



Measuring individual differences in internal versus external attention: The attentional style questionnaire



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ABSTRACT

Attentional capacity can vary amongst individuals, along several dimensions. Currently available questionnaires confound distinct dimensions of attention, such as top-down versus bottom-up attentional processes, and the orientation of these processes towards internal versus external objects of attention. This study proposes a novel questionnaire that measures the attentional style of an individual by taking into account both the type and orientation of attention. The structure of the questionnaire was first explored in an exploratory factor analysis, which yielded two factors representing externally and internally oriented attention. This factor structure was validated in a second study using confirmatory factor analysis, and its construct was validated in a third study using attention-related questionnaires. This study proposes a new questionnaire allowing to characterize an individual's attentional style according to top-down/bottom-up and internal/external dimensions of attention, and provides further insights into the subdivisions of functionally relevant attentional dimensions.

1. Introduction

Stimulation coming from the external and internal world can be overwhelming. Attention helps us to process the huge amount of information we are confronted with, and enables us to selectively focus on the information that is relevant to our goals (Chun, 2011; Desimone & Duncan, 1995; Pashler, Johnston, & Ruthruff, 2001). This attentional capacity is driven by at least two antagonistic processes which have been labelled top-down and bottom-up attention. Top-down attention correspond to goal-directed, controlled attentional processes, while bottom-up attention is characterized by the spontaneous attraction of attention towards novel, salient, and unexpected stimuli (Corbetta & Shulman, 2002; Steve Majerus et al., 2012). Studies have shown that when top-down attentional processes are challenged, as is the case for example in a high-load short-term memory condition, bottom-up attentional processes decrease, as reflected by a decreased sensitivity towards task-irrelevant distractor stimuli (Steve Majerus et al., 2012; Shulman, Astafiev, McAvoy, D'Avossa, & Corbetta, 2007; Todd, Fougny, & Marois, 2005).

Top-down and bottom-up attentional processes can both be externally (exogenous) or internally (endogenous) oriented (Posner, 1980). Externally oriented top-down attention refers to deliberate, goal-

directed processing of the external environment, while internally oriented top-down cognition is involved in deliberate and goal-directed internal mentation (Christoff, 2012; Gilbert, Simons, Frith, & Burgess, 2006). Bottom-up external attention involves the sudden and unexpected attentional capture of stimuli in the immediate environment (e.g., suddenly hearing the neighbour start the engine of his lawnmower). Importantly, bottom-up attention can also be oriented internally, for example when attention is captured by an intrusive thought, such as suddenly thinking about a forthcoming appointment you had completely forgotten. Intrusive thoughts are unintended, often interfere with ongoing activity, and are difficult to control (Clark & Purdon, 1995). It is important to note that the internal versus external orientation and top-down versus bottom-up nature of attention can interact in different ways. For example, while performing a visual detection task (external top-down attention), a person can be distracted by a sudden noise (external bottom-up attention) or an intrusive thought (internal bottom-up attention). Similarly, when intentionally planning the future (internal top-down attention), we can be distracted by a sudden noise or an intrusive thought.

Despite the potential importance of these different attentional dimensions for understanding everyday human cognition, there are currently very few instruments available to measure individual differences

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Table 1
Items and properties of the first version of the Attentional Style Questionnaire (17 items).

