

Personality and mental time travel: A differential approach to auto-noetic consciousness

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Abstract: Recent research on auto-noetic consciousness indicates that the ability to remember the past and the ability to project oneself into the future are closely related. The purpose of the present study was to confirm this proposition by examining whether the relationship observed between personality and episodic memory could be extended to episodic future thinking and, more generally, to investigate the influence of personality traits on self-information processing in the past and in the future. Results show that Neuroticism and Harm Avoidance predict more negative past memories and future projections. Other personality dimensions exhibit a more limited influence on mental time travel (MTT). Therefore, our study provides additional evidence to the idea that MTT into the past and into the future rely on a common set of processes by which past experiences are used to envision the future.

Keywords: Episodic future thinking ; Auto-noetic consciousness ; Mental time travel ; Personality

1. Introduction

"Mental time travel" (MTT), i.e., the capacity to remember our past experiences and to project ourselves into possible future events, is considered as a crucial ability for human-beings (Gilbert & Wilson, 2007; Schacter, Addis & Buckner, 2007; Suddendorf & Corballis, 1997; Suddendorf & Corballis, 2007; Wheeler, Stuss & Tulving, 1997). Mental time travel importantly involves auto-noetic consciousness, i.e., "the kind of consciousness that mediates an individual's awareness of his or her existence and identity in subjective time extending from the personal past through the present to the personal future" (Tulving, 1985, p. 1). Auto-noetic consciousness is thought to allow not only the subjective experience associated with re-experiencing a past event but also the ability to project oneself forward in time to mentally "pre-experience" an event (Wheeler et al., 1997). However, although the ability to consciously remember past events (i.e., episodic memory) has been extensively investigated (Tulving, 2002; Wheeler et al., 1997), relatively few studies have examined what Atance and O'Neill called "episodic future thinking," which is "the ability to project the self forward in time to pre-experience an event" (Atance & O'Neill, 2001, p. 537). As argued by previous researchers, mental time travel into the future and into the past may rely on a common set of processes by which past experiences are used adaptively to imagine perspectives and events beyond those that emerge from the immediate environment (Atance & O'Neill, 2001; Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Okuda et al., 2003; Wheeler et al., 1997). The past may indeed constrain the generation of possible and likely futures, by supplying expectancies and determining what is plausible (Johnson & Sherman, 1990). Additionally, imagining future events involves combining some basic elements (e.g., actors, objects, and actions), some of which are extrapolations from past events while others come from general semantic knowledge, to generate potential scenarios (D'Argembeau and Van der Linden, 2006).

Findings suggesting a relationship between episodic memory and episodic future thinking can be summarized as follows. First, developmental research suggests that episodic memory and episodic future thinking emerge approximately at the same time (around age of three to four) (Atance & O'Neill, 2005; Busby & Suddendorf, 2005; Levine, 2004; Suddendorf & Busby, 2005). Second, patients with brain damages who are unable to recall their personal past typically have difficulties in imagining possible future experiences (Hassabis, Kumaran, Vann & Maguire, 2007; Klein, Loftus & Kihlstrom, 2002; Tulving, 1985). Third, some functional neuroimaging data suggest that common cerebral substrates might underlie thinking about the future and past (Addis & Schacter, 2008; Addis, Wong & Schacter, 2007; Botzung, Denkova & Manning, in press; Okuda et al., 2003; Szpunar, Watson, & McDermott, 2007) although there are specific areas in the frontal pole and medial temporal lobes that are more involved with the future than with the past (Okuda et al., 2003). Finally, the factors that influence the phenomenal characteristics associated with remembering, such as the emotional valence of the events and their temporal distance from the present, have similar effects on the phenomenal characteristics associated with projecting oneself into the future (D'Argembeau and Van der Linden, 2004).

An additional important element of validation for linking past and future thinking is to investigate the relationship between MTT into the past and into the future from a personality theory perspective. This is the

purpose of the present study.

The existence of relations between personality and emotion is well documented, especially between personality dimensions associated with the Behavioral Activation System (BAS) (e.g., extraversion and novelty seeking) and positive affect, and between personality dimensions associated with the Behavioral Inhibition System (BIS) (e.g., neuroticism and harm avoidance) and negative affect (Corr, 2002; Gable, Reis & Elliot, 2000; Heponiemi, Keltikangas-Jarvinen, Puttonen & Ravaja, 2003). Many studies reported also that personality consistently modulates the interactions between emotion and cognition (Bradley & Mogg, 1994; Gomez & Gomez, 2002; Rusting, 1999). For instance, Gomez and Gomez (2002) found that high-BIS subjects generated more negative words in a word-fragmentation task, recognized more negative words in a word recognition task and recalled more negative words in a free word-recall task than low-BIS subjects, whereas high-BAS subjects displayed, recognized and recalled more positive words in the three tasks than low-BAS subjects. These results indicate that BIS is mainly associated with the processing of unpleasant information, while BAS is mainly associated with the processing of pleasant information, and more generally, that cognitive processing of emotional information is modulated by personality.

The majority of the studies on this topic investigated the relationships between personality and emotion with tasks involving mainly semantic rather than episodic memory. However, episodic memory is a central feature of auto-noetic consciousness, i.e., a crucial element of self-representation in time. Indeed, a few studies have shown that neuroticism is particularly associated with the preferential processing of negative information about the self (Furnham & Cheng, 1996; Martin, Ward & Clark, 1983; Ruiz Caballero & Bermudez, 1995). However, it should be mentioned that all information related to the self is not necessarily episodic and may instead be personal semantic. Instead, episodic memory (and auto-noetic consciousness) refers to memory for events that are specific in time and place that can be (p)re-experienced. Recent data also indicate that some personality dimensions are related to the phenomenology of episodic memory. Rubin and Siegler (2004) found that, of all the domains and facets of personality assessed by the NEO PI (Costa & McCrae, 1992), openness to feelings showed by far the strongest relation to the phenomenology of memory for past events, correlating with measures of belief in the accuracy of memories, sense of recollection, amount of sensory details, and feeling of emotions while remembering.

