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Emotional Response to Testing in Gifted and Highly Gifted Children

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Abstract

Whether intellectually gifted children have a greater emotional response when tested is still unclear. This may be due to the marked heterogeneity of this particular population, and the fact that most studies lack the power to reduce the noise associated with this heterogeneity. The present study examined the relationship between performance and emotional response in 468,423 Italian fifth-graders taking a national test on mathematics and language. Analyses were performed using statistical models with polynomial terms. Special attention was paid to estimating the mean emotional response of the children who were gifted (1.5-2.5 standard deviations above the mean) or highly gifted (more than 2.5 standard deviations above the mean). The results showed that, although a lower emotional response correlated with a higher achievement, this relationship is nonlinear, and the estimates for gifted and highly gifted children were virtually the same. Girls showed a greater emotional response than boys on all levels of performance. The theoretical and practical implications of these findings are discussed.

Keywords: archival, factor analysis, multiple regression, academic giftedness, test anxiety, emotional response to test, gender differences

Emotional Response to Testing in Gifted and Highly Gifted Children

The present study examines whether children who are gifted and highly gifted, based on their results in general tests of mathematics and language, have a greater emotional response in terms of negative emotions of worry, anxiety, block, and impression of doing poorly than their classmates when taking important academic tests. This question has remained unclear. It has been claimed that gifted students may have accentuated emotional characteristics that pose problems in their everyday school lives (Pfeiffer & Stocking, 2000). For example, it has been suggested that they are typically overexcited (Dabrowski, 1964) and oversensitive (Mendaglio, 1995) and, therefore, more emotionally involved in their activities than their peers. Reference to the construct of overexcitability has been criticized (Vuyk et al., 2016), but it continues to influence opinions in the field of giftedness, not only of families and practitioners but also of researchers (e.g., Ackerman, 1997; Chang & Kuo, 2019).

Gaesser (2018) argued that there are many anxiety-inducing stressors in the everyday experience of gifted individuals (see also Cross & Cross, 2015; C. G. Goetz, 2003; Harrison & Van Haneghan, 2011). They may need greater stimulation and be better able to recognize the complexities and nuances of concepts and questions than their peers in the population at large. These aspects also may have implications during school tests because gifted children may be ambitious but also uncertain of their abilities. Their difficulties during tests may also be exacerbated by a competitive spirit because there are reports of gifted students reacting negatively to being compared with other brilliant students (Zeidner & Schleyer, 1999b). They may have an accentuated fear of failing to meet the expectations of people around them and a strong degree of perfectionism—a trait that seems to be more prevalent in gifted children, though it does not necessarily have negative implications (Ogurlu, 2020). The highest achieving students want to perform best, and this may make them more anxious than their peers before a test. For instance, the recent PISA (Programme for International Student

Assessment) international survey (Organisation for Economic Co-operation and Development [OECD], 2019) found that the percentage of 15-year-olds in the OECD countries who reported agreeing with the statement “I want to be one of the best students in my class” correlated positively (r = .37) with the percentage of students who agreed with the statement “Even if I am well prepared for a test, I feel very anxious.”

Despite the popular view that gifted children face emotional difficulties, there is also a considerable body of research to the contrary. For example, Francis et al. (2016) considered the personality traits of individuals with a standard score above 125 on instruments commonly used to assess IQ and found that their mental health was better than in the typical population (see also Godor & Szymanski, 2017; Shechtman & Silektor, 2012; Wirthwein et al., 2019). The same applies to gifted students’ emotional response to testing: gifted students tend to be less anxious (Scholwinski & Reynolds, 1985; Zeidner & Schleyer, 1999a), particularly when compared with the overall population rather than with other gifted students (Zeidner & Schleyer, 1999b).

