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Enhancing inhibition: How impulsivity and emotional activation interact with different implementation intentions

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ABSTRACT

Implementation intentions, a strategy in which a strong link is created between a cue and a to-be-performed action, have been shown to be efficacious in improving self-regulation. The relative efficacy of verbal and visual implementation intentions, however, has yet to be determined. Implementation intentions have also been shown to be inefficacious in participants with high impulsivity, specifically in individuals who reported having a high tendency to commit rash or regrettable actions as a result of intense affect (high urgency). Nevertheless, previous studies did not assess whether the individuals were in an emotional context at the time of the experiment. In the current study, we compared different forms of implementation intentions (verbal/visual/combined verbal–visual) on a computerized inhibition task while assessing impulsivity and emotional activation. The results showed that all types of implementation intentions improved inhibition performances significantly in participants with high urgency, but only when their emotional activation was low. There was no difference between the three types of implementation intentions.

1. Introduction

Inhibition of a prepotent response, defined as the ability to deliberately control or suppress an automatic response (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000), is a core executive function in self-regulation. Indeed, difficulties in inhibiting dominant responses have been considered as central in the occurrence of impulsive and unplanned behaviors (Enticott & Ogloff, 2006; Logan, Schachar, & Tannock, 1997). Furthermore, low inhibition performances have been found in various problematic psychological states, such as pathological gambling (Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2006) or alcohol dependence (Noël, Bechara, Dan, Hanak, & Verbanck, 2007).

One interesting tool that may be used to overcome difficulties in inhibiting prepotent responses is "implementation intentions." Defined as a self-regulatory planning strategy, implementation intentions (Gollwitzer, 1993, 1999) have been shown to be very effective in improving a wide range of cognitive functions and goal-directed behaviors (Gollwitzer & Sheeran, 2006). Formulating implementation intentions implies specifying in as much detail as possible, when, where, and how one will perform a specific action. The plan is usually formulated in the form of an "if-then contingency," using the structure "If situation *x* arises, then I will perform behavior *y*," for example, "If I come back home hungry, then I will withhold eating chocolate." Thus the "if component" specifies a suitable occasion for the implementation. The "then component" identifies an adequate response to these target stimuli, a behavior that allows one to reach the goal.

Implementation intentions have already been shown to be effective in improving prepotent response inhibition performance. They allowed an increase in inhibition performance in a sample of young adults on the Simon task whereby spatial conflict was induced between stimuli location and response key location (Cohen, Bayer, Jaudas, & Gollwitzer, 2008). In another study, implementation intentions also helped ego-depleted individuals in the general population to improve their performance on the Stroop task (Webb & Sheeran, 2003). Finally, several experiments support the efficacy of implementation intentions in diminishing or compensating for inhibition deficits in children who received a diagnosis of attention deficit hyperactivity disorder in an adaptation of a stop-signal task (Gawrilow & Gollwitzer, 2008; Paul et al., 2007).

1.1. Different forms of implementation intentions

Methodologically, the operationalization of the concept of implementation intentions has important variations across studies: Participants are

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requested to read (e.g., Gilbert, Gollwitzer, Cohen, Oettingen, & Burgess, 2009), repeat (Gawrilow, Gollwitzer, & Oettingen, 2011), or write (Chapman & Armitage, 2010) an if-then sentence and/or to visualize themselves in the situation while achieving the intended action (e.g., Grilli & McFarland, 2011). We propose to distinguish two types of implementation intention instructions: (1) those that guide participants to imagine themselves in the situation, facing the cue and performing the action (*visual implementation intentions*); (2) those that invite participants to formulate (write, read, or repeat) an if-then sentence (*verbal implementation intentions*).

Some authors have recently compared different operationalizations of implementation intentions based on their encoding modality (Andersson & Moss, 2011; Knäuper, Roseman, Johnson, & Krantz, 2009; Knäuper et al., 2011; McFarland & Glisky, 2011; Meeks & Marsh, 2010), with, however, contrasting results.[1] On the one hand, in a study by McFarland and Glisky (2011), combined verbal–visual implementation intentions were as efficient as simple verbal or simple visual implementation intentions. Similarly, Meeks and Marsh (2010) showed that adding a verbal implementation intention component to a visual implementation intention was no more efficient than a simple visual implementation intention. In fact, in comparison with unimodal implementation intentions, combined verbal–visual implementation intentions directed at improving performance on a prospective memory task even led to decreased performances on the (secondary) ongoing task in these two studies (McFarland & Glisky, 2011; Meeks & Marsh, 2010). On the other hand, Knäuper and colleagues demonstrated in two different studies that adding a visual implementation intention component to a verbal implementation intention (Knäuper et al., 2009, 2011) permitted better goal attainment. The question of whether combined implementation intentions are more efficient than simple verbal or simple visual implementation intentions hence remains open. Another unanswered question is whether unimodal verbal and visual implementation intentions are equally efficacious. McFarland and Glisky (2011) compared these two conditions and found no difference. In their study, however, the simple visual implementation intention condition contained not only the visual component, but also an if–then sentence that had to be read silently, written on a sheet of paper, and repeated aloud. In consequence, it remains unclear whether the visual component itself was efficacious or whether it was the combination of the verbal and visual components. To make use of the technique in concrete interventions, it seems of primary importance to determine which type of implementation intention is most efficient.

Beyond the type of implementation intention instruction, other variables that might modulate the effect of implementation intentions on a target behavior should also be taken into account.

