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Examining the influence of mind wandering and metacognition on creativity in university and vocational students☆

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ABSTRACT

We examined the relationship between mind wandering, metacognition and creativity in 116 university and 117 vocational Chilean students. They took a test of divergent thinking, a test of creative problem solving and a fluid intelligence test. Additionally, they answered mind wandering, metacognition, and reading difficulties self-report scales. We performed multivariate analyses of variance, hierarchical regression models and tests of moderation. Fluid intelligence predicted performance on both creativity tests. The reading difficulties scale predicted the test of creative problem solving but not the test of divergent thinking. Mind wandering significantly predicted both creativity measures above the contribution of fluid intelligence and reading difficulties. Metacognition did not significantly predict the measures of creativity. The type of school where the participants studied moderated the effect of metacognition on creativity. We discuss the implications of these results for research and assessment on mind wandering, metacognition and creativity.

1. Introduction

During the last decade there has been an increased interest in investigating the nature of mind wandering, its biological foundations and its impact on cognitive processing (Smallwood & Schooler, 2006; Smallwood, Schooler, & Fiske, 2015). Despite these advances, the educational consequences of mind wandering are yet to be fully recognized and explored (Immordino-Yang, Christodoulou, & Singh, 2012). Most of the educational research on mind wandering has emphasized its negative consequences, especially on academic tasks requiring a strong attentional component (Smallwood, Fishman, & Schooler, 2007). That is not surprising. School learning is highly dependent on focused and sustained attention and mind wandering is "a situation in which executive control shifts away from a primary task to the processing of personal goals" (Smallwood & Schooler, 2006, p. 946). When mind wandering, the student's attentional focus shifts away from those stimuli relevant for learning or assessment.

Since mind wandering is more frequent during instruction than other activities, several studies have explored the impact of mind wandering on learning from a lecture (Szpunar, Moulton, & Schacter, 2013). As the time passes during a lesson, mind wandering increases and memory for content diminishes (Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2012). And as the frequency of self-reported task unrelated images and thoughts augments during lectures, students display worse academic performance in course examinations (Lindquist & McLean, 2011). Learning from a lecture is not the only educational process affected by mind wandering. It negatively impacts performance on standardized academic achievement tests (Mrazek et al., 2012), affects the ability to build a mental model of a narrative (Smallwood, McSpadden, & Schooler, 2008) and impairs reading comprehension, especially of difficult texts (Feng, D'Mello, & Graesser, 2013). Specifically, the detrimental effects of mind wandering on reading are heightened in situations where participants lack comprehension-monitoring strategies (Smallwood et al., 2007).

This view of mind wandering as harming educational performance is consequence of a bias associated with the study of cognition in terms of information processing in analytical tasks, which is characteristic of the study of human abilities (Sternberg, 1999; Sternberg & Grigorenko, 2000). As noted below, this emphasis on the impact of mind wandering on analytical tasks ignores its deep neurobiological roots, its prevalence, and its role in creativity (Baird et al., 2012). Depending on both the nature of the task and the individuals' meta-cognitive and regulatory capacities, mind wandering not only has costs but also potential benefits (McMillan, Kaufman, & Singer, 2013; Schooler et al., 2011). Unless a more diverse picture of relevant educational tasks and activities considered, our knowledge of the impact of mind wandering will remain

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limited. In order to contribute to the growing literature addressing its educational consequences, this study investigates the impact of mind wandering on divergent thinking and creative problem solving. Additionally, it assesses whether this impact is similar or opposite to that of metacognition.

1.1. Mind wandering and creativity

Mind wandering is not a monolithic phenomenon with purely negative consequences. Thus, a number of researchers have begun to uncover positive aspects of this process (e.g., Baird, Smallwood, & Schooler, 2011; Baird et al., 2012; Cosmelli & Preiss, 2014; Feng et al., 2013; Mooneyham & Schooler, 2013). Emphasis on the constructive dimension of mind wandering is not new. It was initially highlighted by work advanced during the 60s and 70s by Jerome Singer and his colleagues (McMillan et al., 2013). Today, three lines of research show that mind wandering is not simply a disruptive process or a mere epiphenomenon of mental life. Quite the contrary, they show that it plays an adaptive psychological role. These include work on its neurobiological roots, its resilience in everyday life, and its positive consequences on creativity.

First, substantial evidence points to the deep neurobiological roots of mind wandering. Researchers have described what is now known as the brain's default network, a baseline default mode of brain function during the awake but resting state that shows reduced activity during specific goal-directed behaviors (Gusnard, Akbudak, Shulman, & Raichle, 2001; Raichle & Snyder, 2007; Raichle et al., 2001). The activity of this brain network correlates with self-referential emotionally charged thoughts (Gusnard et al., 2001), is associated to the evaluation of possible future scenarios (Buckner, Andrews-Hanna, & Schacter, 2008) and is increased during periods of mind wandering (Gusnard et al., 2001). Furthermore, it has been observed that neuronal connectivity between these regions correlate positively with general intelligence and creativity (Takeuchi et al., 2011a). Additionally, more creative individuals maintain a higher level of activity in the posterior regions of the brain network when performing working memory tasks (Takeuchi et al., 2011b). Second, mind wandering is extremely resilient in a diversity of conditions, both everyday and experimental. The seminal studies of daydreaming (McMillan et al., 2013; Pope & Singer, 1978; Singer, 1974, 1975) as well as more recent work (Kane et al., 2007), suggest that people are in a state of mind wandering a large part of their waking time. Mind wandering and thoughts unrelated to the task never disappear in experimental conditions where participants must perform complex or demanding tasks (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; McVay & Kane, 2012).