Item	Attention	Orientation	Questionnaire
1. J'ai des difficultés à me concentrer lorsqu'il y a du mouvement dans la pièce. (<i>I have trouble concentrating when there is movement in the room I am in</i>)	+	E	ASQ
2. En général, je garde le contrôle sur mes pensées et je ne me laisse pas distraire par des pensées intrusives. (<i>In general, I stay in control of my thoughts and do not let myself get distracted by interfering thoughts</i>)	–	I	ESQ
3. Je suis facilement attiré(e) par des stimuli nouveaux (par exemple, les voix de personnes qui passent, un bruit dans la maison, ...) et qui n'ont rien à voir avec la tâche que je suis en train d'effectuer. (<i>I am easily drawn to new stimuli (for example, voices of people passing by, a sound in the house, ...) that are not relevant to a task I am doing.</i>)	+	E	ESQ
4. Je suis souvent tellement absorbé(e) par un flot de pensées que je deviens plus ou moins inconscient(e) de ce qui m'entoure. (<i>I can be so absorbed by a line of thoughts that I become more or less unaware of my surroundings</i>)	–	E	ESQ
5. Lorsque je réalise une tâche, je suis souvent tellement concentré(e) que je ne remarque rien d'autre autour de moi. (<i>When I am doing a task, I am often so focused I do not notice my surroundings.</i>)	–	E	ASQ
6. Je n'ai pas de difficultés à travailler tout en écoutant de la musique. (<i>I do not have difficulties to work while listening to music.</i>)	–	E	TAS
7. Il m'est difficile de faire une seule activité durant une heure. (<i>It is hard for me to stay on one activity for a whole hour.</i>)	+	I	ASQ
8. Souvent, des pensées et des images sans lien avec l'activité en cours me viennent à l'esprit. (<i>During an activity, unrelated mental images and thoughts come to my mind.</i>)	+	I	TAS
9. Il m'arrive fréquemment d'interrompre une activité en cours pour en démarrer/continuer une autre parce que je viens d'y penser. (<i>I often put hold to an activity because I suddenly think about another one I have to start or continue.</i>)	+	I	ASQ
10. Je reste généralement concentré(e) sur une seule tâche jusqu'à ce qu'elle soit terminée. (<i>I generally stay focused on a single task until it is finished.</i>)	–	I	ASQ
11. Je peux facilement ignorer l'environnement qui m'entoure. (<i>I can easily ignore my surroundings.</i>)	–	E	ASQ
12. Il m'arrive d'interrompre une activité pour vérifier un détail qui n'est pas en lien avec cette activité. (<i>Sometimes I interrupt an activity to check an unrelated detail.</i>)	+	I	ASQ
13. Quand je travaille sur mon ordinateur, il m'arrive souvent d'aller sur internet pour consulter des sites sans lien avec mon travail. (<i>When I am working on my computer, I often go on the internet to visit websites that are unrelated to my work.</i>)	+	I	ASQ
14. Je peux facilement me concentrer sur une tâche, même si il y a du mouvement ou du bruit dans la pièce où je me trouve. (<i>I can easily concentrate on a task, even when there is movement in the room I am in.</i>)	–	E	ASQ
15. Je peux passer plusieurs minutes sur une question et essayer de la décortiquer. (<i>I can spend several minutes on a question and try to dissect it.</i>)	–	I	ASQ
16. J'ai des difficultés à penser lorsqu'il y a des bruits, même s'ils sont peu intenses. (<i>I have trouble thinking when there are noises, even if these noises are not intense.</i>)	+	E	ASQ
17. Je suis souvent le premier/la première à remarquer un changement dans une pièce. (<i>I am often the first one to notice something has changed in a room.</i>)	+	E	ASQ

Attention depicts the bottom-up oriented (+) or top-down oriented (–) nature of the item. Orientation states the external (E) or internal (I) orientation of attention. Questionnaire states the provenance of inspiration of the item. ASQ = Attentional Style Questionnaire, TAS = Tellegen Absorption Scale (Tellegen & Atkinson, 1974), ESQ = Encoding Style Questionnaire (Billieux et al., 2009).

in these dimensions. The most widespread questionnaire that attempts to assess individual differences in attention (mostly in the context of psychopathology) is the Attentional Control Scale (Derryberry & Reed, 2002). The Attentional Control Scale (ACS) results from the merging of two questionnaires measuring attentional focus and attentional shifting (Derryberry & Rothbart, 1988). This scale mainly measures externally oriented top-down attentional control capacity, but lacks the dimension of internally oriented top-down attentional control. The aim of the present study is to propose a more exhaustive attentional style questionnaire that takes both the top-down versus bottom-up and the external versus internal dimensions of attention into account. Because of the antagonistic nature of bottom-up and top-down attentional states, we designed items to reflect a continuum between both attentional states. A low score would thus reflect low bottom-up attention and high top-down attention, whereas a high score would indicate high bottom-up attention and low top-down attention. The measure (the individual's score) is considered to reflect the capacity of an individual to maintain attention on task-related stimuli and not to be distracted by interfering stimuli.

The first study presents the development of the Attentional Style Questionnaire (ASQ) and determines its structure via exploratory factor analysis. In a second study, we test the robustness of the factorial structure of the ASQ using confirmatory factor analysis on a new independent sample of participants (Schreiber, Nora, Stage, Barlow, & King, 2006). Finally, in a third study, we assess the questionnaire's construct validity by investigating its relation with existing questionnaires assessing various phenomena involving top-down or bottom-

up attentional processes such as the occurrence of daydreaming, ruminations, and cognitive failure.

2. Study 1

2.1. Method

2.1.1. Participants

206 French speaking participants between 18 and 45 years of age ($M = 23.25$, $SD = 5.2$) with at least a high school degree were invited to fill out the Attentional Style Questionnaire (ASQ) using Google Forms, providing data for the exploratory factor analysis. Participants were recruited via advertisements posted on student forums, via announcements sent via emails to students, and via postings on student social media groups; the advertising texts included a link to the online survey. A first screen mentioned general information about the study (including the requirement of being a French-speaker for participating to the study), contact information of the researcher responsible for the study, and an ethical statement of the rights of the participant (guarantee of anonymity, ability to interrupt participation at any time without any need to provide a justification, and the right to receive results of the study). The participants were also asked to provide information about their age and gender. They had to check a box in order to confirm that the provided information had been fully read, understood, and that they agreed to participate to this survey. If this checkbox was not checked, or any information was missing, the participant was not able to continue to the next screen. Participants were

Table 2
Item loadings of pertinent items of the extracted factors.

