The effect of print exposure upon performance on the Raven Progressive Matrices Test

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Abstract
This study examines a potential relationship between reading and performance on a fluid intelligence test. Participants were 89 adults (*M* age= 39.0) of various educational backgrounds. Reading volume was assessed by the Greek versions of the Author and Magazine Recognition test (here ART-GR and MRT-GR respectively) initially developed by Stanovich and West (1989). Fluid intelligence was assessed by the Raven Progressive Matrices Test (Raven 1938), a non-verbal, graphical test. Participants with greater print exposure as measured both by the ART-GR and the MRT-GR reported greater fluid intelligence scores. The same was true for participants with more advanced than lower educational background.

Keywords: print exposure, fluid intelligence, education

1. Introduction

Human intelligence highlights individual differences and has been well studied in the field of psychology and cognitive science (Brody 1992; Fancher 1985). Individual differences in intelligence are evident from childhood to old age (Deary et al. 2000). From early on, evidence has shown that the level of intelligence can dramatically change (Boyne & Clark 1959). Presumably the best example of this is the so-called secular change of intelligence, namely, that there is a significant increase of intelligence levels in society over time.

Greater levels of intelligence were observed since 1930’s with the global level of intelligence being increased by about one standard deviation (Flynn 1984, 1987, 1999; Neisser 1998). A potential explanation of the secular change that has been suggested was the general increased level of education (Husen & Tuijnman 1991). Adding to that observation, a more recent study by Brinch and Galloway (2012) reported that in Norway in the 1960's there was an increase of the duration of compulsory schooling from 7 to 9 years which resulted in an observed IQ increment among young people of about 3.7 IQ points per year of schooling. In the same line, Ceci (1991) examined a sample of 4,416 Swedish and found that individuals with only few years of education scored lower on IQ scores when compared to individuals with more years spent on education. Thus, a positive relationship between educational achievements and achievements on cognitive tasks has been suggested (Ceci & Williams 1997; Gustafsson 2001). Portin et al. (1995) showed that among a group of male and female elders (mean age: 62) those who spent more years of schooling performed better in four Wechsler Adult Intelligence Scale (WAIS) subtests (digit span, similarities, digit symbol and block design). Under this rationale, the aforementioned study highlights the positive effect that schooling exerts on cognitive performance especially among older people.

On the other hand, there is evidence highlighting the unique contribution of voluntary reading (i.e., the amount of reading outside of formal schooling curriculum) upon cognition. For instance, it has been suggested that voluminous reading ameliorates memory (e.g. Rice & Meyer 1985), it protects individuals from developing cognitive pathology (Wilson et al. 2000), while it increases general knowledge acquisition (Stanovich & Cunningham 1992) and crystallised abilities (i.e., the ability to apply knowledge to given situations) (Stanovich, West & Harrison 1995). The benefits of voluntary reading have been found even among elders. For instance, elders who spend more time on reading activities are suggested to display greater memory skills (Payne et al. 2012), as well as better executive control, verbal working memory and visual attention (Moss et al. 2011). The above evidence shows that reading can function as a cognitive reserve, i.e., as a protective mechanism against the brain’s cognitive decline due to aging.