As opposed to neuroticism, neither the role of extraversion nor the other personality dimensions on positive information about the self have ever been investigated. Moreover, no study has ever investigated the role of neuroticism and extraversion on the ability to project oneself into the future. Therefore, this study aims to investigate the influence of personality traits (especially neuroticism and extraversion) on episodic past and future thinking.

More specifically, based on previous findings we hypothesize that people with high levels of neuroticism will generate a greater amount of negative projections during a verbal fluency task, i.e., the quantity task (*hypothesis 1a*) and will write projections with a more negative content in a story completion task, i.e., the preferential content task (*hypothesis 1b*). Conversely, we hypothesize that people high in extraversion will generate a greater amount of positive projections during the quantity task (*hypothesis 2a*) and will write projections with a more positive content in the preferential content task (*hypothesis 2b*). By extension, we also hypothesize to find the same links for harm avoidance (HA) and novelty seeking (NS) dimensions of Cloninger's model as these two dimensions are strongly related to neuroticism and extraversion, respectively (De Fruyt, Van De Wiele & Van Heeringen, 2000). Thus HA should be related to a greater number of negative projections (*hypothesis 3a*) and projections with a more negative content (*hypothesis 3b*) while NS should be related to a greater number of positive projections (*hypothesis 4a*) and projections with a more positive content (*hypothesis 4b*). The investigation of the influence of the other personality dimensions is purely exploratory.

As regards the phenomenal characteristics associated with MTT, we hypothesize that people with high levels of openness (*hypothesis 5*) and self-transcendence (ST; *hypothesis 6*) will report more phenomenal characteristics for both past and future. Indeed, Rubin and Siegler (2004) have found that openness was related with the phenomenology of autobiographical memory. Moreover, ST relates to imagery abilities (Cloninger, Svrakic & Przybeck, 1993) which in turn affects phenomenal characteristics of MMT (D'Argembeau and Van der Linden, 2006). The investigation of the influence of the other personality dimensions on phenomenal characteristics is exploratory.

2. Methods

2.1. Participants

This study was conducted on a sample of 35 healthy adults. The sample was made up of 24 women with a mean age of 30.8 years ($SD = 12.7$) and 11 men with a mean age of 29.7 years ($SD = 10.7$). All participants gave written informed consent to participate in the study.

2.2. Materials and procedure

Personality was assessed by the *Revised NEO Personality Inventory* (NEO PI-R; Costa & McCrae, 1992) and by the *Temperament and Character Inventory-Revised* (TCI-R; Cloninger, 1999). The NEO PI-R is a self-rating questionnaire of 240 items measuring the five major personality dimensions: neuroticism (N), extraversion (E), openness to experience (O), agreeableness (A), and conscientiousness (C). Each dimension is made up of six facets. Responses are made on a 5-point Likert-type scale, ranging from strongly disagree to strongly agree. A validated French version of the NEO PI-R was used (Rolland, 1998). TCI-R is a 240-item self-reported questionnaire measuring four innate temperamental dimensions (novelty seeking, harm avoidance, reward dependence, and persistence) and three acquired character dimensions (self-directedness, cooperativeness and self-transcendence). Briefly, novelty seeking (NS) is the tendency to respond actively to novel stimuli leading to pursuit of rewards and escape from punishment. Harm avoidance (HA) is the tendency to inhibit responses to signals of aversive stimuli that lead to avoidance of punishment and non-reward. Reward dependence (RD) is the tendency for a positive response to conditioned signals of reward that maintain behavior. Persistence (PS) is perseverance despite frustration and fatigue. Self-directedness (SD) is the ability of an individual to control, regulate and adapt his or her behavior to fit the situation in accord with individually chosen goals and values. Cooperativeness (C) accounts for individual differences in identification with and acceptance of other people. Self-transcendence (ST) is associated with spirituality. Responses are made on a 5-point Likert-type scale, ranging from absolutely false to absolutely right. The French version of the TCI-R has been validated and shows excellent psychometric properties (Hansenne, Delhez, & Cloninger, 2005).

MTT was assessed at three different levels, i.e., (1) in terms of quantity, (2) in terms of preferential content when people can freely remember or imagine past/future events, and (3) in terms of quality of the representations created in the mind.

The Quantity of MTT was assessed by an adapted version of the verbal fluency paradigm developed by MacLeod and Byrne (1996) and refers to the quantity of experiences a subject can remember and generate. In this task, participants had to think of personal experiences over six different time periods: the past/next week, including today; the past/next year; the past/next 5 to 10 years. For each time period, participants had three minutes to orally remember or generate as many positive or negative events as possible (e.g., "Please try to think of as many specific positive events that could reasonably happen to you over the next year"). Participants were informed that the responses could be trivial or important; they just had to tell whatever comes to mind. In addition, for episodic future thinking, the responses had to be events that participants knew were going to happen or events that they thought might reasonably happen. All events were tape recorded and the number of events for each time period and valence condition was calculated for each temporal direction.

The Preferential Contents of MTT was assessed by a story completion task in which participants were presented with stimulus sentences and had to write short self-related stories (10 to 15 lines) based on the content of each sentence. For instance, participants were presented with a sentence such as "I am looking out at the sunset" or "I am looking to my-self in the mirror". Subjects had to complete a set of six stories in reference with three past events (1 positive, 1 negative, and 1 neutral) and three future events (1 positive, 1 negative, and 1 neutral). Two independent judges rated the emotional valence of each story on a 7-point scale from -3 (extremely negative) to +3 (extremely positive). Judges' ratings for each subject were aggregated into a mean score for each temporal direction. Interjudge reliability was excellent with a Cohen's Kappa coefficient of 0.81 (Fleiss, 1981).