Yet, "not all mind wandering is created equal" (Seli, Carriere, & Smilek, 2015, p. 750). There are individual differences concerning mind wandering's characteristic contents and these differences are relevant to assess how adaptive mind wandering is. Singer (1975), using the Imaginal Processes Inventory (McMillan et al., 2013), classified mind wandering in three types: two more negative, focused either on tortured self-examination or anxious self-doubting, and one more positive, reflecting an acceptance of inner experience and elaborated imagery and fantasy, probably more related to creativity. A more recent distinction is that between intentional (or deliberate) versus unintentional (or spontaneous) mind wandering (Seli et al., 2015). The former is characteristic of creative work: artists and creative writers are prone to engage in volitional daydreaming (McMillan et al., 2013). Not surprisingly, artists are more open to fantasy and imagination than non-artists (Feist, 1999) and guided imagery has been used to enhance creativity (Singer & Barrios, 2009). Still, not only deliberate mind wandering is linked to creativity. Spontaneous mind wandering is associated to creativity, particularly during the *incubation* of new ideas (Baird et al., 2012). And not only professional creators engage in incubation processes: "people spend more of their daily lives engaged in an incubation-like state than they probably realize: People typically are only consciously aware of one-half of their mind wandering episodes. This suggests an interesting possibility that creativity researchers might study further: these brief episodes of mind wandering may provide the mind with moments of 'mini incubation' that contribute to creative thought, by temporarily taking conscious attention away from the problem at hand and providing a brief opportunity for insight to occur" (Sawyer, 2011, p. 146). The positive impact of mind wandering on incubation depends on variables such as the type of the task and the cognitive load. A meta-analysis performed on 117 studies revealed that incubation periods of high or low cognitive demand might have different effects depending on the task type. The incubation process benefits more divergent thinking tasks than linguistic or visual insight tasks. Additionally, longer periods of incubation with a low cognitive load are more beneficial than brief periods of incubation or those involving a demanding task (Sio & Ormerod, 2009). Indeed, participants that go through an incubation stage specially designed to trigger mind wandering have a better performance on creative tasks than those who perseverate in the problem or just rest during that same period (Baird et al., 2012). Yet, there is contradictory evidence. A recent study failed to replicate the relation between probe-caught mind wandering and creativity. Using incubation tasks of varying demand, it found that the rates of self-reported task unrelated thought during those tasks were not correlated with post incubation divergent thinking scores (Smeekens & Kane, 2016).

1.2. Metacognition, mind wandering and creativity

Mind wandering has been related to the concept of meta-awareness or metacognitive awareness, which can be defined as "one's explicit knowledge of the current contents of thought" (Schooler et al., 2011, p. 321). Schooler et al. (2011) theorize that meta-awareness could help to regulate mind wandering and improve the regulation of conscious thought in three possible ways. First, meta-awareness could allow the identification of mind wandering episodes and, therefore, facilitate re-engagement with the primary task. Second, when a lapse of mind wandering finishes because of an external disruption or a low-level monitoring process, it could trigger an illusion of control. The individual realizes that mind wandering is taking place just before the interruption and, therefore, noticing the episode of mind wandering could produce an illusion of control. Third, when we realize we have been mind wandering we could engage in activities that enable us to have more control of our cognitive activity, such as taking a break from work or engaging in meditation. Although mind wandering and metacognitive awareness are related, not enough is known about how mind wandering impacts students with different metacognitive or regulatory capacities. Additionally, metacognition is related to meta-consciousness but is not exactly the same. Schooler (2002) proposes that, although metacognition may involve awareness, it often happens without awareness.

Specifically, research has distinguished three dimensions of metacognition: metacognitive knowledge, metacognitive experiences and metacognitive abilities (Efklides, 2006, 2008). Metacognitive knowledge refers to the declarative knowledge the subject has about him or herself and the others as cognitive subjects (e.g., how good I am at solving equations), tasks (e.g., types of equations and their particular processing requirements), strategies (e.g., what strategies are used to solve them and which are the most appropriate in specific contents) and goals (e.g., to perform well in a university admission test.) In turn, metacognitive experiences refer to the fact that the person is aware when she or he is processing a specific task. Finally, metacognitive abilities are related to procedural knowledge. They involve the deliberate use of strategies to control cognition, helping to regulate performance through monitoring problem solving during a task. All these dimensions of metacognition most likely work in an interrelated manner: metacognitive abilities make use of task-related online knowledge as well as metacognitive knowledge. To activate metacognitive abilities, it is necessary to access information provided by metacognitive experiences about the flow of cognitive processing. Finally, awareness of the possible mistakes and difficulties when performing the task is needed as well (Efklides, 2008).

