The effect of rumination on mental connections, mind wandering and eye gaze behavior

Dorottya Rusz

ANR: 382862

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Communication and Information Sciences,

Master Track Business Communication and Digital Media,

Faculty of Humanities

Tilburg University

Supervisor: Dr. M. Postma

Second Reader: Dr. M. Goudbeek

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Abstract

Rumination has been linked to attentional bias towards negative information and difficulties in concentration, which is represented by changes in gaze behavior. In the present study we tested the effect of repetitive self-focused thoughts on mental connections in a word association game on a student sample from Tilburg University (N= 61). In the course of the game, participants' eye movements were recorded. Relative to the control condition, participants who were induced to ruminate had more negative associations during the game. Moreover, ruminators reported more task unrelated thoughts. Regarding eye movements, the induction procedure did not show differences between the two conditions. However, rumination measured prior to the experimental manipulation predicted the number of blinks and the reported task unrelated thoughts predicted the number of saccades and the average fixation duration. The results provide evidence for the negative impact of rumination on cognition, which can arguably prolong and exacerbate depression. Moreover, rumination seemed to be a substantial cause of mind wandering. Finally, the increase in the number blinks can be an indicator of the switch from the external world to internal thoughts.

Keywords: rumination, task unrelated thoughts, mind wandering, eye gaze behavior

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Introduction

Sometimes when we read, our eyes are following the lines, but our mind is far away from the here and now, and afterwards, when we try to recall the content, we fail to remember what we were reading about. When a task is not cognitively demanding, our attention can shift away and we become concerned with other thoughts. This phenomenon is called mind wandering (absent mind) and it refers to the state when one's cognitive focus is substituted by other, task unrelated thoughts (Uzzaman & Joordens, 2011).

Although previous studies argued that mind wandering has both positive and negative effects (Mooneyham & Schooler, 2013), the majority of past research particularly stressed the drawbacks of the experience. During mind wandering episodes, due to the lack of attention to the major task, efficient processing of the external information decreases (Smallwood & Schooler, 2006). An absent mind comes at cost, which can undermine everyday performance. In past research mind wandering has been associated with impaired academic performance (Smallwood, Fishman & Schooler, 2007), more specifically with difficulties in concentration, slower response times, poor reading comprehension and errors on a certain task (Mooneyham & Schooler, 2013). The recognized negative impact of mind wandering on performance makes it increasingly important to consider it as a problem that many students face and to investigate what states, moods and situations increase the occurrence of a wandering mind.

Past research implied that a negative, dysphoric mood often leads the mind to wander (Smallwood & O'Connor, 2011; Smallwood, Fitzgerald, Miles & Phillips, 2009). These studies suggested that individuals with high levels of dysphoria and negative mood are more likely to have task unrelated thoughts which leads their minds to wander. Although dysphoric and negative moods are often associated with rumination, none of the previous studies examined a

direct link between rumination and mind wandering. Rumination is a way to respond to distress that includes continuous and passive thoughts about one's own feelings, symptoms and states (Nolen-Hoeksema, 1991). Rumination does not involve active problem solving; thus, people who ruminate are very likely to have excessive negative states, which can create a downward spiral of thoughts that can lead to and exacerbate depression related illnesses. This highly negative inwardly focused mind is likely to lead the attention to drift away from the task at hand. Since this process appears to be highly connected to mind wandering, it is possible that rumination leads the mind to wander.

A wandering mind is measurable through eye movement behavior. Previous research (Uzzaman & Joordens, 2011) suggested that eye gaze behavior is an objective representation of cognitive processes and has linked mind wandering and task unrelated thoughts to slower and less frequent eye behavior. However, no studies have examined the effect of rumination on eye movement behavior. Given the strong linkage between rumination, negative mood, mind wandering and eye gaze behavior, the present study raises the question of whether rumination leads to negative mental connections. We further aim to examine whether rumination increases the occurrence of mind wandering. Finally, we applied eye tracking methodology to investigate whether rumination causes slower and less frequent eye movements.

Theoretical Background

Rumination is characterized by unintentional thoughts that switch one's attention from the main task to other irrelevant thoughts. These irrelevant thoughts are related to the self, in particular to one's own emotions and problems (Nolen-Hoeksema, Wisco & Lyubomorsky, 2008). Examples (Lyubomirsky, Kasri & Zehm, 2003) include thinking about the source of one's distress (e.g., *"What if I can't arrange for childcare"*) or the reason for feeling sad or depressed

(e.g., *"What is wrong with me?"*). According to Nolen-Hoeksema (1991) individuals who ruminate are more likely to focus on their own negative state to an excessive degree, without any intervention to improve their current state. Overall, rumination consists of persistent, repetitive and maladaptive thoughts, which recur around a certain theme (Nolen-Hoeksema, 1991).

Due to the presence of repetitive thoughts, rumination and worry are often confused with each other. Even though they both involve recurring thoughts about a common theme, the most striking difference between worry and rumination is that the former is related to future events, while the latter focuses the attention towards the past. Although worry is more likely to create anxiety and rumination often enhances depression, they both include repetitive thoughts (McLaughlin, Borkovec & Sibrava, 2007). Thinking continuously and passively around a current theme particularly increases negative and dysphoric mood in individuals (Segerstrom, Tsao, Alden & Craske, 2000).

Dysphoria, which refers to depressed and unhappy mood, has been widely linked to rumination (Lyubomirsky et al., 2003; Hertel, 1998; Broderick, 2005), which implies that both rumination and dysphoria consist of excessive self-related concerns that can lead to negative mood and thinking (Nolen-Hoeksema et al., 2008). The negative influence of rumination and dysphoria was widely investigated in depressed clinical samples and generally suggested that self-focused rumination and dysphoria are strongly related to negative affect (Mor, & Winquist, 2002). Lyubomirsky and Nolen-Hoeksema (1995) examined the effect of rumination on thinking and problem solving in dysphoric individuals, emphasizing the negative impact of self-focused thoughts. The authors found that dysphoric ruminators were more likely to engage in negative thinking, to interpret the hypothetical situations negatively and to be more pessimistic about future events. Furthermore, Donaldson, Lam and Mathews (2007), found that depressed

participants who ruminate are more likely to show attentional bias towards negative information. Thus, depressed and clinically treated participants who ruminate are more likely to have negative thoughts and focus their attention towards the negative aspect of the information.