	Item	Loadings F1	Loadings F2		
ID	2	0.50	.	+	
	3	0.35	0.46	+	
	7	0.55	.	+	
	8	0.64	.	+	
	9	0.77	.	+	
	10	-0.71	.	-	
	12	0.67	.	+	
	13	0.53	.	+	
	ED	1	.	0.74	+
		5	.	-0.32	-
		6	.	-0.52	-
		11	.	-0.64	-
		14	.	-0.84	-
16		.	0.73	+	
NS	4	.	.	-	
	15	.	.	-	
	17	.	.	+	

ID: Internal distraction; ED: External distraction; NS: Non-significant loadings; (-): reversed item; (+) non-reversed item. Significant item loadings > 0.50 in bold.

encouraged to contact the researcher in case of doubt or question. All questions needed to be answered in order to proceed to the submission of the responses. The participants were free to end their participation at any time, in which case data was not recorded. A final screen thanked the participants and briefly described the context and aims of the study. An option for contacting the investigator for a full debriefing and/or for additional information about the study was also provided. The study was approved by the local Ethics Committee.

2.1.2. ASQ development

Items of the Attentional Style Questionnaire were created to measure attentional style involving top-down and bottom-up attention, and internal versus external orientation of attention. A pool of items portraying everyday behavior that requires attentional control for external or internal orientation was created by the investigators. The items were designed to avoid measuring attentional control for a specific situation and instead referred to an overall tendency of keeping attentional control in a situation that was likely to repeat over time. An item was included when a consensus of its pertinence was reached by all investigators. Alongside items specifically created for the purpose of this study, items of the Tellegen Absorption Scale (TAS) and Encoding Style Questionnaire (ESQ) relevant to the measurement of attentional style were added and modified to include externally and internally oriented attention (see Table 1). The TAS is a questionnaire designed to assess the tendency of absorption, defined as “attention that fully engages one’s representational resources” (Tellegen & Atkinson, 1974), that includes relevant items for measuring an internally oriented attentional focus. The ESQ evaluates the tendency to allocate internal schemata to external stimuli (Billieux, D’Argembeau, Lewicki, & Van der Linden, 2009), which involves the spontaneous projection, initiated by bottom-up attention, of internally generated contents onto the external environment (e.g., mistaking a bag that is carried by the wind for an animal). The initial version of the Attentional Style Questionnaire contained 17 items (see Table 1). Respondents were asked to rate each item using a Likert-scale ranging from 1 (*in total disagreement*) to 6 (*in total agreement*). A Likert-type scale provided the ideal solution to reflect the continuous nature of attentional control as attentional control has been shown to fluctuate over time and to vary in quantity (Kurth et al., 2016; S. Majerus & Barisnikov, 2018; Van Calster, D’Argembeau, Salmon, Peters, & Majerus, 2017). The rate of agreement reflects the extent of bottom-up versus top-down attentional dimension (score of 1: strong top-down oriented attention; score of 6: strong bottom-up oriented attention). In order to avoid response biases affecting the ratings, for some items, these dimensions were reversed (see

Table 1). The overall score on the questionnaire (after re-reversing reversed items) reflects the individual’s attentional style, with a higher score indicating a marked bottom-up oriented attentional style, and a lower score indicating a marked top-down oriented attentional style. Internally oriented attention was measured by 8 items and externally oriented attention by 9 items (see Table 1).

2.1.3. Statistical analyses

The factorial structure of the ASQ was explored through a principal component analysis. A parallel analysis (Horn, 1965; O’connor, 2000) was conducted to extract the number of contributing factors by comparing eigenvalues from the real data to random data sets that are generated from raw data permutations. The number of eigenvalues of real data explaining more variance than the random data, reveals the number of factors to be retained. Velicer’s Minimum Average Partial (MAP) test was also performed using both the original test and the revised MAP test, the latter raising the partial correlations to the 4th power instead of their square (Velicer, Eaton, & Fava, 2000). Estimation of internal reliability of the scale was calculated with Cronbach’s Alpha for which values > 0.70 are generally considered to be acceptable (Bland & Altman, 1997). Regarding pattern fit of sample-to-population, loadings were considered acceptable above 0.50 (Billieux et al., 2009; Billieux, Rochat, & Ceschi, 2012; Vandeweghe et al., 2016).

