Published in : Acta Psychologica (2008), vol. 129, n°3, pp. 332-339
DOI: 10.1016/j.actpsy.2008.08.010
Status : Postprint (Author's version)

Heterogeneous inhibition processes involved in different facets of self-reported impulsivity: Evidence from a community sample

Philippe Gay[a,b], Lucien Rochat[b], Joël Billieux[b], Mathieu d'Acremont[a], Martial Van der Linden [a,b,c]

[a] *Swiss Center for Affective Sciences, University of Geneva, Rue des Battoirs 7, CH-1205 Geneva, Switzerland*

[b] *Cognitive Psychopathology and Neuropsychology Unit, Department of Psychology, University of Geneva, Boulevard du Pont d'Arve 40, CH-1205 Geneva, Switzerland*

[c] *Cognitive Psychopathology Unit, Department of Psychology, University of Liège, Belgium*

KEYWORDS*:* Impulsivity; Inhibition; Prepotent responses; Proactive interference Task-unrelated thoughts

ABSTRACT

Whiteside and Lynam (Whiteside, S. P., & Lynam, D. R. (2001). The Five Factor Model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences, 30,* 669-689) clarified the multifaceted nature of impulsivity by identifying four distinct facets of self-reported impulsive behaviors: urgency, (lack of) premeditation, (lack of) perseverance, and sensation seeking. Building on work by Bechara and Van der Linden (Bechara, A., & Van der Linden, M. (2005). Decision-making and impulse control after frontal lobe injuries. *Current Opinion in Neurology, 18,* 734-739), the main objective of this study was to investigate the hypothesis that perseverance and urgency map onto the two distinct inhibitory functions distinguished by Friedman and Miyake (Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General, 133,* 101-135): prepotent response inhibition and resistance to proactive interference. Participants (N = 126) completed the UPPS Impulsive Behavior Scale and three tasks: a recent-negatives task to assess proactive interference in working memory, and two Go/ No-Go tasks at different paces, the slower of which also assessed task-unrelated thoughts (TUTs). Consistent with the hypothesis, TUTs were positively correlated with lack of perseverance, and multiple regressions revealed that urgency was specifically related to errors in prepotent response inhibition, and lack of perseverance to errors due to difficulties overcoming proactive interference.

1. Introduction

Impulsivity is an important construct in almost all major personality theories (Whiteside & Lynam, 2001) and plays a prominent role in numerous psychopathological states (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). In

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particular, different aspects of impulsivity have been related to addictions (e.g., Tcheremissine, Lane, Cherek, & Pietras, 2003), heavy alcohol consumption (Cyders et al., 2007), borderline personality disorder (e.g., Paris, 2005), antisocial personality disorder (e.g., Barratt, Stanford, Kent, & Felthous, 1997), psychopathy (e.g., Miller, Flory, Lynam, & Leukefeld, 2003), Attention Deficit/Hyperactivity Disorder (ADHD) (e.g., Schachar, Tannock, & Logan, 1993), conduct problems (e.g., Lynam & Miller, 2004), bipolar disorder (e.g., Swann, Anderson, Dougherty, & Moeller 2001; Swann, Janicak, et al., 2001), bulimia nervosa (e.g., Claes, Nederkoorn, Vandereycken, Guerrieri, & Vertommen, 2006; Claes, Vandereycken, & Vertommen, 2005; Fischer, Smith, & Anderson, 2003), insomnia (e.g., Schmidt, Gay, & Van der Linden, 2008), and other problematic behaviors such as procrastination (e.g., Dewitte & Schouwenburg, 2002), risky sexual activities (e.g., Miller et al., 2003), compulsive buying (e.g., Billieux, Rochat, Rebetez, & Van der Linden, 2008), dependence on and problematic use of mobile phones (Billieux, Van der Linden, d'Acremont, Ceschi, & Zermatten, 2007), and tobacco craving (e.g., Billieux, Van der Linden, & Ceschi, 2007).

However, despite the widespread use of the concept of impulsivity, it is still poorly defined. In this context, several authors have underscored the need to consider impulsivity as a multifaceted construct (e.g., Enticott & Ogloff, 2006; Evenden, 1999; Whiteside & Lynam, 2001). In an attempt to delimit the facets underlying impulsivity, Whiteside and Lynam (2001) administered several widely used measures of impulsivity and the Revised NEO Personality Inventory (NEO-PI-R) (Costa & McCrae, 1992) to 437 undergraduate students. A factor analysis conducted on these impulsivity scales and on the facets of the NEO-PI-R related to impulsivity resulted in a four-factor solution, which was the basis for the creation of a scale called the UPPS Impulsive Behavior Scale. The four dimensions of impulsivity measured by the UPPS are (1) urgency, defined as the tendency to experience strong reactions, frequently under the condition of negative affect; (2) premeditation, defined as the tendency to take into account the consequences of an act before engaging in that act; (3) perseverance, defined as the ability to remain focused on a task that may be boring and/or difficult; and (4) sensation seeking, considered as a tendency to enjoy and pursue activities that are exciting, and openness to trying new experiences.