But what do we really mean with the term 'intelligence'? Intelligence is not a unitary construct but rather it is comprised of two equally important factors: *fluid* intelligence and *crystallized* intelligence (Cattell 1967). *Fluid* intelligence refers to the person's ability to abstract reasoning independent of previous acquired knowledge or in other words *fluid* intelligence is the ability to solve abstract problems in novel situations. On the other hand, *crystallised* intelligence is comprised of acculturated knowledge and skills that are acquired through education and experience (Cattell 1987). The literature seems to provide inconsistent results on the effects of reading upon fluid abilities (e.g. Wicherts et al. 2010). To state it differently, it is not clear as yet, whether reading increases one's '*g*' level (where '*g*' refers to *fluid* intelligence) (Spearman1946: 127). According to Ceci (1991) schooling paves the path to intelligence by activating individuals' cognitive abilities to express their intelligence. For example, Finlayson, Johnson and Reitan (1977) examined whether there is a relationship between level of schooling (Grade school, High school, University) and performance on a psychometric intelligence test, the Wechsler-Bellevue scale. The participants' performance (51 brain-damaged patients; 51 controls) revealed a positive significant correlation between years of schooling and IQ scores. Most importantly, brain-damaged participants who had attended a University scored greater than controls with only high school education. This finding, although not robust, indicates that reading might somehow compensate the negative effects of brain damage. In the same line, a more recent study by Kaufman et al. (2009) found a positive relationship between various academic skills, such as math, reading and writing performance, and scores not only on *fluid* but also on *crystallised* intelligence, as measured by the Kaufman Brief Intelligence Test-Second Edition (KBIT-II). Importantly, this study recruited a large sample size (N= 1,125) that ranged in age from 22 to 90 years. Other studies have also shown that people with higher levels of education do exhibit better performance on a number of instruments measuring *fluid* intelligence (e.g. Brinch & Galloway 2012; Colom et al. 2002; Dolan et al. 2006). Finally, some scholars have shown that it is not the duration of education that has a positive effect upon *fluid* intelligence but rather the amount of time one has spent in voluntary reading activities. For instance, Manly et al. (2003) have shown that what affected immediate and delayed memory recall was the amount of time elders spent in voluntary reading rather than their educational background, as measured by the years of education. Similar results were also found by Wilson et al. (2000) in a cohort of more than 500 elders. This study shown that *fluid* intelligence was positively correlated to the amount of time elders spent in reading activities rather than to the years spent on education.

The question that arises here is how reading can have a positive effect upon *fluid* intelligence? Kosmidis, Zafiri and Politimou (2011) argue that this positive effect is related to their working memory capacity. Working memory refers to the person's ability to recall a number of items during a working memory task (Garcia-Madruga et al. 2014). Many scholars seem to agree that working memory and *fluid* intelligence are intimately related (e.g. Ackerman, Beier & Boyle 2005; Colom et al. 2008; Cornoldi 2006; Kyllonen & Christal 1990). High-working memory span students exhibit greater reading comprehension skills compared to low-spanners (e.g. Cain, Oakhill & Bryant 2004; Vukovic & Siegel 2006). This is due to the central role of working memory on cognition, including writing, arithmetic and problem solving (Gathercole et al. 2006; Swanson 2011; Swanson & Siegel 2001; Yienad et al. 2013). The importance of working memory on academic skills is highlighted by studies showing that its role on literacy and numeracy performance is greater than the one played by IQ levels (for a review see also Alloway & Alloway 2010).

The present study aims to further explore the role of literacy upon *fluid* intelligence skills. We assess literacy both in terms of print exposure, as measured by the ART-GR & MRT-GR tasks designed for the purpose (see below *2.2 Materials*), but also in terms of educational background of the participants, as calculated by their final degree. *Fluid* intelligence is measured by the Raven Progressive Matrices Test (Raven 1938), a non-verbal test of fluid intelligence. Based on the discussion outlined above it is expected that individuals with greater reading activities will exhibit higher fluid intelligence scores as measured by the Raven Progressive Matrices Test. Participants' level of education is believed to have no effect on the *fluid* intelligence scores.

2. Method

2.1 Participants

Participants were 89 male (*N*= 44) and female (*N*= 45) Greek adults (age range= 18-77, *M* age= 39.0, *S.D.*= 20.2). 7.8% had completed only formal/compulsory (gymnasium) schooling, 24% had attended a Higher National Diploma or a college, 42% had acquired a University degree and the remaining 15% had further proceeded to a postgraduate course (either to a Masters or to a Doctoral level).