However, rumination also influences the mental connections of people who are not suffering from any chronic depression or anxiety. First, rumination generally increases negative mood in individuals. McLaughlin et al. (2007) instructed participants to focus on their most worrisome or ruminative topics. Self-reported questionnaires revealed that both rumination and worry, enhance negative mood in participants. Second, rumination leads to attentional bias towards negative information. Morrison and O'Connor (2008) conducted a study on a student sample about the effect of rumination on attention. They applied rumination/distraction and mood induction in order to investigate whether participants would focus on negative or positive information. They found that participants primed with negative mood and self-focused rumination were less likely to focus on positive information than participants primed with positive mood or distraction. Third, dysphoria also leads to an attentional bias towards negative information. The study of Bradley, Mogg and Lee (1997) examined how dysphoria affects the attention by exposing participants to three types of words (depression-related, anxiety related and neutral). The authors found that dysphoric (both induced and naturally occurring) individuals are more likely to focus their attention on depression related words than non-dysphoric individuals. Thus, rumination, independent of depression or chronic diseases, has a negative influence on mood and mental connections, which leads people to focus on the negative aspect of the information.

Overall, the results from previous studies (McLaughlin et al., 2007; Morrison and O'Connor 2008; Bradley et al., 1997) suggest that rumination leads to excessive negative

thoughts. Focusing on the negative aspect of certain events and thinking passively and negatively around a certain theme interferes with active problem solving and can prolong and exacerbate negative affect, such as depression (Nolen-Hoeksema, 1991). Previous research examined negative thinking with tasks where the information was already given. Thus, it is clear that when ruminators have to passively focus their attention on a stimulus, they tend to concentrate on the negative aspects of that stimulus. However, it is not clear whether ruminative individuals, who have to engage in active thinking, are also likely to generate negative associations. Therefore, in the present study we used a word association game in order to investigate how rumination affects participants' responses in the game. The first hypothesis of this study is:

H1: Rumination increases the occurrence of negative associations.

Rumination, dysphoria and negative mood often predict the occurrence of shifted attention from the main task towards task unrelated thoughts (Smalwood, O'Connor, Sudbery & Obonsawin, 2007). The occurrence of task unrelated thoughts has been conceptualized in different ways, such as stimulus independent thoughts (Smallwood et al., 2007), an absent mind, or mind wandering (Mooneyham & Schooler, 2013). In general, mind wandering refers to the state when one's attention is drifted away from the current task towards other, irrelevant, private thoughts (Smallwood & Schooler, 2006).

Past research suggested that dysphoria leads the mind to wander. Smallwood et al. (2007) instructed dysphoric and non-dysphoric participants to read words on the computer screen that later they would have to remember. The results suggested that dysphoric individuals tended to focus their attention inwards on their own concerns as the task proceeded. Moreover, dysphoric

participants had long response times, which imply that their attention towards the external information was impaired. Thus, in general the results provided evidence that dysphoria switches the attention away from the external world to self-relevant concerns and leads the mind to wander.

Although dysphoria and rumination are highly connected terms, previous research (Smallwood et al., 2007) only focused on the impact of dysphoria, but did not examine the direct link between rumination and mind wandering. However, there is empirical evidence that implies that self-focused rumination impairs cognitive performance and concentration, which is widely associated with mind wandering. First, rumination has a negative impact on academic performance in general. Lyubomirsky et al. (2003) conducted a study where dysphoric and non-dysphoric participants were randomly assigned to rumination or distraction conditions. Afterwards they had to read a certain text, listen to a videotaped lecture and correct mistakes in a text. The results revealed that dysphoric ruminators reported more difficulties to concentrate, spent more time on the tasks and made more mistakes compared to the distraction condition. Second, self-focused attention, which is a main component of rumination, impairs successful recalling of the information. Hertel (1998) conducted an experiment where dysphoric and non-dysphoric participants were randomly assigned to neutral, unconstrained and self-focused conditions. They were instructed to watch word pairs on a computer screen that they would have to remember afterwards. The results revealed that dysphoric participants who were induced to think about self-relevant items showed impaired memory. Third, rumination impairs switching ability, which is a result of an inwardly focused attention. Koster, De Lissnyder and De Raedt (2013) randomly assigned preselected ruminative and non-ruminative participants to non-emotional and emotional conditions. Participants had to perform an internal shift task, which

measures how quickly one can switch between the stimuli. The results of the experiment revealed that ruminators had reacted more slowly and showed significantly more switching impairments, especially over emotional stimuli. In general, ruminators report more difficulties to concentrate, show impaired memory and longer response times, which are all indicators of mind wandering (Mooneyham & Schooler, 2013).

Considering the strong link between rumination, impaired performance and mind wandering, it is possible that the attention of ruminative individuals is mainly focused on themselves. Thus, they have a great amount of task irrelevant thoughts, and are consequently very likely to engage in mind wandering. Therefore, the second hypothesis of the present study is:

H2: Rumination increases the occurrence of task unrelated thoughts.

Previous research suggested that cognitive processes and personality traits can be detected in eye gaze behavior. A novel and current measurement of behavior, which has been considered objective and can reconcile the discrepancies that can come from applying only subjective measurement, is eye gaze behavior (Uzzaman & Joordens, 2011). The objectivity of recording eye movements derives from the fact that even though individuals can direct their gaze to a certain place, they are entirely unaware of their micro eye movement behavior. Furthermore, it is physically impossible to have control over fixations and saccades (Rayner, 1978). Thus, by recording eye movements we gain access to individuals' cognitive processes and intrinsic motivations.

Research implied that personality traits are biologically determined (MacDonald, 1995), and can therefore influence eye gaze behavior. Rauthmann, Seubert, Sachse, and Furtner (2012)

hypothesized that the Big Five should predict eye movements, independent on the stimulus or other factors. The results demonstrated that neuroticism, whose main component is rumination (Muris, Roelofs, Rassin, Franken, & Mayer, 2005), manifested less fixations and longer fixation durations, indicating a slower processing of information.