The Quality of MTT measure was aimed to investigate the quality, i.e., the phenomenal characteristics, of time projections. Participants were asked to remember three past events and to imagine three future events from different temporal windows: an event that happened/might happen the past/next week, an event that happened/might happen the past/next year, and an event that happened/might happen the past/next five to ten years. Immediately after having remembered or imagined each event, participants had to write a very brief description of the event and then rate their subjective experience with a 7-point phenomenal characteristics rating scale adapted from D'Argembeau and Van der Linden (2004), D'Argembeau and Van der Linden (2006)

Memories of past events and representations of future events were rated for visual details (1 = none, 7 = a lot), sounds (1 = none, 7 = a lot), smell/taste (1 = none, 7 = a lot), clarity of location (1 = not at all clear, 7 = very clear), clarity of the spatial arrangement of objects (1 = vague, 7 = clear and distinct), clarity of the spatial arrangement of people (1 = vague, 7 = clear and distinct), clarity of the time of day (1 = not at all clear, 7 = very clear), feeling of experiencing emotions as if the event was actually happening (1 = not at all, 7 = extremely strong), emotional intensity of the event, and auto-noetic consciousness, i.e., feelings of re-experiencing (or pre-experiencing) the event when remembering (or imagining) it (1 = not at all, 7 = a lot). Before performing the analyses, the ratings for visual details, sounds, smell/taste, clarity of location, clarity of spatial arrangement of objects and clarity of spatial arrangement of people were averaged into a general quality of representation measure.

The order of time period and valence of events in which participant had to project for all MTT measures has been counterbalanced through the whole sample.

Additional measures were included to control some potentially extraneous variables.

A general verbal fluency task (Cardebat, Doyon, Puel, Goulet, & Joanette, 1990) was used to control for differences in terms of general cognitive fluency (both phonologic and semantic) in the quantity of MTT assessment. The phonologic fluency task involved asking the participant to report aloud as many words in one minute as they could think of beginning with the letter "p", excluding proper nouns, numbers, the same word with a different suffix, and repetitions. The semantic fluency task involved asking the participant to report aloud as many animal names as they could think of in one minute.

The Positive and Negative Affect Schedule (Watson, Clark, & Tellegen, 1988) was used to control the effect of mood. The PANAS is a self-report measure of mood in the present moment. It consists of a list of 20 mood related adjectives, for which participants are asked to indicate the extent to which they feel this way presently on a 5-point scale where 1 = "very slightly or not at all" and 5 = "extremely". The scale yields two subscales of positive affect (PA) and negative affect (NA), which have been found to be largely uncorrelated and show good internal and test-retest reliability (Watson et al., 1988).

2.3. Statistical analyses

The effect of gender, age, and conditions (i.e., the order of time period to which subjects were asked to answer) on the three measures of MTT were analysed using MANOVAs. The impact of personality was assessed using multiple regression analysis for all tasks.

3. Results

3.1. Content of the events

The amount of positive and negative events generated in the quantity task was summed across time periods (i.e., one week, one year, five to ten years). To give an idea of the content of the events that were recalled and imagined in the present study, we classified the descriptions of events into broad categories: health and physical appearance, family, romance and sex, social relationships, money and material goods, work, leisure, reflexivity (e.g., remembering being thinking about something), and finally "other" for events that could not be classified in the above categories. Percentages of events in each condition for each category are presented in Table 1.

3.2. Gender and age

Results from multivariate analysis do not show any significant effect of gender on the quantity task [$F(3, 31) = 1.69; p = .19$], the preferential content task [$F(2, 32) = 1.87; p = .17$], or the quality task [$F(20, 14) = 1.14; p = .40$]. As regards age, regression analysis do not show any effect either on the number of reported events [$F(3, 31) = 0.49; p = .69$], on the preferential content task [$F(2, 32) = 2.90; p = .07$], or the quality task [$F(20, 14) = 1.38; p = .27$].

3.3. Effect of condition

Results from multivariate analysis yield no significant effect of the order of presentation of positive versus negative events and of the temporally close versus distant events time period to which subjects were asked to answer (e.g., starting with the positive future rather than the negative past) on the quantity task [$F(9, 71) = 1.21$;

$p = .30$], on the preferential content task [$F(22, 44) = 0.94$; $p = .55$], or on the quality task [$F(60, 37) = 0.79$; $p = .80$].

Table 1: Percentages of events in each category for each time period considered during interviews

	Past		Future	
	Positive (%)	Negative (%)	Positive (%)	Negative (%)
Health & physical appearance	3	7	5	15
Family	15	28	22	27
Romance & sex	12	13	11	10
Social relationships	16	11	11	7
Money & material goods	4	8	9	11
Work	23	21	22	23
Leisure	23	9	18	5
Reflexivity	3	1	3	1
Other	1	1	0	1

Table 2 : Multiple regression analysis with the number of generated events in the four conditions as dependent variables and the five dimensions of NEO PI-R as predictors

	Past						Future					
	Positive			Negative			Positive			Negative		
	β	$t(29)$	p	β	$t(29)$	p	β	$t(29)$	p	β	$t(29)$	p
Neuroticism	-0.04	-0.20	.84	0.19	0.92	.36	0.04	0.20	.84	0.49	2.65	.01
Extraversion	0.15	0.62	.54	0.06	0.25	.80	0.20	0.86	.40	0.23	1.16	.25
Openness	0.05	0.21	.84	-0.13	-0.55	.58	-0.09	-0.38	.71	-0.25	-1.20	.24
Agreeableness	0.04	0.17	.86	0.04	0.22	.83	-0.04	-0.21	.84	-0.09	-0.50	.62
Conscientiousness	-0.09	-0.36	.72	-0.21	-0.92	.36	-0.11	-0.48	.64	-0.03	-0.13	.90

Note. Positive past: Adjusted $R^2 = -0.14$. $p = .96$; Negative past: Adjusted $R^2 = -0.01$. $p = .49$; Positive future: Adjusted $R^2 = -0.12$. $p = .91$; Negative future: Adjusted $R^2 = 0.18$. $p = .05$.