2.2 Materials

A. Print exposure Measurements: Print exposure was assessed by the administration of the Author Recognition Test (ART) and the Magazine Recognition Test (MRT). These are two checklists which were initially developed by Stanovich and West (1989) and require participants to choose among a number of author names and magazine titles only the real ones and ignore the “decoy” items. To prevent social desirability responses (not true responses by an intention to be seen favorably by others), participants get a penalty for any false response, by subtracting the number of false responses from the number of correct responses. For the purpose of the present study participants were administered the Greek versions of the ART and the MRT (ART-GR and MRT-GR respectively). The ART-GR consists of a total of 80 author names (40 real and 40 foil [made up] items). The real items are names of literature authors, while the foil items are names of authors from other genres (e.g., fashion, sports). Participants are told to choose only the names of literature authors. The requirements to choose an item were either the author to have been awarded the prize of reader's best choice, the 2012 National Literature Prize or to have been among the best-seller books as indicated by famous Greek bookstores (e.g. Soti Triantafyllou, Isidoros Zourgos, Lena Manta, Irvin Yalom, to name a few). The final selection of the items was based on two prior pilot studies with an initial list of 150 items. The MRT-GR similarly, consisted of 80 items, 40 of real magazine titles and 40 of titles of TV programmes or newspapers. Again, participants were asked to choose only the titles of magazines. The items included magazines that have high circulation as indicated by the Magazines’ Catalogue of the Central Public Library of northern Greece (http://catalogue.libver.gr/webopac/Vubis.csp) and they appeared in the same way that appeared in the magazine titles, i.e. in English or in Greek (e.g. Esquire, Nifi [Νύφη= 'bride' in Greek], Katikia [Κατοικία= 'residence' in Greek] . Magazines that were new in circulation (< 6 months) or magazines that were no longer in circulation were not included. Again, the item selection for the MRT-GR was based on two pilot studies with 214 and 122 titles respectively.

B. Fluid Intelligence Measurement: *Fluid* intelligence was assessed by the Raven Standard Progressive Matrices Test (Raven 1938) (hereafter abbreviated as RPM). This is a non-verbal graphical format test of *g*, comprised of 60 problem solving items in five sets, A to E. Set A and the first half of Set B assessed perceptual abilities (visuospatial abilities), whereas the rest of Set B and the Sets C to E measured analytic abilities (the abilities to solve complex problems based on the available information) (Van der Ven & Ellis 2000). The RPM is considered to be “...the best of all non-verbal tests of g” (Spearman 1946: 127) and as “an almost pure g test” (Vernon & Parry 1949: 234).

2.3 Procedure

The experimental sessions took place at the Language Development Lab of the Aristotle University of Thessaloniki. Participants were administered the ART-GR and the MRT-GR followed by the RPM. Demographic information required was participant's age and educational background (i.e. the level of their final degree). Each session lasted approximately 40 minutes.

3. Results

Preliminary analysis showed that scores on the ART-GR ranged from 0 to 34 (*M*= 13.5, *S.D.*= 7.6) whereas scores on the MRT-GR ranged from 0 to 33 (*M*= 10.3, *S.D.*= 8.8). Next, the median split procedure was adopted in order to group participants as high or low print exposure groups. Participants who scored 17 and above were classified as high-spanners and those that scored 0-15 were classified as low-spanners. This process did not exclude any participant. In the ART-GR 37.8% of the participants were identified as being in the 'low' group and 51.1% as being in the 'high' group. In the MRT-GR, on the other hand, 56.7% of the participants were classified as being in the 'low' group and 32.2% as being in the 'high' group.

Next, a univariate analysis was performed with the RPM scores as the dependent variable and the ART-GR ('high' vs. 'low' group), MRT-GR ('high' vs. 'low' group), Educational Level (Formal Schooling vs. Higher National Diploma vs. University vs. Postgraduate studies) and Gender (Males vs. Females) as fixed factors. The results revealed a significant main effect of ART-GR, F (1, 59) = 9.55, p= .003, η^2 = .3, with those in the high compared to the low ART-GR group scoring greater on the RPM (*M*= 49.5 vs. *M*= 42.8). However, the RPM scores were not significantly affected by the participants' performance on the MRT-GR (p= .117). These results are graphically presented in *Figure 1.*