Probably, recognizing and correcting for mind wandering capitalizes on the three above-mentioned dimensions of metacognition. Still, because of its declarative nature, the most teachable of those dimensions is the declarative one. Educators could prevent mind wandering's undesired effects on learning by teaching metacognitive strategies that students can implement when studying. However, if we are to promote metacognition as a way to remediate the negative impact of mind wandering, we should also assess whether metacognition has an impact on the positive consequences of mind wandering, creativity especially. Fox and Christoff (2014) propose that metacognition has a different impact on the process of generation of new ideas and the process of evaluation of those ideas. The generative process is based on spontaneous thought processes. Creative evaluation requires metacognitive engagement. The authors propose that metacognition may inhibit spontaneous idea generation but it can improve creative evaluation. Additionally, metacognition can be attenuated during the generative processes so spontaneous thinking emerges. Based on the results a creator obtains during the creative phase, metacognitive evaluation can guide future creative generation. As shown by Fox and Christoff, both metacognitive and default mode brain networks are co-activated during creative evaluation and exhibit connectivity during the creative processes. As a consequence of the interaction between these two networks, people obtain optimal creative results.

1.3. Goal and context of the study

The main purpose of this study is to clarify whether mind wandering and metacognition impact on creativity after taking into consideration intellectual ability and reading difficulties. Thus, we implemented an individual differences study that included measures of human ability (both of creativity and intelligence) as well as self-report measures of reading difficulties, mind wandering, and metacognition. We collected information about the students' history of reading difficulties because of the verbal nature of our creativity measures. Mind wandering was investigated using a measure of mind wandering as a trait. As regards metacognition, we focused on participants' declarative knowledge about their metacognitive strategies including planning, monitoring and regulating (Dowson & McInerney, 2004).

The study was implemented in a mid-income country, Chile. We recruited students enrolled in a vocational (technical) school and a selective university. In Chile, students attending vocational schools and universities have very different socio-economic backgrounds and educational trajectories. Approximately 60% of the students enrolled in vocational institutions belong to the three lower socioeconomic quintiles of the population whereas approximately 60% of the students enrolled in universities belong to the two upper socioeconomic quintiles of the population (Meller & Brunner, 2009). On the other hand, vocational students enroll in non-selective programs whereas university students are admitted to their programs depending upon their academic credentials: i.e., their high school grades, high school ranking and scores in standardized tests.

1.3.1. Hypotheses

Since mind wandering is positively associated to creativity, we expect that those students reporting a higher frequency of mind wandering episodes will obtain higher scores in a measure of divergent thinking and a measure of creative problem solving. Second, as metacognition helps to correct mind wandering, we expect to find a significant negative correlation between the students' level of metacognitive knowledge and a self-report measure of mind wandering episodes in everyday life. Third, since metacognition may inhibit the spontaneous generation of new ideas, we expect to find a negative correlation between metacognitive knowledge and students' performance in our creativity measures. More specifically, we expect that mind wandering will positively predict our creativity measures, after taking into consideration individual differences in fluid intelligence and reading difficulties. On the other hand, we expect that metacognition will negatively predict creativity, after taking into consideration the same set of variables. Last but not least, we expect that academic background (i.e., being enrolled in a selective university or a non selective vocational school) will moderate the impact of mind wandering on creativity and the impact of metacognition on creativity. Because of their overall academic competence, we believe university students are better equipped to capitalize on mind wandering and metacognition to think creatively and less exposed to their negative consequences than vocational students. A university setting, probably, trains them in the sort of open ended thinking strategies that are compatible with a creative use of mind wandering and helps them to counter the negative impact of metacognition on the generative processes and strengthen its positive impact on creative evaluation.

2. Methods

2.1. Sample and procedure

245 students participated in the study. Three students did not fill one or more of the self-report measures and nine others left some of the items unanswered. As these cases were $<5\%$ of the sample, they were excluded from further analysis. We performed our analyses on data collected from 233 participants. 116 participants were enrolled in a highly selective university (92 female; 24 male; age mean = 21.68; age S.D. = 2.89) and 117 in a non-selective technical school (50 female; 67 male; age mean = 21.65; age S.D. = 3.47). Both schools were located in Santiago, Chile. University and vocational students were recruited on campus and invited to participate at the beginning and end of their regular lessons. Six testing sessions were implemented at the university and four at the technical school by six trained research assistants. They explained the study, obtained informed consent and implemented assessments. The ethics committees of the researchers' institution and the FONDECYT grant program reviewed and approved all the research procedures. Only one student declined to participate after reading the consent form.