A growing number of studies based on Whiteside and Lynam's (2001) conception of impulsivity have highlighted specific relationships between the various components of impulsivity and several psychopathological states and problematic behaviors: urgency may be more specifically related to borderline personality disorders (Miller et al., 2003; Whiteside & Lynam, 2003; Whiteside, Lynam, Miller, & Reynolds, 2005), tobacco craving (Billieux, Van der Linden, & Ceschi, 2007), compulsive buying (Billieux et al., 2008), bulimia nervosa (Claes et al., 2005; Fischer et al., 2003), and nighttime as well as daytime aspects of insomnia (Schmidt, Gay, & Van der Linden, 2008); lack of premeditation may be closely related to antisocial personality and psychopathic features (d'Acremont, 2005; Miller et al., 2003; Whiteside & Lynam, 2003; Whiteside et al., 2005); and lack of perseverance may represent a particularly important facet in the evaluation of predominantly inattentive subtypes of ADHD (d'Acremont, 2005; Miller et al., 2003; Whiteside & Lynam, 2001) and insomnia-related impairments in daytime functioning (Schmidt, Gay, & Van der Linden, 2008). Finally, sensation seeking could be associated with involvement in delinquent acts, drug and alcohol use, and risky sexual behaviors (e.g., Miller et al., 2003). More specifically, sensation seeking may be related to the frequency of engaging in risky behaviors, whereas urgency may be specifically related to problematic levels of engagement in those behaviors (Smith et al., 2007).

Inhibitory problems have recently attracted renewed interest in the assessment and comprehension of impulsivity (Bechara & Van der Linden, 2005; Enticott & Ogloff, 2006; Kertzman, Grinspan, Birger, & Kotler, 2006). Moreover,

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such problems may be related to a number of different problematic behaviors involving impulsivity such as ADHD (e.g., Barkley, 1997; Schachar et al., 1993), obsessive-compulsive disorder (OCD) and/or trichotillomania (e.g., Chamberlain, Fineberg, Blackwell, Robbins, & Sahakian, 2006; Van der Linden, Ceschi, Zermatten, Dunker, & Perroud, 2005), borderline personality disorder (e.g., Domes et al., 2006), alcoholism (e.g., Nigg et al., 2006; Noël et al., 2001), smoking (e.g., Krishnan-Sarin et al., 2006), and chronic cocaine use (Fillmore & Rusch, 2002).

However, despite interesting results suggesting that self-reported impulsivity is related to inhibition performance in laboratory tasks (e.g., Enticott, Ogloff, & Bradshaw, 2006; Keilp, Sackeim, & Mann, 2005; Kooijmans, Scheres, & Oosterlaan, 2000; Marsh, Dougherty, Mathias, Moeller, & Hicks, 2002), several studies have found no such relationship (e.g., Claes et al., 2006; Horn, Dolan, Elliott, Deakin, & Woodruff, 2003; Lane, Cherek, Rhoades, Pietras , & Tcheremissine, 2003; Reynolds, Ortengren, Richards, & de Wit, 2006). For instance, Reynolds et al. (2006) found a significant correlation between one dimension of self-reported impulsivity and commission errors in a Go/No-Go task, but no correlation was found between the different dimensions of self-reported impulsivity and the stop reaction time in a Go-Stop task. Furthermore, Keilp et al. (2005) reported that, among several executive performance variables, number of errors on a Go/No-Go task was the strongest correlate of a range of self-rated impulsive facets; on the other hand, using a different Go/No-Go task, Horn et al. (2003) found no significant correlation between commission errors and general impulsivity.

Several lines of thought could be proposed to explain these contradictory results concerning the relationship between impulsivity and inhibition. This lack of significant correlation could be due not only to the lack of consensus concerning the dimensions of impulsivity, but also to the misconceptions surrounding inhibition processes. Indeed, it is still debated in the literature whether inhibition (or executive functions in general) is a unitary construct or not. In this context, Friedman and Miyake (2004) performed an experiment to examine the relationships between tasks chosen to represent three theoretical inhibitory functions in 220 normal adults. The results of their latent variable analysis suggested that prepotent response inhibition was closely related to the ability to resist interference from irrelevant (distracting) information in the external environment (resistance to distracter interference), but both abilities were unrelated to resistance to proactive interference (i.e., the ability to resist the intrusion into memory of information that was previously relevant but has since become irrelevant).

