest that accurate monitoring during learning is associated with better memory performance [33,34]. Thus, awareness of metacognitive processes and strategies to monitor and control cognitive performance may help middle-aged and older people to compensate for age-related cognitive decline [35].

The Goal of the Study

The ability to self-report beliefs about memory may be considered a process associated with metacognitive beliefs and the ability to monitor and control one's own cognitive activities. Although individual differences, generally attributed to biological or cognitive factors, exist among middle-aged and older adults in memory performance [36] the assumption that age-related memory decline might be tied to variations in metamemory and metacognition [37] and beliefs about memory [38] has emerged as a new explanation in recent years. The attitudes (e.g. positive or negative) that individuals hold towards how their own memories function may affect their metacognitive beliefs. In addition, early and middle-aged adults might be better able than younger adults to regulate their cognitive functioning, leading to more realistic and positive metacognitive strategies. Significant differences in metacognitive performance have been observed over the life span, with middle-aged and late middle-aged characterized by greater awareness of one's own memory abilities. The most significant difference between older and younger individuals is the difference in accuracy of strategy detection, which includes reliability of memory, attitudes towards changes in memory, differences in metacognitive knowledge, awareness and reflection on one's own thinking processes [26,39,40] argues that individuals become more reflective and self-aware over time due to increased inward orientation. The second difference is that previous studies [20,37,41,42] have suggested that middle-aged and above middle-aged adults have lower self-efficacy, hold more negative beliefs about retrospective and prospective changes in their memory, and have lower control beliefs than younger adults. According to Berger and Thompson, [43] holding a negative view of metacognitive beliefs, cognitive abilities or of old age implicitly and prejudicially affects cognitive performance. Supporting this, Irak and Çapan [44] showed that middle-aged adults had more negative beliefs about memory than young adults. Thus, the effect of age on relationships between metacognitive beliefs might be driven by changes in attitudes towards beliefs about memory, including changes in memory and reliability of memory. Thus, our first hypothesis is that individuals who have positive attitudes towards their memory will be more likely to hold positive metacognitive beliefs compared to those with negative attitudes towards memory. It is known that cognitive complaints and negative beliefs about memory increase with aging. Therefore, our second hypothesis is that young and middle-aged adults who hold positive beliefs about their memory functions will also report more positive metacognitive beliefs than those who have negative beliefs about their memory functions.

Previous research shows that metacognitive beliefs, intrusive beliefs and thoughts are affected by age. However, the scales used to measure these variables contain sub-dimensions which may be influenced by effects of age, leading to inconsistent results. It has previously been shown that the metacognitive questionnaire (MCQ) is negatively related to a cognitive failures score [1] the thought control questionnaire [2] and TAF [3-5]. How these relationships change with age is not clear. Our third hypothesis is that the relationship between MCQ and TAF will vary with age. To test these hypotheses, the MCQ-30 and TAF scales were administered to participants in three age groups (17-29 years: Early adulthood, 30-44 years: Middle-aged, 45-64 years: Late middle-aged) (Table 1). In addition beliefs regarding reliability of memory and retrospective changes in memory were assessed using the Beliefs about Memory Survey [29,30].

Method

Participants

The study included 812 participants aged 17 to 64 (*M* = 34.03, *SD* = 10.51). Fifty-five percent of the participants were female (*n* = 459) and 45% were male (*n* = 348). Level of education was divided into two categories: high school (n = 453; 56%) and university and/or postgraduate degree (n = 357; 44%). Five participants did not report sex and two participants did not report level of education (Table 1). The exclusion criteria were: (1) History of psychiatric/ neurological disorder or head injury; (2) Current use of medications with central nervous system effects; (3) Substance use disorder; and (4) Color blindness.

Table 1: Demographic characteristics of the study participants.

		Age			Total (%)
Sex	Education	17-29 (%)	30-44 (%)	45-64 (%)	
Female	High School	132(23.7)	134(24.1)	46(8.3)	312(56.0)
	Graduate	96(17.2)	116(20.8)	33(5.9)	245(44.0)
Male	High School	50(20.2)	53(21.4)	35(14.1)	138(55.6)
	Graduate	46(18.5)	42(16.9)	22(8.9)	110(44.4)

Table 2: Changes in MCQ-30 and TAF Subscales According to Age, RCM and RoM: MANOVA Results' Summary.