Table 3: Multiple regression analysis with the number of generated events in the four conditions as dependent variables and the seven dimensions of TCI-R as predictors

	Past						Future					
	Positive			Negative			Positive			Negative		
	β	$t(27)$	p	β	$t(27)$	p	β	$t(27)$	p	β	$t(27)$	p
Novelty seeking	0.14	0.61	.55	0.21	1.01	.32	0.18	0.84	.41	0.26	1.31	.20
Harm avoidance	-0.23	-0.82	.42	0.24	0.88	.39	-0.05	-0.17	.87	0.44	1.74	.09
Reward dependence	-0.15	-0.58	.57	-0.31	-1.31	.20	-0.03	-0.11	.91	0.10	0.46	.65
Persistence	0.03	0.13	.89	-0.05	-0.22	.83	0.22	0.99	.33	0.24	1.20	.24
Self-directedness	-0.26	-0.97	.34	-0.26	-1.02	.32	-0.36	-1.38	.18	-0.32	-1.34	.19
Cooperativeness	0.26	0.89	.38	0.23	0.81	.42	-0.02	-0.06	.95	-0.19	-0.73	.47
Self-transcendence	0.18	0.93	.36	0.11	0.61	.54	0.23	1.22	.23	0.09	0.54	.60

Note. Positive past: Adjusted $R^2 = -0.10$. $p = .78$; Negative past: Adjusted $R^2 = 0.01$. $p = .43$; Positive future: Adjusted $R^2 = 0.05$. $p = .62$; Negative future: Adjusted $R^2 = 0.13$. $p = .15$.

Table 4: Multiple regression analysis with the valence of self-related stories in the past and in the future as dependent variables and the five factors of NEO PI-R as predictors

NEO PI-R	Past			Future		
	β	t	p	β	t	p
Neuroticism	-0.40	-2.14	.04	-0.49	-2.70	.01
Extraversion	0.22	1.03	.31	0.07	0.36	.72
Openness	-0.17	-0.78	.44	-0.27	-1.32	.20
Agreeableness	-0.00	-0.00	1.00	0.15	0.88	.39
Conscientiousness	-0.19	-1.00	.32	-0.01	-0.07	.95

Note. Adjusted R^2 for NEO PI-R and Past = 0.08; $p = 0.20$. Adjusted R^2 for NEO PI-R and Future = 0.14; $p = 0.09$.

3.4. Personality and Quantity of MTT

Results from multiple regression analysis with the amount of generated events in the four conditions (i.e., negative past, positive past, negative future, and positive future) as dependent variables and the five dimensions of NEO PI-R as predictors are presented in Table 2. Results yield a significant effect of neuroticism on the number of generated negative future events.¹

The effects of other personality dimensions, including extraversion, on the numbers of projections were not significant in any condition.

When looking at specific time periods separately (i.e., next week, next year, and next five to ten years), results show a significant effect of neuroticism for all time periods in the future negative condition (a week: $p < .01$; a year: $p = .05$; 5 to 10 years: $p = .02$). Other personality dimension did not predict the number of event in any time period and condition.

Table 3 provides results from multiple regression analysis with the amount of generated events in the four conditions as dependent variables and the seven dimensions of TCI-R as predictors. No significant effects of Cloninger's dimensions of personality on the number of generated events were found for any condition though there is a trend toward significance ($p = .09$) for an effect of harm avoidance on negative projections in the future. When looking at specific time periods separately, results show no significant effect of TCI-R dimension in any condition either.

Table 5: Multiple regression analysis with the valence of self-related stories in the past and in the future as dependent variables and the seven dimensions of TCI-R as predictors

TCI-R	Past			Future		
	β	t	p	β	t	p
Novelty seeking	-0.25	-1.13	.27	-0.37	-1.85	.08
Harm avoidance	-0.61	-2.40	.02	-0.64	-2.71	.01
Reward dependence	0.25	1.09	.28	0.42	2.00	.06
Persistence	-0.05	-0.23	.82	-0.30	-1.56	.13
Self-directedness	-0.38	-1.63	.12	-0.08	-0.37	.71
Cooperativeness	0.16	0.63	.54	-0.00	-0.02	.98
Self-transcendence	-0.07	-0.42	.68	0.12	0.75	.46

Note. Adjusted R^2 for TCI-R and past = 0.02; $p = .40$. Adjusted R^2 for TCI-R and future = 0.16; $p = .11$.

Additional regression analysis including mood (i.e., PANAS) as well as phonologic and semantic fluencies as predictors were conducted for both NEO PI-R and TCI-R analysis. Including these variables does not induce any modification in the results thus revealing the absence of effect of mood on the number of generated event in all conditions and the independence of the quantity task with regard to the general verbal fluency.

¹ Though usually considered as metric, personality measures use ordinal scales. Therefore, we additionally conducted nonparametric analyses (i.e. rank-order correlations). Results show that neuroticism is also related to the amount of negative future projections (Spearman $R = .31$; $p = 0.07$) even if the correlation does not reach the level of significance.