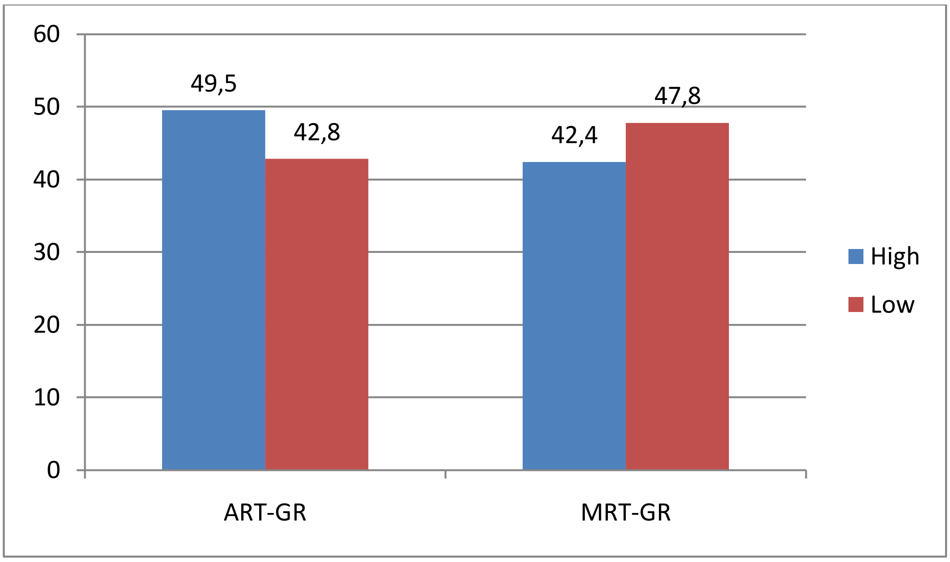

Figure 1: Performance on RPM by the ART-GR & MRT-GR

The main effect of educational level turned to be significant, F (3, 39) = 3.93, p= 015, η^2 = .1. Bonferroni post-hoc comparison tests showed that the participants with postgraduate studies (M= 56.5) scored significantly higher in the RPM compared to those with higher national diploma (M= 46.3, p< .001), those with University degree (M= 44.1, p< .001) and those with formal schooling (M= 40.2, p< .001). These findings are depicted in *Figure 2*. A further regression analysis was performed to test the amount of variance that educational level predicts upon performance on the RPM. The results showed that the participant's education was a highly significant predictor upon their performance on the fluid intelligence test, i.e., the RPM test (R^2 = .11, β= .34, p= .001).

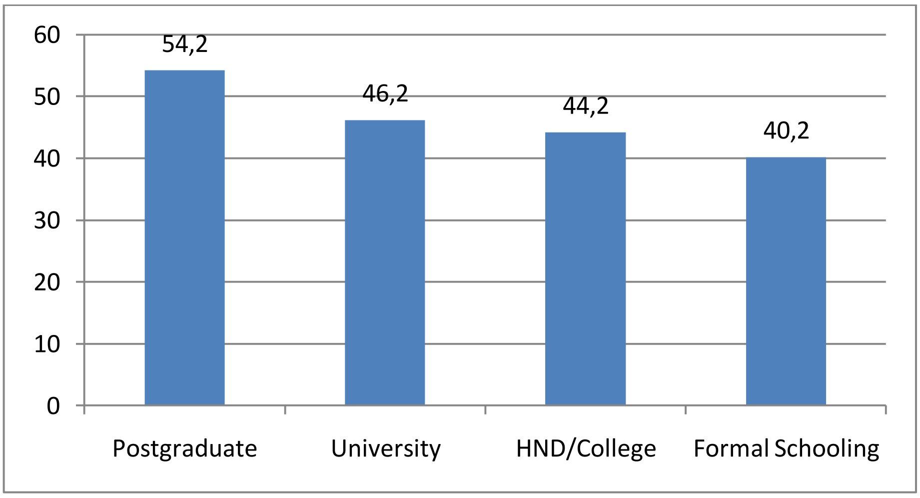

Figure 2: Performance on RPM as a function of participants' educational level

A significant interaction was also found between ART-GR and the participants' gender, $F(1, 59) = 9.23$, $p= .004$, $\eta^2 = .13$. Follow-up independent sample t-tests revealed that, among males, those in the high ART-GR group scored greater on the RPM than those in the low ART-GR group (M=49.8 vs. M= 41.1, t (33) = -2.54, p= .016). No significant difference, however, was found among females as a function of ART-GR level (p= .46). This effect is shown in *Figure 3*. The same interaction was also found on scores on the MRT-GR, $F(1, 59) = 8.28$, $p= .006$, $\eta^2 = .12$, which effect, however, disappeared in the following-up analysis.