3. Results

The total score of participants on the ASQ ranged from 34 to 90 ($M = 63$, $SD = 9.35$). Both the parallel analysis and Velicer’s MAP test recommended the extraction of two factors. The principal component analysis on two factors performed using R software (R Core Team, 2014) showed that two factors are sufficient, $\chi^2(103, 206) = 174.6$, $p < 0.001$. Items (4) “I can be so absorbed by a line of thoughts that I become more or less unaware of my surroundings”, (15) “I can spend several minutes on a question and try to dissect it”, and item 17 “I am often the first one to notice something has changed in a room” showed non-significant loadings and were therefore withdrawn from the questionnaire and further analysis. Only items with significant loadings considered as a “moderate” to “very good” fit were retained for the questionnaire (see Table 2). The remaining items were items (2) “In general, I stay in control of my thoughts and do not let myself get distracted by interfering thoughts”, (7) “It is hard for me to stay on one activity for a whole hour”, (8) “During an activity, unrelated mental images and thoughts come to my mind”, (9) “I often put hold to an activity because I suddenly think about another one I have to start or continue”, (12) “Sometimes I interrupt an activity to check an unrelated detail”, (13) “When I am working on my computer, I often go on the internet to visit websites that are unrelated to my work”, and (10) “I generally stay focused on a single task until it is finished” belonged to the first factor. And the items (1) “I have trouble concentrating when there is movement in the room I am in”, (16) “I have trouble thinking when there are noises, even if these noises are not intense”, (6) “I do not have difficulties to work while listening to music”, (11) “I can easily ignore my surroundings”, and (14) “I can easily concentrate on a task, even when there is movement in the room I am in” belonged to the second factor. The first factor includes items that are related to internally generated contents that act as distractors and disrupt the attentional focus. By contrast, the second factor reflects external attention, where items refer to a sensibility for distractors originating from the external environment. Internal consistency was good for both the first ($\alpha = 0.82$) and the second ($\alpha = 0.81$) factor.

4. Discussion

An exploratory factor analysis on the ASQ using principal component analysis revealed two factors, distinguishing items of attentional control for external and internal stimuli. Irrelevant items were withdrawn from the questionnaire, leaving a 12-item questionnaire. All remaining items were relevant to the dimension of attentional control

even when reversed, as shown in Table 2. Because items of the ASQ portray general and repeatable situations devoid of state, results suggest that reported attentional control of participants is an individual's style of attention rather than an attentional behavior for a specifically defined situation or state at a certain time. In order to confirm the distinction between these two factors in a new population sample, a confirmatory analysis was performed.

5. Study 2

5.1. Methods

5.1.1. Participants

A new sample of 294 French speaking participants, aged between 18 and 45 years ($M = 22.98$, $SD = 4.29$) with a high school degree or higher, filled out the revised version of the ASQ using Google Forms, to test the robustness of the initial factorial model obtained from the first sample. Participants were recruited via advertisements posted on student forums, via announcements sent via emails to students, and via postings on student social media groups; the advertising texts included a link to the online survey. A first screen mentioned general information about the study (including the requirement of being a French-speaker for participating to the study), contact information of the researcher responsible for the study, and an ethical statement of the rights of the participant (guarantee of anonymity, ability to interrupt participation at any time without any need to provide a justification, and the right to receive results of the study). The participants were also asked to provide information about their age and gender. They had to check a box in order to confirm that the provided information had been fully read, understood, and that they agreed to participate to this survey. If this checkbox was not checked, or any information was missing, the participant was not able to continue to the next screen. Participants were encouraged to contact the researcher in case of doubt or question. All questions needed to be answered in order to proceed to the submission of the responses. The participants were free to end their participation at any time, in which case data was not recorded. A final screen thanked the participant and briefly described the context and aims of the study. An option for contacting the investigator for a full debriefing and/or for additional information about the study was also provided. The study was approved by the local Ethics Committee.

The ASQ questionnaire was completed anonymously using Google Forms. The revised version of the ASQ was composed of the 12 items assessing attentional style and having obtained significant factor loadings in the first, exploratory factor analysis. Items 2, 7, 8, 9, 10, 12 and 13 measured attentional control in situations where attention is captured by an internally generated stimulus (with item 10 as a reversed item), while the items 1, 6, 11, 14 and 16 (with items 6, 11, and 14 as a reversed items) measured attentional control in situations where attention is captured by an external stimulus. The global score of the 12-item ASQ for this sample could range between 12 and 72, while the internal bottom-up attention component could range between 7 and 42 and the external bottom-up attention component between 5 and 30.

5.1.2. Statistical analyses

Confirmatory factor analysis (CFA) with maximum likelihood estimation was performed using R software (R Core Team, 2014). The model of the questionnaire was tested using structural equation modeling. Goodness of fit was tested with the chi-square for degrees of freedom ratio, where a ratio inferior to 3 depicts a good fit of the model (Iacobucci, 2010; Schermelleh-Engel, Moosbrugger, & Müller, 2003). This ratio was preferred to the chi-square value because a non-significant value, corresponding to an acceptable fit, is unlikely to be obtained for a CFA on self-reporting questionnaires for our sample size. Indeed, due to the integration of sample size (N) in the equation of the chi-square test, it is likely that the null hypothesis would be rejected even if there is little difference between the covariance matrix and the

matrix of the model (Byrne, 2005; Detandt, Leys, & Bazan, 2017; Gatignon, 2010). Three supplementary indices of fit were calculated, namely the Root Mean Square Error of Approximation (RMSEA), the Standardized Root Mean Square Residual (SRMR), and the Comparative Fit Index (CFI). Values for an acceptable fit are below 0.08 for the RMSEA and below 0.10 for the SRMR (Schermelleh-Engel et al., 2003). CFI represents an acceptable fit when values are above 0.90 (Hu & Bentler, 1999).