2.2. Measures

2.2.1. Self-report scales

To measure reading difficulties, we developed a 14 items self-report scale using selected items from the Spanish version of the *Adult Reading History Questionnaire* (Mourgues, Preiss, & Grigorenko, 2014; Parrila, Corkett, Kirby, & Hein, 2003). The scale asks participants to report both past and present reading difficulties by means of a Likert scale with five options for each item. The average of all items was calculated to create a global score for each subject with a minimum possible value of zero and a maximum of four. Higher scores evidence a greater extent of reading difficulties. The reliability of the reading difficulties scale, measured using Cronbach's alpha, was 0.83. To assess individual differences in mind wandering we developed a Spanish version of the *Daydreaming Frequency Scale*, taking as a reference the scale reported in Giambra (1993) and using a back translation procedure. This scale has 12 items and is one of the 28 scales included in the *Imaginal Process Inventory* (Giambra, 1993; McMillan et al., 2013). The assessment involves a Likert scale with five options for each item, with a minimum possible value of one and a maximum of five. Higher scores evidence that participants report a higher frequency of mind wandering episodes. The average of all items was calculated to create a global score for each individual. The Cronbach alpha for the scale was 0.91. Finally, in order to assess individual differences in metacognition we adapted a self-report scale taken from the *Goal Orientation and Learning Strategies Survey*, which evaluates declarative knowledge about the use of metacognitive strategies including planning, monitoring and regulating (Dowson & McInerney, 2004). Specifically, we developed an 11-item Spanish Likert scale with five options for each item. The minimum possible value was zero and the maximum was four. Higher scores evidence more knowledge about the use of metacognitive strategies. The average of all items was calculated to create a global score for each subject. The Cronbach alpha for the scale was 0.77. Appendices A, B and C present sample items for each one of the abovementioned self-report scales.

2.2.2. Cognitive ability measures

To measure fluid intelligence we applied the FIX test, a commercially available and completely non-verbal test of intelligence created by the Pontificia Universidad Catolica de Chile's Center for the Development of Inclusive Technologies (CEDETI UC). Its application lasts 10 min. It allows the estimation of general intellectual abilities in individuals whose age ranges from 16 years to 90 years and 11 months. The FIX test has been standardized in 375 adults according to age, sex and educational level. It has been concurrently validated with the WAIS -IV and with comprehensive cognitive assessments. The reported Cronbach's alpha for the test is 0.83 (Rosas et al., 2012). Additionally, we applied the OI Test, a measure of attentional capacity commercialized as a complement to the FIX test by CEDETI UC. Its application lasts 5 min. The test assesses attentional capacity in individuals whose age ranges from 16 years to 90 years and 11 months. The reported split-half reliability of the OI test is 0.79 ($p < 0.001$) (Rosas et al., 2012). After the application of these assessments, CEDETI UC generated the percentile scores for each participant according to the norms of each test. We did not pursue specific hypotheses about attentional capacity in this study, so we used this test mostly in an exploratory manner.

2.2.3. Creativity measures

We employed two measures: a divergent thinking test and a creative thinking test. To assess divergent thinking, we used a task based on *Guilford's Alternative Uses test* (Guilford, 1967). We asked participants to list i) alternative uses for a newspaper, and ii) alternative uses for a clip. For scoring, we only took into consideration appropriate responses. Thus, we discarded those that were either not physically possible or that included the use of an additional object to the one considered in the task. Additionally, we measured the number of categories related to the students' answers. Students had 3 min to complete each task. Two raters assessed 27% of the students' answers. The percent of agreement between raters was acceptable for estimating both *appropriate use* (newspaper task, $p > 0.81$; clip task, $p > 0.76$) and *categories of use* (newspaper task, $p > 0.78$; $p > 0.82$). We added the scores of both tasks to create an *appropriate use* and *categories of use* score for each participant. Because of the high level of correlation between these two measures ($r = 0.84$; $p < 0.0001$), we only used *appropriate use* as the final Alternative Uses score for each subject.

In addition to the divergent thinking test, we employed a Spanish Compound Word Association task (Mourgues et al., 2014). This task is inspired on an English set of problems developed by Bowden and Jung-Beeman (2003) to investigate the experience of insight in problem solving. Specifically, the test assesses the ability to draw relationships between semantically distant words. The test includes 14 items. Its application lasts 10 min. Each item includes three stimulus words. To solve the problem participants have to generate a response word. The response word should relate to the three stimulus words such that one stimulus word can be used to compose a 3-word phrase (stimulus word, response word, and a preposition), other stimulus word can be used to form a compound word, and a third stimulus word is a synonym of the response word. The test's reliability, measured with Cronbach's alpha, was 0.82. Total scores were the sum of correct responses.

2.3. Data analysis

First, we performed descriptive and correlational analyses on the variables of interest for the full sample. Next, we explored the differences between university and vocational students and between men and women. Thus, using the SPSS GLM procedure, we performed a 2×2 between-subject multivariate analysis of variance on four dependent variables: the FIX test percentile score and the final score of the three self-report scales (reading difficulties, metacognition, and mind wandering). Independent variables were type of school (university and vocational) and sex (men, women). We inspected the univariate tests on the dependent variables and, using the SPSS MANOVA procedure, run a Roy-Bargmann stepdown analysis on the DVs prioritized as follows: fluid intelligence, reading difficulties, metacognition and mind wandering. There were no substantial differences between both the univariate tests and the Roy-Bargmann stepdown analysis so we report the univariate tests only. Then, two different multivariate hierarchical regression models were built to predict the two creativity tests. For each model, in the first step, the FIX test percentile score and the Reading History scale score were entered as predictors. In the second step, the Metacognition scale score and the Daydreaming Frequency Scale score were added to those predictors entered before. Finally, using PROCESS (Hayes, 2013), we tested whether the interaction of type of school with mind wandering or with metacognition had any impact on our creativity measures.