Source	Test Score	F	p	η^2
Age (A)	PB	1.284	0.278	0.004
	CC	0.600	0.549	0.002
	UCD	4.928	0.007	0.014
	CSC	3.047	0.048	0.008
	NCT	6.139	0.002	0.017
	Probability	1.802	0.166	0.005
	Moral	1.621	0.198	0.005
RCM (B)	PB	1.604	0.202	0.004
	CC	18.512	0.000	0.049
	UCD	2.069	0.127	0.006
	CSC	2.268	0.104	0.006
	NCT	2.106	0.123	0.006
	Probability	1.321	0.267	0.004
	Moral	2.221	0.186	0.003
RoM (C)	PB	9.390	0.000	0.026
	CC	72.673	0.000	0.170
	UCD	2.156	0.117	0.006
	CSC	5.301	0.005	0.015
	NCT	17.402	0.000	0.047
	Probability	2.279	0.103	0.007
	Moral	0.514	0.599	0.002
AxB	PB	0.103	0.982	0.001
	CC	2.006	0.092	0.011
	UCD	0.938	0.441	0.005
	CSC	1.814	0.124	0.010
	NCT	1.255	0.286	0.007
	Probability	0.102	0.982	0.001
	Moral	0.910	0.458	0.005
AxC	PB	3.465	0.008	0.019
	CC	4.048	0.003	0.022
	UCD	0.423	0.792	0.002
	CSC	3.502	0.008	0.019
	NCT	0.930	0.446	0.005
	Probability	0.695	0.595	0.004
	Moral	0.442	0.778	0.003

Materials

Metacognitions Questionnaire (MCQ-30; [12])

The MCQ-30 assesses metacognitive beliefsacross five subfactors: positive beliefs about worry (PB), cognitive confidence (CC), negative beliefs about uncontrollability of thoughts and danger (UD), cognitive self-consciousness (CSC) and beliefs about the need to control thoughts (NCT). Participants responded to questionnaire items using a4-point Likert-type scale (4 = strongly agree; 1 = strongly disagree). Possible scores range from 30 to 120 with higher scores indicating more negative metacognitive beliefs. Standardization of the Turkish form of the MCQ-30 was completed by Tosun and Irak [45]. In our sample, Cronbach's alpha coefficient was found to be 0.82.

Thought-Action Fusion Scale (TAF Scale; [19])

The TAF scale aims to measure the cognitive biases that might play a role in the overestimation of the significance and consequences of obsessional thoughts. The items group into two subfactors: 'moral' and 'probability' and are rated using a 5-point Likert-type scale (0 = strongly disagree; 4 = strongly agree). Total TAF scale scores range from 0 to 76 and higher scores indicate strong TAF. Standardization of the Turkish form of the TAF was done by Yorulmaz, Yılmaz and Gençöz [46]. In our sample, Cronbach's alpha coefficient was found to be 0.91.

Beliefs about memory survey (BMS; [30])

The BMS was first used by Magnussen, et al. [30]. The BMS consists of 13 general and specific questions regarding beliefs and opinions about human memory. Each question has different response alternatives. The BMS was translated to Turkish by Irak [29] using a standard translation-back translation procedure. Two specific questions were selected from the BMS to measure retrospective changes in memory ("Do you think your own memory has become better or worse during the last five years, or is it unchanged?") and reliability of memory ("We sometimes remember incorrectly. How good are you at judging the reliability of your own memory?").

Procedure

All participants were recruited on a voluntary basis. Participants were recruited via advertisement at public and private work places, community centers and schools. Participants gave informed consent to participate in the study after the purpose and the nature of the experiment was fully explained. Administrations were done at class or a particular

testing room (for 17-29 age groups) or in a quiet room at participants' home or work place in a single session. The duration of each session was approximately 15 to 20 minutes.

Results

To test the first and second hypotheses, we analyzed response store liability of memory and retrospective changes in memory questions, separately. Thus, participants were grouped according to their responses to the reliability of memory (better, worse, or unchanged) and retrospective changes in memory (bad, neither good nor bad, or good) questions, separately. Multivariate analyses of variance (MANOVA) were conducted for TAF and MCQ subscales, separately, with reliability of memory and retrospective changes in memory response categories as independent variables and MCQ-30 and TAF subfactors as the dependent variables. To reduce the complexity of the result section, MANOVA results are summarized in Table 2, and descriptive statistics are presented in Table 3 and Table 4. Finally, to test our third hypothesis, Pearson's correlations were conducted to investigate relationships between age, MCQ-30 and TAF subfactors.