1.2. Implementation intentions and urgency

Different variables are known to limit the efficacy of implementation intentions. One moderator of special interest for this study is the construct of "urgency," i.e., one facet of impulsivity referring to the tendency to commit rash or regrettable actions as a result of intense affect (Whiteside & Lynam, 2001). Prepotent response inhibition has been postulated to be linked with urgency (Bechara & Van der Linden, 2005) and empirical works have confirmed the presence of the association between poorer inhibition of prepotent responses and higher self-reported impulsivity (Logan et al., 1997) or urgency scores (Cyders & Coskunpinar, 2011; Gay, Rochat, Billieux, d'Acremont, & Van der Linden, 2008). Note that in one study using a stop-signal task with emotional stimuli, this relationship was not direct, but mediated by decision-making abilities under risk (Billieux, Gay, Rochat, & Van der Linden, 2010).

Yet, two studies of Churchill and Jessop (2010, 2011) concerning dieting behavior pointed out that people who were high in urgency did not benefit from implementation intentions. In these studies, only participants who had low urgency scores benefited from implementation intentions aimed at avoiding snacking (Churchill & Jessop, 2010) and at increasing fruit and vegetable consumption (Churchill & Jessop, 2011). Because implementation intentions had been effective in several populations known for their difficulties in self-regulation (e.g., in individuals who received a diagnosis of schizophrenia; opiate addicts under withdrawal, Brandstätter, Lengfelder, & Gollwitzer, 2001; or individuals with cerebral lesions, Lengfelder & Gollwitzer, 2001), these results were unexpected.

One hypothesis that Churchill and Jessop (2010, 2011) propose to explain this discrepancy is that the relationship between the difficulty to achieve the goal and the efficacy of implementation intentions is a U-shaped relationship: Implementation intentions are effective only if goal achievement is of moderate difficulty, but not when it is easy or difficult. From their point of view, difficulty in goal achievement depends on the interaction between the difficulty of the task itself and individual differences, for example, in the level of urgency (or self-regulation abilities). Thus, implementation intentions would be effective for individuals low in urgency when they are confronted with a difficult task or for individuals high in urgency who face an easy task (both situations leading to moderate difficulty in goal achievement). The planning technique would not be efficacious in individuals low in urgency who are confronted with easy tasks (goal achievement of low difficulty; implementation intentions unnecessary), or in individuals high in urgency who are confronted with difficult tasks (goal achievement of high difficulty; "out of reach" of implementation intentions). The divergent results between studies might therefore result from differences in task difficulty or from differences between the samples in urgency or self-regulation. What makes a task difficult for individuals with high urgency remains, however, unclear.

As Churchill and Jessop (2011) point out, urgency is not defined as difficulty in regulating behavior in general, but as difficulty in regulating behavior *in an emotional context*. More specifically, when experiencing a strong emotion, individuals high in urgency cannot prevent themselves from engaging in actions to lessen the intensity of their emotional state in the short term, even though these actions are incompatible with their long-term goals (Cyders & Smith, 2008). Although emotions are a key component of urgency, the level of emotional activation (i.e., the intensity of the emotional state, the emotional arousal) at the moment that the implementation intentions were used was not assessed in either of the studies by Churchill and Jessop. These studies do not answer the question of whether implementation intentions are inefficacious in general in individuals high in urgency who are confronted with a difficult task, or whether these implementation intentions are ineffective specifically when individuals with high urgency experience an intense emotion and are in an at-risk situation (i.e., confronted with the task to control their behavior when being emotionally aroused). Emotional activation could therefore be integrated in the goal achievement difficulty hypothesis outlined above, according to which implementation intentions would only be effective for moderate difficulty levels of goal achievement (not for low or high difficulty levels). For individuals with high urgency levels, one key factor in making goal achievement difficult would be emotional activation. Indeed, urgency is by definition related to emotional contexts. According to this hypothesis, a task that is easily realizable in a nonemotional context for individuals with high urgency would thus become a difficult task under emotional activation. A task that is already difficult in a nonemotional context (e.g., a task requiring inhibition of a predominant response) would become such a difficult task under emotional activation that implementation intentions would no longer be efficient (see Verbruggen & De Houwer, 2007, for

[1] Note that other studies compared different implementation intentions that varied not in their encoding modality, but in their exact formulation (implementation intentions containing negative versus positive sentences; Adriaanse, Van Oosten, De Ridder, De Wit, & Evers, 2011) or in the choice of cues (some of them detailed situational information, i.e., when and where, whereas others detailed motivational information, i.e., why a behavior must be performed; Adriaanse, Ridder, & de Wit, 2009).

evidence that inhibition of a predominant response is hampered by emotional stimuli).

1.3. Objectives of the present study

In the current study, we aimed to compare the effects of verbal, visual, and combined verbal–visual implementation intentions. We explored whether all implementation intention types are of equal efficacy or if bimodal encoding – i.e., combined verbal–visual implementation intentions – is more efficacious than unimodal encoding (simple verbal or visual implementation intentions). Our second aim was to investigate the role of affect in relation to urgency in the efficacy of implementation intentions on a prepotent response inhibition task. We assessed urgency and the current affective state with self-report questionnaires before administering the experimental computerized inhibition task, a stop-signal paradigm. Because we were already manipulating different implementation intentions, we chose not to also manipulate emotional arousal, but to assess the current affective state of the participants. We hypothesized that implementation intentions would improve inhibition performances only in individuals with low urgency, or in individuals with high urgency but low emotional activation. We expected implementation intentions to be inefficacious in individuals with high urgency when they are emotionally aroused.