3.5. Personality and preferential content of MTT

The results of the two multiple regression analysis assessing the effects of NEO PI-R and TCI-R dimensions on the valence of self-related stories in the past and in the future are presented in Tables 4 and 5, respectively. Results show a significant negative effect of neuroticism on the valence of both past ($\beta = -0.40$; $p < .05$) and future ($\beta = -0.49$; $p < .01$) self-related stories. Harm avoidance was also found to be negatively related to the valence of the past ($\beta = -.61$; $p < .05$) and future ($\beta = -0.64$; $p < .01$) stories.² As for the quantity task, the predicted effects of extraversion, novelty seeking, and self-directedness on positive affect in the story completion task were not found.

Additional regression analysis including mood as predictor were conducted for both NEO PI-R and TCI-R analysis. Including this variable does not induce any modification in the results thus confirming the absence of effect of mood on the valence and specific emotions in the story completion task.

3.6. Personality and Quality of MTT

The results of the regression analysis assessing the effects of NEO PI-R and TCI-R dimensions on the phenomenal characteristics associated to MTT in the past and in the future are presented in Tables 6 and 7, respectively.

Results in Table 6 show that neuroticism positively predicts the quality of memories for negative events. Moreover, conscientiousness also positively predicts the quality of representations in the positive future, negative future and negative past conditions as well as the coherence of imagined positive future events and the emotional intensity of both positive and negative future events. However, openness did not significantly relate to any phenomenal characteristics.³

Concerning the TCI-R dimensions, results in Table 7 show that novelty seeking negatively predicts the emotional intensity of past and future positive events. Novelty seeking also positively predicts the amount of auto-noetic consciousness, i.e., the feeling of mentally travelling through time and experiencing the event as if it was happening, only in the positive future condition. Auto-noetic consciousness is also positively predicted by cooperativeness in the positive future, negative future and negative past conditions and there is a trend toward significance for the positive past condition ($\beta = 0.41$; $p = .06$). Additionally, cooperativeness also predicts the degree to which subjects tend to feel emotions when imagining positive future events as well as the quality of representation for positive past events. At last, persistence is a significant predictor of coherence of generated events for both positive and negative past events. Conversely, no links were found between phenomenal characteristics and self-transcendence.⁴

Additional regression analysis including mood as predictor were conducted for both NEO PI-R and TCI-R analysis. Including this variable does not induce any modification in the results thus confirming the absence of effect of mood on the phenomenal characteristics of generated events.

² Non parametric analyses show significant correlations between neuroticism and the valence of past (Spearman $R = -.40$; $p < .05$) and future (Spearman $R = -.47$; $p < .01$) stories. Though in line with parametric analyses, correlations between harm avoidance and the valence of past and future stories were not significant (Spearman $R = -.30$; $p = .08$ and Spearman $R = -.23$; $p = .19$, respectively).

³ Non parametric analyses were in line with parametric findings regarding conscientiousness (C). This dimension significantly correlated with Quality of representation for positive (.51**) and negative future events (.43*) as well as negative past events (.52**). C also correlated with Coherence for positive future events (.59***). However, the relationships between C and Emotional intensity for positive (.28, $p = .10$) and negative (.27, $p = .11$) future events did not reach the level of significance. The relationships between neuroticism and Emotional intensity for negative future events (.25, $p = .15$) as well as Quality of representation for negative past events (.01, $p = .97$) were not significant. Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

⁴ Non parametric analyses were globally consistent with parametric results. NS negatively correlated with Emotional intensity for positive future (-.44") and positive past events (-.39*). However, the relationship between NS and Auto-noetic consciousness for positive future events was not significant (-.15, $p = .40$). Regarding the relationships between Ps and Coherence, results also show a significant positive correlation for positive past events (.39*) and a trend toward significance for negative past events (.31, $p = 0.07$). Finally, CO significantly correlated with Pre-experiencing emotions (.36*) and Auto-noetic consciousness (.40*) for positive future events as well as with Auto-noetic consciousness for negative past events (.40*). Correlations between CO and Auto-noetic consciousness for negative future events (.29, $p = .09$) as well as with Quality of representation for positive past events (.19, $p = .29$) did not reach the level of significance. Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 6: Multiple regression analysis with the phenomenal characteristics associated with MTT in the past and in the future as dependent variables and the five factors of NEO PI-R as predictors