Considering impulsivity as a multidimensional construct and inhibition as a multi-determined process should help us to disentangle the cognitive mechanisms associated with impulsivity. Based on this approach, the multifaceted model of impulsivity proposed by Whiteside and Lynam (2001) will be adopted to explore the relationships between impulsivity and two specific inhibition capacities. Within this theoretical framework, Bechara and Van der Linden (2005) (see also Van der Linden, Rochat & Billieux, 2006) recently proposed to relate the various facets of impulsivity to specific psychological processes. More specifically, they tentatively suggested that urgency may be related to the ability to deliberately suppress dominant, automatic or prepotent responses. Several studies have found that impulsive individuals have problems with tasks assessing prepotent response inhibition such as Go/No-Go tasks or stop-signal tasks (e.g., Enticott et al., 2006; Keilp et al., 2005; Logan, Schachar, & Tannock, 1997). Bechara and Van der Linden (2005) further proposed that the lack of perseverance could be related to vulnerability to proactive interference. Thus, one way to tap into the processes at play in impulsivity, and more particularly in the ''lack of perseverance" aspects of the construct, could consist of using modified tasks based on an item recognition paradigm (for a review, see Jonides & Nee, 2006) that specifically assesses resistance to proactive interference in

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working memory. Interestingly, rumination has been found to be related to deficient inhibition of previously relevant information in such tasks (Whitmer & Banich, 2007), extending previous findings highlighting the relationship between resistance to proactive interference and cognitive intrusions (Friedman & Miyake, 2004).

Another way of understanding impulsivity, and particularly the lack of perseverance dimension, may be the use of thought sampling methods to assess mind wandering or task-unrelated thoughts (TUTs) during the execution of different activities. One such method involves interrupting participants during a task in which they have to indicate whether, at the moment just before the interruption, they felt their mind wandering (a drift of attention toward off-task thoughts) or whether their thoughts were related to the task (on-task thoughts or no thoughts). It has been suggested that mind wandering episodes involve executive control and a growing number of studies have found that TUTs interfere with task performance (for a review, see Smallwood & Schooler, 2006). Considering our suggestions concerning the relationships between inhibition and impulsivity, we hypothesized that mind wandering may be related to lower perseverance and to difficulty in resisting proactive interference.

The first objective of this study was to examine the extent to which facets of impulsivity, measured with a self-reported questionnaire (UPPS), are related to performance on objective measures of inhibition. Following Bechara and Van der Linden's (2005) suggestions (1) the urgency facet of impulsivity should be related to difficulties suppressing dominant responses, as assessed by a traditional Go/No-Go tasks with infrequent targets, and (2) the lack of perseverance facet should be related to the ability to overcome proactive interference in working memory, as assessed by a recent-negatives task. The second objective was to examine how attention drifting toward "off-task thoughts" or mind wandering, as assessed by the number of reported TUTs, may be related to the lack of perseverance component of impulsivity and to the related ''resistance to proactive interference" mechanisms.

2. Method

2.1. Participants and procedure

Participants were volunteers and received no compensation for their participation. They were recruited by the first three authors and four student helpers by means of advertisements and personal contacts and through snowballing techniques. Exclusion criteria were any recent or ongoing major depressive episode, anxiety disorder or neurological disorder. Four subjects were excluded because they reported depressive episodes. Moreover, nine subjects were excluded because of the missing values. Thus, the final sample is composed of 126 individuals (64 females and 62 males) with an average age of 24.59 years (SD = 3.79, range = 18-35). Participants' mean years of education were 15.44 (SD = 2.55, range = 922). Participants were individually assessed in a quiet room with a white background behind the computer. They were informed of the duration and content of the study and were debriefed at the end. They signed an informed consent form before completing the tasks and questionnaires in the same order: a modified sustained attention to response task with the detection of task-unrelated thoughts (SART-TUTs), the UPPS Impulsive Behavior Scale (UPPS), the recent-negatives task (RNT), and the SART-basic. As both time on task and practice increase the frequency of mind wandering (Smallwood & Schooler, 2006), this predefined order was chosen to avoid artificially enhancing proneness to such mind wandering. At the beginning of the study, all participants were given some practice in distinguishing what is a TUT and what is not (according to Smallwood,

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Obonsawin, & Reid, 2003) and then completed the SART-TUTs.

2.2. Questionnaire

2.2.1. UPPS Impulsive Behavior Scale

Self-reported impulsivity was assessed by the French version of the UPPS (Van der Linden, d'Acremont, et al., 2006), which contains 45 items that are rated on a four-point Likert scale ranging from 1 *(agree strongly)* to 4 *(disagree strongly).* The UPPS comprises four subscales corresponding to the four distinct, yet related facets of impulsivity identified by Whiteside and Lynam (2001): (1) urgency (12 items; e.g., ''When I feel rejected, I will often say things I later regret"); (2) (lack of) premeditation (11 items; e.g., ''I usually make up my mind through careful reasoning"); (3) (lack of) perseverance (10 items; e.g., ''Once I start a project, I almost always finish it"); and (4) sensation seeking (12 items; e.g., ''I welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional"). For each facet, higher scores indicate a higher level of impulsivity.

2.3. Tasks

2.3.1. SART-basic (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997)

This Go/No-Go task involves withholding a key press in response to a rare target (the digit ''3" among all digits). Participants were required to respond, as fast and as accurately as possible, with the space bar to all digits except the 3. Digits were presented for 250 ms and then replaced by a duration mask (composed of an X presented within a ring) for 900 ms, which creates an onset-to- onset interval of 1150 ms. Both digits and mask were white and appeared against a black background. In the original testing of the SART, errors demonstrated significant correlations with self-reports of everyday attentional failures, as well as with informant reports of these failures (Robertson et al., 1997).