Slow eye gaze behavior can also be an indicator of dysphoria, mind wandering and task unrelated thoughts. First, dysphoric individuals are likely to demonstrate fewer fixations. A study by Sears, Thomas, LeHuquet and Johnson (2010) observed dysphoric and non-dysphoric participants' eye movements while they were looking at positive, neutral, anxiety related and depression related pictures. They found that the number of fixations of dysphoric participants were lower in all four types of pictures. Second, when the attention is drifted from the task at hand to unrelated thoughts the eye movements are likely to be less frequent. Uzzaman and Joordens (2011) measured eye movements during a reading task. Results showed that during mind wandering episodes participants had fewer fixation count, saccade count and total number of saccades. Third, the occurrence of task unrelated thoughts can be represented by the increase in the number of blinks. A study by Smilek, Carriere and Cheyne (2010) assumed that blinks (visual interruptions) might indicate a shift from processing external information to internal thoughts. In their experiment, participants had to read a certain text while their eye movements were recorded. The results of this experiment suggested that the number of blinks were significantly higher during periods when participants were thinking about something else than the task. Moreover, they also found that during mind wandering episodes, the eyes fixated less often than during on-task periods. Overall, dysphoric moods and the shifted attention from the main task tend to lead to slower information processing, which will increase the number of blinks and manifest a slower and less frequent micro eye movement behavior.

In sum, neuroticism and dysphoria induce slower eye movements, while task unrelated thoughts lead to an increase in the number of blinks. Considering that rumination is a main component of neuroticism and is highly connected to dysphoria and that rumination causes an inward focus of attention which impairs concentration and increases task unrelated thoughts, it is possible that ruminators will blink more often and will have slower eye movements. The third hypothesis in this study then is:

H3: Rumination increases the number of eye blinks, decreases the number of saccades and fixations and increases the average fixation durations.

Method

Participants

Sixty-two international bachelor and master students were recruited from Tilburg University to participate in the current experiment for no compensation. One participant had to be excluded due to complications with the data saving procedure. The final sample, thus, included 61 participants, 32 females and 29 males, ranging in age from 18 – 33 (*M*= 23.8). Each participant had to fill out a consent form after a brief explanation of the consent of the experiment.

Design

The present experiment used a between participant design. Half of the participants were assigned to rumination condition where they were instructed to think of self-relevant items. The other half of the participants were assigned to distraction condition where they were told to think of a series of neutral items. As dependent variables, self-reported rumination, task unrelated

thoughts, the polarity of the words that participants generated during the word association game and eye movement parameters (number of blinks, saccades, fixations and the average fixation duration) were measured.

Material

In order to assess eye movement behavior an eye tracking device called SMI RED 250 was used in this study (sampling rate: 250 Hz). The computer and the eye tracking device was placed in a soundproof booth (40dB) to make sure that the recordings will not contain any environmental noise. The experimental material was presented on a 22 inch monitor (resolution 1680 x 1050) with a display refresh rate of 60Hz on a #4C759C color background. The distance between the participants and the computer was held constant (approximately 70 cm).

The experiment was set up with E-Prime (Psychological Software Tools Inc, Pittsburgh, Pennsylvania, USA). The stimulus was presented using a male Embodied Interactive Agent (EIA) (created by: Postma-Nilsenová, Brunninkhuis & Postma, 2013) with a male voice (Figure 1). The agent was always presented in a frontal position with directed gaze. He uttered only monosyllabic words with the same facial expression. The sound files were pre-recorded and edited by using Audacity 2.0.3. The words used in this experiment were all related to academic context and presented in a random order (See Appendix A). The sound files were combined with the video (.avi) files, each 5 seconds long. The stimuli were presented in a random order and each stimulus began with a centralized fixation cross. After one second the agent uttered a word, then, the participants had approximately three seconds to answer (see Figure 2). The answers of the participants were recorded.



Figure 1: Male frontal face EIA with directed gaze

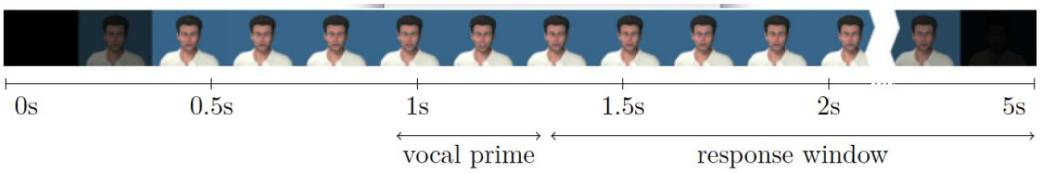


Figure 2: An example of the stimulus material

Instrumentation

Induction of relaxed mood: Before the rumination/distraction induction procedure participants were exposed to a 1,5 minutes long video that showed an aquarium. The purpose of the video was to create a relaxed, neutral mood in participants in order to make the induction procedure efficient. The video was downloaded from YouTube and was cut with Windows Movie Maker. (Source: http://www.youtube.com/watch?v=VIrBecB746c)

Measure of rumination: Participants completed the Rumination Inventory (RI) (McIntosh & Martin, 1992) a ten-item scale (*M*= 4.90, *SD*= 0.76) measuring repetitive and aversive ruminative thoughts (See Appendix B). Participants had to indicate whether the statements (*e.g., "When I have a problem, I tend to think about it a lot of the time"*) describe them well or not (McLaughlin, Borkovec & Sibrava, 2007). The ten item scale was found to be reliable for the first (α = .66) and the second time (α = .75) respectively.

Response manipulation tasks (Induction): The study included two conditions. In the rumination condition participants were instructed to think about self-related statements such as *"why you react the way you do"* that would focus their attention on the self. In the distraction condition the same "think about" 45 item scale was used, however the statements in this case were related to random situations, which do not refer to symptoms, feelings or the self, such as *"a parking lot at a drive in"* (Lyubomirsky et al., 2003). The motivation behind using the distraction condition instead of a control condition can be explained by Response Style Theory (Nolen-Hoeksema, 1991), which suggests that the best way to lead the attention away from self-related issues is to use pleasant or neutral distractions. Moreover, the previously mentioned study by Hertel (1998) also supports the fact that distracting someone from self-related concerns can help to focus the attention on the task. (See Appendix C for the rumination and Appendix D for the distraction induction)

Mind wandering: The thinking component of the Dundee Stress State Questionnaire (Smallwood et al., 2009) was used to assess mind wandering (See Appendix E). This measure is a 16-item scale (M= 2.18, SD= 0.71) that refers to thoughts during a recently completed task. The measure has two parts: one refers to the task related interference, which includes thoughts that were focused on the task performance itself (*e.g., "I thought about the difficulty of the task."*). The other half of the questions refer to thoughts that are not coming from the current context. These are called task unrelated thoughts (*e.g., "I thought about something that happened in the distant past."*). The thinking component of the questionnaire has been widely used in previous research to assess mind wandering after a certain task (Smallwood et al., 2009; Mrazek, Chin, Schmader, Hartson, Smallwood & Schooler, 2011). The 16-item scale was found to be highly reliable (α = .89).

