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**Personality traits affect older adults' memory differently depending on the
environmental support provided at encoding**

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1 **Personality traits affect older adults' memory differently depending on the**
2 **environmental support provided at encoding**

3

4 **Abstract**

5

6 Research suggests that personality traits are associated with memory performance,
7 particularly as people age. In two studies, we examined two personality traits (openness to
8 experience and neuroticism) that have been hypothesized to modulate episodic memory
9 performance in older adults. We tested the hypothesis that these traits would be differently
10 associated with episodic memory according to the amount of cognitive support provided at
11 encoding. We examined the role of these personality traits in free recall when performance
12 was supported by prior task success versus no prior task success (Experiment 1) and by
13 generating versus reading (Experiment 2). Results showed that prior task success and
14 generating items led to superior memory performance. In both studies, openness to experience
15 was positively associated with memory performance and neuroticism was negatively
16 associated with memory performance. Further, openness accounted for the most variability in
17 recall performance under conditions providing low cognitive support and neuroticism, on the
18 other hand, accounted for recall in both high and low support conditions. Results suggest that
19 neuroticism is a key personality trait implicated in memory performance, but for the most
20 difficult memory tasks, a high level in openness may aid memory performance.

21

22 *Keywords: episodic memory, personality, prior task success, generation effect, openness,*
23 *neuroticism, aging*

24

25

26 **1. Introduction**

27 The effects of aging on episodic memory are well documented (e.g., McDaniel et al.
28 2008) and are characterized by important external and internal sources of variability. Older
29 adult's performance varies with the context in which the memory task is taken, the type of
30 memory task, and notably with environmental support provided at encoding or retrieval stages
31 (Craik, 1986). Age-related differences in memory performance are greater when
32 environmental support is absent, because the tasks are demanding and cognitive resources are
33 low in older adults (Rabinowitz et al., 1982). Moreover, according to the Cognitive Reserve
34 Hypothesis (Stern, 2002), life experiences (emotional, social, and environmental) and
35 intelligence can protect against age-related episodic memory declines (Angel et al., 2010;
36 Gombart et al., 2018; Park & Reuter-Lorenz, 2009). More recently, research demonstrates a
37 relationship between personality dimensions and cognition, whereby personality modulates
38 the way people process and remember information (e.g., Karsazi et al., 2021; Simon et al.,
39 2019; Soubelet et al., 2010). However, we do not fully understand how personality traits
40 influence memory performance or which aspects of memory are affected by personality traits,
41 particularly in older adults. Therefore, the current studies examined the effects of two
42 personality traits hypothesized to modulate memory performance in older adults: neuroticism
43 and openness to experience. We tested the hypothesis that these two traits may be differently
44 associated with episodic memory performance, depending on the amount of encoding support
45 provided.

46 Previous research suggests that personality may contribute to cognitive performance,
47 especially as people age (e.g., Karsazi et al., 2021; Simon et al., 2019; Soubelet & Salthouse,
48 2010). For example, cognitive performance might be associated with the five personality traits
49 described by the Big Five model (Agreeableness, Conscientiousness, Extraversion, Neuroticism
50 and Openness; Costa & McCrae, 1992). However, the most robust results show that two

51 personality traits are closely related to cognitive performance, and in particular memory:
52 openness, the tendency to be intellectually curious, creative and imaginative, and neuroticism,
53 the disposition to experience negative affect, including anger, anxiety, self-consciousness,
54 irritability, emotional instability, and depression (e.g., Allen et al., 2019; Karsazi et al., 2021).
55 Openness is positively associated with memory performance, whereas neuroticism is
56 negatively associated with memory performance. A recent longitudinal study confirmed the
57 important role of these two personality traits for memory, showing that high levels of
58 openness and low levels of neuroticism were associated with reduced memory decline
59 (Stephan et al. 2020). Studies conducted with older adults show that a high level of openness
60 has a protective effect against cognitive decline (e.g., Franchow et al., 2013; Jackson et al.,
61 2020; Karsazi et al., 2021; Luchetti et al., 2016; Simon et al., 2019).

62 There are several reasons why openness may be related to cognitive performance.
63 Openness to experience is related to the tendency to be creative and unconventional, and
64 seems to be beneficial for developing crystallized intelligence, i.e., knowledge accumulated
65 throughout one's life (e.g., Jopp & Hertzog, 2007; Salthouse et al., 2002), as well as fluid
66 intelligence, i.e., the ability to solve problems in new situations (e.g., Zimprich et al., 2009).
67 These two cognitive components are critical for the development of knowledge in the long
68 term (Soubelet & Salthouse, 2010) and episodic memory (Bouazzaoui et al., 2013, 2014).
69 Moreover, openness is associated with participation in cognitively-stimulating activities,
70 possibly leading to preservation of cognitive functions (Ihle et al., 2016; Soubelet &
71 Salthouse, 2010). With regard to memory, a positive association between openness and
72 memory has been found in numerous studies (e.g., Jackson et al., 2020; Martinez et al., 2021;
73 Soubelet & Salthouse, 2010). In a recent study, Talpain and Soubelet (2020) showed that high
74 levels of openness were associated with good memory performance because people with high
75 levels of openness use efficient memory strategies. Research on memory strategies also

76 showed that the most efficient strategies require a substantial amount of controlled processes
77 (e.g., Burger et al., 2017) unless they are driven by particular experimental context (type of
78 stimuli, type of task, or particular instructions at the learning stage, Craik, 1986; Taconnat et
79 al., 2004). Therefore, one would predict that a high score on openness would be particularly
80 useful for the most difficult memory tasks—those that require a significant amount of
81 controlled processes and require people to select and use the most efficient memory strategies
82 (Talpain & Soubelet, 2020).