A practice block of 18 digits (including two targets) was performed before the participants began the real block, lasting about 416 min, in which 234 digits were presented. Each digit appeared 26 times (which makes the target number 3 a low-probability target of 1/9 or 11%) in a quasi-random order, and in one of five randomly assigned fonts. The dependent variable was the number of commission errors (false alarms).

2.3.2. Modified slow SART-TUTs

This task was derived from a previous research concerning the presentation pace of stimuli (Smallwood et al., 2004). Digits were presented for 250 ms and then replaced by a mask (composed of an X presented within a ring) with a duration of 2050 ms, resulting in an onset-to-onset interval of 2300 ms. Here again, both digits and mask appeared in white against a black background. Thus, the rate of presentation of the digits was about half as fast as in the SART, and the task took about twice as long to do. Smallwood et al. (2004, experiment 3) evaluated TUTs during this task via a standardized retrospective questionnaire. We evaluated TUTs during this task with randomized thought sampling during which participants characterized their thoughts as TUT vs. Non-TUT. Thus, another difference from the SART-basic is that the SART-TUTs includes thought detection pauses where participants must indicate, via a key press, whether or not they had experienced a TUT in the instant just before the pause. This procedure comprised nine blocks (after one practice block), each one terminating with a thought probe detection to tap mind wandering or TUT episodes during the task of responding to all digits between 1 and

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9 except 3 as fast and accurately as possible. Smallwood and Schooler (2006) provided evidence of the validity of this measure as an estimation of how often mind-wandering episodes occur, without requiring participants to be constantly monitoring and aware of the content of their own experiences. A practice block of nine digits (comprising one target digit and two thought probes) was performed before participants began the nine real blocks. The task, which lasted about 8 or 9 min in total, contained 216 digits, presented the same randomization as in the SART-basic. Each digit appeared 24 times (the probability of the target was still 11%) in quasi-random order, and in one of five randomly assigned fonts. The duration between thought probe detections was randomized with three possible intervals: a long one (a probe after 33 stimuli), a medium one (a probe after 22 stimuli), and a short one (a probe after 17 stimuli). The dependent variables for this task were the number of commission errors (i.e., false alarms) and the number of TUTs experienced just before a pause.

2.3.3. Recent-negatives task (RNT)

This task was adapted from the work of Hamilton and Martin (2005) in order to assess proactive interference in the working memory. This kind of speeded-up item recognition task has its origins in the work of Monsell (1978), who introduced a test protocol that allows past trials to influence the current one. A target set of three words is presented sequentially and has to be stored for a retention interval of about 3 s. Then, a probe word is presented, which may or may not match one of the words of the target set. Participants have to indicate (as quickly and accurately as possible) whether the probe word was presented in the last set of three words. When the probe does not match the current target set (thus requiring a negative response), two conditions are distinguished: (1) negative probes drawn from the previous trial's target set (i.e., recent negative probes); and (2) negative probes that did not occur in a recent target set but were presented three trials before the current one (i.e., non-recent negative probes). The two negative conditions are compared in terms of both reaction time and errors; the more interfering condition (recent negative probes) is expected to cause more errors and longer reaction times than its less interfering counterpart (non-recent negative probes). There were 20 trials in each negative condition (20 recent and 20 non-recent) and 40 trials in the positive condition (i.e., trials requiring ''yes'' responses). The stimuli were presented in a fixed pre-randomized order to form the recent negative and non-recent negative conditions. Two practice trials with other words were administered before the beginning of the 80 real trials.

The items were drawn from a set of 16 neutral, frequent, and semantically and phonologically unrelated disyllabic words composed of five or six letters. The words were selected to have neutral valence, excitation and imagery levels, and had a lexical frequency of between 1506 and 5066 per 100 million occurrences (for lexical and form frequencies; Content, Mousty, & Radeau, 1990).

In the sets of three sequential words, each word was presented for 750 ms, followed by a 100 ms interstimulus interval; after the third word, a row of stars was presented for 400 ms, heralding the arrival of the probe word. The probe word was presented for 600 ms, followed by a blank screen that remained until the subject responded. Then a fixation cross appeared for 250 ms and the next set of three words started. Participants were instructed to respond as quickly as possible after the probe word was presented.

Only RTs for correct responses were retained. The reaction time was log transformed (LogRT) to decrease the skewness of the distribution. Interference indices were computed for errors and LogRT by subtracting performances in the low-interference condition from performances in the high-interference condition (i.e., ''the

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number of errors for recent negative probes" minus ''the number of errors for non-recent negative probes"; and ''mean LogRT for recent negative probes" minus ''mean LogRT for non-recent negative probes"). These indices give measures of proactive interference induced by recently studied probes, controlling for non-recent probes. Thus, the dependent variables were the two indices of proactive interference (based on errors and based on LogRT) computed by the differences between the two negative conditions (high-low- interference condition).