Procedure

Participants were invited via the university mailing system and each of them was told that they would participate in an eye tracking experiment. After arriving at the lab they were given general instructions, signed a consent letter and seated in a soundproof booth. As a first step they were asked to fill out the Rumination Inventory (McIntosh & Martin, 1992). Afterwards, they were exposed to a relaxation video for one and a half minutes in order to create a relaxed, neutral mood. After watching the video, participants were introduced to the response manipulation task (Lyubomirsky et al., 2003). They were instructed to focus their attention on a series of thoughts and ideas that were presented on the screen. After eight minutes the experimenter returned to the booth to give further instructions. In the next phase, the participants' eye movements were recorded. After successful calibration and validation of the eyes, participants were told explicitly to avoid rapid and wide head movements in order to ensure the accurate assessing of the eye gaze behavior. Then, they performed in a word association game with the agent on the computer screen. Participants were exposed to 22 trials in a way that the frontal face digital male avatar uttered a certain word that participants had to respond to as quickly as possible with the first word that came to their minds. Afterwards, participants filled out the Dundee Stress State questionnaire to assess task unrelated thoughts and the Rumination Inventory for the second time. Finally, all participants were debriefed and thanked for their participation. The entire study took about 20 minutes.

Data analysis

Prior to the lexical analysis several words had to be adjusted in order to be recognized by the semantic analysis tools. Words in the past tense had to be modified to present tense and plural words had to be changed to their singular form. When the response of the participants

contained more than one word (e.g., “hard work”), the words were analyzed separately, and both words were included in the final analysis. When they were undecided about their answers and said multiple words, always the first word was analyzed (e.g., “words/limit/word limit”).

The polarity (positive/negative) of the words were analyzed by the online version of LIWC (Linguistic Inquiry and Word Count), a text analysis software that is widely used in a broad range of experimental settings to evaluate emotionality. The tool divides words in psychologically meaningful categories (Tausczik & Pennebaker, 2010). After typing the words in, the program provides the percentage of positive and negative emotions. The words the participants came up with during the experiment were entered separately for each individual. In the LIWC, the compound words, such as “give up”, are analyzed as two single entries. This can clearly weaken the results, because “give up” is a word with negative connotation in everyday language, however when it is analyzed separately (“give” and “up”), it is considered neutral in the LIWC.

In order to increase the validity of the measurement, the words were analyzed by a second tool called SentiWordNet, a publicly available lexical source for opinion mining. SentiWordNet determines the polarity of a word by assigning three numbers to it, the positivity, negativity and the objectivity of a word that are always added up to one (Esuli & Sebastiani, 2006). In this tool, contrary to the LIWC, compound words are recognized as single entries, which can provide more detailed results about the participants’ responses.

Results

Prior to the analysis, descriptive statistics (*M, SD,* α) for the self-reported questionnaires of rumination (measured before (I.) and after (II.) the experiment), task unrelated thoughts, eye

movement parameters and the polarity of the words were measured divided by condition (see Table 1).

Table 1

Descriptive Statistics for Self-reported Rumination, Task Unrelated Thoughts, Eye Movements and the polarity of the words in the Rumination and Distraction Conditions (N=61).

Variables	*M* (Rumination)	*M* (Distraction)	*SD* (Rumination)	*SD* (Distraction)	*α*
Tests					
Rumination I. [a]	4.90		0.76		.66
Rumination II.	5.05	4.57	0.84	0.85	.75
Task unrelated thoughts	2.39	1.98	0.76	0.61	.89
Eye movements					
Blinks	2.90	2.67	2.25	1.60	
Saccades	11.65	10.68	5.69	5.59	
Fixations	10.13	10.25	4.06	4.36	
Average fixation duration [b]	.64	.62	0.37	0.25	
Polarity of the words					
	Mdn	*M*	*Mdn*	*M*	
Positive (LIWC)	1.35	5.28	4.55	5.20	8.35	6.00
Negative (LIWC)	9.31	10.86	5.26	6.96	8.88	6.93
Positivity (SWN)	.05	.07	.07	.08	0.04	0.04
Objectivity (SWN)	.78	.76	.82	.80	0.12	0.12
Negativity (SWN)	.08	.20	.05	.06	0.62	0.05

Note:
[a] *For the first rumination questionnaire the overall mean was reported.*
[b] *The average fixation duration was reported in seconds.*

In order to investigate whether the induction procedure was effective, a mixed design ANOVA with the rumination scores as within-subjects (Rumination I, II) and the conditions (rumination vs. distraction) as between subjects was conducted. The between subject factor revealed a significant main effect of condition in the rumination scores, $F(1,59)= 4.50$, $p= .038$, $\eta p^2= .071$.

To analyze the differences in task unrelated thoughts between the two conditions an independent *t*-test was conducted. The results indicated that participants in the rumination condition ($M = 2.39$, $SD = 0.76$) engaged in significantly higher levels of task unrelated thoughts than participants in the distraction condition ($M = 1.98$, $SD = 0.61$), $t(59) = 2.33$, $p = .024$).

In order to examine how conditions affected eye movements, an independent *t*-test was computed. The results showed that there was no significant difference between the number of blinks in the rumination ($M= 2.90$, $SD= 2.25$) and in the distraction condition ($M=2.68$, $SD= 1.60$); $t(59)= 0.45$, $p= .655$. The results also indicated that there was no significant difference in the number of saccades between the rumination ($M= 11.65$, $SD= 5.69$) and the distraction ($M= 10.68$, $SD= 5.59$) conditions; $t(59)= 0.67$, $p= .507$. Moreover, no significant results were found with respect to the number of fixations between the experimental ($M= 10.13$, $SD= 4.06$) and the control ($M= 10.25$, $SD= 4.36$) conditions; $t(59)= - 0.11$, $p= .914$. Finally, the average fixation duration did not show significant differences between the rumination ($M= .64$, $SD= 0.37$) and the distraction condition ($M= .62$, $SD= 0.25$; $t(59)= 0.25$, $p= .806$.