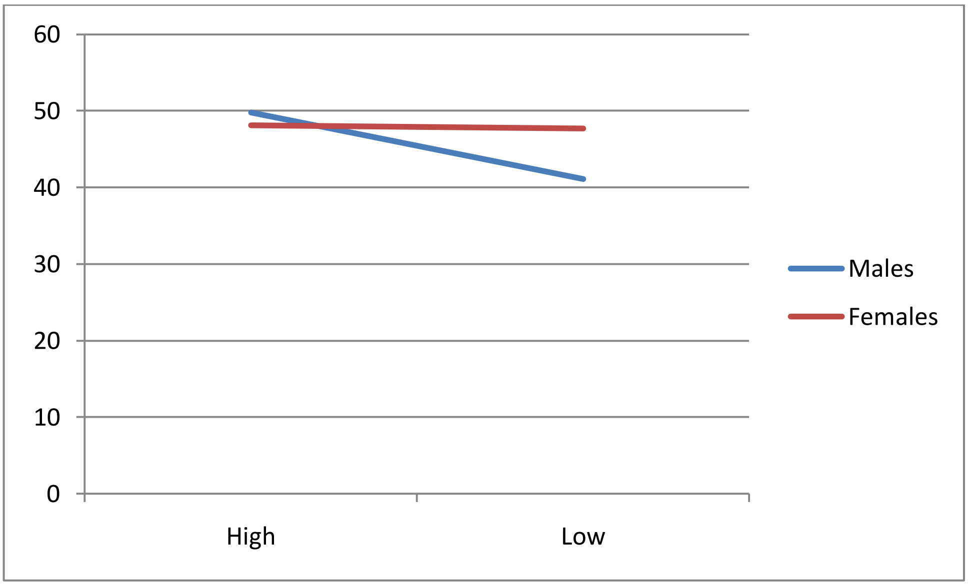

Figure 3: High scores on the ART-GR were positively related for males (but not for females) scores on the RPM

A final significant 2-way interaction was found between ART-GR level and the participants' educational level, $F(1, 39) = 5.28$, $p= .027$, $\eta^2 = .1$. A follow-up t-test analysis showed that, among participants with formal schooling, those who scored high in the ART-GR performed higher on the RPM than those who were assigned to the low ART-GR group (M= 42.4 vs. M= 37.3, t(33) = -1.45, p= .029). Similarly, in the group of participants with postgraduate studies, those in the high ART-GR group scored more accurately on the RPM than those in the low ART-GR group (M= 56.8 vs. M= 50.3, t(33) = 3.45, p= .031). This finding is depicted in *Figure 4* below.

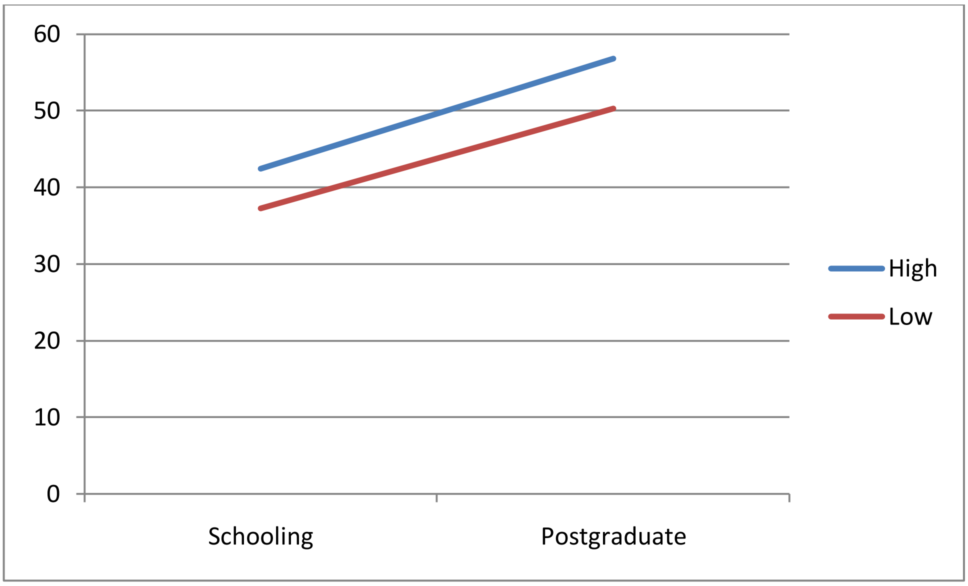

Figure 4: Participants with greater print exposure level as measured by the ART-GR scored higher on the RPM