	Adjusted R ²	p	N	E	O	A	C
Positive future events							
Quality of representation	0.15	.08	$\beta = -0.05$	$\beta = -0.03$	$\beta = 0.17$	$\beta = -0.01$	$\beta = 0.45^*$
Coherence	0.22	.04	$\beta = 0.12$	$\beta = 0.11$	$\beta = 0.11$	$\beta = 0.10$	$\beta = 0.52^{**}$
Pre/re experiencing emotions	0.09	.18	$\beta = 0.03$	$\beta = -0.27$	$\beta = 0.36$	$\beta = 0.08$	$\beta = 0.23$
Emotional intensity	0.09	.19	$\beta = 0.32$	$\beta = -0.21$	$\beta = 0.07$	$\beta = 0.00$	$\beta = 0.44^*$
Autooetic consciousness	0.17	.07	$\beta = -0.07$	$\beta = -0.30$	$\beta = 0.37$	$\beta = 0.09$	$\beta = 0.32$
Negative future events							
Quality of representation	0.18	.06	$\beta = 0.19$	$\beta = 0.25$	$\beta = 0.08$	$\beta = 0.21$	$\beta = 0.40^*$
Coherence	0.08	.19	$\beta = 0.15$	$\beta = 0.28$	$\beta = -0.00$	$\beta = 0.31$	$\beta = 0.21$
Pre/re experiencing emotions	-0.08	.75	$\beta = 0.25$	$\beta = 0.19$	$\beta = -0.03$	$\beta = -0.02$	$\beta = 0.22$
Emotional intensity	0.05	.26	$\beta = 0.40^*$	$\beta = 0.12$	$\beta = -0.29$	$\beta = -0.19$	$\beta = 0.44^*$
Autooetic consciousness	0.04	.30	$\beta = 0.21$	$\beta = -0.20$	$\beta = 0.32$	$\beta = -0.08$	$\beta = 0.33$
Positive past events							
Quality of representation	0.06	.25	$\beta = 0.04$	$\beta = 0.18$	$\beta = 0.17$	$\beta = 0.12$	$\beta = 0.25$
Coherence	0.29	.01	$\beta = 0.07$	$\beta = -0.39$	$\beta = 0.28$	$\beta = 0.03$	$\beta = 0.30$
Pre/re experiencing emotions	0.07	.23	$\beta = -0.01$	$\beta = -0.38$	$\beta = 0.32$	$\beta = 0.08$	$\beta = 0.18$
Emotional intensity	0.02	.35	$\beta = -0.06$	$\beta = -0.26$	$\beta = -0.06$	$\beta = 0.07$	$\beta = 0.27$
Autooetic consciousness	-0.03	.55	$\beta = 0.20$	$\beta = -0.11$	$\beta = 0.05$	$\beta = 0.05$	$\beta = 0.34$
Negative past events							
Quality of representation	0.29	.01	$\beta = 0.36^*$	$\beta = 0.34$	$\beta = -0.11$	$\beta = -0.13$	$\beta = 0.67^{***}$
Coherence	0.24	.02	$\beta = 0.21$	$\beta = 0.32$	$\beta = 0.27$	$\beta = 0.10$	$\beta = 0.28$
Pre/re experiencing emotions	0.01	.40	$\beta = 0.29$	$\beta = 0.07$	$\beta = -0.13$	$\beta = 0.18$	$\beta = 0.18$
Emotional intensity	-0.02	.51	$\beta = 0.31$	$\beta = 0.32$	$\beta = -0.04$	$\beta = 0.13$	$\beta = 0.01$
Autooetic consciousness	0.03	.33	$\beta = 0.21$	$\beta = -0.10$	$\beta = 0.03$	$\beta = 0.31$	$\beta = 0.12$

Note. * $p < .05$; ** $p < .01$; *** $p < .001$; N, Neuroticism; E, Extraversion; O, Openness; A, Agreeableness; C, Conscientiousness.

4. Discussion

The purpose of the present study was to determine whether the relationship observed between neuroticism and episodic memory could be extended to episodic future thinking and, more generally, to investigate the influence of the other personality traits on self-information processing in the past and in the future. The main results are (1) that neuroticism is related to negative events, particularly future events; and (2) that harm avoidance is related to the content of negative past and future events.

4.1. Personality and MMT in term of quantity

We first predicted that people with high levels of neuroticism would generate a greater amount of negative future projections during the quantity task (*hypothesis 1a*). Results gave support to this hypothesis as people with high neuroticism generate more negative future events than emotionally stable subjects in the verbal fluency task. This finding is in agreement with previous studies showing that subjects with high neuroticism preferentially remember negative self-information (Martin et al., 1983; Ruiz Caballero & Bermudez, 1995) and experience more negative emotions (McCrae & Costa, 1991) as well as with the study of MacLeod and Salaminiou (2001) where anxious individuals were differentiated from controls by an increase in negative anticipated experiences. Neuroticism seems to play a role in both past and future MTT, adding therefore new evidences to the idea that these two abilities rely on similar mechanisms. However, our results did not confirm the relationship between neuroticism and negative memories. One possible explanation could be that subjects in our sample had relatively average scores on this trait and one can reasonably think that the relationship would have appeared in a more scatter sample. This absence of results might also suggest that the effect of neuroticism on MTT is more robust for the future than for the past. This makes sense considering that from an evolutionary perspective, it is only the present and the future, not how we represent the past, that matter (Gilbert & Wilson, 2007; Suddendorf & Corballis, 2007). Moreover, the relationship between neuroticism and retrieval of episodic memories is constrained by reality, i.e., the actual events a person experiences, whereas as regards episodic future thinking, the effect of neuroticism might be more direct. It is also noteworthy to mention that, though some studies have shown that the effect of neuroticism on memory retrieval was affected by mood (Bradley & Mogg, 1994; Kuiper

& MacDonald, 1982) while other studies did not (Lloyd & Lishman, 1975 ; Martin et al., 1983 ; Ruiz Caballero & Bermudez, 1995) and that the ability to generate future events was significantly altered by changes in mood (Hepburn, Barnhofer & Williams, 2006), the present finding show an impact of neuroticism on negative future thinking even when mood is controlled.