83 The other personality trait that is strongly linked to cognitive performance in general,
84 and to memory in particular, is neuroticism (e.g., Klaming et al., 2017; Simon et al., 2020;
85 Neupert et al., 2008). People who score high in neuroticism tend to experience negative
86 emotions easily and frequently, are vulnerable to stress, and show performance decrements on
87 cognitive tasks (Boyle et al., 2010; Chapman et al., 2012; Graham & Lachman, 2014; Munoz,
88 et al., 2013; Wettstein, et al., 2017). They are also more unstable (Elliott, et al., 1994) and
89 have weaker adaptive capacities (Kokkonen & Pulkkinen, 2001) which may cause people
90 with high levels to this trait to behave less efficiently in certain situations, such as when
91 performing cognitive tests. Furthermore, older adults with a high level of neuroticism report
92 more intense negative affect (e.g., Bolger & Schilling, 1991; Bolger & Zuckerman, 1995;
93 David & Suls, 1999; Gunthert et al., 1999) more memory failures (Neupert et al., 2008) and
94 more memory complaints (Merema et al., 2013) than older adults with low neuroticism.

95 The deleterious effect of a high level of neuroticism on memory performance has been
96 explained by the fact that people with high levels of neuroticism have more negative beliefs
97 about their ability to control their memory (i.e., perceived control) and lower self-esteem,
98 which can negatively influence their behavior in new or difficult situations (Judge, et al.,
99 2002; Lachman et al., 2011; Pinard et al., 2021). Chronic stress can cause structural damage
100 in the hippocampus, a structure both involved in the regulation of stress hormones through the

101 HPA axis and in memory, and therefore lead to impaired memory and accelerated memory
102 decline (Kim & Diamond, 2002). Therefore, one can predict that a high level of neuroticism
103 would be associated with poor memory performance, regardless of the nature of the task.

104 In the current studies, we examined how openness and neuroticism contribute to older
105 adults' memory performance as a function of whether environmental support is provided or
106 not at encoding. Providing environmental support may help older adults implement memory
107 strategies that are particularly resource demanding, because one crucial factor for age-related
108 memory decline is the lack of cognitive resources in older adults (Rabinowitz et al., 1982).
109 Environmental support can be provided in different ways. Classically, environmental support
110 refers to the use of orientation tasks that guide the implementation of effective cognitive
111 processes for memory (Craik, 1986; Tacconat & Isingrini, 2004). Thus, environmental
112 support can correspond to any experimental situation that promotes memorization. For
113 example, Sindi et al. (2013) showed that when older adults performed a memory task under
114 conditions that were favorable to them (the experimenter was the same age as the participants,
115 instructions did not mention a memory task to avoid stereotype threat, experimentation was
116 conducted in a familiar place and in the morning, which is the preferred time of day of older
117 adults), they were more successful than when they performed the task in more unfavorable
118 conditions. To create conditions of environmental support, we provided older adults with
119 prior task success (Experiment 1) and encouraged effective study strategies using generation
120 versus reading (Experiment 2).

121 In Experiment 1, we examined the role of openness to experience and neuroticism on
122 memory performance when it was either facilitated or not by success on a prior task. The prior
123 task success effect refers to the finding that older adults perform better on a task after having
124 succeeded on a prior unrelated cognitive task than after failing or not performing a prior task
125 (Geraci & Miller, 2013; Geraci et al., 2016; Rossi-Arnaud et al., 2018). For example, Geraci

126 and Miller (2013) showed that older adults' memory performance was better when they had
127 succeeded on an unrelated sentence scramble task prior to participating in a memory test
128 compared to when they did not succeed on the prior task. This effect of prior task success on
129 memory performance could be the consequence of decreased anxiety, and increased self-
130 esteem (Geraci et al., 2016), both of which facilitate engagement in effective cognitive
131 processing, such as efficient strategy selection (see Lemaire & Brun, 2018). Thus, prior task
132 success can be considered as a form of environmental support.

133 In Experiment 2, we examined the role of openness to experience and neuroticism on
134 memory performance using a different paradigm in which the engagement of controlled
135 processes varied: a generation effect protocol. The generation effect (Slamecka & Graf, 1978)
136 refers to the finding that more words are remembered after generating (e.g. saddle-ho---) than
137 after reading (e.g., roof-house). Young adults as well as older adults demonstrate the
138 generation effect (Taconnat & Isingrini, 2004). This effect is due to the fact that in the reading
139 condition, memory-efficient encoding processes are self-initiated, whereas in the generation
140 condition, these processes are driven by the production task itself, and thus less costly to
141 implement. Thus, remembering words that were simply read would require additional self-
142 initiated processes, and more control-demanding processes, which make the task more
143 difficult for older adults who have reduced cognitive resources (Taconnat & Isingrini, 2004).

144 Given the facilitating effects of prior task success and of generating words on
145 subsequent performance, we predicted that openness to experience would contribute most to
146 memory performance in the conditions in which self-initiated control processes are required
147 by the memory tasks, such as in the control (no prior task success) condition of Experiment 1
148 and the reading condition of Experiment 2. We predicted that neuroticism would contribute to
149 memory performance in both more and less supportive conditions because high levels of this
150 personality trait could affect memory regardless of whether controlled processes are required.