3. Results

3.1. Descriptive and correlational analyses

Table 1 shows the basic statistics and Table 2 the bivariate correlations for the variables of the study. The Compound Words Association task displayed negative kurtosis. As underestimates of the variance associated with negative kurtosis disappear with samples of 200 or more (Tabachnick & Fidell, 2001), we did not transform the distribution of the Compound Words Association task scores. Three variables departed from symmetry: the scale of reading difficulties had severe positive skewness, the scale of metacognition had severe negative skewness and the scale of mind wandering had moderate negative skewness. We transformed the asymmetrical variables. Specifically, a log transform was applied to the reading difficulties and metacognition scales and a square root transform was applied to the scale of mind wandering. We ran all of the analyses using both the original variables and the transformed ones. Because the same pattern of results was observed when using both sets of variables, we report the results based on the original variables. Below, we report just one correlation where we obtained a different result in statistical significance using the transformed variables.

First we explored the bivariate correlations. As shown in Table 2, the creativity measures had significant positive correlations with fluid intelligence and negative correlations with reading difficulties. The correlation between both creativity measures was significantly positive.

Table 1
Descriptive statistics for key study variables.

	M	SD	Min	Max	Skewness		Kurtosis	
					Stat.	SE	Stat.	SE
Fix percentile	49.30	18.73	2	99	0.18	0.16	−0.17	0.32
Reading difficulties	1.08	0.54	0.00	2.79	0.58	0.16	0.06	0.32
Mind wandering	3.39	0.81	1.08	5.00	−0.40	0.16	−0.35	0.32
Metacognition	2.92	0.60	0.73	4.00	−0.53	0.16	0.18	0.32
Compound Words association test	6.79	3.42	0.00	14.00	−0.06	0.16	−0.94	0.32
Alternative Uses test	15.36	5.42	3.00	31.00	0.13	0.16	−0.33	0.32

Notes. N = 233.

Table 2
Intercorrelations among key study variables.

	1	2	3	4	5	6
Fix percentile (1)	1					
Reading difficulties (2)	−0.21**	1				
Mind wandering (3)	0.13	−0.04	1			
Metacognition (4)	−0.03	−0.15*	−0.11	1		
Compound Words Association test (5)	0.42**	−0.31**	0.28**	−0.06	1	
Alternative Uses test (6)	0.20**	−0.14*	0.25**	−0.01	0.35**	1

Notes. N = 233.
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Students with a higher score in the fluid intelligence test reported significantly less reading difficulties. As predicted, both creative measures have significant positive correlations with mind wandering. Yet, there were no significant correlations between the creativity measures and the metacognition scale. When testing correlations using the transformed variables, all relationships remained the same except for the correlation between metacognition and mind wandering, which reached significance ($r = -0.14$, $p < 0.05$).

As mentioned, we applied the OI test just in an exploratory manner. Twenty students did not follow the OI test instructions when responding it. Therefore, their score was not generated. Accordingly, we tested the correlation between the OI test and all the other measures for a slightly smaller sample of 213 participants. This test had a significant positive correlation with the FIX test ($r = 0.17$, $p < 0.05$), and a significant negative correlation with the self-report of reading difficulties ($r = -0.25$, $p < 0.01$), so students with a higher attentional capacity demonstrated a higher fluid intelligence and reported less reading difficulties. It did not have any other significant correlation with other variables of the study.

3.2. Group differences

Next, we report results of the multivariate analysis of variance. With the Wilks' criterion, the combined DVs (fluid intelligence, reading difficulties, metacognition and mind wandering) were significantly affected by School, $F(4, 226) = 22.38$, $p < 0.001$, *Partial* $\eta^2 = 0.28$ and by Sex, $F(4, 226) = 5.89$, $p < 0.001$, *Partial* $\eta^2 = 0.09$. The interaction was not significant, $F(4, 226) = 0.52$, $p = 0.72$, *Partial* $\eta^2 = 0.01$. The univariate tests revealed significant differences between university and vocational students in the FIX Test, $F(1, 229) = 48.77$, $p < 0.001$, *Partial* $\eta^2 = 0.18$; the Reading Difficulties scale, $F(1, 229) = 13.47$, $p < 0.001$, *Partial* $\eta^2 = 0.06$; the Mind Wandering scale, $F(1, 229) = 31.56$, $p < 0.001$, *Partial* $\eta^2 = 0.12$; but not the Metacognition scale, $F(1, 229) = 0.78$, $p = 0.38$, *Partial* $\eta^2 = 0.003$. In summary, university students performed better than vocational students in the fluid intelligence test, and reported a higher frequency of mind wandering episodes and fewer difficulties in their history of reading. Additionally, the univariate tests revealed significant differences between men and women in the FIX Test, $F(1, 229) = 15.34$, $p < 0.0001$, *Partial* $\eta^2 = 0.06$ and a marginally significant difference in the mind wandering scale, $F(1, 229) = 3.76$, $p = 0.053$, *Partial* $\eta^2 = 0.02$. Men performed better than women in the fluid intelligence test and reported fewer mind wandering episodes than women. There were no significant interactions. Table 3 reports the estimated marginal means and standard error by the GLM procedure as well as the confidence intervals for the four dependent variables by school type and sex.