Change in Memory Performance

We asked our respondents about subjective changes in their memory performance (retrospective changes in memory) during the last five years ("Do you think your own memory has become better or worse during the last five years, or is it unchanged?"). Interestingly, those who answered 'worse' were mostly from the middle-aged group (47.7%), followed by young (40.3%) and late middle-aged (12.1%) groups. We observed the same pattern for those who selected 'unchanged' (middle-aged = 44.3%, younger = 34.1%, and late middle-aged = 21.6%), while those who responded with 'better' were mostly from the young adult group (49.1%), followed by middle-aged (28.8%) and late middle-aged (22.1%) groups (X^2 (4, N = 808) = 26.47, p = 0.000).

The MCQ-30 cognitive confidence subscale was significantly related to retrospective changes in memory. Participants who responded to the retrospective changes in memory question with 'better' had significantly higher cognitive confidence scores than participants who responded with 'unchanged' and 'worse' (Table 2). The main effect of age was significant for MCQ-30 UCD, cognitive self-consciousness, and NCT subscales. Participants in the late middle-aged group scored significantly lower on the UCD subscale than those in the middle-aged and early adulthood groups. For the cognitive self-consciousness and NCT subscales, participants in the late middle-aged group scored significantly higher than those in the middle-aged and early adulthood groups. The interaction effect was significant for cognitive confidence. Younger and middle-aged participants who responded to the reliability of memory question with 'better' had lower cognitive confidence scores compared to those who replied 'worse'. On the other hand, late middle-aged participants who responded to the reliability of memory question with 'better' also had higher cognitive confidence scores compared to those who replied with 'unchanged' and 'worse' (Table 3). No significant results

Table 3: Participants' Mean and Standard Deviations for MCQ-30 and TAF Subscale Scores According to age and Their Responses to Retrospective Memory Change Question.

	Age Groups									
	17-29			**30-44**			**45-64**			
	"Do you think your own memory has become better or worse during the last five years, or is it unchanged?"									
	Worse	Unchanged	Better	Worse	Unchanged	Better	Worse	Unchanged	Better	
Subscales	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	
PB	13.70 (4.02)	12.70 (4.20)	13.62 (4.20)	13.17 (4.01)	12.74 (3.95)	13.32 (4.13)	13.55 (5.09)	14.10 (4.04)	14.67 (4.57)	
CC	14.57 (4.68)	11.70 (3.98)	11.42 (3.08)	14.53 (4.20)	11.88 (4.23)	10.67 (3.52)	13.62 (4.72)	11.71 (3.93)	14.18 (4.04)	
UCD	18.92 (4.11)	17.69 (4.90)	18.25 (4.18)	18.02 (4.15)	16.57 (4.13)	15.95 (4.66)	16.69 (4.23)	17.04 (4.24)	17.22 (4.17)	
CSC	14.02 (2.74)	14.51 (2.95)	14.75 (2.38)	14.19 (2.63)	14.35 (2.59)	15.32 (2.28)	15.31 (2.76)	14.79 (3.21)	15.59 (2.57)	
NCT	13.58 (3.96)	12.83 (3.94)	13.72 (3.51)	13.22 (3.60)	13.07 (3.72)	12.67 (4.24)	13.86 (4.24)	14.71 (4.08)	16.81 (2.73)	
Probability	5.98 (5.93)	5.74 (5.76)	4.95 (5.90)	7.08 (7.27)	6.04 (6.36)	6.0 (6.53)	6.90 (6.88)	6.10 (5.67)	5.33 (5.40)	
Moral	16.56 (10.26)	14.92 (10.09)	13.15 (9.06)	16.05 (9.90)	15.32 (10.87)	15.44 (9.76)	18.98 (10.49)	17.86 (10.32)	13.18 (8.57)	

Note: PB: Positive Beliefs; CC: Cognitive Confidence; UCD: Uncontrability and Danger; CSC: Cognitive Self-Consciousness; NCT: Needs to Control Thoughts

Table 4: Participants' Mean and Standard Deviations for MCQ-30 and TAF Subscale Scores According to age and Their Responses to Reliability of Memory Question.