These two objectives are treated as being interrelated: The current study compares different implementation intentions *while* taking into account the levels of urgency and emotional activation. In order to ensure that the observed results could not be explained by interindividual differences in working memory, gender, education, and age, we controlled for all of these variables in our analyses.

2. Method

2.1. Population

We recruited 173 young adults living in the region of Geneva, Switzerland. Participants were volunteers who received no compensation for their inclusion in the study. Inclusion criteria were defined as follows: age 18 to 40 years and good mastery of the French language. Exclusion criteria were being a psychologist or a psychology student and the presence of neurological antecedents or psychiatric problems. All participants gave their written informed consent to participate in the study, which respects the Code of Ethics of the Faculty of Psychology and Educational Sciences from the University of Geneva. Three participants reported having spontaneously used strategies that were identified as implementation intentions corresponding to another experimental group (two participants in the control group used a verbal implementation intention, and one participant in the verbal implementation intention group used a combined implementation intention) and were therefore excluded. Two additional subjects were excluded for presenting extreme results on a stop-signal variable ($N = 1$) and for having an extreme residual in the analyses ($N = 1$). The final sample thus comprised 168 participants.

2.2. Design

Participants were randomly allocated to one of four groups: verbal implementation intentions, visual implementation intentions, combined verbal–visual implementation intentions, or control.

2.3. Tasks

2.3.1. Experimental stop-signal task

The experimental task was a computerized inhibition task based on a *stop-signal* paradigm. First, participants learned to categorize one of two geometric forms that appeared sequentially in the middle of the computer screen by pressing the corresponding key (automation phase of 60 trials). The stop-signal phase then started (three blocks of 96 trials): Participants had to categorize the stimuli in the same way ("go trials"), but were told to withhold their response if a red frame appeared around the geometric form ("stop trials"; 25% of the trials).

Each stimulus was preceded by a fixation cross in the middle of the screen for 150 ms. The geometric form then appeared until a response was given, for a maximum of 2000 ms. The stop signal appeared 150, 200, 250, or 300 ms after the stimulus. To avoid any unwanted sequence effects, we created two tasks with stimuli presented in a different order. We also counterbalanced the answer keys between participants to ensure the absence of lateralization effects. This task allowed us to compute a measure of the latency of the stop process, the stop-signal reaction time (SSRT), an index that integrates "go" reaction times and inhibition errors (Logan & Cowan, 1984). The idea of this index is that the latency of the stop process can be estimated from the start and the end of the stop process. The stop process starts at the occurrence of the stop signal (which is experimentally controlled and therefore easily identified). Its end has to be inferred from the reaction time distribution in the observed go trials. If responses are not stopped in *n*% of the stop trials, the end of the stop process is on average equal to the *n*th percentile of the reaction time distribution in the go trials. The stop-signal interval is subtracted from the *n*th reaction time to estimate the SSRT. SSRTs are calculated for each interval and then averaged. A longer SSRT represents lower inhibition performances (Logan, 1994).

At the end of the experimental task, all participants were asked whether they spontaneously used a strategy to withhold responding when the red frame appeared. In addition, control participants and those of the visual implementation intention group were asked whether they inwardly repeated the instruction to withhold responding when the red frame appeared and, if yes, what they told themselves. Participants in the control group and in the verbal implementation intentions group were asked whether they visualized themselves withholding responding when the red frame appeared. This was done in order to check that participants did not spontaneously use strategies attributed to another group.

2.3.1.1. Experimental manipulation. The participants of the experimental groups were guided in the formation of implementation intentions before the beginning of the first test block. The instructions varied according to the experimental group, as follows.

In the *visual implementation intention condition*, the participants were read the following instructions: "Before you start, I would like you to close your eyes. Try to imagine, to visualize yourself doing the task, categorizing squares and circles. Can you imagine this situation? Imagine now that, as before, you see one of the two forms appearing on the screen, followed by the red frame, okay? Try now to imagine that you withhold your response. Can you imagine it?"

In the *verbal implementation intention condition*, the experimenter held out a card to the participant, with the sentence, "If the red frame appears, then I withhold my response."

In the *combined verbal–visual implementation intention condition*, the participants were first guided in the formation of a visual implementation intention, and were then invited to open their eyes to read the verbal implementation intention.

2.3.2. UPPS-P

To assess impulsivity – and more specifically urgency – we used the short UPPS-P impulsive behavior scale (Billieux et al., 2012). This questionnaire measures five impulsivity components – negative and positive urgency, lack of perseverance, lack of premeditation, and sensation seeking – in 20 items on a 4-point Likert scale (between 1, "agree strongly," and 4, "disagree strongly"). The scores of the items of one facet are summed (after reversing the items that require it), giving a score between 4 and 16. Higher scores indicate higher impulsivity.

Because we are interested in urgency independently of the emotional valence, we used the mean score between positive and negative urgency.

Indeed, the factor structure of this scale allows consideration that positive and negative urgency form a unique factor, as both facets depend on a higher order latent factor of general urgency. Although positive and negative urgency are two different facets of impulsivity, they both describe a process by which emotionality is tied to ill-advised, rash action, and both positive and negative emotions can lead to rash action (Cyders & Smith, 2008). Note that we reran the confirmatory factor analysis in our data and confirmed that this model also fit our data well ($\chi^2(df = 165) = 236.99$, $CFI = 0.95$, $RMSEA = 0.05$, $SRMR = 0.08$).