3.3. Hierarchical regression analyses

Next, we report whether addition of the participants' self-report estimates of mind wandering and metacognition improved prediction of our two measures of creativity (the Alternative Uses and Compound Words Association tests), beyond that afforded by individual differences in fluid intelligence and reading difficulties. Additionally, we report the results of our tests of moderation.

Table 3
Estimated marginal means, S.E., and C.I., for fluid intelligence, reading difficulties, mind wandering and metacognition according to school type and sex.

Factor	Dependent variable	*School*	M	S.E.	95% confidence interval	
					Lower bound	Upper bound
School	Fix percentile	*Vocational*	41.90	1.59	38.77	45.02
		University	59.44	1.95	55.60	63.28
	Reading difficulties	*Vocational*	1.22	0.05	1.12	1.32
		University	0.93	0.06	0.81	1.05
	Mind wandering	*Vocational*	3.09	0.07	2.96	3.23
		University	3.70	0.08	3.54	3.87
	Metacognition	*Vocational*	2.93	0.06	2.82	3.04
		University	2.86	0.07	2.72	2.99
Sex	Fix percentile	*Female*	45.75	1.49	42.81	48.69
		Male	55.59	2.02	51.61	59.57
	Reading difficulties	*Female*	1.08	0.05	0.98	1.17
		Male	1.08	0.06	0.95	1.20
	Mind wandering	*Female*	3.50	0.06	3.38	3.63
		Male	3.29	0.09	3.12	3.47
	Metacognition	*Female*	2.98	0.05	2.87	3.08
		Male	2.81	0.07	2.67	2.95

Notes. N = 233.

3.3.1. Alternative Uses test

Table 4 displays the unstandardized regression coefficients (B), the standardized regression coefficients (β), the semi-partial correlations, and the collinearity statistics for the hierarchical multiple regression analyses predicting the Alternative Uses test score. After the first step, with fluid intelligence and reading difficulties in the equation, we obtained an $R^2 = 0.05$, $F_{inc}(2, 230) = 6.20$, $p < 0.003$. After the second step, with mind wandering and metacognition added to prediction of the Alternative Uses test score we obtained an $R^2 = 0.10$, $F_{inc}(2, 228) = 6.28$, $p < 0.0001$. As predicted, the subsequent addition of mind wandering and metacognition resulted in a statistically significant increase in the prediction of divergent thinking, explaining a further 5% of the variability ($p < 0.003$). In the first step, fluid intelligence (but not reading difficulty) significantly predicted the Alternative Uses test score. Once all of the variables were entered into the analysis, mind wandering (but not metacognition) accounted for unique variability above the contributions of the two initial control measures. The impact of intelligence remained significant. Next, using PROCESS, the interaction term between type of school and mind wandering was tested in a regression model, treating the scores in fluid intelligence and reading difficulties as covariates. The model accounted for a significant proportion of the variance in divergent thinking, $R^2 = 0.17$, $F(5, 227) =$

Table 4
Hierarchical multiple regression analyses predicting the Alternative Uses test score from the FIX test and the reading difficulties, metacognition and mind wandering scales.

Predictor	B	β	sr_i	Tolerance	VIF
Step 1					
Fix percentile	0.05	0.18**	0.18	0.96	1.04
Reading difficulties	–1.03	−0.10	−0.10	0.96	1.04
Step 2					
Fix percentile	0.04	0.15**	0.15	0.94	1.06
Reading difficulties	–0.99	−0.10	−0.10	0.93	1.07
Metacognition	0.004	0.0004	0.0004	0.96	1.04
Mind wandering	1.51	0.22**	0.22	0.97	1.03

Notes. N = 233.
** p < 0.01.

9.40, $p < 0.0001$, but the interaction term did not significantly affect divergent thinking scores, $R^2_{inc} = 0.006$, $F(1, 227) = 1.64$, $p = 0.20$. We ran a similar test of the interaction term between type of school and metacognition, treating the scores in fluid intelligence and reading difficulties as covariates. The model accounted for a significant proportion of the variance in divergent thinking, $R^2 = 0.16$, $F(5, 227) = 8.34$, $p < 0.0001$, but the interaction term did not significantly affect divergent thinking scores, $R^2_{inc} = 0.00004$, $F(1, 227) = 0.001$, $p = 0.98$.

3.3.2. Compound Words Association test

Table 5 displays the unstandardized regression coefficients (B), the standardized regression coefficients (β), the semi-partial correlations, and the collinearity statistics for the hierarchical multiple regression analyses predicting the Compound Words Association test score. After the first step, with fluid intelligence and reading difficulties in the equation we obtained an $R^2 = 0.22$, $F_{inc}(2, 230) = 33.29$, $p < 0.0001$. After the second step, with mind wandering and metacognition added to prediction of the Compound Words Association test score, $R^2 = 0.28$, $F_{inc}(2, 228) = 8.72$, $p < 0.0001$. As predicted, the subsequent inclusion of mind wandering and metacognition resulted in a statistically significant increase in the prediction of the Compound Words Association test score, explaining an additional 6% of the variability. In the first step, fluid intelligence and reading difficulty significantly predicted the dependent variable score. Once all of the variables were entered into the analysis, mind wandering (but not metacognition) accounted for unique variability above the contributions of the two initial control measures whose effects remained significant.