151

152 **2. Experiment 1: Effect of prior task success on memory performance in relation with**
153 **Openness and Neuroticism**

154 In Experiment 1, we sought to examine the role of openness to experience and
155 neuroticism on memory when performance was either facilitated or not by success on a prior
156 task. To induce task success, participants in the task success group completed a vocabulary
157 test prior to participating in the memory portion of the experiment. We used a vocabulary test
158 to instantiate task success because vocabulary is one domain in which performance remains
159 stable or increases with age (Park & Reuter-Lorenz, 2009) such that the test could be
160 successfully completed by older participants. Moreover, a vocabulary test is the type of task
161 (i.e., verbal task) that has been shown to be effective in achieving prior task success effects
162 (e.g., Geraci et al., 2016). We therefore hypothesized that participants would recall more
163 words when the memory task was completed after the vocabulary task (prior task success
164 condition) than when it was completed following no prior task (standard condition), indicating
165 a prior success effect. We predicted that openness would be positively associated with recall
166 performance, and neuroticism would be negatively associated with recall performance overall.
167 We hypothesized that the main predictor of memory performance in the standard condition,
168 i.e., the condition with higher cognitive demands, would be openness to experience because
169 high scores on openness favor controlled processes required by this task. Neuroticism should
170 explain memory performance to a lesser extent because neuroticism is associated with
171 anxiety, which can affect memory performance regardless of the situation. On the other hand,
172 in the prior task success condition, neuroticism should be the main predictor of memory
173 performance because this personality trait should affect memory performance in any situation,
174 regardless of the condition in which memory test is taken. Openness, and the qualities
175 associated to this personality trait, would not be useful in this “easier” condition.

1762.1. Methods

177 **2.1.1. Participants** Eighty-one older adult volunteers (45 women) ages 60-78 years ($M =$
 178 69.53 years, $SD = 4.55$) participated in this study. Participants lived independently and had
 179 no learning, neurological or psychiatric disorders. They were not taking any medication that
 180 could affect the central nervous system. An informed consent to participate was signed by
 181 all participants. To reduce the risk of including people with anxiety and/or depressive
 182 symptoms at a pathological level, participants were assessed using the two HADS subscales
 183 (Hospital Anxiety and Depression Scale; Zigmond & Snaith, 1983). All participants scored
 184 below 11 to both subscales (pathological threshold). They scored an average of 5.29 ($SD =$
 185 2.57) and 6.21 ($SD = 1.94$) on the Anxiety and Depression subscales, respectively. All
 186 participants scored higher than 27/30 ($M = 28.72$, $SD = 0.74$) on the MMSE (Mini Mental
 187 State Examination; Folstein et al., 1975), which reduces the risk of including participants
 188 with major neurocognitive disease. Participants in this sample had an average of 12.27 years
 189 of education ($SD = 1.85$). Participants of each group's characteristics are presented in Table
 190 1.

191

192 Table 1: Participants' mean characteristics and Standard Deviations (SD) in each condition in
 193 Experiment 1.

	Standard condition (n=41)	Prior task success condition (n=40)	t(79); p
Age	69.00 (4.57)	70.07 (4.53)	-1.06, p=.29
Educational level*	12.48 (1.95)	12.05 (1.66)	1.09, p=.27
MMSE	28.75 (.80)	28.70 (.69)	.34, p=.73
Vocabulary	24.65 (.99)	24.32 (1.24)	1.33, p=.19

Anxiety	5.27 (2.58)	5.32 (2.59)	-.10, p=.92
Depression	6.36 (2.12)	6.05 (1.75)	.73, p=.46

194 Note: * in years, MMSE: Mini Mental State Examination, Vocabulary: Vocabulary score
 195 from the Mill-Hill vocabulary test; Anxiety and Depression scores from the Hospital
 196 Anxiety/Depression Scale (HADS)

197 **2.1.2. Materials and procedure**

198 *Memory assessment.* Participants' memory was assessed under two conditions, the standard
 199 (no support) condition and the prior task success (encoding support) condition. They were
 200 randomly assigned either to the standard condition or to the prior task success condition. They
 201 were first interviewed to collect demographic data, and they completed the MMSE and
 202 HADS, and then given the personality questionnaire. Finally, they completed the task in
 203 standard or prior task success condition. They had to learn a list of 20 common words of 4 to
 204 9 letters and 2 to 3 syllables. In each condition, the 20 words were presented on a computer
 205 screen at a rate of 3 seconds per item and 500 ms between each item. The experimenter asked
 206 participants to memorize the word-list in order to recall as many words as possible during the
 207 subsequent recall phase. At the end of the word presentation, participants performed a short
 208 countdown task to avoid any recency effect. At the end of this task, participants were asked to
 209 recall orally all the words they could remember (free recall) without any order or time
 210 constraints. The dependent variable was the number of words correctly recalled under each
 211 condition. Last, participants were debriefed on the objectives of the study.

212 *Prior task success manipulation.* Participants in both the standard and the task success
 213 conditions completed a shortened version of the Mill-Mill vocabulary test (Raven et al.,
 214 1989). In the task success (encoding support) condition, participants completed the
 215 vocabulary test before participating in the memory portion of the experimental session. In the

216 standard (no encoding support) condition, they completed the vocabulary test afterwards. For
217 the vocabulary test, participants were asked to choose the synonym of a word from a list of
218 six other words. To create a feeling of success on this vocabulary test, we created a version of
219 the test that consisted of 26 items instead of 34 by removing the most difficult items. To
220 further instantiate a sense of task success, the experimenter informed participants that they
221 had done well on this test (regardless of their condition). As shown in Table 1, the two groups
222 performed equivalently on vocabulary (the score corresponds to the number of correct
223 answers). One might wonder whether taking a vocabulary test after a more difficult memory
224 test might result in poorer vocabulary test scores than when the test occurred before the
225 memory experiment. However, we did not expect this effect since vocabulary is a cognitive
226 ability that is generally not impaired with aging and for which older adults are expected to
227 perform proficiently.