2.3.3. PANAS

The Positive and Negative Affect Schedule (PANAS, French version, Gaudreau, Sanchez, & Blondin, 2006; English version, Watson, Clark, & Tellegen, 1988) was administered to assess the participant's current emotional state. In this 20-item scale, the participant reports the extent to which the proposed affect adjectives correspond to his or her present state on a 5-point Likert scale (from 1, "very slightly or not at all," to 5, "extremely"). According to Watson and colleagues (Watson, Wiese, Vaidya, & Tellegen, 1999), this scale allows assessment of positive and negative emotional activation. Because Verbruggen and De Houwer (2007) showed that it was the arousal, not the valence, of the stimuli that interfered with inhibition performances, we chose not to distinguish between positive and negative affects in this study. Consequently, we chose to use the total score of the PANAS, summing the scores of all the items (Cronbach's alpha in the current sample: .79).

2.3.4. LNS

The Letter-Number Sequencing task (LNS, Wechsler Adult Intelligence Scale-III, Wechsler, 2000) was used to assess verbal working memory. The task consists of reorganizing progressively increasing sequences of numbers and letters read by the experimenter by enumerating first the numbers in increasing order, and then the letters in alphabetical order. Each correctly answered item scores 1 point (maximum 21 points). As this task was shown to be a good predictor of fluid intelligence (Shelton, Elliott, Hill, Calamia, & Gouvier, 2009), we wanted to be able to control for it in our analyses in order to ensure that the observed results could not be explained by interindividual differences in working memory.

2.4. Procedure

Participants were tested individually. For all participants, the tasks and questionnaires were given in the same order: PANAS, LNS, stop signal, UPPS-P. A short socio-demographical form was completed by each participant at the beginning of the testing session, which included questions about age, education (i.e., number of years of education), and neurological and psychiatric problems.

2.5. Statistical analyses

For all statistical analyses, α was set at .05. After establishing the equivalency of all four groups (verbal, visual, and combined implementation intentions; control group) by using analyses of variance (ANOVA), we used a general linear model to analyze the effect of condition (verbal, visual, and combined implementation intentions; control group), urgency, affect, and their interactions on the main dependent variable: SSRT. As mentioned above, we controlled for working memory, gender, education, and age. All continuous independent variables entered in the model were previously centered unless otherwise specified. Gender was dummy coded (0 for men, 1 for women).

3. Results

3.1. Sample characteristics and randomization check

Graphical analysis confirmed normality of data on all variables after we excluded the participant who presented an extreme value on the SSRTs mentioned in Subsection 2.1. Table 1 presents characteristics of the four groups and the ANOVAs conducted to identify any differences between them. The analyses revealed no significant differences between groups for age, education, cognitive functioning (LNS), affect (PANAS), and urgency (UPPS-P). A chi-square test revealed that there was also no difference between groups regarding gender (χ^2 (3) = 0.39, $p = .94$).

3.2. Stop-signal performance and implementation intentions

Table 2 presents the descriptive statistics of performance in the stop-signal task by condition. Overall, the percentage of correct categorization responses was high (97%), whereas nonresponses on go trials were rare (0.1%). An ANOVA revealed no significant difference between groups in response times during the automation phase ($F(3,164) = 2.18$, $p = .09$), ensuring that there was no speed difference between groups before the manipulation. A mixed ANOVA on response times, with condition as the between-subjects factor and task phase (go trials during stop-signal task versus automation trials) as the within-subjects factor, showed no significant interaction between condition and task phase ($F(3, 164) = 1.30$, $p = .28$), confirming that the experimental groups did not slow down more than the control group.

3.3. The role of urgency and emotional state in the efficacy of implementation intentions

We then used a general linear model to assess the effects of condition, urgency, emotional activation (PANAS), and their interactions on SSRT, while controlling for age, gender, education and LNS (see Table 3). The results revealed a significant model ($F(19,148) = 2.67$, $p < .001$, R^2adj. = .16). The covariates age ($F(1,148) = 23.78$, $p < .001$), education ($F(1,148) = 6.14$, $p = .01$), and gender ($F(1,148) = 5.81$, $p = .02$) contributed significantly to the variance of the SSRT, whereas LNS did not ($F(1,148) = 0.54$, $p = .46$). The parameter estimates revealed that higher age, shorter education, and being a woman are associated with higher SSRTs. There was also a significant two-way interaction of PANAS × Urgency ($F(1,148) = 5.63$, $p = .02$), which was subsumed by a three-way interaction of Condition × PANAS × Urgency ($F(3,148) = 3.42$, $p = .02$).

To further analyze this three-way interaction and to determine in which situation(s) the main effect of condition is significant, a method proposed by Aiken and West (1991) is to check whether the effect of condition is significant at high and low levels (+1 *SD* / −1 *SD*) of the moderating variables. For this purpose, we reran the same general linear model analysis as before, except that we entered modified versions of the PANAS and urgency variables (modified by adding or subtracting 1 *SD*) instead of using the centered variables. Thus, we reran the model 4 times with the different combinations of the new variables: low PANAS and low urgency; low PANAS and high urgency; high PANAS and low urgency; high PANAS and high urgency.