Taking into account intelligence and reading difficulties scores, the interaction term between school type and mind wandering was tested using PROCESS. The regression model accounted for a significant proportion of the variance in the Compound Words Association test score, $R^2 = 0.45$, $F(5, 227) = 36.46$, $p < 0.0001$, but the interaction term did not significantly affect the dependent variable, $R^2_{inc} = 0.004$, $F(1, 227) = 1.62$, $p = 0.20$. Additionally, treating fluid intelligence and reading difficulties as covariates, the interaction term between school type and metacognition was tested using PROCESS in a regression model. The model accounted for a significant proportion of the variance in the Compound Words Association test score, $R^2 = 0.46$, $F(5, 227) = 39.31$, $p < 0.0001$. The interaction term significantly affected the Compound Words Association test score, $R^2_{inc} = 0.02$, $F(1, 227) = 8.25$, $p < 0.005$. Inspection of the conditional effect of metacognition on the Compound Words Association test score, at the two values of the moderator, shows that this effect is significant and negative for university students ($p = 0.002$), but not significant for vocational students ($p = 0.41$). In brief, this effect shows that the negative relation between metacognition and creative problem solving is only significant for university students, whereas vocational students show no relation between these variables.

Table 5
Hierarchical multiple regression analyses predicting the Compound Words Association test score from the FIX test and the reading difficulties, metacognition and mind wandering scales.

Predictor	B	β	sr_i	Tolerance	VIF
Step 1					
Fix percentile	0.07	0.37***	0.36	0.96	1.04
Reading difficulties	−1.46	−0.23***	−0.23	0.96	1.04
Step 2					
Fix percentile	0.06	0.34***	0.33	0.94	1.06
Reading difficulties	−1.50	−0.24***	−0.23	0.93	1.07
Metacognition	−0.36	−0.06	−0.06	0.96	1.04
Mind wandering	0.94	0.22***	0.22	0.97	1.03

Notes. N = 233.
*** $p < 0.001$.

4. Discussion

The relationship between trait mind wandering and creativity was as expected. Those students reporting more episodes of mind wandering obtained higher scores in both creativity measures. The relationship between metacognition and creativity was not as expected: there were no significant correlations between performance in any of the two measures of creativity and the students' self-report of metacognition. As expected, the correlation between mind wandering and metacognition was negative, although it reached significance when it was tested using the transformed variables only. Results between our ability measures demonstrated concurrent validity. Students that obtained a higher score in the measure of divergent thinking obtained a higher score on the measure of creative problem solving too. The fluid intelligence test was positively correlated with both creativity measures. Results between our ability measures, the Reading History scale and the Metacognition scale demonstrated concurrent validity too. A history of reading difficulties was negatively correlated with performance on both creativity measures, which was expected given the verbal nature of these measures. Students reporting more reading difficulties obtained lower scores in the fluid intelligence test and reported less metacognitive knowledge than those with less reading difficulties. The lack of relationship between the OI test, which is a test of attentional capacity, and the scale of mind wandering, was not entirely unexpected: probably, a measure of state mind wandering would have shown a significant negative relationship with a performance measure of attentional capacity such as the OI. Yet, that is not necessary the case for a measure of trait mind wandering. Indeed, the Mind Wandering scale used here did not display a significant correlation with fluid intelligence either.

Tests of group differences were, in part, consistent with the composition of our sample, which included two groups with different academic backgrounds. There were significant differences in fluid intelligence and reading difficulties between vocational and university students. Vocational students obtained lower scores in the fluid intelligence test and reported more difficulties in reading than university students. Unexpectedly, these groups did not differ in their self-report of metacognitive knowledge. Lack of group differences may be a consequence of the nature of the measure: assessing metacognitive knowledge using a self-report scale may provide an imprecise estimate of the construct, especially among students with relatively lower analytical skills. There is a clear difficulty to collect evidence about metacognition through a set of self-report questions about strategies to plan, monitor and regulate academic activities. As a way to address these limitations, rather than metacognitive experiences or metacognitive skill, we focused on declarative knowledge about metacognitive strategies. The direction of the differences between groups in mind wandering was unexpected as well. Given its presumed negative impact on academic achievement, we anticipated that those students enrolled in a vocational school would report more mind wandering episodes than those enrolled in a selective university. The results showed the opposite. Higher ability students may have a higher awareness and understanding of the nature of mind wandering and, therefore, they might end up simply reporting more episodes of distraction. Still, we cannot relate these differences to the presumably higher metacognitive knowledge of the most academically capable students since our measure did not reveal group differences in metacognition. Therefore, these results illustrate some of the limitations of using self-report measures.

It is telling that the effect of mind wandering on creativity remains significant after controlling for the effects of fluid intelligence and reading difficulties, since these variables were significantly correlated with the creativity measures. Although reading difficulties predicted the Compound Words Association test only, fluid intelligence predicted performance on both creativity tests. Successful completion of the Compound Words Association test requires a higher level of knowledge of the lexical and morphological dimensions of language than the Alternative Use tasks. Probably, such knowledge positively interacts with fluency in reading.