Prior to the analysis, a Pearson's product-moment correlation coefficient was computed to assess the relationship between rumination, task unrelated thoughts and the eye movement parameters (number of blinks, saccades, fixations). Intercorrelations can be found in Table 2 in Appendix F.

There was a marginally significant weak positive correlation between rumination and task unrelated thoughts (r= .250, p= .052). Moreover, the number of blinks were significantly correlated with rumination (r= .257. p= .045). Task unrelated thoughts were positively correlated with the number of saccades (r= .347, p= .006) and negatively correlated with the average fixation duration (r= -.267, p= .038). Furthermore, a positive correlation was found between the number of blinks, the number of saccades (r= .363, p= .004) the number of fixations (r= .333, p= .009). Finally the number of fixations and saccades were also positively correlated (r= .905 p= .000).

Furthermore, a Kendall's tau correlation was used to investigate the relationship between self-reported rumination, task unrelated thoughts, the eye movement parameters and the polarity of the words. A positive significant correlation was found between the negativity score on the SentiWordNet (SWN) and task unrelated thoughts (r= .179, p= .045), the number of blinks (r= .247, p= .005) and the number of saccades (r= .215, p= .015). Moreover, the negativity score on the LIWC was significantly related to the second rumination scores (r= .181, p= .049) and the number of blinks (r= .197, p= .030). Finally, the results of the lexical analysis tools showed consistency. First, the positivity score on the LIWC significantly positively correlated with the positivity scores on the SWN (r= .510, p= .000). Second, the negativity scores on the LIWC and the SWN were also significantly correlated (r= .628, p= .000).

Multiple regression analysis was used to test whether rumination, task unrelated thoughts and the conditions significantly predicted participants' eye movements. The results of the regression indicated that rumination explained 6.6 % of the variance of the number of blinks (R^2= .05, F(1,59)= 4.18, p= .045). Moreover rumination significantly predicted the number of blinks (β= .26, p= .045) when task unrelated thoughts and the conditions were not included in the

analysis. The results of the regression coefficients of the predictors regarding the number of blinks are shown in Table 3.

Table 3

The Predictors of the Number of Blinks

		b	*SE b*	*β*	*P*
Blinks					
Step 1					
	Constant	-.42	1.58		.794
	Rumination	.65	.32	.26	.045
Step 2					
	Constant	-.72	1.63		.661
	Rumination	.59	.33	.23	.082
	TUT	.29	.35	.11	.409
Step 3					
	Constant	-.88	1.80		.628
	Rumination	.60	.34	.24	.083
	TUT	.31	.37	.12	.397
	Condition	.11	.52	.03	.829

Note. R^2= .07 for Step 1: ΔR^2= .01 for Step 2: ΔR^2= .00 for Step 3.
Note: F= 4.18* for Step 1: ΔF= .69 for Step 2: ΔF= .05 for Step3.
**.F change is significant at the level 0.01
*. F change is significant at the level 0.05

The results of the analysis also indicated that task unrelated thoughts explained 14.4% of the variance (R^2= .11, F(1,58)= 4.81, p= .012) and was a significant predictor of the number of saccades when rumination was also included in the analysis (β= .31, p= .017). The results of the regression coefficients of the predictors regarding the number of saccades are shown in Table 4.

Table 4

The Predictors of the Number of Saccades

	B	*SE b*	*β*	*P*
Saccades				
Step 1				
Constant	2.85	4.63		.541
Rumination	1.70	.93	.23	.074
Step 2				
Constant	.34	4.56		.941
Rumination	1.13	.93	.15	.227
TUT	2.43	.99	.31	.017
Step 3				
Constant	-.35	5.04		.945
Rumination	1.19	.95	.16	.217
TUT	2.51	1.03	.32	.018
Condition	.48	1.45	.04	.743

Note. R^2= .05 for Step 1: ΔR^2= .09 for Step 2: ΔR^2= .00 for Step 3.
Note: F= 3.30 for Step 1: ΔF= 6.03* for Step 2: ΔF= .11 for Step3.
**.F change is significant at the level 0.01
*. F change is significant at the level 0.05

Regarding the number of fixations none of the predictors demonstrated significant results. The results of the regression coefficients of the predictors regarding the number of fixations are shown in Table 5.

Table 5

The Predictors of the Number of Fixations

	b	*SE b*	*β*	*P*
Fixations				
Step 1				
Constant	5.37	3.48		.128
Rumination	.98	.70	.18	.167
Step 2				
Constant	4.32	3.55		.229
Rumination	.75	.72	.14	.306
TUT	1.02	.77	.18	.189
Step 3				
Constant	3.03	3.91		.442
Rumination	.85	.73	.15	.255
TUT	1.18	.80	.20	.144
Condition	.90	1.12	.11	.429

Note. R^2= .03 for Step 1: ΔR^2= .03 for Step 2: ΔR^2= .01 for Step 3.
Note: F= 1.96 for Step 1: ΔF= 1.77 for Step 2: ΔF= .64 for Step3.
**.F change is significant at the level 0.01
*. F change is significant at the level 0.05

Finally, task unrelated thoughts explained 9.8% of the variance (R^2= .05, F(1,59)= 2.07, p= .044) and significantly predicted the average fixation duration when both rumination and the condition were included (β= -.28, p= .044). The results of the regression coefficients of the predictors regarding the average fixation duration are shown in Table 6.