Table 1
Sample characteristics by experimental groups.

Demographical and psychological data	Control group	Visual II	Verbal II	Combined II	$F(3,164)$
Number of participants	50	39	37	42	
Gender (% of women)	54	56	59	60	
Age	25.0 (4.0)	25.6 (3.1)	25.5 (4.2)	24.8 (3.4)	0.449
Education	15.1 (2.7)	15.2 (2.3)	14.7 (2.5)	15.6 (2.2)	0.887
PANAS	46.2 (7.8)	48.5 (7.7)	46.9 (6.7)	48.9 (7.2)	1.297
LNS	11.8 (2.5)	11.8 (2.7)	11.7 (2.1)	11.7 (2.2)	0.037
Mean urgency	10.1 (2.1)	10.0 (2.5)	10.4 (2.1)	9.6 (2.3)	0.822

Notes: All *ps* > .05. The table displays mean values with standard deviations shown in parentheses. LNS = Letter-Number Sequencing; PANAS = Positive Affect and Negative Affect Schedule; II = implementation intentions.

Table 2
Stop-signal data for the four groups.

Stop-signal data	Control group	Visual II	Verbal II	Combined II	$F(3,164)$
Automation RT, ms	410 (56)	430 (62)	422 (56)	440 (60)	2.183
Go RT, ms	419 (63)	426 (57)	431 (56)	431 (63)	0.445
Inhibition errors	39 (13)	37 (13)	35 (12)	37 (12)	0.725
SSRT	192 (41)	191 (28)	193 (40)	198 (34)	0.278

Notes: The table displays mean values, with standard deviations shown in parentheses. Automation RT = response time during the automation phase; Go RT = response time on go trials; SSRT = stop-signal reaction time. II = implementation intentions. All $ps > .05$.

Analyses revealed that the main effect of condition was not significant when urgency and PANAS were high ($F(3,148) = 1.76$, $p = .16$), nor when urgency and PANAS were low ($F(3,148) = 1.63$, $p = .18$), nor when urgency was low and PANAS was high ($F(3,148) = 0.89$, $p = .45$). However, the main effect of condition was significant when urgency was high but PANAS was low ($F(3,148) = 3.68$, $p = .01$). Planned Helmert contrasts revealed that the SSRTs of the control group differed significantly from the SSRTs of the three experimental groups taken together ($t(166) = 3.08$, $p = .002$), but that the SSRTS of the group with combined implementation intentions did not significantly differ from the SSRTs of the simple verbal or visual implementation intentions groups ($t(116) = 1.00$, $p = .32$) and that the SSRTs of the two latter groups did not differ from one another ($t(74) = 0.72$, $p = .47$). Fig. 1, depicting the SSRT means and 0.95 confidence intervals by condition at high urgency ($M + 1\ SD$) and low PANAS ($M - 1\ SD$), suggests that the control group differed from the three experimental groups by its higher SSRTs. Analysis of the residuals showed that they were normally distributed.

4. Discussion

In the current study, we aimed to compare the effect of three different implementation intentions in enhancing inhibition performances on a computerized stop-signal task. In addition, we assessed not only urgency, which is known to limit the efficacy of implementation intentions, but also the emotional state, which is closely related to urgency by definition. Indeed, individuals high in urgency do not necessarily act rashly in all situations, but specifically when they are emotionally aroused.

Table 3
General linear model for the dependent variable SSRT.

Entered variable	*df*	*F*-value	*p*-value
Corrected model	19	2.67	0.000**
(Intercept)	1	1893.27	0.000**
Age	1	23.78	0.000**
Education	1	6.14	0.014*
Gender	1	5.81	0.017*
LNS	1	0.54	0.464
Condition	3	0.78	0.509
Urgency	1	0.54	0.463
PANAS	1	0.03	0.864
Condition × urgency	3	1.22	0.304
Condition × PANAS	3	1.59	0.194
Urgency × PANAS	1	5.63	0.019*
Condition × PANAS × Urgency	3	3.42	0.019*
Error	148		

Notes: SSRT = stop-signal reaction time; LNS = Letter-Number Sequencing; PANAS = Positive Affect and Negative Affect Schedule.
* $p < .05$.
** $p < .01$.

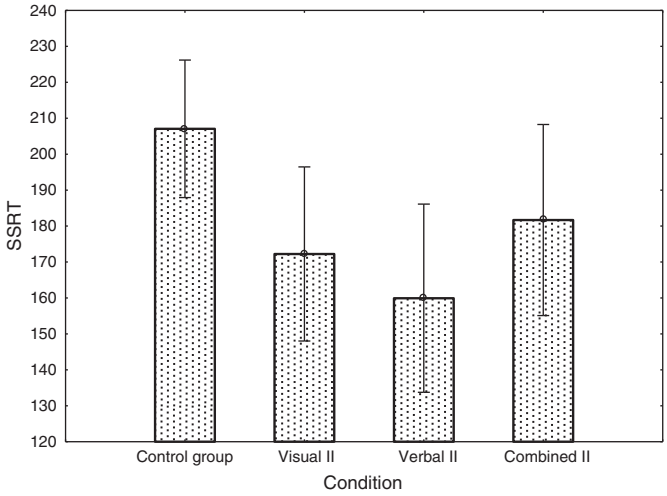

Fig. 1. Mean stop-signal reaction time (SSRT; whiskers represent 95% confidence intervals) by experimental condition at high urgency ($M + 1\ SD$) and low PANAS ($M - 1\ SD$). II = implementation intention.