6. Results

Data from the new sample yielded a mean score of 44 for the global score ($M = 44.28$, $SD = 8.11$), and a mean score of 26 ($M = 26.42$, $SD = 5.99$) and 18 ($M = 17.85$, $SD = 4.86$) for the two components, respectively. Internal consistency was deemed acceptable for both the first ($\alpha = 0.79$) and second ($\alpha = 0.76$) factor. The chi-square/degrees of freedom ratio was equal to 2.88, indicating a good fit of the model, $\chi^2(53, 294) = 152.92$, $p < 0.01$. Furthermore, the RMSEA value was 0.08 ($RSMEA = 0.080$), the SRMR value was below 0.10 ($SRMR = 0.076$), and the CFI was slightly below 0.90 ($CFI = 0.89$). These results depict an acceptable fit of the model (Hu & Bentler, 1999; Iacobucci, 2010; Schermelleh-Engel et al., 2003).

7. Discussion

The confirmatory factor analysis confirmed the two factors initially observed in the exploratory factor analysis of Study 1. Thus, the 12-item questionnaire shows a solid structure that distinguishes two factors we interpreted to reflect attentional control for internal and external stimuli, respectively. In a third study, we investigated the construct validity of the ASQ more directly by examining the association between the ASQ scores and various questionnaires assessing everyday situations involving top-down and bottom-up attention to external and internal stimuli. The aim of this third study was to provide further empirical evidence for our interpretation of the two-factor structure as reflecting attentional control to internal and external stimuli.

8. Study 3

To the best of our knowledge, no previous questionnaire has explicitly taken into consideration the distinction between internal and external attentional control. However, a number of existing questionnaires assess attentional control for situations involving either internal or external stimuli or a mix of the two. Our aim here was to investigate their association with the ASQ to assess its construct validity. We first investigated the relation between the ASQ and the tendency of an individual to ruminate; a high tendency to ruminate has been linked to impaired cognitive control particularly for internal stimuli such as thoughts (Gay, Schmidt, & Van der Linden, 2010). This dimension was assessed using the Rumination- Reflection Questionnaire (Trapnell & Campbell, 1999; French adaptation by Jermann, Billieux, Bizzini, Van der Linden, & Bondolfi, 2010), a self-report questionnaire measuring two components of private self-attentiveness, namely reflection and rumination. We also assessed an individual's self-assessed ability to conduct various tasks involving the ability to control attention to external stimuli and to disengage attention from distracting stimuli (Vom Hofe, Mainemarle, & Vannier, 1998) by using the Cognitive Failure Questionnaire developed by Broadbent, Cooper, FitzGerald, and Parkes (1982). This self-report questionnaire measures the frequency of errors due to cognitive (attentional) failure during trivial tasks, but does not distinguish between external and internal sources of attentional distraction. A third questionnaire assessed an individual's tendency to daydream. Daydreaming, also referred to as mind wandering, may occur when attentional control processes are insufficient to deal with interference created by internal off-task thoughts (McVay & Kane, 2010), and recent findings also suggest that

daydreaming involves a redirection of attention from external stimuli towards internal mentation (Stawarczyk, Majerus, Catale, & D'Argembeau, 2014). We used the Daydream Frequency Scale by Antrobus and Singer (1964), a commonly used self-report questionnaire assessing the general frequency of daydreaming in daily life. Finally, we used items from the Self-assessed Attention Questionnaire (Coyette et al., n.d.) assessing various situations of attentional control to internal and external stimuli (e.g., When in a conversation, I lose the thread of the conversation because my mind wanders and I can't stop thinking of something else; When in a conversation, I lose the thread of the conversation because I am distracted by the noise and/or movement around me).

We expected a positive correlation between the internal attention factor of the ASQ and the questionnaires assessing failures of attentional control involving internal stimuli, namely the rumination score of the Rumination-Reflection Questionnaire and the main score of the Daydreaming Frequency Scale. We further expected a significant association between both factors of the ASQ and the Cognitive Failure Questionnaire and the Self-assessed Attention Questionnaire given that these questionnaires measure attentional control independently of the orientation of the distracting stimuli.

9. Methods

9.1. Participants

A new sample of 111 French speaking participants, aged between 18 and 45 years ($M = 24.60$, $SD = 7.95$) with a at least 12 years of education, filled out the ASQ and the other questionnaires using Google Forms. Participants were recruited via advertisements posted on student forums, via announcements sent via emails to students, and via postings on student social media groups; the advertising texts included a link to the online survey. A first screen mentioned general information about the study (including the requirement of being a French-speaker for participating to the study), contact information of the researcher responsible for the study, and an ethical statement of the rights of the participant (guarantee of anonymity, ability to interrupt participation at any time without any need to provide a justification, and the right to receive results of the study). The participants were also asked to provide information about their age and gender. They had to check a box in order to confirm that the provided information had been fully read, understood, and that they agreed to participate to this survey. If this checkbox was not checked, or any information was missing, the participant was not able to continue to the next screen. Participants were encouraged to contact the researcher in case of doubt or question. All questions needed to be answered in order to proceed to the submission of the responses. The participants were free to end their participation at any time, in which case data was not recorded. A final screen thanked the participant and briefly described the context and aims of the study. An option for contacting the investigator for a full debriefing and/or for additional information about the study was also provided. The study was approved by the local Ethics Committee.