Table 6

The Predictors of Average Fixation Duration

	b	*SE b*	*β*	*P*
Average fixation duration				
Step 1				
Constant	.95	.26		.001
Rumination	-.07	.05	-.16	.215
Step 2				
Constant	1.06	.26		.000
Rumination	-.04	.05	-.10	.442
TUT	-.11	.06	-.24	.068
Step 3				
Constant	1.19	.29		.000
Rumination	-.05	.05	-.12	.350
TUT	-.12	.06	-.28	.044
Condition	-.09	.08	-.14	.296

Note. R^2= .11 for Step 1: ΔR^2= .10 for Step 2: ΔR^2= .04 for Step 3.
Note: F= 6.10* for Step 1: ΔF= 6.33* for Step 2: ΔF= 2.61 for Step3.
**.F change is significant at the level 0.01
*. F change is significant at the level 0.05

In order to assess the difference in the negativity of the words between the rumination and the distraction condition a Mann-Whitney Test was computed. When we compared the scores provided by the LIWC, the results of the test indicated that participants came up with marginally significantly more negative words in the experimental (*Mdn*= 9.31) than in the control condition (*Mdn*= 5.26), *U*= 331.00, *z*= -1.94, *p*= .052, *r*= -.25. The scores from SentiWordNet showed consistent results with the LIWC. The negativity scores of the words were significantly higher in the rumination condition (*Mdn*= .08) than in the distraction condition (*Mdn*= .05), *U*= 307.00, *z*= -2.28, *p*= .023, *r*= -.29.

Discussion

The primary aim of this paper was to investigate how rumination affects negative thinking and mind wandering. Moreover, we used eye tracking methodology in order to test whether rumination has an effect on eye gaze behavior. It was expected that rumination increases the occurrence of negative word associations and leads to more task unrelated thoughts during a certain task. Furthermore, we hypothesized that rumination would increase the number of blinks, decrease the number of saccades and fixations and will finally result in longer fixation durations.

Consistent with the first hypothesis, participants in the rumination condition generated more negative associations than in the distraction condition. Thus, those who were induced to think about their own states, symptoms and feelings were more likely to have negative thoughts than those who were instructed to think about unrelated items to the self. This finding highly corroborates and extends previous studies that emphasized the negative effect of rumination on cognition. This study confirms that when people are mainly concerned with themselves and their attention is inwardly directed, they do not only focus on the negative aspect of the given information, but also have negative thoughts and emotions, which are manifested in their words.

The self-focused, repetitive thoughts lead people to interpret certain events negatively, which in a long term can prolong and exacerbates depression (Nolen-Hoeksema, 1991).

With regards to the second hypothesis, participants who were induced to ruminate had more task unrelated thoughts than participants in the distraction condition. The majority of past research (Smallwood et al., 2007; Smallwood et al., 2009; Hertel, 1998; Lyubomirsky et al., 2003) suggested that rumination impairs concentration only with the presence of negative, dysphoric mood. The results of the current study showed consistency with past research, however, it took out the negative or dysphoric mood induction and demonstrated that rumination, independent of mood and dysphoria, can cause absent mindedness. The present study made progress in understanding the underlying reasons for poor performance. It is clear that rumination leads the mind to wander, which has a negative effect on performance since it impairs the efficient processing of external information. Our results demonstrated that the students in our sample were generally high on rumination, which can lead us to assume that rumination might be a generally present phenomenon among students. The ubiquitous nature of rumination makes it important to pay particular attention to it as a potential facilitator of an absent mind, especially in education, where concentration is mostly needed. Thinking about one's own feelings, symptoms and concerns leads the attention inward, which impairs concentration and in a long term can undermine academic performance.

The third hypothesis postulated that gazing behavior changes under rumination. Contrary to the expectations, the present study did not find significant difference between the number of blinks, saccades, fixations and the average fixation duration between the two conditions. To further investigate eye movements we tested whether rumination measured prior to the experiment predicts eye gaze behavior. We found that pre-existing levels of rumination

significantly predicted the number of blinks. It has been suggested that the increase in blinks might represent mental workload. Thus, when one has to concentrate on multiple tasks at the same time, the number of blinks might increase (Recarte, Pérez, Conchillo & Nunes, 2008). Moreover, Smilek et al. (2010) suggested that blinks can be indicators of the switch from processing external information to internal thoughts. It might be the case that people who ruminate during a task focus their attention on the external stimuli and their internal thoughts at the same time. Therefore, they might experience a high cognitive workload, which can be detected by the high number of blinks. The results further revealed that task unrelated thoughts significantly predicted the number of saccades and the average fixation duration. Contrary to the expectations, the number of saccades increased and the fixation durations decreased with the number of task unrelated thoughts.

The rejection of the third hypothesis can be explained with practical matters. These rather contradictory results may be due to the nature of the lab task that was applied in this study. Previous research suggested that mind wandering is more likely to occur in "functionally transparent" tasks (Smallwood et al., 2007). A functionally transparent task refers to an activity that individuals perform without even being aware of its little facets (e.g., reading, driving). These are usual practices, not cognitively demanding and one does not need to focus on performance. These tasks, contrary to highly demanding tasks, require less working memory resources, so there are relieved resources that can be used for something else than the task. Since mind wandering requires these free working memory resources, it is more likely to occur when performing an automatic, less demanding, functionally transparent task (Smallwood & Schooler, 2006). Previous studies that measured eye movements mostly used functionally transparent tasks, such as reading. The word association game that we used in our experiment cannot be considered

as functionally transparent, since one had to actively participate in the game and draw full attention in order to come up with new words every five seconds. Thus, the eye movements that were measured in previous studies (Uzzaman & Joordens, 2011; Smilek et al., 2010) might have been specifically present only during functionally transparent tasks. Moreover, the eye movements in previous research were measured only on reading tasks (Uzzaman & Joordens, 2011; Smilek et al., 2010), which require high visual processing of information. In the present study, we recorded eye movements during a word association game whose nature differs from reading and does not require a visual processing of the information on the screen. Hence, participants only had to look at the computer screen, but did not have to visually process any information from it. It could be that the eye movement parameters, which were measured in past research, only apply to tasks that are not cognitively demanding and that require high visual information processing. For tasks such as the word association game, different eye movement parameters should be established.

Future implications

People often suffer from difficulties in concentration, which can negatively influence everyday performance, especially in academic context. These difficulties might be due to the vicious cycle of rumination. Constantly and repetitively thinking on one's own states can lead the mind to wander. Previous research (Lyubomirsky et al., 2003; Hertel, 1998) widely recommended that distracting one from thinking of the self can help to lead the attention back from the internal thoughts to the current task, and thus, can lead to better concentration and performance. The present study corroborates this concept. We found evidence that at the end of the experiment participants both in the rumination and in the distraction condition ruminated less. The word association game was cognitively demanding and required participants to actively

participate. The exciting and the challenging nature of the task might have distracted participants and temporarily eliminated negative and repetitive thoughts.