228 *Personality measures.* The NEO-PI-R French version (BFI-Fr) was used to assess personality.
229 This self-questionnaire corresponds to the French version (Plaisant et al., 2010) of the NEO-
230 PI-R developed by Costa & McCrae (1992). It is based on the Big Five model and allows the
231 positioning of individuals on five scales corresponding to five personality traits: Extraversion,
232 Agreeableness, Conscientiousness, Neuroticism and Openness. In this study, we collected
233 only the scores from the dimensions "Openness to experience" and "Neuroticism".
234 Participants in the standard condition and the participants in the prior task success had
235 equivalent scores to Openness trait (respectively $M = 29.34$, $SD = 8.49$ and $M = 31.62$, $SD =$
236 9.62 ; $p = .26$) and to Neuroticism trait (respectively $M = 24.40$, $SD = 6.97$ and $M = 23.75$, SD
237 $= 7.86$; $p = .56$).

238

239 **2.1.3. Data processing**

240 First, to test our first hypothesis, the mean recall scores in each condition were
241 compared with t tests. Then, correlational analyses were performed to examine the
242 relationship between recall performance and the two personality traits in the two learning
243 conditions. To control for the variables possibly associated to recall, the correlations (Bravais-
244 Pearson r) between the recall score and the following variables: The HADS measures of
245 anxiety and depression, age, education, and vocabulary were analyzed. Correlational analyses
246 between personality traits and recall were therefore conducted under the control of measures
247 correlated with recall (i.e., partial correlations). In addition, correlational analyses between
248 openness and recall were performed controlling for neuroticism, and correlational analyses
249 between neuroticism and recall were performed controlling for openness (i.e., partial
250 correlations).

251 If a personality trait was not associated with recall in the same way in the prior task
252 success condition and in the standard condition, a General Linear Model (GLM) analysis was
253 conducted. The GLM analysis was used to analyze models with combinations of continuous
254 (as individual openness and neuroticism scores) or categorical (as condition) predictors when
255 applied to quantitative scales. This analysis allowed us to examine the interaction between the
256 variable condition (categorical variable) on one hand and the openness score or the
257 neuroticism score (as continuous variables) on the other hand. Last, regression analyses were
258 conducted to assess the best predictors of recall in the standard condition and in the prior task
259 success condition.

260

261 **3. Results**

262 ***3.1. Effect of prior task success on memory performance***

263 In accord with our first hypothesis, participants who learned the word list in the prior task success
264 condition recalled more words ($M = 8.55$, $SD = 1.97$) than participants who learned in the

265 standard condition ($M = 6.97$, $SD = 2.05$), $t(79)=3.51$, $p<.001$, Cohen's $d = .78$, indicating a
266 large effect size.

267 ***3.2. Relationship between recall and the two personality traits***

268 First, we examined the correlations between the recall score and the following variables:
269 The HADS measures of anxiety and depression, age, education, and vocabulary. In the
270 Standard condition, only the anxiety score was correlated with the recall ($r = -.46$, $p = .002$).
271 In the prior task success condition, anxiety was correlated with recall ($r = -.45$, $p = .003$),
272 education ($r = .34$, $p = .03$), and vocabulary ($r = .33$, $p=.03$).

273 Partial correlations performed on recall in standard condition showed that openness
274 was significantly and positively correlated with the number of words recalled ($r = .53$, $p <$
275 $.001$), and neuroticism was significantly and negatively correlated with recall ($r = -.32$, p
276 $=.048$). On the recall score under the prior task success condition, openness was not correlated
277 with recall ($r = .07$, $p =.65$), whereas neuroticism was significantly and negatively correlated
278 with recall score ($r = -.35$, $p = .04$).

279 Because openness was not equally associated with recall in the prior task success
280 condition and in the control condition, we performed a GLM to test the interaction between
281 the learning condition and openness to experience. The effect of condition was significant,
282 $F(1,77) =9.71$, $p=.002$, $\eta_p^2 =.11$, indicating that participants recalled more words in the
283 previous task success condition than in the standard condition. The effect of openness to
284 experience was significant, $F(1,77) =25.61$, $p<.0001$, $\eta_p^2 =.25$. The interaction between
285 condition and openness was significant, $F(1,77) =4.98$, $p=.02$, $\eta_p^2 =.06$, indicating that the
286 effect of openness was different according to the condition. According to the correlational
287 analyses, this result indicates that the effect of openness is greater in the standard condition
288 than in the prior task success condition. In the standard condition, the higher the score to

289 openness, the higher the recall performance. Moreover, the interaction suggests that
 290 individuals with lower levels of openness benefit more from environmental support (prior task
 291 success condition) than individuals with high levels of openness.

292

293 **3.3. Predictors of recall**

294 The main objective was to determine the best predictor(s) of recall performance under
 295 each condition. Hierarchical linear regression analyses were performed for each experimental
 296 situation. All measures correlated with recall in each group were entered into the model, in
 297 addition to measures of openness and neuroticism. Thus, in the standard condition, the
 298 Anxiety score was entered into the analysis, and in the prior task success condition, the
 299 Anxiety score, Vocabulary score and Educational level were also entered into the analysis. All
 300 variables are entered in the equation at the same time, and they appear in decreasing order of
 301 reliability in the analysis. The results are presented in Table 2.

302

303 **Table 2: Results of the Regression Analysis on Recall (Standard and prior task success**
 304 **Conditions)**

Steps	Standard Condition (N=41)	Prior Task Success Condition (N=40)
1	Openness $\beta = 0.54, p < .001$ $R^2 = 0.42$; $R^2C = 0.42, p < .0001$	Neuroticism $\beta = -0.48, p < .001$ $R^2 = 0.268$; $R^2C = 0.268, p < .001$
2	Neuroticism $\beta = 0.29, p = .04$ $R^2 = 0.48$; $R^2C = 0.06, p = .04$	Education level $\beta = 0.21, p = .15$ $R^2 = 0.31$; $R^2C = 0.04, p = .13$

305

306 Regression analyses showed that in the standard situation, openness was the first
307 predictor of recall and accounted for 54% ($p < .0001$) of the variance of recall; neuroticism
308 added 29% ($p = .04$). In the prior task success condition, neuroticism was the only predictor of
309 recall with 37% ($p < .001$) of variance explained, Educational level accounted for a non
310 significant 4%.