The academic background of the students did not moderate the effect of mind wandering on both creativity measures, but it moderated the impact of metacognition on creative problem solving. Metacognition had a negative effect on creative problem solving in university students. It did not have a significant effect on creative problem solving in vocational students. A negative effect of metacognition on creativity and a moderation of this effect by the academic background of the students were between the possible results we considered. Yet, university students were more affected than we anticipated to the adverse influence of metacognition on creativity. That said, the results associated to the metacognition measure have to be interpreted cautiously and should be explored using a more sophisticated measure of metacognition than a self-report scale.

5. Conclusion

Our study makes a specific contribution to the literature on mind wandering and creativity because it shows that the effect of mind wandering on creativity remained significant after controlling for intellectual ability and reading difficulties notwithstanding the verbal nature of our creative tasks. Since the two tests we used are of verbal nature, future research should explore the connection between mind wandering and creativity using other tasks, such as drawing or visual synthesis, which have also been employed to measure creativity (Finke, Ward, & Smith, 1992). Although we focused on the verbal domain, it is worth noting that we replicated the positive effect of mind wandering on creativity using tasks based on two distinctive processes: divergent thinking and insight in problem solving. Additionally, our study makes a specific contribution to the literature on metacognition and creativity. Our results suggest that academically successful students may be more exposed to the deleterious effect of metacognition on creativity than students characterized by a lower academic competence. Since successful students learn to apply metacognition to analytical problem solving mainly (Sternberg & Grigorenko, 2000), when these students face creative problems requiring the use of generative processes, the regulatory nature of the metacognitive strategies they use successfully in other contexts may restrict their problem solving.

These results are correlational and focus on trait mind wandering. Consequently, they do not answer the question about whether there is a causal relation between state mind wandering and creativity. A recent study showed that state mind wandering was not associated to higher scores in divergent thinking tasks (Smeekens & Kane, 2016). Future research should elucidate what kinds of creative tasks are more impacted by mind wandering and whether they are responsive both to state and trait mind wandering or only to one of them. Additionally, it should investigate whether these associations vary across development. Here, we showed that trait mind wandering was associated to verbal creativity, as measured in divergent thinking and problem solving tasks.

Before concluding, we would like to note that, to our knowledge, this is the first study investigating the relationships between mind wandering, metacognition and creativity implemented in a Latin American sample. Most of the research on this topic originates in North American and European institutions. Unfortunately, empirical research on creativity in Latin America is still not commensurate with that of other regions (Preiss, Grau, Ortiz, & Bernardino, 2016; Preiss & Strasser, 2006). We hope that this contribution helps us to place the study of this phenomenon in a broader international context and, additionally, to increase our empirical knowledge of creativity in Latin America.

Appendix A. Sample items of Reading Difficulties Survey-Spanish Version

Past reading difficulties

¿Cuánta dificultad tuvo para aprender a leer?

Ninguna				Mucha
0	1	2	3	4

En comparación con sus compañeros de colegio ¿cómo eran sus habilidades para la lectura?

Sobre el promedio		Promedio		Bajo el promedio
0	1	2	3	4

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Present reading difficulties

¿Cómo es su velocidad de lectura en comparación con otras personas de su misma edad y nivel educacional?

Sobre el promedio		Promedio		Bajo el promedio
0	1	2	3	4

¿Tiene dificultades para elaborar un texto escrito en el que desarrolle sus propias ideas?

No		Ocasionalmente		Muchas veces
0	1	2	3	4

Appendix B. Sample items of Daydreaming Frequency Scale-Spanish Version

Sueño despierto:

a) Con poca frecuencia.
b) Una vez a la semana.
c) Una vez al día.
d) Algunas veces durante el día.
e) En muchos momentos durante el día.

Cuando tengo tiempo libre:

a) Nunca sueño despierto.
b) Rara vez sueño despierto.
c) A veces sueño despierto.
d) Con frecuencia sueño despierto.
e) Siempre sueño despierto.

Cuando estoy en una reunión o en un evento que no es muy interesante:

a) Nunca sueño despierto.
b) Rara vez sueño despierto.
c) A veces sueño despierto.
d) Con frecuencia sueño despierto.
e) Siempre sueño despierto.

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Appendix C. Sample items of Knowledge of Metacognitive Strategies Scale-Spanish Version

Monitoring

A menudo me hago preguntas para ver si entiendo lo que estoy estudiando.

En desacuerdo		Ni de acuerdo ni en desacuerdo		De acuerdo
0	1	2	3	4

Planning

En general me planifico con anticipación para poder hacer bien mis trabajos para la Universidad.

En desacuerdo		Ni de acuerdo ni en desacuerdo		De acuerdo
0	1	2	3	4

Regulating

Si estoy teniendo problemas para aprender algo en la Universidad, pido ayuda a mi profesor, compañeros u otras personas.

En desacuerdo		Ni de acuerdo ni en desacuerdo		De acuerdo
0	1	2	3	4

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