A number of limitations should be borne in mind when considering the results of this study. First of all, the experiment was conducted in English, which was a second language for the majority of the participants. A word association game requires fluency and a wide range of vocabulary. Even though all the participants' language of study is English, which led us to assume that they all had high proficiency, they might have found it difficult to come up with a word that can truly represent their current state of mind. Second, we found that the sample on average was high on rumination, thus, low and high-ruminators could not be compared in this study. This can clearly lead us to draw false conclusions. Third, mind wandering or task unrelated thoughts were only assessed by self-report questionnaires, which could have limited the results. An absent mind is difficult to recreate and thus to measure in experimental settings and most of the existing methods seem to have deficiencies (Smallwood et al., 2007). Retrospective self-report methods rely on the participants own opinion regarding how they performed during a certain task who are not always capable of monitoring themselves. Some participants might have avoided giving honest answers in order not to be seen in a bad light. For example they might have not wanted to admit that they had been mind wandering instead of concentrating on the task at hand. Moreover, other existing methods, such as "probe-caught" or "self-caught" mind wandering, where participants are randomly stopped during a task and asked about their experiences, are too disruptive and subjective. Overall, mind wandering is a phenomenon that is difficult to measure in experimental settings and it is particularly important to combine different methods to increase the reliability of the results (Smallwood & Schooler, 2006).

Future research should take into consideration and build on the limitations of the present study. First, an experiment that contains a word association game should be conducted in the mother tongue of the participants in order to gain a better insight of mental connections and to avoid biases that may derive from language deficiencies. Second, the present study could not preselect high and low ruminators due to time constraints. However, because rumination is considered as a stable personality trait, it is highly recommended to distinguish ruminators and non-ruminators prior to the experiment. By preselecting participants we can make a comparison between high and low ruminators, which can further strengthen the results. Finally, mind wandering or task unrelated thoughts should be measured in multiple ways in a future experiment. Smallwood et al. (2009) suggested that the lab task itself can also function as a measure of mind wandering. Future research could apply a reading task that can fulfill the definition of a functionally transparent task, since it is automated and skilled in individuals. Moreover, reading is visually demanding like all the tasks that were used in previous research to measure mind wandering. By using a reading task, eye movement parameters could be compared between high and low ruminators. Furthermore, apart from retrospective self-report questionnaires, mind wandering could further be assessed in an indirect way. Previous research (Smallwood & Schooler, 2006) implied that during mind wandering the external information processing is superficial. Moreover, people who mind wander spend more time on a certain task. Thus, by applying a content recalling task and measuring the time spent on task, we could indirectly examine the occurrence of mind wandering. In sum, reading as a lab task provides a wide range of possibilities to measure mind wandering that is highly recommended for future research.

Since mind wandering is a ubiquitous phenomenon and so far very few studies have examined the predictors of it (Smallwood et al., 2007; Smallwood et al., 2009), a novel research direction could further investigate what other factors or situations might increase the occurrence of an absent mind. It is already clear that during mind wandering the attention is shifted from the main task to other irrelevant concerns (Smallwood & Schooler, 2006). This process seems to show similarities with the cognition during multitasking, which refers to the act of performing several tasks at the same time (Salvucci, Taatgen & Borst, 2009). During multitasking individuals can experience cognitive overload (Carr, 2010), which means that the working memory becomes overtaxed with information, and loses the capability to store information in the long term memory. Carr (2009: 11) suggested that in this case it is very difficult to differentiate between relevant and irrelevant information and thus, people become "*mindless consumers"* of the information. It could be the case that cognitive overload, keeping too many pieces of information in the working memory can lead the mind to wander, which can be represented by eye movement behavior, such as the number of blinks. Due to the fast proliferation of mobile technology more and more people engage in multitasking during work and studying (Salvucci et al., 2009), which scatters the attention that can impair concentration. Therefore, the connection between multitasking and mind wandering could give a breeding ground for future research.

Conclusion

The current study presented evidence of the link between rumination, negative thinking and mind wandering. The downward spiral of rumination leads people to create negative associations and have more task unrelated thoughts, which can be the underlying cause of poor performance. The present study corroborated previous studies and filled the research gap regarding the direct effect of rumination on mind wandering. The results revealed that

rumination, without the induction of negative mood, can increase the occurrence of task unrelated thoughts. Moreover, rumination increased the number of blinks, which can be an indicator of the presence of internal thoughts and the shifted attention from the external world towards the self. The present research is consistent with past studies in emphasizing the negative effect of rumination and its influence of an absent mind and further provides research directions that can be implied in future studies.

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Appendix A

Words used in the word association game:

1. add
2. class
3. drop
4. teach
5. effort
6. essay
7. test
8. exam
9. fail
10. goal
11. grade
12. group
13. time
14. mark
15. notes
16. pass
17. point
18. quiz
19. rules
20. school
21. work
22. write

Appendix B

Ruminations Inventory

DIRECTIONS: Indicate how well each of the statements below describes you by filling in the appropriate number.

1. I seldom think about things that happened in the past.

   Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

2. I often get distracted from what I am doing with thoughts about something else.

   Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

3. If I don't want to think about something, I'm able to just stop thinking about it.

   Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

4. I often think about what my life will be like in the future.

   Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

5. When I have a problem, I tend to think about it a lot of the time.

   Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

6. I often become "lost in thought".

   Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

Me Well

7. When I know that I am going to have an important talk or an argument with someone in the near future, I rehearse in my mind what I will say and what they will probably say in response.

Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

8. Sometimes I feel like I have no control over my thoughts.

Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

9. I have no trouble focusing all of my attention on one thing.

Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

10. When I don't understand something that happens, I tend to run it over in my mind until I can make sense out of it.

Does not Describe Me Well A/1 : B/2 : C/3 : D/4 : E/5 : F/6 : G/7 Describes Me Well

Appendix C

Rumination Induction

PACKET B: IMAGINING IDEAS (TIMED TASK)

Instructions:

For the next few minutes, try your best to focus your attention on each of the ideas on the following pages.

Read each item slowly and silently to yourself. As you read the items,use your imagination and concentration to focus your mind on each of the ideas. Spend a few moments visualizing and concentrating on each item.

Please continue until the experimenter returns.