4.1. Efficacy of implementation intentions at high urgency: the role of emotional state

The main result of this study showed that implementation intentions were efficacious in improving inhibition performances on a stop-signal task in individuals with high urgency, as long as their emotional activation was low. When the participants with high urgency were emotionally activated, the use of Gollwitzer's strategy (1993, 1999) was no more efficient than standard instructions. Hence, the limitation of the efficacy of implementation intentions does not seem to be related to high urgency as a personality trait. This result highlights the importance of taking into account the emotional context or emotional state when considering one specific facet of impulsivity, urgency, and in consequence, the moderating role of urgency on the efficacy of implementation intentions.

This result may reconcile some divergences observed in the literature by going one step further in the analysis. On the one hand, Churchill and Jessop (2010, 2011) showed that implementation intentions did not allow a reduction in snack consumption or an increase in fruit and vegetable consumption in individuals with high urgency. On the other hand, recent data from a sample of elderly individuals showed that combined verbal–visual implementation intentions were efficacious in improving prospective memory and inhibition performances independently of the level of urgency of the participants (Burkard et al., submitted for publication). The current result suggests that this divergence could be related to differences in terms of emotional arousal. We hypothesize that in the case of the results of Churchill and Jessop, the real-life situations that the participants were confronted with induced more emotions than did the tasks in the laboratory study of Burkard et al. In fact, reducing one's snack consumption and changing one's eating habits can be a difficult and therefore an emotional task.

But at which moment does emotional activation have a negative impact on individuals with high urgency? Is it at the moment of implementation intention encoding (when the instructions are given) or at the time of task realization? On the one hand, it is possible that individuals who are high in urgency and are emotionally activated at the time of implementation intention encoding do not have enough resources left to properly encode the implementation intention. In fact, according to Pessoa (2009), strong emotions capture processing resources from a limited capacity pool. In the context of the current study, emotionally activated individuals who were also high in urgency (acting rashly in emotional situations) could not allocate enough attention to the implementation intention instructions. On the other hand, the emotional

arousal could interfere at the time of task realization. As inhibiting prepotent responses is a highly difficult task for emotionally activated individuals with high urgency, even previously well-formed implementation intentions would then be insufficient for improving their performance. To address this issue, further studies should separate implementation intention encoding and task realization by spacing them out in order to manipulate the emotional state experimentally at either moment.

Another related question is whether these results are task specific or not. In other words, do emotional activation and urgency moderate the efficacy of implementation intention only in prepotent response inhibition (which is closely related to urgency), or do they also do so for other cognitive functions and more complex multicomponential behaviors? The fact that high urgency is often associated with poorer prepotent response inhibition performances (Cyders & Coskunpinar, 2011; Gay et al., 2008)–precisely the type of inhibition assessed by the stop-signal task we used–would constitute an argument in favor of a specific effect. Nonetheless, the design of the current study uses a unique stop-signal task, predominantly assessing inhibition of previously automatized responses, and does not allow a response to this question. If a specific moderating effect of urgency and emotional activation is found on inhibition (and therefore not on prospective memory, divided attention, or other cognitive functions), this would constitute strong evidence against the possibility that high urgency and high emotional activation hinder appropriate implementation intention encoding.

In the present study, we used a measure of positive and negative urgency and a questionnaire assessing emotional activation that included different affects. We did so because the experience of emotions in general (not the experience of a specific emotion) recruits cognitive resources, for example, by focusing on the affectively significant stimulus or by requiring emotional regulation strategies (Pessoa, 2009). However, the hypothesis that different emotions (joy, sadness, anger, etc.) could have different effects on task performance and on the efficacy of implementation intentions is also worth exploration and should constitute the object of future studies. Indeed, recent experiments of Maglio, Gollwitzer, and Oettingen (2013) have shown that participants who received an anger-inducing manipulation formed more and more efficient implementation intentions than did participants in the control neutral condition, with those participants who felt sad forming even fewer and less efficient implementation intentions.

4.2. Efficacy of implementation intentions at low urgency

In the current study, the analyses run at low urgency/low PANAS and low urgency/high PANAS showed no significant effect of condition, illustrating that implementation intentions were not efficient in improving inhibition abilities in individuals with low urgency, whether they reported feeling emotionally aroused or not. We hypothesize that individuals low in urgency could not further improve their performance because it was already optimal under standard instructions. In support of this hypothesis, and corroborating previous studies (Cyders & Coskunpinar, 2011), a small but significant relationship was found between urgency and SSRT in the control group (one-tailed Pearson's $r = .273$, $p = .03$), confirming that individuals with low urgency had better performances on the stop-signal task.