2.4. Statistical analyses

Pearson's correlations were used to evaluate the relations between variables. Pearson's point-biserial correlation was used to evaluate the effect of gender on task variables. Women were set at -1 and men at +1; thus, a positive correlation corresponds to a higher score for men. Multiple regression analyses were performed with the four facets of impulsivity, age and gender as predictors in order to evaluate specific associations between impulsivity and task variables when other impulsive traits, age and gender were partialed out. Different measures of impulsivity have been found to decrease with age (Caci et al., 2005; Deakin, Aitken, Robbins, & Sahakian, 2004; Eysenck, Pearson, Easting, & Allsopp, 1985) and to be higher for men than for women (Billieux et al., 2008; Deakin et al., 2004; Schmidt, Gay, d'Acremont, & Van der Linden, 2008; Van der Linden, d'Acremont, et al., 2006; Waldeck & Miller, 1997). We therefore chose to control for these variables in the regression analyses. In addition, although we made specific hypotheses concerning urgency and the lack of perseverance, the four facets of impulsivity were introduced as independent variables in the regression analyses to highlight the fact that the other two dimensions are related to other processes, and to reinforce the existence of a specific association between urgency and prepotent response inhibition, and the lack of perseverance and proactive interference.

3.Results

3.1. Preliminary analyses

Cronbach's α-coefficients, mean scores and standard deviations for the UPPS are presented in Table 1. The range of Cronbach's α-coefficients (82-86) suggests that the subscales of the UPPS show excellent internal consistency. Mean scores and standard deviations on measures for all three tasks are presented in Table 1. Mean RT (and LogRT) in the SARTs showed no correlation with impulsivity or with TUTs, and will not be further reported here. In the RNT, the mean log reaction time (LogRT) was higher in the recent negative condition than in the non-recent negative condition, showing that an interference effect was induced experimentally, $t(125) = 8.46$, $p < .01$. The number of commission errors was also greater in the recent than in the non-recent condition, $t(125) = 6.49$, $p < .01$.

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Correlations among variables are presented in Table 2, and regression analyses in Table 3. In order to control for the presence of multicollinearity before interpreting the regression coefficients, we computed the Variance Inflation Factor (VIF), which shows how much the variance of the coefficient estimate is inflated by multi-collinearity, and the tolerance score. According to several authors (e.g., Allison, 1999), VIF values over 2.5 and tolerance below .40 are considered as problematic for multicollinearity. The strongest VIF and the lowest tolerance concerned lack of premeditation (the VIF was 1.468 and the tolerance amounted to .68) and lack of perseverance (the VIF was 1.409 and the tolerance .71). According to the above-mentioned criteria, there was no sign of multicollinearity.

Table 1 *- Descriptives*

		α	Mean	SD
Impulsivity	Urgency	.86	28.77	6.02
	Lack of premeditation	.82	23.06	4.43
	Lack of perseverance	.83	19.12	4.48
	Sensation seeking	.86	31.96	7.29
SART-basic	Commission errors		11.88	6.44
SART-TUTs	Commission errors		10.13	6.04
	Number of TUTs		3.76	2.38
RNT	Proactive interference index (based on errors)		0.96	1.66
	Proactive interference index (based on LogRT)		0.08	0.11

Notes: SART-basic = original sustaining attention to response task; SART-TUTs = slower-paced SART with thought probes; TUTs = task-unrelated thoughts; RNT = recent-negatives task.

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Table 2 *- Correlations between variables*

	1	2	3	4	5	6	7	8	9	10
1. Gender	-									
2. Age	.06	-								
3. Urgency	-.20*	-.25*	-							
4. Lack of premeditation	.04	-.25*	.18*	-						
5. Lack of perseverance	.08	-.17	.25*	.49*	-					
6. Sensation seeking	.33*	-.20*	-.20*	.23*	-.01	-				
7. SART-basic: # Commissions	.01	-.09	.17	.04	.02	-.01	-			
8. SART-TUTs: # Commissions	.10	-.20*	.24*	.13	.17	-.06	.73*	-		
9. SART-TUTs: # TUTs	.01	.00	.13	.16	.18*	.08	.14	.19*	-	
10. PI index (Errors)	.10	.19*	-.02	.00	.18*	-.10	-.12	-.04	.17	-
11. PI index (LogRT)	.00	.04	-.26*	-.12	-.15	-.02	-.16	-.22*	-.14	-.12

** Notes: Pearson's point-biserial correlation was used to evaluate the effect of gender on other variables: A positive correlation corresponds to a higher score for men; PI = proactive interference. *p < .05.*

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Table 3

Standardized and non-standardized regression coefficients for gender, age, and the four subscales of impulsivity regressed on commission errors in the SART-basic, commission errors in the SART-TUTs, RNT interference index based on errors, and TUTs