9.2. Questionnaires

Participants filled out the ASQ as well as the French versions of the Rumination-Reflection Questionnaire (Jermann et al., 2010), Cognitive Failure Questionnaire (Broadbent et al., 1982), Daydreaming Frequency Scale (Stawarczyk, Majerus, Van der Linden, & D'Argembeau, 2012), and items of the Self-assessed Attention Questionnaire (Coyette et al., n.d.). The Rumination-Reflection questionnaire is a 24-item questionnaire that distinguishes two types of self-attentiveness, named 'rumination' and 'reflection'. Rumination is a form of self-attentiveness motivated by threat, losses, and injustice while reflection is motivated by curiosity or epistemic interest in the self (Trapnell & Campbell, 1999). A high frequency of rumination has been linked to impaired

cognitive control (Gay et al., 2010), and a ruminative cognitive style would be associated with more frequent mind-wandering (Smallwood, 2013) and generally repetitive thought processes (Baars, 2010) reflecting increased bottom-up internally oriented attention. This is clearly noticeable in items such as "Sometimes it is hard for me to shut off thoughts about myself" or the reversed item "It is easy for me to put unwanted thoughts out of my mind". The Daydream Frequency Scale is a scale from the Imaginal Process Inventory (Antrobus & Singer, 1964) that measures the frequency with which a person daydreams, using 12 items with reference to a five-point Likert scale, ranging from 'A' to 'E'. Similarly to a previous study, numerical values were attributed by replacing the answer 'A' with the lowest value 1 and answer 'E' with the highest value 5 (see Stawarczyk et al., 2012). The higher the score, the more frequently a person daydreams. The Cognitive Failure Questionnaire is a questionnaire that aims to measure the frequency of errors for a person when performing a mundane task using 25 items ranging from 1 (never) to 5 (very often). This questionnaire is designed to measure performance rather than personality traits that could predict a behavior, but does not differentiate between internally or externally oriented distractions. Finally, the Self-assessed Attention Questionnaire assesses attention in everyday situations. Amongst a variety of different items, it includes some items that can be linked with attentional control for internal and external stimuli (e.g.: When reading, I lose the thread of the story because my mind wanders and I can't stop thinking of something else; When reading, I lose the thread of the story because I am distracted by the noise and/or movement around me). We specifically selected 13 Likert-type items that reflect attentional control and we disregarded the open questions included in this questionnaire. Note, however that one single score of the Self-assessed Attention Questionnaire was used as not all selected items of the Self-assessed Attention Questionnaire provided a clear distinction between attentional control for internal and external stimuli. Also, as for the Cognitive Failure Questionnaire, this questionnaire assesses attentional control in terms of self-evaluation of task performance rather than personality traits.

9.3. Statistical analyses

Correlational analyses were performed to investigate the link between the ASQ and aforementioned questionnaires. A hierarchical multiple regression analysis was then conducted to see if attentional control for internal stimuli was able to predict scores of questionnaires that are linked to internal stimuli, after controlling for variance explained by attentional control for external stimuli, and vice versa.

10. Results

As shown in Table 3, a significant positive correlation was observed between the ASQ internal score and the rumination and reflection score of the Rumination-Reflection Questionnaires, the Daydreaming Frequency Scale, the Cognitive Failure Questionnaire, and the Self-assessed Attention Questionnaire. The ASQ external score positively correlated with the Cognitive Failure Questionnaire and the Self-assessed

Table 3
Correlations of the attentional style questionnaire and attention-related questionnaires.

	RRQ Rum	RRQ Ref	DDFS	CFQ	SAQ
ASQ Int	0.55***	0.26**	0.448***	0.47***	0.44***
ASQ Ext	0.18	0.07	0.10	0.21*	0.39***

ASQ Int, Attentional Style Questionnaire internal score; ASQ Ext, Attentional Style Questionnaire external score; RRQ Rum, Rumination-Reflection Questionnaire rumination score; RRQ Ref, Rumination-Reflection Questionnaire reflection score; CFQ, Cognitive Failure Questionnaire; SAQ Self-assessed Attention Questionnaire.

* Significant at $p < 0.05$ (two-tailed).