4.3. Differentiated effects of different implementation intention modalities

Another finding was that the three implementation intention instructions that we used – verbal, visual, and combined verbal–visual – did not differ significantly from one another. Depending on the level of urgency and emotional activation, either all types of implementation intentions were efficient or none were. This finding suggests that when the instructions to form implementation intentions guide the participant to create a strong mental link, associating the situational cue and the to-be-performed behavior either verbally (with an if–then sentence, in the first person, without negation) or visually, the modality of implementation intention encoding does not matter. Even participants who were guided in both encoding modalities (combined implementation intentions) did not have better performances. These results are compatible with those of McFarland and Glisky (2011) and Meeks and Marsh (2010), who showed that combined verbal–visual implementation intentions were not more efficient than simple verbal or simple visual implementation intentions. Although Knäuper et al. (2009) showed a benefit of adding a visual implementation intention component to a verbal implementation intention, this result is not incompatible with the results of the current study. Their implementation intentions were not formulated in an if–then format, which has been shown to be less effective (Chapman, Armitage, & Norman, 2009; Oettingen, Hönig, & Gollwitzer, 2000, experiment 3), and the addition of a visual implementation intention may have been useful to maximize the performance. Only one study (Knäuper et al., 2011) found the combined verbal–visual implementation intentions to be more efficacious than verbal if–then implementation intentions in a field experiment that aimed to increase fruit consumption. In conclusion, it seems that combined verbal–visual encoding is not more efficient than "simple" verbal or visual encoding of implementation intentions, at least in laboratory tasks (which are often less complex than real-life tasks). In the future, studies should nevertheless compare the use of verbal implementation intentions while "blocking" visual encoding, and visual implementation intentions while "blocking" verbal encoding. Although we checked at the end of the stop-signal task that participants of one group did not consciously also use the other modality, we cannot exclude that they did it automatically and unconsciously. Further studies should also include a careful manipulation check to ensure not only that participants did not use a technique corresponding to another group, but also that they really used the techniques they were intended to (e.g., did participants of the visual implementation intentions group really visualize themselves withholding responding?).

In summary, this research sheds light on the role of emotional activation when considering the moderating role of urgency in the efficacy of different types of implementation intentions. Implementation intentions are efficacious in individuals who are high in urgency, as long as they are not emotionally activated. To more deeply probe the nature of the interaction effect of urgency and emotional arousal on the efficacy of implementation intentions, future studies should manipulate emotional activation, while separating implementation intentions and task execution in time, for tasks that examine different cognitive functions.

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References

Adriaanse, M.A., Ridder, D. T. D., & de Wit, J. B. F. (2009). Finding the critical cue: Implementation intentions to change one's diet work best when tailored to personally relevant reasons for unhealthy eating. *Personality and Social Psychology Bulletin, 35*, 60–71.

Adriaanse, M.A., Van Oosten, J. M. F., De Ridder, D. T. D., De Wit, J. B. F., & Evers, C. (2011). Planning what not to eat: Ironic effects of implementation intentions negating unhealthy habits. *Personality and Social Psychology Bulletin, 37*, 69–81.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, London, England: Sage.

Andersson, E. K., & Moss, T. P. (2011). Imagery and implementation intention: A randomised controlled trial of interventions to increase exercise behaviour in the general population. *Psychology of Sport and Exercise, 12*, 63–70.

Bechara, A., & Van der Linden, M. (2005). Decision-making and impulse control after frontal lobe injuries. *Current Opinion in Neurology, 18*, 734–739.

Billieux, J., Gay, P., Rochat, L., & Van der Linden, M. (2010). The role of urgency and its underlying psychological mechanisms in problematic behaviours. *Behaviour Research and Therapy, 48*, 1085–1096.

Billieux, J., Rochat, L., Ceschi, G., Carré, A., Offerlin-Meyer, I., Defeldre, A. -C., et al. (2012). Validation of a short French version of the UPPS-P impulsive behavior scale. *Comprehensive Psychiatry, 53*, 609–615.