311 **4. Discussion**

312 Consistent with previous results (e.g., Geraci & Miller, 2013; Geraci et al., 2016),
313 the effect of previous task success was confirmed in the present study. Previous results by
314 Geraci and colleagues were thus extended, showing that participants who completed the
315 vocabulary test prior to participating in the memory experiment recalled more words than
316 those who completed the vocabulary test after the memory experiment. Note that participants
317 of both groups were in fact successful on the vocabulary test (about 92% success on the
318 vocabulary test on average whatever the experimental condition) suggesting that performance
319 on this test was not impacted by the episodic memory test. Moreover, consistent with previous
320 research and with our prediction, we found a positive association between openness and
321 memory performance in the standard condition (e.g., Jackson et al., 2020; Martinez et al.,
322 2021; Soubelet & Salthouse, 2010; Talpain & Soubelet, 2020) and a negative association
323 between neuroticism and memory performance (e.g., Kim & Diamond, 2002; Stephan et al.,
324 2020). Finally, our data showed that the two personality traits did not act in the same way in
325 the two experimental conditions. In the standard condition, i.e., the most demanding condition
326 with the least amount of support, openness was the main predictor of recall. This finding
327 suggests that the characteristics of people with a high level of openness, i.e., those who enjoy
328 new experiences, perhaps such as taking a memory test in a laboratory, perform better than
329 those with lower levels of openness. This test situation could be less stressful for these people,
330 and, being in better position to take a test, they could therefore allocate more resources to the

331 memory task, which would be more successful. However, the level of neuroticism appears as
332 a second predictor. Thus, even when individuals are high on openness, a high level of the
333 neuroticism can negatively influence memory scores. In the prior task success (support)
334 condition, only neuroticism predicted memory performance. Overall, participants who
335 participated in the memory experiment following a successful task experience performed
336 better on the memory test than those who simply participated in the memory experiment.
337 However, having a high level of neuroticism negatively influenced memory performance,
338 even in the prior task success condition that we might consider to be easier, suggesting that
339 even in the supported and potentially less stressful experimental condition, neuroticism was
340 negatively associated to memory scores. The level of the openness trait did not predict
341 memory performance in the prior task success condition. This could mean that when the
342 memory task is easier, the qualities of people with a high level of openness are not needed to
343 succeed on the memory task.

344

345 **5. Experiment 2: Effect of word generation on memory performance in relation with** 346 **Openness to experience and Neuroticism**

347 In Experiment 2, we sought to examine the role of these personality traits on memory
348 performance when memory was supported through specific strategies at encoding. To do this,
349 we used a word generation paradigm to enhance encoding (e.g. the “generation effect”;
350 Slamecka & Graf, 1978; Taconnat & Isingrini, 2004). In this paradigm, participants learn a
351 list of words according to two modalities, reading and generation. In the reading condition, a
352 target word associated to a cue word must simply be read (e.g., roof-house), in the generation
353 condition, the target word must be produced from the cue word (e.g., saddle-ho---) and a
354 generation rule (here: produce a semantic associate).

355 Based on a previous research (Martinez et al., 2021), we predicted that openness
356 would be more strongly associated with recall of read words than with recall of generated
357 words because this personality trait seems to be especially associated to cognitive tasks that
358 require highly cognitive control. By contrast, and in line with the literature and the results of
359 Experiment 1, a negative association was expected between neuroticism and memory
360 performance. Neuroticism would be negatively correlated to the recall score of both read
361 words and generated words, but more highly in the former, reading being a condition more
362 dependent of control processes than generation, and neuroticism being especially deleterious
363 for these processes.

364 **5.1. Methods**

365 **5.1.1. Participants**

366 Forty-two older adults between the ages of 60 and 82 years ($M = 71.22$, $SD = 6.70$)
367 participated in the experiment (21 men and 21 women). To characterize the participants, we
368 used the same measures that were used in Experiment 1. All participants had a score above 27
369 to the Mini-Mental Status Examination (MMSE, Folstein et al., 1975). The mean scores to the
370 anxiety and depression components of the HADS (Zigmond & Snaith, 1983) were 5.81 ($SD =$
371 2.67) and 5.52 ($SD = 2.34$) respectively. The Mill-Hill vocabulary test (Raven et al., 1989)
372 was used to evaluate and compare the level of vocabulary across participants in the two study
373 conditions. Note that because our goal was simply to measure participants' vocabulary
374 knowledge, and not to manipulate task success, we used a standard version of the vocabulary
375 test with 34 items and we used a standard administration procedure that did not include
376 feedback. The sample mean score was 24.07 ($SD = 4.78$) and thus comparable to the
377 participants' vocabulary level in Experiment 1. The overall level of education of participants
378 in the sample was 11.24 years of school completed ($SD = 2.68$). All the tests and
379 questionnaires were given before the memory test.

380 **5.1.2. Materials and procedure**

381 **Episodic-memory task.** Participants studied a list of 24 semantically associated word pairs
382 (Ferrand & Alario, 1998). This list consisted of two sub-lists of 12 word pairs,
383 counterbalanced across the two conditions: reading (roof-house) and generation (saddle-hor--
384). The pairs of items were presented randomly within a block, on a screen, for 5s each, with an
385 inter-stimulus time of 1s. Participants were instructed to try to learn the words in preparation
386 for a recall phase in which the first word (cue word) would be presented again and they would
387 need to recall the second word of the pair (target word). In order to ensure the correct
388 understanding of the instructions, participants were given practice trials with 4 word-pairs per
389 condition (no used in the test). Then, participants were given the study list. At the end of the
390 study phase, participants completed a one-minute distractor task (letter-pairs comparison XO
391 task, Salthouse, 1990) to avoid any recency effect. Finally, participants were given the cued
392 recall test and had unlimited time to recall the target words from the cue words. Note that in
393 the generation condition, participants produced 100% of the words from the cues and the
394 fragment of the target words. Thus, the number of words learned in the reading condition and
395 the generation conditions were equivalent, i.e., 12 words. Recall performance is the total
396 number of words read and produced that were correctly recalled.