Task/criterion	Predictor	*B*	*SEB*	*t*	β	*p*
SART-basic: Commission errors	(Intercept)	9.90	7.68	1.29	-	.20
	Gender	0.37	0.63	0.59	.06	.56
	Age	-0.10	0.17	-0.60	-.06	.55
	URG	0.19	0.11	1.77	.18	.08
	LackPREM	0.03	0.16	0.17	.02	.86
	LackPERS	-0.08	0.15	-0.49	-.05	.63
	SenSeeking	-0.01	0.09	-0.07	-.01	.95
SART-TUTs: Commission errors	(Intercept)	11.58	6.89	1.68	-	.10
	Gender	1.09	0.56	1.93	.18	.06
	Age	-0.27	0.15	-1.80	-.17	.08
	URG	0.19	0.10	1.97	.19	.05
	LackPREM	0.07	0.14	0.48	.05	.63
	LackPERS	0.07	0.14	0.54	.06	.59
	SenSeeking	-0.10	0.08	-1.25	-.12	.21
RNT: Interference index (errors)	(Intercept)	-1.48	1.92	-0.77	-	.44
	Gender	0.17	0.16	1.05	.10	.30
	Age	0.08	0.04	1.97	.19	.05
	URG	-0.01	0.03	-0.21	-.02	.83
	LackPREM	-0.01	0.04	-0.36	-.04	.72
	LackPERS	0.08	0.04	2.14	.22	.03
	SenSeeking	-0.02	0.02	-0.90	-.09	.37
SART-TUTs: Number of TUTs	(Intercept)	-2.44	2.80	-0.86	-	.39
	Gender	-0.05	.23	-0.20	-.02	.85
	Age	0.06	0.06	0.95	.09	.34
	URG	0.05	0.04	1.27	.13	.21
	LackPREM	0.03	0.06	0.60	.06	.55
	LackPERS	0.07	0.06	1.27	.13	.21
	SenSeeking	0.04	0.03	1.12	.12	.27

Notes: URG = urgency; LackPREM = lack of premeditation; LackPERS = lack of perseverance; SenSeeking = sensation seeking.

To sum up, the questionnaire used in this study showed good psychometric properties. An experimental effect of

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proactive interference in the RNT was found for both reaction time and errors.

3.2. Relationship between urgency and prepotent response inhibition

Urgency showed a negative correlation with age, and women reported higher urgency than men (see Table 2). Consistent with our hypotheses, urgency was significantly and positively correlated with errors of commission in the SART-TUTs, and tended to correlate positively (p = .054) with commission errors in the SART-basic. Partially attesting to their divergent validity, lack of perseverance was only marginally related to commission errors in the SART- TUTs and unrelated to such errors in the SART-basic; both lack of premeditation and sensation seeking were unrelated to commission errors.

Regression analyses were then computed including age, gender, and the four impulsive subscales as simultaneous predictors of the commission errors in the SARTs (Table 3). The results indicated that errors in the SART-TUTs were predicted by urgency ($\beta = .19$; $t(119) = 1.97$; $p = .05$) and marginally by gender ($\beta = .18$; $t(119) = 1.93$; $p = .06$) and age ($\beta = -.17$; $t(119) = -1.79$; $p = .08$). Errors of commission in the SART-basic were only marginally predicted by urgency ($\beta = .18$; $t(119) = 1.77$; $p = .08$). Consistent with our hypotheses, these results indicate that urgency is the best predictor of problems inhibiting prepotent responses.

3.3. Relationship between lack of perseverance and proactive interference

Lack of perseverance was marginally negatively correlated with age, and unrelated to gender (see Table 2). Consistent with the pre-dictions, only the lack of perseverance correlated significantly with the higher number of TUTs. Moreover, concerning task performance and further attesting to divergent validity, the lack of perseverance was the only aspect of impulsivity to show a significant positive correlation with the proactive interference index based on errors. It should also be noted that, surprisingly, the proactive interference index based on LogRT was significantly negatively correlated with urgency and with commission errors on the SART-TUTs.

Regression analyses were then computed including age, gender, and the four dimensions of impulsivity as simultaneous predictors of the proactive interference indices based on errors (Table 3). Consistent with our hypotheses, proactive interference was significantly predicted by the lack of perseverance ($\beta = .22$; $t(119) = 2.14$; $p < .05$). Age was also a marginal predictor ($\beta = .19$; $t(119) = 1.97$; $p = .051$).

3.4. Relationship with TUTs

Mind wandering, as assessed by the number of TUTs noticed just before the pauses during the SART-TUTs, was unrelated to age or gender. As predicted, TUTs showed a significant positive correlation with the lack of perseverance. It must be noted that marginal effects indicated that TUTs may also be more frequent in participants with higher scores on the urgency and lack of premeditation subscales of impulsivity. Concerning task performance, TUTs correlated significantly with more commission errors in the SART-TUTs, and marginally with higher proactive interference based on errors (p = .060).

Published in : Acta Psychologica (2008), vol. 129, n°3, pp. 332-339
DOI: 10.1016/j.actpsy.2008.08.010
Status : Postprint (Author's version)

Regression analyses were then computed including age, gender, and the four dimensions of impulsivity as simultaneous predictors of the number of TUTs prompted during the task. However, inconsistent with the hypothesis that there is a unique relationship between TUTs and the lack of perseverance, no significant predictor was found.