	Age Groups											
	17-29				30-44				45-64			
	"How good are you at judging the reliability of your own memory?"											
	Bad	NGNB	Good		Bad	NGNB	Good		Bad	NGNB	Good	
Subscales	*M (SD)*	*M (SD)*	*M (SD)*		*M (SD)*	*M (SD)*	*M (SD)*		*M (SD)*	*M (SD)*	*M (SD)*	
PB	14.24 (4.13)	13.73 (4.08)	13.06 (4.13)		14.41 (3.86)	12.24 (4.07)	13.19 (3.92)		15.53 (4.33)	14.70 (4.23)	12.05 (4.35)	
CC	15.33 (6.01)	15.88 (3.49)	11.16 (3.55)		16.67 (4.94)	15.62 (3.57)	11.21 (3.48)		12.42 (4.89)	15.76 (3.15)	11.19 (3.35)	
UCD	18.56 (4.13)	18.89 (4.73)	18.23 (4.16)		18.08 (4.64)	18.15 (4.35)	16.68 (4.07)		17.00 (4.66)	17.33 (3.16)	16.38 (4.47)	
CSC	14.09 (2.87)	14.19 (2.86)	14.46 (2.63)		14.82 (2.89)	14.36 (2.23)	14.32 (2.70)		16.58 (2.82)	14.48 (2.68)	14.33 (2.72)	
NCT	14.69 (4.36)	13.60 (4.05)	13.04 (3.55)		14.85 (4.11)	13.78 (3.29)	12.42 (4.68)		16.40 (3.44)	15.58 (3.75)	12.95 (4.05)	
Probability	4.67 (5.46)	5.56 (6.02)	6.01 (5.94)		6.61 (7.36)	7.24 (7.23)	6.19 (6.54)		4.67 (5.24)	6.75 (6.22)	7.16 /6.55)	
Moral	15.72 (9.81)	14.55 (10.12)	15.40 (10.06)		16.55 (10.16)	14.76 (11.10)	16.07 (9.70)		15.36 (11.04)	17.20 (9.35)	18.32 (10.04)	

Note: PB: Positive Beliefs; CC: Cognitive Confidence; UCD: Uncontrability and Danger; CSC: Cognitive Self-Consciousness; NCT: Needs to Control Thoughts; NGNB: Neither Good nor Bad

were found for TAF subscales.

Reliability of Memory

We asked participants to rate how good they were at judging the reliability of their memory ("We sometimes remember incorrectly. How good are you at judging the reliability of your own memory?"). Participants who responded with 'bad' were mostly from the young adult group (36.9%) followed by the late middle-aged (34.9%) and middle-aged (28.2%) groups. Those who reported 'neither good nor bad' were mostly in the middle-aged group (46.3%), followed by the younger (36.1%) and late middle-aged (17.6%) groups. Middle-aged participants also made up the majority of those who responded with 'good' (46.1%), followed by young adulthood (42.9%) and late middle-aged (11.1%) participants (X^2 (4, N = 810) = 47.74, p = 0.000).

There was a significant effect of reliability of memory on all MCQ-30 subfactors except UCT. Post-hoc comparisons indicated that for all significant MCQ-30 subscales, participants who responded to the reliability of memory question with 'good' scored more positively (low score) compared to those who responded with 'neither good nor bad', and 'bad'. In addition, the interaction effect between reliability of memory and age was significant for positive beliefs about worry, cognitive confidence, and cognitive self-consciousness. For all three subscales, participants who responded with 'good' had lower subscale scores. Across all age groups, those who responded with 'good' had low and similar scores on MCQ subscales. However, participants in the late middle-aged group who responded with 'bad' scored higher than those in young and middle-aged groups for these subscales (Table 4). No significant results were found for TAF subscales.

Relationships between age, MCQ-30, and TAF subfactors

Pearson's correlations (Table 5) indicated low to moderate correlations between TAF and MCQ-30 subfactors. While small but significant correlations were observed among age and MCQ-30 UD (r = -0.125; p < 0.05), NCT (r = 0.139; p < 0.05), and cognitive self-consciousness (r = 0.103; p < 0.05), age and TAF subscales were not significantly correlated. In addition, MCQ positive beliefs about worry was significantly correlated with TAF-probability (r = 0.084; p < 0.05) and TAF-moral (r = 0.082; p < 0.05). Correlations between MCQ-30 and TAF subscales were conducted for each age group with similar results.