397 **5.1.3. Personality measures.**

398 The same questionnaire used in Experiment 1 was used to assess openness and neuroticism in
399 Experiment 2. The participants mean scores for these traits were 31.88 ($SD = 7.17$) and 25.26
400 ($SD = 6.52$), respectively.

401 **5.1.4. Data processing**

402 To test our first hypothesis, the mean recall scores in each condition were compared with t
403 tests. Then, correlational analyses were performed to examine the relationship between recall

404 performance and the two personality traits for the read words and the generated words. To
405 control for the variables possibly associated to recall, the correlations (Bravais-Pearson r)
406 between the recall score and the following variables: The HADS measures of anxiety and
407 depression, age, education, and vocabulary were analyzed. Correlational analyses between
408 personality traits and recall were therefore conducted under the control of measures correlated
409 with recall (i.e., partial correlations). In addition, correlational analyses between openness and
410 recall were performed controlling for neuroticism, and correlational analyses between
411 neuroticism and recall were performed controlling for openness (i.e., partial correlations).
412 General Linear Model (GLM) analysis was conducted under the same conditions as in
413 Experiment 1

414

415 **6. Results**

416 **6.1. *Effect of generation on memory performance***

417 As expected, the t -test showed a significant generation effect $t(82) = 3.80, p < .001$, indicating
418 that the recall was higher for words that had been generated at study ($M = 5.38, SD = 2.19$)
419 than those that had been read ($M = 3.67, SD = 1.92$), Cohen's $d = .817$ indicating a large
420 effect, in accord with the literature.

421 **6.2. *Correlational analyses***

422 First, we examined the correlations between the recall of read and generated words and the
423 following variables: Anxiety, depression, age, education, and vocabulary. Only vocabulary
424 was correlated with recall of generated words ($r = .356, p = .021$). The number of read words
425 recalled was correlated with education ($r = .465, p = .002$) and vocabulary ($r = .379, p =$
426 $.013$). Analyses of the correlations between measures of personality traits and recall were
427 therefore conducted by controlling for vocabulary, and while controlling for both vocabulary

428 and the educational (i.e., partial correlations). In addition, correlation analyses between
429 openness and recall were performed controlling for neuroticism, and correlation analyses
430 between neuroticism and recall were performed controlling for openness. Analyses performed
431 on recall of read words showed that openness to experience was significantly and positively
432 correlated with the number of words recalled ($r = .606, p < .001$), whereas neuroticism was
433 negatively correlated with recall ($r = -.35, p = .03$). For recall of generated words, openness
434 was not correlated with recall ($r = .11, p = .45$), whereas neuroticism was significantly and
435 negatively correlated with recall ($r = -.38, p = .016$).

436 Because openness was not equally associated with recall for the generated words and for the
437 read words, we performed a GLM to test the interaction between the learning condition and
438 openness to experience. The generation effect was significant $F(1,40) = 24.25, p < .0001, \eta_p^2 = .37$,
439 indicating that the recall was higher for words that had been generated at than those that
440 had been read. The effect of openness was significant, $F(1,40) = 21.22, p < .0001, \eta_p^2 = .35$.
441 The interaction between the encoding condition and openness was significant, $F(1,40) =$
442 $14.53, p = < .001, \eta_p^2 = .26$, indicating that the effect of openness was not the same according
443 to the encoding condition. According to the correlational analyses, this result indicates that the
444 effect of openness is greater for the recall of the read words than for the generated words. This
445 suggests that individuals with lower levels of openness benefit more from environmental
446 support (generation) than individuals with high levels of openness.

447

448

449 **6.3. Regression analyses**

450 The main objective was to determine the best predictor(s) of recall performance under
451 each condition. Hierarchical linear regression analyses were performed for the read words and

452 for the generated words separately. All measures that were correlated with recall were entered
 453 into the model, in addition to measures of openness and neuroticism. Thus, for the read words,
 454 Educational level, Openness and Neuroticism were entered into the analysis, and for the recall
 455 of generated words, Vocabulary Score and Neuroticism were entered into the analysis. All
 456 variables were entered in the equation at the same time, and they appear in decreasing order of
 457 reliability in the analysis. The results are presented in Table 3.

458

459 **Table 3: Results of the Regression Analysis on Recall (reading and generation**
 460 **Conditions).**

	Reading Condition (N=42)	Generation Condition (N=42)
Steps	Variables	Variables
	Openness	Neuroticism
1	$\beta = 0.54, p < .001$ $R^2 = 0.53$; $R^2C = 0.53, p < .0001$	$\beta = -0.32, p = .027$ $R^2 = 0.23$; $R^2C = 0.10, p = .02$
	Neuroticism	Vocabulary
2	$\beta = -0.29, p = .03$ $R^2 = 0.59$; $R^2C = 0.06, p = .01$	$\beta = 0.14, p = .02$ $R^2 = 0.127$; $R^2C = 0.127, p = .02$
	Educational Level	/
3	$\beta = .18, p = .09$ $R^2 = .62$; $R^2C = 0.02, p = .13$	
	Vocabulary	/
4	$\beta = .15, p = .17$ $R^2 = .64$, $R^2C = .018, p = .17$	

461

462

463 Regression analyses showed that for the read words, openness was the first predictor
464 of recall performance and accounted for 53,4% ($p < .0001$) of the variance of recall scores.
465 Neuroticism added 6.5% ($p = .028$). Education and vocabulary added respectively non
466 significant 2% and 1% of the variance. For generated word recall, vocabulary accounted for
467 12.6 % of the variance in recall ($p = .02$) and neuroticism accounted for 10.4% ($p = .027$) of
468 the variance.