4. Discussion

The aim of this study was to investigate the relationships between the four dimensions of impulsivity distinguished by Whiteside and Lynam (2001), specific inhibition processes, and mind wandering (TUTs) during a 9-min task. Following Bechara and Van der Linden (2005), we specifically hypothesized that urgency and lack of perseverance would map separately on the two inhibitory functions proposed by Friedman and Miyake (2004). Furthermore, we examined whether TUTs are related to impulsivity and resistance to proactive interference in working memory.

Generally confirming the dissociation proposed by Bechara and Van der Linden (2005), the multiple regression analyses controlling for age, gender, and facets of impulsivity showed that: (1) higher self-reported lack of perseverance is specifically related to increased difficulties overcoming proactive interference (in a recent-negatives task), as indicated by more instances of false recognition due to familiarity of the probes; and (2) higher self-reported urgency is specifically related to greater difficulties inhibiting prepotent responses, as indicated by more commission errors in a Go/No-Go task with infrequent No-Go targets. Interestingly, the lack of premeditation and sensation seeking were unrelated to inhibition performance.

It should be noted that the relations detected were small in magnitude. However, the assumption has never been made that behavioral measures and self-reported facets of impulsivity are isomorphic. Consequently, strong associations cannot be expected between one-time measures of cognitive skills and personality facets. Nevertheless, with regard to the first objective, the results provide evidence that two facets of impulsivity may be specifically related to different specific inhibition processes. Thus, the tasks used in this study to evaluate prepotent response inhibition and resistance to proactive interference may be of primary interest for the laboratory assessment of cognitive aspects related to distinct facets of impulsivity, namely urgency and the lack of perseverance, respectively. As behaviors related to urgency and the lack of perseverance may be considered as resulting from two distinct forms of self-control problems (related to the impulsiveness facet and the self-discipline facet, respectively, of the NEO-PI-R; Costa & McCrae, 1992; Whiteside & Lynam, 2001), these findings may extend and clarify previous research showing that overall self-reported self-control capacities predict success at behavioral self-control (in an eye-blink inhibition test and a cold pressor persistence test; Schmeichel & Zell, 2007). In particular, our findings support the view that self-control must be fractionated into a number of specific mechanisms.

More specifically, the dissociation of inhibitory function related to urgency and the lack of perseverance may shed some light on certain processes involved in some psychopathological conditions. For instance, in OCD, it might be hypothesized that urgency (and the related inhibition of prepotent response mechanism) is specifically related to compulsions while the lack of perseverance (and the related resistance to proactive interference mechanism) is related to obsessions. In this regard, Van der Linden et al. (2005) showed that poor response inhibition abilities in

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OCD patients were specifically associated with compulsive manifestations. In the same vein, hyperactive-impulsive symptoms in ADHD may relate to urgency and difficulties in inhibiting prepotent responses, whereas inattention symptoms may be better explained by the lack of perseverance and difficulties in overcoming proactive interference.

It is noteworthy that as predicted in our hypotheses, the lack of premeditation and sensation seeking were found to be unrelated to inhibition performances, which indicates that these two dimensions may depend on other psychological processes. The absence of a relationship between inhibition and the lack of premeditation is in accordance with Bechara and Van der Linden's (2005) hypothesis that the lack of premeditation is specifically related to decision-making processes influenced by somatic markers or emotion-related signals. Along the same lines, it has previously been shown that this facet of impulsivity is related to disadvantageous decisions on the Iowa Gambling Task (Zermatten, Van der Linden, d'Acremont, Jermann, & Bechara, 2005). As for sensation seeking, the absence of any relationship with inhibition in this study or with decision-making processes, as shown in a previous one (Zermatten et al., 2005), may underscore the fact that this facet of impulsivity is not related to executive control (Van der Linden, Rochat, et al., 2006). More specifically, this dimension of impulsivity may have to be considered at a different level of analysis, reflecting temperamental constructs related to the theories of motivation such as, on the one hand, approach behaviors and sensitivity to reward, and on the other hand, withdrawal behaviors and sensitivity to punishment (e.g., Cloninger, Adolfsson, & Svrakic, 1996; Lissek et al., 2005; Van der Linden, Rochat, et al., 2006).

Surprisingly, sensation seeking showed a negative correlation with urgency, whereas previous studies indicated a positive correlation between these two facets (e.g., Smith et al., 2007; Whiteside & Lynam, 2001) or no relation at all (e.g., Billieux, Van der Linden, & Ceschi, 2007; Billieux et al., 2008; Schmidt, Gay, d'Acremont, et al., 2008; Van der Linden, d'Acremont, et al., 2006). This heterogeneity may be due, at least partly, to the fact that sensation seeking, as assessed by the UPPS, refers to different dispositions, some of which are adaptive and others less so (e.g., the identical score for sensation seeking could be due to openness to trying new experiences or proneness to take risks), which could lead to different types of associations with urgency depending on the dominant aspect that is favored in a particular sample.