Table 7: Multiple regression analysis with the phenomenal characteristics associated with MTT in the past and in the future as dependent variables and the seven factors of TCI-R as predictors

	Adjusted R ²	p	NS	HA	RD	Ps	SD	C	ST
Positive future events									
Quality of representation	0.01	.41	$\beta = -0.31$	$\beta = -0.28$	$\beta = -0.15$	$\beta = 0.09$	$\beta = -0.02$	$\beta = 0.42$	$\beta = -0.21$
Coherence	0.02	.40	$\beta = -0.20$	$\beta = 0.13$	$\beta = 0.20$	$\beta = 0.29$	$\beta = 0.27$	$\beta = -0.22$	$\beta = 0.09$
Pre/re experiencing emotions	0.26	.03	$\beta = -0.37$	$\beta = -0.07$	$\beta = -0.33$	$\beta = 0.21$	$\beta = 0.06$	$\beta = 0.58^{**}$	$\beta = -0.10$
Emotional intensity	0.05	.32	$\beta = -0.44^*$	$\beta = 0.10$	$\beta = -0.02$	$\beta = 0.23$	$\beta = -0.10$	$\beta = -0.11$	$\beta = 0.06$
Autonoetic consciousness	0.32	.01	$\beta = -0.39^*$	$\beta = -0.26$	$\beta = -0.22$	$\beta = 0.10$	$\beta = 0.17$	$\beta = 0.57^{**}$	$\beta = -0.16$
Negative future events									
Quality of representation	0.05	.30	$\beta = 0.21$	$\beta = 0.25$	$\beta = 0.22$	$\beta = 0.21$	$\beta = 0.23$	$\beta = 0.25$	$\beta = 0.17$
Coherence	-0.11	.81	$\beta = -0.17$	$\beta = -0.33$	$\beta = 0.20$	$\beta = -0.03$	$\beta = -0.12$	$\beta = 0.17$	$\beta = -0.18$
Pre/re experiencing emotions	-0.07	.68	$\beta = -0.12$	$\beta = -0.03$	$\beta = -0.16$	$\beta = -0.05$	$\beta = -0.03$	$\beta = 0.40$	$\beta = -0.28$
Emotional intensity	0.00	.44	$\beta = -0.26$	$\beta = -0.02$	$\beta = 0.13$	$\beta = -0.03$	$\beta = -0.10$	$\beta = -0.17$	$\beta = -0.31$
Autonoetic consciousness	0.04	.32	$\beta = -0.21$	$\beta = -0.03$	$\beta = -0.25$	$\beta = 0.17$	$\beta = -0.01$	$\beta = 0.50^*$	$\beta = -0.14$
Positive past events									
Quality of representation	0.01	.43	$\beta = -0.14$	$\beta = -0.22$	$\beta = -0.23$	$\beta = 0.04$	$\beta = -0.03$	$\beta = 0.53^*$	$\beta = -0.23$
Coherence	0.11	.18	$\beta = -0.25$	$\beta = 0.08$	$\beta = 0.28$	$\beta = 0.45^*$	$\beta = 0.00$	$\beta = -0.08$	$\beta = 0.06$
Pre/re experiencing emotions	0.24	.04	$\beta = -0.33$	$\beta = 0.11$	$\beta = -0.22$	$\beta = 0.17$	$\beta = 0.24$	$\beta = 0.40$	$\beta = 0.00$
Emotional intensity	0.17	.10	$\beta = -0.59^{**}$	$\beta = -0.11$	$\beta = -0.14$	$\beta = 0.05$	$\beta = -0.04$	$\beta = 0.26$	$\beta = -0.06$
Autonoetic consciousness	0.30	.02	$\beta = -0.28$	$\beta = 0.24$	$\beta = -0.13$	$\beta = -0.17$	$\beta = -0.17$	$\beta = -0.41$	$\beta = -0.27$
Negative past events									
Quality of representation	-0.04	.58	$\beta = -0.06$	$\beta = 0.20$	$\beta = 0.01$	$\beta = 0.31$	$\beta = 0.19$	$\beta = -0.02$	$\beta = -0.13$
Coherence	0.12	.16	$\beta = -0.17$	$\beta = -0.23$	$\beta = 0.31$	$\beta = 0.41^*$	$\beta = -0.24$	$\beta = 0.05$	$\beta = 0.15$
Pre/re experiencing emotions	0.10	.19	$\beta = -0.24$	$\beta = 0.20$	$\beta = -0.05$	$\beta = -0.13$	$\beta = 0.09$	$\beta = -0.33$	$\beta = -0.22$
Emotional intensity	-0.07	.68	$\beta = -0.14$	$\beta = -0.31$	$\beta = -0.09$	$\beta = -0.01$	$\beta = -0.45$	$\beta = 0.52$	$\beta = -0.03$
Autonoetic consciousness	0.27	.02	$\beta = -0.23$	$\beta = 0.10$	$\beta = -0.11$	$\beta = -0.20$	$\beta = 0.04$	$\beta = 0.63^{**}$	$\beta = -0.27$

Note. * $p < .05$; ** $p < .01$; NS, Novelty seeking; HA, Harm avoidance; RD, Reward dependence; PS, Persistence; SD, Self-directedness; CO, Cooperativeness; ST, Self-transcendence.

Beside neuroticism, results do not show any relationship between either the NEO PI-R or the TCI-R and the number of memories or projections. However, several lines of evidence suggest that extraversion is associated with positive emotion (Hotard, McFatter, McWhirter & Stegall, 1989; McCrae & Costa, 1991 ; Meyer & Shack, 1989; Williams, 1981) and Larsen and Ketelaar (1991) found that extraverts show heightened emotional reactivity when imagining agreeable events. Therefore, we expected that extraversion and, by extension, novelty seeking could be related to the number of positive memories or projections (*hypothesis 2a* and *4a*, respectively). Nevertheless, in the above studies, subjects had to imagine standard events developed by the authors and not personal events. Thus, one possible explanation of the absence of significant effect is that relationships between extraversion and positive emotions could be principally observed when dealing with semantic information (Rusting, 1999) or, at least, does not imply episodic processing. Indeed, extraverts are mainly oriented toward external stimulations and therefore less oriented toward themselves. Additionally, one could also have imagined that agreeableness could be positively related to the number of positive memories/projections as agreeable people tend to experience more positive emotion and that conscientiousness could be positively related to the number of positive future projections as conscientious people tend to plan for future in a more considered way. Results of the present study suggest that, beside neuroticism, personality dimensions do not play an important role in MTT as regards the quantity of memory/projection an individual can generate.