469 7. Discussion

470 Consistent with previous research, generated words were better recalled than read
471 words (Isingrini & Taconnat, 2004; Marticnez et al., 2021). Because participants in
472 Experiment 2 completed a vocabulary test prior to the memory test, whereas those in
473 Experiment 1 only did so in one condition (the prior task success condition), one might
474 predict that overall memory performance would be higher in Experiment 2 than in Experiment
475 1. However, the vocabulary tests and procedures differed across the two experiments, so their
476 potential effects on subsequent memory performance cannot be easily compared. The
477 vocabulary test used in Experiment 1 was designed to instantiate a feeling of task success,
478 whereas the vocabulary test used in Experiment 2 was used simply to measure vocabulary
479 knowledge following the standard procedure. In Experiment 1, the vocabulary was shortened
480 to help ensure that participants would successfully complete most of the items. They correctly
481 identified 92% of the words. In Experiment 2, the full set of 34 items was used and
482 participants correctly identified 72% of them. Also, in Experiment 1, participants received
483 positive feedback on their performance, whereas they received no feedback in Experiment 2,
484 following the standard procedure.

485 We also found that these two personality traits act differently according to the level of
486 environmental provided at the learning stage. There was a positive association between recall

487 of read words and openness (e.g., Jackson et al., 2020; Martinez et al., 2021; Soubelet &
488 Salthouse, 2010; Talpain & Soubelet, 2020). However, openness was not correlated to the
489 recall of generated words, consistent with our hypothesis. This lack of correlation between
490 openness and memory for generated words could be due to the fact that both encoding
491 (generation) and retrieval stages (cued recall) provided support. Possibly, this relatively easy
492 task does not require the cognitive competencies usually found to be associated with
493 openness. We found a positive correlation between vocabulary and recall of generated words,
494 in accord with Martinez and al.'s study (2021). Having a good vocabulary may facilitate rapid
495 and fluent generation of words, allowing more time to learn the words, and thus better recall
496 of them. Negative associations between neuroticism and recall of read words (e.g., Kim &
497 Diamond, 2002; Stephan et al., 2020) and generated words were found. The recall of read
498 words was predicted first by the score to the openness trait, consistent with Experiment 1
499 results. In Experiment 2, recall of read words was the most difficult condition, in which
500 individuals need to use most cognitive resources. These cognitive resources might be higher
501 and/or more available in people with a high level on openness. Neuroticism accounted for a
502 significant part of the variance of recall of read words. This result confirms the negative
503 influence of neuroticism on memory, especially when the task requires significant cognitive
504 resources.

505 Neuroticism was the first predictor of memory for generated words, confirming the
506 prediction that this personality trait negatively contributes to episodic memory, even when the
507 task is relatively easy. Thus, a high level of neuroticism may have a negative influence on
508 memory, regardless of the difficulty level of the task. Vocabulary was the second significant
509 predictor of memory performance in this condition, in accord with results from Martinez et al.
510 (2021), though they did not examine the role of neuroticism in memory for generated words.

511 That suggests that having a strong vocabulary may facilitate encoding and thus recall of
512 words.

513

514 **8. General Discussion**

515 In two experiments, we examined how neuroticism and openness to experience were
516 associated with memory performance depending on whether the tasks provided environmental
517 support or not. In Experiment 1, participants successfully completed a vocabulary task, either
518 prior having the memory task (prior task success, high environmental support condition), or
519 after (standard, low support condition). In Experiment 2, participants learned a list of word-
520 pairs either by generating them (high environmental support condition) or by reading them
521 (low environmental support condition). In both experiments, results showed that memory
522 performance was higher when greater environmental support was provided. These results are
523 consistent with previous findings showing a prior task success effect (Geraci et al., 2013;
524 2016) and a generation effect in older adults (e.g., Martinez et al., 2021; Taconnat et al.,
525 2004).

526

527 ***8.1. Effect of neuroticism on memory***

528 In both experiments, neuroticism was a significant predictor of memory performance
529 regardless of whether experimental conditions provided environmental support or not. High
530 levels of neuroticism were associated with lower performance, in accord with previous
531 research (e.g., Kim & Diamond, 2002; Stephan et al., 2020). Although neuroticism was not
532 the main factor accounting for memory performance in all conditions, it always contributed to
533 performance even in the facilitating conditions. That finding suggests that individuals higher

534 in neuroticism do not get a boost in performance from environmental support. These results
535 are consistent with the view that individuals with a high level of neuroticism have a general
536 decline in memory capacity, due to chronic stress that causes damage in the hippocampus, and
537 thus to encoding processes and storage of information (Kim & Diamond, 2002).

538 Beyond the structural effects of neuroticism on memory, individuals with a high level
539 of this trait may also have lower self-esteem, control, and memory self-efficacy than those
540 with a low level of neuroticism (Judge et al., 2002), which may affect memory (see Pinard et
541 al., 2021 and Bouazzaoui et al., 2020 for discussions on these points). Regarding personality
542 traits, Metternich and colleagues (2009) suggested a “vicious circle”, whereby individuals
543 who are conscious of their memory failures experience stress, which in turn may provoke
544 memory lapses. In general, older adults report more memory complaints than younger adults,
545 even when they are performing normally, suggesting that these complaints could be
546 considered as a type of stress-related psychosomatic disorder (Commissaris et al., 1998). This
547 phenomenon can become important in individuals with a high level of neuroticism. In accord
548 with this idea, Munoz and colleagues (2013) showed that intrusive thoughts, perhaps
549 stemming from negative beliefs about memory for people with high a level of neuroticism,
550 mediate the association between neuroticism and cognitive performance. This finding may
551 explain why this personality trait is so important in accounting for memory performance: it
552 would be so in two ways, 1) a direct effect on memory, by the action of stress on
553 hippocampus, and/or 2) a metacognitive effect, via the relationships between memory beliefs
554 and memory performance.