Think about:

1. the physical sensations you feel in your body
2. your character and who you strive to be
3. the degree of clarity in your thinking right now
4. why you react the way you do
5. the way you feel inside
6. the possible consequences of your current mental state
7. how similar/different you are relative to other people
8. what it would be like if your present feelings lasted
9. why things turn out the way they do
10. trying to understand your feelings
11. how awake/tired you feel now
12. the amount of tension in your muscles
13. whether you are fulfilled
14. your physical appearance
15. whether you feel stressed right now
16. the long-term goals you have set
17. the amount of certainty you feel
18. your present feelings of fatigue/energy
19. possible explanations for your physical sensations
20. how hopeful/hopeless you are feeling
21. the level of motivation you feel right now
22. the degree of helplessness you feel
23. the degree of calmness/restlessness you feel
24. the possible consequences of the way you feel

25. what your feelings might mean
26. how sad/happy you are feeling
27. the expectations your family has for you
28. why your body feels this way
29. why you get this way sometimes
30. how passive/active you feel
31. what people notice about your personality
32. the kind of student you are and wish you were
33. how weak/strong your body feels now
34. the degree of relaxation/agitation you feel
35. the kind of person you think you should be
36. the degree of control you feel right now
37. what would happen if your current physical state lasted
38. sitting down and analyzing your personality
39. why you turned out this way
40. the things that are most important in your life
41. how quick/slow your thinking is right now
42. the degree of decisiveness you feel
43. trying to understand who you are
44. how you feel about your friendships
45. whether you have accomplished a lot so far

Appendix D

Distraction Induction

PACKET B: IMAGINING IDEAS (TIMED TASK)

Instructions:

For the next few minutes, try your best to focus your attention on each of the ideas on the following pages.

Read each item slowly and silently to yourself. As you read the items, use your imagination and concentration to focus your mind on each of the ideas. Spend a few moments visualizing and concentrating on each item.

Please continue until the experimenter returns.

Think about:

1. and imagine a boat slowly crossing the Atlantic
2. the layout of a typical classroom
3. the shape of a large black umbrella
4. the movement of an electric fan on a warm day
5. raindrops sliding down a windowpane
6. a double-decker bus driving down a street
7. and picture a full moon on a clear night
8. clouds forming in the sky
9. the layout of the local shopping center
10. and imagine a plane flying overhead
11. fire darting around a log in a fire-place
12. and concentrate on the expression on the face of the Mona Lisa
13. a parking lot at a drive-in
14. two birds sitting on a tree branch
15. the shadow of a stop sign
16. the layout of the local post office
17. the structure of a high-rise office building
18. and picture the Eiffel Tower
19. and imagine a truckload of watermelons
20. the pattern on an Oriental rug
21. the “man in the moon”
22. the shape of the continent of Africa
23. a band playing outside
24. a group of polar bears fishing in a stream

25. the shape of the torch on the Statue of Liberty
26. the shape of the state of California
27. the way the Grand Canyon looks at sunset
28. the structure of a long bridge
29. a train stopped at a station
30. a lone cactus in the desert
31. the shape of the country of Italy
32. a row of shampoo bottles on display
33. a gas station on the side of a highway
34. the fuzz on the shell of a coconut
35. the Presidents' faces on Mount Rushmore
36. and picture the UCR watch tower
37. a band playing "The Star Spangled Banner"
38. the shape of a cello
39. a puddle in the middle of a sidewalk
40. the shape of the United States
41. the baggage claim area at the airport
42. the size of the Statue of Liberty
43. the shape of a baseball glove
44. a freshly painted door
45. the shiny surface of a trumpet

Appendix E

Dundee Stress State Questionnaire (Thinking Component measuring Task Unrelated Thoughts and Task Related Interference)

The following set of questions concerns the kinds of thoughts that go through people's heads during a task. Please indicate how often you had each thought during the test.

1 – Never 2 – Once 3 – A few times 4 – Often 5 – Very Often

1.	I thought about how I should work more carefully.	1 2 3 4 5
2.	I thought about how much time I had left.	1 2 3 4 5
3.	I thought about how others have done on the task.	1 2 3 4 5
4.	I thought about the difficulty of the task.	1 2 3 4 5
5.	I thought about my level of ability.	1 2 3 4 5
6.	I thought about the purpose of the experiment.	1 2 3 4 5
7.	I thought about how I would feel if I were told how I performed.	1 2 3 4 5
8.	I thought about how often I get confused.	1 2 3 4 5
9.	I thought about members of my family.	1 2 3 4 5
10.	I thought about something that made me feel guilty.	1 2 3 4 5
11.	I thought about personal worries.	1 2 3 4 5
12.	I thought about something that made me feel angry.	1 2 3 4 5
13.	I thought about something that happened earlier today.	1 2 3 4 5
14.	I thought about something that happened to me days ago.	1 2 3 4 5
15.	I thought about something that happened in the distant past.	1 2 3 4 5
16.	I thought about something that might happen in the future.	1 2 3 4 5

Appendix F

Table 2

Intercorrelation Matrix among Self-reported Rumination, Task Unrelated Thoughts, Eye Movement Parameters and the polarity of the words

Variables	1	2	3	4	5	6	7	8[b]	9[b]	10[b]	11[b]	12[b]
Tests												
1. Rumination												
2. Rumination II.	.842**											
3. Task unrelated thoughts	.250	.261*										
Eye movements												
4. Number of blinks	.257*	.100	.166									
5. Number of saccades	.230	.096	.347**	.363**								
6. Number of fixations	.179	.068	.209	.333**	.905**							
7. Average fixation duration	-.161	-.031	-.267*	-.478**	-.771**	-.779**						
Polarity of the words												
8. Positivity (SWN)	.040	.026	.048	.060	.066	-.088	-.050					
9. Objectivity (SWN)	-.098	-.083	-.163	-.079	-.085	-.019	.127	-.267**				
10. Negativity (SWN)	.045	.136	.179*	.247**	.215*	.145	-.210*	.090	-.371**			
11. Positive (LIWC)	.055	-.011	.038	.022	-.041	-.113	.025	.510**	-.272**	.122		
12. Negative (LIWC)	.123	.181*	.130	.197*	.169	.122	-.184*	-.023	-.289**	.628**	.084	

**.Correlation is significant at the level 0.01 (2-tailed)
*. Correlation is significant at the level 0.05 (2-tailed)
[a] Bivariate Pearson Correlation
[b] Bivariate Kendall's tau Correlation