** Significant at $p < 0.01$ (two-tailed).

*** Significant at $p < 0.001$ (two-tailed).

Attention Questionnaire. Hierarchical regression analyses showed that, after having introduced attentional control for external stimuli, attentional control for internal stimuli still significantly predicted ruminative behavior ($F(2,110) = 25.73$, $p < 0.001$, $R^2 = 0.32$, $\Delta R^2 = 0.29$). Similarly, the frequency of daydreaming was still significantly predicted by attention control to internal stimuli, after attentional control for external stimuli had been taken into account ($F(2,110) = 13.25$, $p < 0.001$, $R^2 = 0.20$, $\Delta R^2 = 0.19$). The same was also true for the prediction of the scores on the cognitive failures test and the Self-assessed Attention Questionnaire ($F(2,110) = 17.43$, $p < 0.001$, $R^2 = 0.23$, $\Delta R^2 = 0.20$; $F(2,110) = 24.31$, $p < 0.001$, $R^2 = 0.30$, $\Delta R^2 = 0.16$). Lastly, the attentional control abilities for external stimuli predicted the score of items of the Self-assessed Attention Questionnaire after controlling for attentional control for internal stimuli ($F(2,110) = 18.75$, $p < 0.001$, $R^2 = 0.30$, $\Delta R^2 = 0.12$) but this was not the case for the score of items of the Cognitive Failure Questionnaire ($F(2,110) = 3.72$, $p = 0.056$, $R^2 = 0.24$, $\Delta R^2 = 0.03$).

11. Discussion

Overall, the results are in line with our predictions as only the internal attentional control score of the ASQ predicted responses on questionnaires exploring exclusively attentional control for internally oriented cognitive experiences. Both the internal and the external attentional control score were associated with questionnaires not distinguishing between internal and external stimuli.

The finding that the rumination score was predicted by the ASQ internal attentional score suggests that participants with a high internal bottom-up attentional style are more likely to ruminate, reflecting a lack of attentional control towards spontaneous thoughts, where attention is more easily captured by internal stimuli. On the other hand, the ASQ external attentional score did not predict rumination or daydream frequency, which is in line with recent findings showing that attentional control capacity for external stimuli is not sufficient to explain the frequency of occurrence of spontaneous internal events such as daydreaming (Stawarczyk et al., 2014). The ASQ internal attention score as a measure of lack of attentional control towards spontaneous thoughts is also supported by the specific association observed between the ASQ internal score and the Daydreaming Frequency Scale score: participants who reported that their attention was easily captured by internal stimuli also reported to daydream more frequently.

The external attention score of the ASQ only predicted the score of the Self-assessed Attention Questionnaire, in line with our predictions. The external attentional control score was not able to predict the score of the Cognitive Failure Questionnaire after controlling for internal attentional control, however their association was observed in the correlational analysis. Influence of external attentional control and the Cognitive Failure Questionnaire can therefore not be excluded, but its lack of predictability may be due to the overall association of attention with the Cognitive Failure Questionnaire coming from a stronger association with internal attentional control and a less robust association with external attentional control. Our results underline the need for a distinction of attentional control for internal and external stimuli. This may be critical for the diagnosis of deficits in attentional control, as clinical scales designed to assess such deficits, such as the Self-Assessed Attention Questionnaire, currently show no distinction of attentional control for internal and external stimuli. Therefore, an important advantage of the ASQ is that it allows distinguishing between these two types of attentional control.

12. General discussion

The purpose of this study was to develop a self-assessment questionnaire measuring an individual's propensity of deploying attentional control in everyday life, as a function of internal and external events. The structure of the ASQ was explored via a principal component

analysis on a first sample and confirmed by a confirmatory factor analysis in a second independent sample. A good fit was observed for the model measuring attentional control (bottom-up vs top-down) along two dimensions (internal vs external distractors), providing solid evidence for the questionnaire's construct. The factor analyses revealed a distinction of attentional control for internal versus external events. Finally, construct validity of the ASQ was confirmed by examining the association between external/internal ASQ scores and questionnaires assessing various situations involving attentional control in the presence of internal or external events or a mix of both.

The finding of distinct attentional dimensions as a function of the internal versus external orientation of the distractor has important implications for the assessment of attentional style, and for attention research more generally. Most research on bottom-up attention typically uses external distractions (Forster & Lavie, 2016; Steve Majerus et al., 2012) while very few studies consider internally generated bottom-up attention (Brewin & Smart, 2005; Kopp, D'Mello, & Mills, 2015). The consideration of internally oriented bottom-up attention would add an additional dimension to the study of attentional processes and their underlying brain networks in healthy individuals. This aspect may also contribute to our understanding of the origin of excessively intrusive thoughts in various psychopathological conditions such as obsessive compulsive disorder or depression, and which may reflect a situation of increased bottom-up attention and decreased top-down attention to internal cognitive and emotional events (Purdon & Clark, 1993; Wenzlaff, Wegner, & Roper, 1988). Furthermore, the integration of attentional control for both internal and external stimuli may be useful during clinical treatments involving attentional processing, such as the "Attention Bias Modification Treatment" aimed at reducing anxiety (for a recent meta-analysis, see Linetzký, Pergamin-Hight, Pine, & Bar-Haim, 2015). The ASQ may be useful as an independent measure of attentional behavior during the monitoring of progression of such treatment.