555

556 ***8.2. Effect of openness on memory***

557 In both of the present studies, people who had higher scores on openness to experience
558 had greater performance in memory than those with lower scores. The effect of openness to
559 experience was greater in the control conditions, which provide less environmental support, as
560 indicated by the significant interaction between condition and openness in the two
561 experiments. This finding suggests that the encoding support helps individuals who are low
562 on openness perform better - perhaps as well as individuals who are high on openness.
563 According to Craik (1986), a task that does not provide environmental support, or that
564 provides limited environmental support, requires substantial engagement of self-initiated,
565 cognitive resources, and older adults, for whom these resources are diminished, have impaired
566 performance to this type of task. In fact, openness was the first predictor of memory scores in
567 the standard condition of Experiment 1 and the first predictor of memory scores for the recall
568 of read words in Experiment 2. These were the conditions that offered the lower support to
569 help implementation of memory processes. Openness seems to be particularly important for
570 memory in these conditions. Openness is associated with both crystallized and fluid
571 intelligence (DeYoung et al., 2005), two cognitive resources important for memory, especially
572 in aging (Bouazzaoui et al., 2013; 2014) and may have a particularly prominent relationship
573 with the development and the maintenance of the cognitive reserve which contributes to
574 cognitive functions in old age (Franchow et al., 2013). A high level of openness reflects also
575 greater intellectual curiosity and comfort with novel experiences. Therefore, the most open
576 individuals may not only have a higher cognitive reserve making them better to memory tasks
577 (Stern, 2009), but they may be less reluctant to undergo a laboratory memory experiment.
578 This point is important because such experience in laboratory may be stressful, which could
579 have a deleterious effect on memory performance. Interest for this new experience
580 (participating to an experiment in laboratory) could counteract the harmful effect of
581 apprehension for this type of experience. Moreover, being less anxious about a memory task

582 could free cognitive resources to complete the task. Thus, these qualities, present in
583 individuals with a high-level in openness, could be particularly beneficial in experimental
584 conditions where memory tasks are the most difficult, i.e., those that offer the low
585 environmental support.

586 **9. Conclusion, limits and perspectives**

587 The current studies demonstrate that personality, in particular openness and neuroticism
588 (Karsazi et al., 2021), is associated with memory performance for older adults, and that this
589 association depends on the amount of environmental support. However, we do not know
590 exactly how these personality characteristics influence memory performance, particularly
591 when there is little environmental support. Future studies should assess the specific
592 mechanisms by which these traits may influence performance with and without environmental
593 support. In addition, future studies should examine the relationship between personality and
594 other forms of environmental support to determine under which situations personality will
595 have the greatest influence on performance, particularly in applied settings using cognitive
596 and neurological assessments.

597 Neuroticism was negatively associated with memory regardless of the experimental
598 condition in which memory is tested. This negative relationship is possibly due to
599 metacognitive factors such as beliefs about ability to control memory (see Bouazzaoui et al.,
600 2019; Lachman et al., 2011; Pinard et al., 2021), or about memory self-efficacy, as people
601 high in neuroticism present high level in memory complaint in general (Merema et al., 2013)
602 or in everyday life situations (Neupert et al., 2008). Thus, neuroticism can act negatively on
603 memory independently of the nature of the memory task. This finding suggests that
604 individuals higher in neuroticism do not get a boost in performance from the environmental
605 support, which has implications for interventions. Future research would thus focus to

606 conditions that would help these people to be more successful in memory tasks, but also in
607 general cognitive tasks.

608 Openness is also crucial for memory in particular for tasks carried out in conditions
609 considered to be the most difficult. A high level to this personality trait could act as a
610 cognitive reserve factor (Franchow et al., 2013; Martinez et al., 2021), and is especially
611 positively associated to memory task providing low environmental support and where
612 memory strategies have to be self-initiated. The present results are in accord with this view,
613 and with previous results showing that older adults with a high level in openness use more
614 efficient memory strategies that may promote memory performance (Pinard et al., submitted;
615 Talpain & Soubelet, 2020). It is possible that people with a high level of openness, who are
616 more creative, are more willing to seek out, find and execute the most effective strategies
617 when there is no support to guide these strategies.

618 In sum, the present study extends previous research on the relationships between two
619 personality traits, neuroticism and openness, and memory, and shows that these relationships
620 may differ according to the nature of memory task. In particular, the present results showed
621 that neuroticism is an important predictor of memory performance, but that openness is
622 crucial in the most difficult memory tasks. Because our hypotheses were specific to
623 Neuroticism and Openness, we collected data only for these two traits. However, it is possible
624 that the other three personality traits, Agreeableness, Extraversion and Conscientiousness,
625 may influence cognitive functions, particularly Conscientiousness (e.g., Chapman et al., 2017;
626 Klaming et al., 2017). Thus, it would be interesting to assess these personality traits in a
627 future research to better understand their influence on memory according to the current
628 experimental test conditions.”

629 Including personality traits analyses in experimental studies about memory and aging
630 may contribute to a better understanding of memory functioning, which would have important
631 implications in experimental research as well as in clinical examinations insofar as people's
632 individual characteristics must be taken into account for a better interpretation of their
633 performance.

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