Discussion

Supporting our first two hypotheses, our results showed that individuals who have positive beliefs regarding the reliability of their memory and retrospective changes in memory also had more positive metacognitive beliefs. Additionally, although young and middle-aged participants scored similarly in terms of MCQ-subscales but different for reliability of memory and retrospective changes in memory, late middle-aged individuals showed a different pattern. Specifically, participants who reported more negative beliefs about the reliability of their memory and retrospective

Table 5: Pearson correlations between age, MCQ-30 and TAF subscales.

	Age	PB	CC	UD	CS	NCT	Moral	Probability
Age	1							
PB	0.02	1						
CC	-0.02	0.05	1					
UD	-0.09*	0.15**	0.22**	1				
CS	0.12**	0.19**	-0.13**	0.27**	1			
NCT	0.09**	0.27**	0.11**	0.40**	0.37**	1		
Moral	-0.07	0.12**	0.02	0.19**	0.18**	0.39**	1	
Probability	-0.07	0.06	0.06	0.21**	0.08*	0.28**	0.33**	1

Note: PB: Positive Beliefs; CC: Cognitive Confidence; UCD: Uncontrability and Danger; CSC: Cognitive Self-Consciousness; NCT: Needs to Control Thoughts

changes in their memory also had higher (more negative) scores on MCQ-30 subscales. However, neither TAF-moral nor TAF-probability subscales were related to reliability of memory and retrospective changes in memory. In addition, contrary to our hypothesis, relationships between age and MCQ-30 subfactors were small, and age was not significantly correlated with TAF subfactors.

Our results have revealed a significant effect of age on aspects of memory beliefs, namely, about retrospective changes in memory and reliability of memory, with young adults showing more positive beliefs than middle-aged and late middle-aged individuals. Also, consistent with previous studies [2,44,47,48], the young adult group held more positive views about memory and reported less cognitive failure compared to the middle-aged and late middle-aged groups. Our results support the suggestion by Berger and Thompson [43] that holding negative beliefs about cognitive abilities and of middle- and old age implicitly and prejudicially affects cognitive performance. Relationships between memory decline and aging are also associated with neurological and biological changes. Decreased memory performance observed after middle-age reflected age-related differences in both cognitive functioning and related beliefs about memory and metacognitive beliefs. It is known that thinking styles become more rational, pragmatic, and flexible with young adulthood [49,50]. Previous studies [51-54] argued that epistemic cognition (justification and truth of beliefs) play a critical role in the reasoning of older adolescents and adults. These studies suggested that changes in assumptions about knowledge in the epistemic sense underlie the ability of adults to deal with conflicting ideas and systems in considering issues of logic, ethical choice, and reality in addition argued that there is a strong relationship between metacognitive monitoring and epistemic cognition. According to Kitchener, metacognitive monitoring plays a critical role in how adults monitor their problem solving when they are engaged in the complex decision making of everyday life. Early adulthood to middle age is not only a time of biological change; it is also a time of new social motivation and experience. There may also be more complex interactions between the changing life experiences that come with different developmental stages and pragmatic thinking, rational thinking, and cognitive flexibility. These interactions may also shed light on the relationship between age and metacognitive and memory beliefs.

Although we did not measure actual memory performance in our study, it is a general finding that cognitive performance decreases with age. Following previous literature, we investigated the relationship between personal beliefs about memory reliability and retrospective changes in memory, metacognition, and age. Young and middle-aged adults held more positive metacognitive beliefs compared to late middle-aged adults. The former two groups also self-reported positive levels of memory reliability and increased feelings of retrospective changes in memory over time. Specifically, we found a significant interaction between age and subjective evaluation about memory on MCQ-30 subfactors, namely positive beliefs about worry, cognitive confidence, and cognitive self-consciousness. 'Cognitive confidence' and 'cognitive self-consciousness' reflect an individuals' level of focus and confidence in their own cognitive (memory and attention) and metacognitive processes. 'Positive beliefs about worry' refers to beliefs about control over worry and whether this aids planning, problem-solving, or the avoidance of unpleasant situations.