4.2. Personality and preferential content of MTT

Along with the number of memories/projections a person can generate in a given amount of time, a second important aspect of MTT involves the type of memories/projections that comes preferentially to people's mind when asked to engage in MMT. Results support *hypothesis 1b* showing that neuroticism is a significant predictor

of the valence of self-related stories for both past and future conditions. Moreover, TCI-R dimension of harm avoidance also has the same negative impact on the valence of projections and memories as we expected in our *hypothesis 3b* given the similarities between neuroticism and harm avoidance and because this dimension has been found to be a very strong predictor of negative affect (Stewart, Ebmeier & Deary, 2005).

Once again, no effect of extraversion was observed although we expected extraverts to generate more positive stories (*hypothesis 2b*). This corroborates results on quantity of MTT. The relationship between extraversion and positive emotions thus does not seem to be observed when dealing with episodic material. This finding needs to be investigated further in future studies.

4.3. Personality and Quality of MTT

Quality of MTT, i.e., phenomenal characteristics accompanying memories and projections, is another important aspect of auto-noetic consciousness (D'Argembeau and Van der Linden, 2004; D'Argembeau and Van der Linden, 2006). The results of the present study suggest that some personality traits are specifically associated with phenomenal characteristics of reported events. More specifically, subjects with high scores of conscientiousness create a more precise representation in their mind for positive and negative future events as well as for negative past events. This means that planning, a core feature of conscientiousness could depend on the ability to elaborate a precise representation of an event. In other words, the richness of representation favours the planning of future events. Moreover, people who recall past negative events with high quality, may be particularly driven to imagine and avoid such events in future, and hence act in a more conscientious way. Neuroticism was also found to be associated with the emotional intensity of negative projection and with the quality of representation for negative memories, which confirms the idea that this dimension plays definitively a role in the representation of self in time.

Surprisingly, we could not confirm our hypothesis 5 according to which subjects with high levels of openness would report more phenomenal characteristics. Openness did not relate to phenomenal characteristics associated with past and future MTT even though this dimension has been previously found to have the strongest relationship with the phenomenology of autobiographical memory (Rubin & Siegler, 2004) and with visual and spatial details. More particularly, the openness to feelings facet (03) correlated strongly with measures of belief in the accuracy of memories, recollection, sensory imagery and feeling of re-experiencing emotions. As the size of our sample was not sufficient to investigate the effect of facet on MTT, no conclusion can be drawn on this issue.

Regarding the TCI-R dimensions, the main results show that subjects with high score of NS generate less emotionally intense positive events in the past and in the future. Moreover, they have less a feeling of pre-experiencing positive events than low NS subjects. This result is not in agreement with previous studies associating NS with positive affect, and could suggest that the expression of positive emotion is not a key facet of NS. The present study also shows that subjects with high scores of cooperativeness report positive memories with more visual, sensorial and spatial details. Additionally, cooperativeness seems to play systematically a role in the feeling of re/pre-experiencing an event (i.e., auto-noetic consciousness) whatever its emotional valence. Since cooperativeness is related to empathy, tolerance, and the social dimension of personality, including non-verbal communication, one can speculate that individuals with high scores on this dimension elaborate a more sensorial representation of events. Indeed, sensorial aspects of a representation are related to the non-verbal dimensions of an event. Finally, results yield an effect of persistence on the coherence of negative and positive memories. Persistence is a personality dimension related to tenacity and perseverance despite fatigue. Consequently, individuals with high scores of persistence are more concrete and logical, and therefore report more coherent memories. Unexpectedly, we could not confirm our hypothesis 6 according to which subjects with high levels of self-transcendence would report more phenomenal characteristics. Indeed, people with high scores of self-transcendence have been found to have better self-detachment and more mental fantasies (Cloninger et al., 1993). ST did not have any effect on quality of representation although this dimension is also usually associated with visual imagery which was found to affect phenomenal characteristics of MMT (D'Argembeau and Van der Linden, 2006).

As it has been reported previously, positive and negative affect did not show any relationship with the quality of MTT. The present findings suggest that the representation of self in time seems to be independent of current mood, and therefore confirm and extend the results of previous studies on episodic memory (Lloyd & Lishman, 1975; Martin et al., 1983; Ruiz Caballero & Bermudez, 1995).

4.4. General conclusion

Before concluding, several limitations of the present study should be mentioned. First, the gender distribution is quite uneven. Indeed, research has shown that females have more detailed and emotionally intense autobiographical memories than men (Davis, 1999; Fujita, Diener, & Sandvik, 1991). Second, the *N* of the study is a bit small, though the statistical analysis shows that it is large enough to obtain significant results. Finally, the statistical validity (type I error inflation with multiple significance tests) should be underlined given the relatively high number of comparisons.

The results of the present study show that some personality traits are related to our ability to remember our past and to project ourselves into the future. The relationships between personality and auto-noetic consciousness are globally consistent with existing data on personality and emotional information processing. More particularly, neuroticism and harm avoidance seem to be strongly related to auto-noetic consciousness. These dimensions relate both to the number of reported events during the interviews and the emotional valence of the free story completion task. These findings thus confirm the influence of neuroticism on negative emotional regulation as regards past events and extend it to future events. Therefore, our study provides an additional evidence to the idea that MTT into the past and into the future rely on a common set of processes by which past experiences are used to envision the future.

Concerning the other personality dimensions our results show that 'surprisingly' extraversion and novelty seeking are not particularly associated with past or future MTT. This suggests that the relationships between these traits and positive emotions could be limited to semantic information. This interesting result should be investigated in further studies.

Acknowledgment

This research was supported by the French Community of Belgium (ARC 06/11-340).

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