Brandstätter, V., Lengfelder, A., & Gollwitzer, P.M. (2001). Implementation intentions and efficient action initiation. *Journal of Personality and Social Psychology*, *81*, 946–960.
Burkard, C., Rochat, L., Emmenegger, J., Juillerat Van der Linden, A. -C., Gold, G., & Van der Linden, M. (2013). Implementation intentions improve prospective memory and inhibition performances in the elderly: The role of visualization (submitted for publication).
Chapman, J., & Armitage, C. J. (2010). Evidence that boosters augment the long-term impact of implementation intentions on fruit and vegetable intake. *Psychology and Health*, *25*, 365–381.
Chapman, J., Armitage, C. J., & Norman, P. (2009). Comparing implementation intention interventions in relation to young adults' intake of fruit and vegetables. *Psychology and Health*, *24*, 317–332.
Churchill, S., & Jessop, D. (2010). Spontaneous implementation intentions and impulsivity: Can impulsivity moderate the effectiveness of planning strategies? *British Journal of Health Psychology*, *15*, 529–541.
Churchill, S., & Jessop, D. C. (2011). Too impulsive for implementation intentions? Evidence that impulsivity moderates the effectiveness of an implementation intention intervention. *Psychology and Health*, *26*, 517–530.
Cohen, A. L., Bayer, U. C., Jaudas, A., & Gollwitzer, P.M. (2008). Self-regulatory strategy and executive control: Implementation intentions modulate task switching and Simon task performance. *Psychological Research*, *72*, 12–26.
Cyders, M.A., & Coskunpinar, A. (2011). Measurement of constructs using self-report and behavioral lab tasks: Is there overlap in nomothetic span and construct representation for impulsivity? *Clinical Psyhology Review*, *31*, 965–982.
Cyders, M.A., & Smith, G. T. (2008). Emotion-based dispositions to rash action: Positive and negative urgency. *Psychological Bulletin*, *134*, 807–828.
Enticott, P. G., & Ogloff, J. R. P. (2006). Elucidation of impulsivity. *Australian Psychologist*, *41*, 3–14.
Gaudreau, P., Sanchez, X., & Blondin, J. -P. (2006). Positive and negative affective states in a performance-related setting: Testing the factorial structure of the PANAS across two samples of French–Canadian participants. *European Journal of Psychological Assessment*, *22*, 240–249.
Gawrilow, C., & Gollwitzer, P.M. (2008). Implementation intentions facilitate response inhibition in children with ADHD. *Cognitive Therapy and Research*, *32*, 261–280.
Gawrilow, C., Gollwitzer, P.M., & Oettingen, G. (2011). If–then plans benefit executive functions in children with ADHD. *Journal of Social and Clinical Psychology*, *30*, 616–646.
Gay, P., Rochat, L., Billieux, J., d'Acremont, M., & Van der Linden, M. (2008). Heterogeneous inhibition processes involved in different facets of self-reported impulsivity: Evidence from a community sample. *Acta Psychologica*, *129*, 332–339.
Gilbert, S. J., Gollwitzer, P.M., Cohen, A. L., Oettingen, G., & Burgess, P. W. (2009). Separable brain systems supporting cued versus self-initiated realization of delayed intentions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*, 905–915.
Gollwitzer, P.M. (1993). Goal achievement: The role of intentions. *European Review of Social Psychology*, *4*, 141–185.
Gollwitzer, P.M. (1999). Implementation intentions. *American Psychologist*, *54*, 493–503.
Gollwitzer, P.M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology*, *38*, 69–119.
Goudriaan, A. E., Oosterlaan, J., de Beurs, E., & van den Brink, W. (2006). Neurocognitive functions in pathological gambling: A comparison with alcohol dependence, Tourette syndrome and normal controls. *Addiction*, *101*, 534–547.
Grilli, M.D., & McFarland, C. P. (2011). Imagine that: Self-imagination improves prospective memory in memory-impaired individuals with neurological damage. *Neuropsychological Rehabilitation*, *21*, 847–859.
Knäuper, B., McCollam, A., Rosen-Brown, A., Lacaille, J., Kelso, E., & Roseman, M. (2011). Fruitful plans: Adding mental imagery to implementation intentions increases fruit consumption. *Psychology and Health*, *26*, 601–617.
Knäuper, B., Roseman, M., Johnson, P. J., & Krantz, L. H. (2009). Using mental imagery to enhance the effectiveness of implementation intentions. *Current Psychology*, *28*, 181–186.
Lengfelder, A., & Gollwitzer, P.M. (2001). Reflective and reflexive action control in patients with frontal brain lesions. *Neuropsychology*, *15*, 80–100.
Logan, G. D. (1994). On the ability to inhibit thought and action: A user's guide to the stop signal paradigm. In D. Dagenbach, & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 189–239). San Diego, CA: Academic Press.
Logan, G. D., & Cowan, W. B. (1984). On the ability to inhibit thought and action: A theory of an act of control. *Psychological Review*, *91*, 295–327.
Logan, G. D., Schachar, R. J., & Tannock, R. (1997). Impulsivity and inhibitory control. *Psychological Science*, *8*, 60–64.
Maglio, S. J., Gollwitzer, P.M., & Oettingen, G. (2013). Action control by implementation intentions: The role of discrete emotions. In A. Clark, J. Kiverstein, & T. Vierkant (Eds.), *Decomposing the will* (pp. 221–243). New York: Oxford University Press.
McFarland, C., & Glisky, E. (2011). Implementation intentions and imagery: Individual and combined effects on prospective memory among young adults. *Memory and Cognition*, *40*, 62–69.
Meeks, J. T., & Marsh, R. L. (2010). Implementation intentions about nonfocal event-based prospective memory tasks. *Psychological Research*, *74*, 82–89.
Miyake, A., Friedman, N.P., Emerson, M. J., Witzki, A. H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100.
Noël, X., Bechara, A., Dan, B., Hanak, C., & Verbanck, P. (2007). Response inhibition deficit is involved in poor decision making under risk in nonamnesic individuals with alcoholism. *Neuropsychology*, *21*, 778–786.
Oettingen, G., Hönig, G., & Gollwitzer, P.M. (2000). Effective self-regulation of goal attainment. *International Journal of Educational Research*, *33*, 705–732.
Paul, I., Gawrilow, C., Zech, F., Gollwitzer, P.M., Rockstroh, B., Odenthal, G., et al. (2007). If–then planning modulates the P300 in children with attention deficit hyperactivity disorder. *NeuroReport*, *18*, 653–657.
Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in Cognitive Sciences*, *13*, 160–166.
Shelton, J. T., Elliott, E. M., Hill, B.D., Calamia, M. R., & Gouvier, W. D. (2009). A comparison of laboratory and clinical working memory tests and their prediction of fluid intelligence. *Intelligence*, *37*, 283–293.
Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and Emotion*, *21*, 391–403.
Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070.
Watson, D., Wiese, D., Vaidya, J., & Tellegen, A. (1999). The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. *Journal of Personality and Social Psychology*, *76*, 820–838.
Webb, T. L., & Sheeran, P. (2003). Can implementation intentions help to overcome ego-depletion? *Journal of Experimental Social Psychology*, *39*, 279–286.
Wechsler, D. (2000). *Echelle d'intelligence de Wechsler pour adultes [Wechsler Adult Intelligence Scale]* (3rd ed.)Paris: Editions du Centre de Psychologie Appliquée.
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.