Although our data provide more information concerning the processes related to urgency and lack of perseverance, the absence of relations with the other two dimensions may also help to extend preliminary support for a model of the separate cognitive processes involved in the four facets of impulsivity: (1) urgency associated with the inability to deliberately suppress dominant, automatic or prepotent responses; (2) lack of premeditation associated with decision-making processes (Zermatten et al., 2005); (3) lack of perseverance associated with the ability to resist proactive interference or to inhibit irrelevant thoughts held in working memory; and (4) sensation seeking linked to non-executive (rather motivational) aspects of impulsivity (Cloninger et al., 1996; Lissek et al., 2005; Van der Linden, Rochat, et al., 2006). However, further studies designed to assess the specific psychological processes underlying the four dimensions of the UPPS are needed.

Concerning our second objective, the number of TUTs was assessed at different random times during the task, thus avoiding retrospective bias due to memory and awareness of mind wandering episodes. This index of mind wandering was significantly correlated with greater lack of perseverance, and marginally correlated with greater

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urgency and lack of premeditation. As these three facets of impulsivity have been proposed to reflect executive aspects of this construct (Bechara & Van der Linden, 2005; Van der Linden, Rochat, et al., 2006), this result is consistent with the recent incorporation of mind wandering into executive models (Smallwood & Schooler, 2006). However, regression analyses showed that TUTs were no longer predicted by the lack of perseverance when we controlled for age, gender, and other facets of impulsivity. Consequently, the relationship between mind wandering and the lack of perseverance is not independent of socio-demographic variables or of other facets of impulsivity. This seems to indicate that the method and the quite brief task used in this study are not appropriate to link TUTs specifically and strongly to the lack of perseverance. Further studies should for instance use longer tasks, and/or other methods asking participants to indicate each TUT they experience.

Concerning TUTs and task performance, correlations indicated that a higher number of TUTs is related to more errors in the SART-TUTs, and almost significantly to more difficulties resisting proactive interference in the RNT (as assessed by the index based on errors). The detrimental effects of TUTs on concurrent performance have already been shown, for instance, in text comprehension, random number generation, and memory (for a review, see Smallwood & Schooler, 2006). However, it must be noted that a distinction has been made between task-related interference (TRI, e.g., ''I thought about my level of ability," ''I thought about the difficulty of the problems," ''What a boring task") and TUTs (e.g., ''I thought about something that happened earlier today," ''Lunch will be good") (e.g., Smallwood et al., 2003). Thus, the investigation of mental intrusions in relation to inhibition and impulsivity should benefit from finer-grained distinctions between different kinds of interfering thoughts (e.g., TUT vs. TRI) in different tasks or activities.

Some aspects of the results remain to be considered. First, the index of proactive interference based on LogRT in the RNT was negatively correlated with urgency and with errors in the SART-TUTs. In other words, individuals who experience more urgency and have more pronounced difficulties with prepotent response inhibition showed diminished effects of proactive interference, as reflected by the log of the reaction times (LogRT). In fact, resisting to proactive interference in the RNT seems to require the execution of several mechanisms (e.g., resolving/inhibiting competition among internal representations, monitoring processes, response selection; see Jonides & Nee, 2006). In this context, it could be tentatively suggested that the participants with higher urgency may present this diminished proactive interference effect (as assessed by Log- RT) because the response-selection mechanism is executed before other processes (e.g., inhibition, monitoring) have been triggered. Alternatively, they may keep a smaller load of previously relevant information in the working memory, or use automatic retrieval schemata based on the current context (with familiarity of the past context and competition among internal representations not being considered). This is in line with the propositions that individuals with higher urgency and inhibitory difficulties tend to ''act rashly".

Second, it should be also noted that urgency does not predict prepotent response inhibition as strongly when one controls for age, gender and other facets of impulsivity in regression analyses. In this context, it must be emphasized that several items of the UPPS assessing urgency refer to the difficulty to resist impulses specifically in the conditions of negative affect (e.g., ''When I am upset I often act without thinking"). It has also been suggested that another side of urgency reflects a propensity to act rashly when in a positive state (Cyders & Smith, 2007; Cyders et al., 2007). In this connection, it has been demonstrated that emotional stimuli are more difficult to inhibit than non-emotional stimuli (Schulz et al., 2007; Verbruggen & De Houwer, 2007). Consequently, further studies

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should examine whether urgency is more closely related to the inhibition of prepotent responses in emotional conditions (e.g., when distressed/elated, or with positive/negative stimuli) than in neutral conditions.

To sum up, our results open new prospects for disentangling the different facets of impulsivity with regard to specific cognitive and neural mechanisms, and for better understanding impulsivity in psychopathology and neuropsychology. In addition, this study supports the importance of research linking mind wandering to both impulsivity and inhibition, as the results indicate positive correlations (1) between mind wandering and impulsivity, particularly the lack of perseverance; and (2) between mind wandering and different forms of inhibitory difficulties.

Acknowledgement

This research was supported by the National Center for Affective Sciences, financed by the Swiss National Science Foundation.

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