The present study underlines the role of internally generated content in disrupting attentional control. This finding may have implications for attentional test batteries which mainly consider attention oriented to external stimuli and rarely consider attentional disruption caused by internal events (e.g., TAP; Zimmermann & Fimm, 1994). Indeed, difficulties in attentional control may occur for at least two distinct reasons: a failure to maintain top-down orientation of attention on external stimuli due to fatigue or diminished attentional capacity, or an excessive reactivity of bottom-up attention towards internal thoughts. The ASQ provides an instrument to explore both internal and external attentional control capacity of an individual. Our results suggest that some individuals may show a strong tendency for top-down attentional control of internal stimuli, while showing a more bottom-up attentional style for external stimuli, while other participants may present a reverse combination of attentional control and orientation; other individuals may show a strong top-down attentional control bias for both external and internal events (see Fig. 1). These attentional styles may also interact with broader personality traits such as the tendency of controlling and suppressing emotions and internal cognitive events.

Another interesting application of the present findings concerns the exploration of attentional networks during the resting state. In the absence of any task, neuroimaging studies have shown that neural networks associated with top-down (intraparietal sulci and frontal eye fields) and bottom-up (temporo-parietal junction and ventral frontal cortex of the right hemisphere) attention are activated and show activation fluctuations across time (Fox, Corbetta, Snyder, Vincent, & Raichle, 2006). This spontaneous activity of attentional networks at rest may reflect a priori biases of cognition such as attentional traits or tendencies (Harmelech & Malach, 2013). Individuals may have a preferred attentional state, or attentional style, acting as a baseline. Individuals with a stronger bottom-up attentional style would be more prone to react to unexpected spontaneous stimuli while a predominantly top-down attentional style would facilitate staying on task.

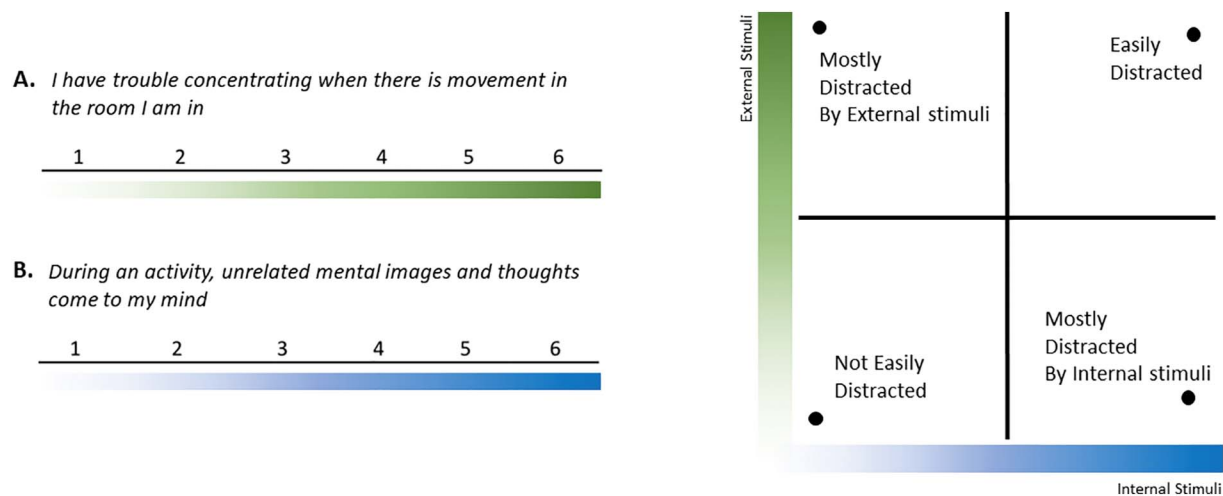


Fig. 1. Example of items measuring attentional style (left) for external stimuli (A) and internal stimuli (B). Examples of attentional style profiles (right) that can be derived from the ASQ.

Attentional style biases at rest are an important topic for future research and its exploration is now made possible by behavioral tools such as the ASQ developed in this study. The combination of measures of functional brain connectivity at rest and reported ASQ scores could inform us about the cognitive function of neural network fluctuations at rest.

Although online recruitment can be more efficient for recruiting large sample sizes (Uhlir et al., 2014) this type of recruitment also has limitations. In our studies, for reasons of privacy, we were unable to verify if our sample included observations other than French-speaking students. The inclusion of such background information has, however, been shown to have only relatively minor effects on the results of online studies (Bethell, Fiorillo, Lansky, Hendryx, & Knickman, 2004; Fontaine, Scherer, & Soriano, 2013; Hohwü et al., 2013; McCambridge et al., 2011). As further limitation of this study is that the questionnaire was developed in French and validated on a French-speaking population and hence the results of this study cannot be generalized to populations speaking other languages. Further research should focus on the adaptation of the ASQ to other languages than French.

In sum, the aim of this study was to develop a questionnaire that measures a person's general tendency of attentional control along a bottom-up – top-down dimension, by distinguishing between internal and external origins of potential distractors. The hypothetical constructs underlying the questionnaire were supported by the factorial structures identified and confirmed in Studies 1–3 and by the validation study (Study 4) comparing the ASQ to other questionnaire measuring various types of attentional behaviour. Further development and validation of the ASQ is necessary for investigating the role and nature of attentional control in everyday life behaviour, and, potentially, in specific personality traits, and for adapting the ASQ to other languages than French.

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