4. Discussion

Overall, this study showed that participants with greater print exposure as measured by the ART-GR performed higher on the RPM, the test used to assess *fluid* intelligence. The same was true for participants who spent more years on education. However, a closer inspection of the results indicates that print exposure as opposed to participants' educational level has a stronger effect upon performance on the RPM.

Regarding the effect of print exposure, the results showed that it is not print exposure per se that matters but rather the quality of the reading materials that individuals are engaged with. This can be seen by the significant effect that was found among participants who scored high on the ART-GR but not among those that scored high on the MRT-GR. Thus, it seems that for print exposure to have an effect upon *fluid* intelligence there must be a certain level of cognitive demand which is assumed to be acquired by reading books but not magazines. Several studies have shown that text difficulty plays a role in several aspects such as fluency development (Hiebert 2006), expressiveness (Young & Bowers 1995) and reading comprehension (Freebody & Anderson 1983). Support of the ART-GR compared to the MRT-GR on a lexical decision latencies were found by Fotiadou et al. (2014). In their study, print exposure, as measured both by the ART-GR and the MRT-GR, resulted in greater word recognition but when reaction time was assessed, a more sensitive variable to assess word recognition abilities, then the ART-GR compared to the MRT-GR was a stronger predictor in assessing individual differences in print exposure. Indeed, Nagy and Herman (1987) provide support for the claim that the benefits of reading can be seen not only when people are engaged in reading activities per se but rather when they are engaged in cognitively demanding reading materials. The authors suggest that this is so because books compared to other materials consist of complex structures and often include low frequency words and are rich in diversity. Similarly, the present study suggests that reading books compared to reading magazines promote greater knowledge as indicated by fluid intelligence levels. Nevertheless, we suggest that one should not diminish the importance of the MRT-GR as a print exposure instrument. This instrument might be particularly useful, especially for measuring individual differences in print exposure among the elders who may experience a potential difficulty in encountering cognitively demanding materials. For instance, due to visual problems elders might be prone to tiredness more by reading books than by reading more *'light'* materials such as magazines.

A potential limitation of the present study is that we did not assess *crystallised* intelligence. According to the Cattell-Horn theory (or Investment theory, Cattell 1943, 1971, 1987; Horn 1965, 1968; Horn & Cattell 1966) of *fluid* and *crystallised* intelligence these two intelligence constructs are likely not to function independently, but rather to be inter-correlated and their role may be mutually significant upon performance on cognitive functioning. Thus, in relation to the present study, participants with greater print exposure level may have functioned better on the RPM thanks to a mediating role played by *crystallised* intelligence in accomplishing the task. One could argue that the role of *crystallised* intelligence upon performance on the RPM is also illustrated by the regression analysis showing that the participants' educational background positively affected the scores on the RPM (*fluid* intelligence). We believe that this finding partly supports the Cattell-Horn theory about the interdependence role between *crystallised* and *fluid* intelligence.

To sum up, this study can be considered to have contributed to the existing literature in a number of different but equally important ways. Firstly, it shows that reading books increases *fluid* intelligence and this is an important finding as it can be used to promote the significance of reading. Secondly, although further studies are needed, the present work introduced the Greek version of two print exposure measurements, namely the ART-GR and the MRT-GR. Finally, this study reveals that although education is important in acquiring knowledge, what matters more is engaging in continuous reading activities in order to ameliorate *fluid* intelligence levels. However, a recent study has shown that *fluid* intelligence is a rather complex structure not well-understood in the literature with a potential heritability component (Davies et al. 2011). This means that, although engaging in reading activities plays a major role in ameliorating *fluid* intelligence, there are also other factors which need to be examined in future studies. Thus, the present findings should only be approached as an indicator of a potential relationship between the engagement in reading activities and the increase of *fluid* intelligence.

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