Our results concerning the positive beliefs about worry subscale are consistent with previous studies [20,37,55,56] which suggest declining memory ability with age relates to control needs and worries. We conclude that late middle-aged individuals are aware of a decline in some of their cognitive abilities. Thus, a feeling of having less control over cognitive functions may lead to increased worry about cognitive and metacognitive processes. This in turn increases beliefs about the need to focus on and control cognitive and metacognitive processes. Interpreting this as a beneficial belief may improve late middle-aged individuals' resilience in coping with their cognitive changes. In this respect, middle-aged adults' metacognitive beliefs and beliefs about memory could be said to resemble those of young adults rather than late middle-aged adults.

Consistent with previous results [1,9,44,45] although late middle-aged participants scored lower on the cognitive confidence subscale than younger and middle-aged

participants, the differences were not significant. However, the interaction effect indicated that late middle-aged participants who reported better retrospective changes in memory also had significantly higher MCQ-30 cognitive confidence subfactor scores than other participants. On the other hand, participants who believed that their memory is reliable also had the lowest cognitive confidence score. Despite that, younger participants who believed that their memory is not reliable also had the highest cognitive confidence score. Previous research suggests that cognitive confidence is not directly related to actual memory performance [44]. Additionally, according to Meccaci and Righi [2] relationships between self-reported failures and decreased cognitive performance are nonlinear, even in the opposite direction. Earlier, Schwarz, et al. [57] argued that this was a typical characteristic of aging literature due to adequate evaluation of the effects of self-representation on the performance itself. Thus, in addition to actual memory performance, the cognitive confidence subfactor may not be a good predictor of beliefs about age-related changes in memory. Similar to 'positive beliefs about worry' subfactors, we also conclude that the observation that late middle-aged participants believe that their memory performance has improved in the last five years may reflect a similar type of resilience and coping strategy, although they lack confidence for memory and attention functions.

Our results indicate that, although young and middle-aged participants scored similarly for reliability of memory and cognitive self-consciousness, late middle-aged participants who reported poorer memory reliability had higher MCQ-30 cognitive self-consciousness scores. Previous studies [58-60] indicated that metacognitive beliefs may influence behaviors related to memory. During expression of internal locus of control, adults and older adults tend to render internally-oriented attributions of diminished cognitive capacity, rather than abilities or performance-based individual attributions [61,62]. According to Lachman [63] middle-aged and late middle-aged adults recognize the constraints and limitations of their memory associated with aging, and this in turn leads to diminished control beliefs. We conclude that having negative beliefs about memory reliability increases worry and a need to focus on cognitive processes during late middle age. However, it should be noted that in terms of our variables of interest there might be nonlinear changes at points of developmental transition, such as the transition from young adulthood to early and late middle age, rather than steady continuous change with accumulated knowledge.

Our findings provide important information about how the relationships between subjective beliefs about memory and metacognitive beliefs change with age. These subjective beliefs have been associated with metacognitive beliefs such as MCQ-30 positive beliefs about worry, cognitive confidence, and cognitive self-consciousness subfactors, but not for TAF subfactors. In terms of the relationships between these variables, late middle-aged individuals display a different profile compared to middle-aged and young individuals. With aging, having negative beliefs about reliability of memory and retrospective changes in memory appears to lead to increased worry as well as an increase in the need to control and focus on cognitive processes. The inconsistent results regarding relationships between metacognitive beliefs and beliefs about memory in late middle-aged individuals may reflect this group's efforts to cope with those feelings of worry. Our results indicate that beliefs about memory and metacognitive beliefs are important considerations for understanding the relationship between age and memory. Therefore, it is important to assess these beliefs to aid understanding and rehabilitation of memory problems associated with healthy aging.

This study has some limitations. It has been suggested that individuals with lower levels of education are less aware of their own memory processes and use less efficient strategies to compensate for perceived losses in memory compared to more highly educated individuals [28,63]. Although our sample is balanced in terms of education level, the lack of participants with a low level of education can be considered a limitation. Also, although our study included a large sample size, the numbers of participants for some education and age conditions were not balanced. Although we screened our participants in terms of their current and previous psychiatric and neurological health conditions, we did not measure actual memory performance and we collected data via self-report measure. Lastly, no participants over 65 years of age were included in the study. Future studies should examine whether our findings generalize to elderly individuals.

Author Notes

Compliance with ethical standards

Authors confirmed that our manuscript meet the guidelines for ethical conduct and report of research.

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Informed consent

Informed consent was obtained from all individual participants included in the study.

Conflict of interest

Authors declare that they have no conflict of interest.

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