Test anxiety appears to be particularly relevant in this context, which is why it has been the object of an impressive number of studies over a long period of time. A meta-analysis carried out more than 30 years ago (Hembree, 1988) had already found more than 500 studies involving the construct of test anxiety, with a particular emphasis on the case of mathematical tests. For numerous reasons (including the presence of immediate feedback and beliefs relating to intelligence and gender biases [Mammarella et al., 2019]), more anxiety is associated with mathematics than with other academic areas. The issue has not been thoroughly investigated in the gifted population, however, and various aspects involved have sometimes been neglected. In fact, when Scholwinski and Reynolds (1985) examined how 584 children with a high IQ answered the questions on an anxiety scale, they found that anxiety can be separated into different components (e.g., physiological, worry/oversensitivity, and concentration), and would be differently associated with any negative emotions, or what we call here "emotional response" to an important test situation. One of these components concerns the worry a child experiences before sitting a test (e.g., T. Goetz et al., 2008; Hembree, 1988), while other aspects relate to the test session itself (see Mammarella et al., 2019). Students can sometimes experience negative emotions severe enough to make them feel mentally blocked. The calmness and emotional control needed during a test may relate to another aspect known as negative feedback, or the impression of doing poorly. This impression is a manifestation of a child's metacognitive monitoring ability and has been examined in research on metacognition (or our capacity to reflect appropriately on our cognitive functioning), also with reference to the testing of language and mathematical skills (e.g., Garcia et al., 2016; Roebers et al., 2009). Students who have the impression of making mistakes may lose their calmness and let their emotions interfere, while those who experience anxiety and a loss of emotional control in a test situation may be convinced of doing poorly.

In short, different aspects of emotional response to a test need to be considered. Other ambiguities in this field of research seem to be due partly to the gifted population being poorly defined. Giftedness is not just about intellectual abilities. Creativity and artistic talents, for example, may also be taken into account when defining giftedness, and these seem to be the aspects more related to emotional difficulties (Baas et al., 2016). Even when only cognitive abilities are considered, however, findings may be affected by a marked degree of variability. For a start, children's intellectual giftedness may be defined in relation either to their intelligence or to their academic achievement, and these two variables do not perfectly overlap (Toffalini et al., 2017).

Another element of variability is represented by gender, which seems to influence both giftedness and emotional response. It has been suggested that gender-related differences in mathematics achievement are emphasized in the right tail of the ability distribution (Hyde

& Mertz, 2009). This claim has been amply studied and hotly debated (Giofrè et al., 2020; Halpern et al., 2007; Makel, Wai, et al., 2016; Wai et al., 2010). Less attention has been paid, however, to the hypothesis that gender-related differences in emotional response can also be found on the far right of the ability distribution and are of the same size as in the remaining population. This is the claim advanced by Preckel et al. (2008), who examined a relatively small sample of sixth graders grouped according to their high versus average level of nonverbal intelligence. They found that gender-related differences in self-concept, interest, and motivation in mathematics were even stronger among students who were gifted than among students of average ability. The typical differences in emotional response to testing whereby females are, on average, more reactive than males (Mammarella et al., 2019) might therefore be accentuated among gifted children.

Another element of variability relates to the degree of intellectual giftedness. The gifted populations involved in studies usually consist of students whose average performance is 2 standard deviations above the mean. It seems important, however, to examine the most exceptional cases of intellectual giftedness as well. It has been argued (e.g., Roedell, 1984) that children with extraordinary intellectual skills differ substantially from moderately gifted children. The former would have unique vulnerabilities and be more liable to uneven development and perfectionism, suffer from excessively high adult expectations, experience intense sensitivity, and role conflict. Such a pessimistic description contrasts, however, with the observation that children with an extremely high IQ may achieve extraordinary things in life (Makel, Kell, et al., 2016). It also contrasts with the hypothesis that highly gifted individuals simply represent the top end of a continuum, with a greater degree of characteristics that can also be found in typically gifted individuals, as seen in the case of genetic (Zabaneh et al., 2018) or cognitive aspects, such as working memory (Dark & Benbow, 1991) and spatial abilities (Lubinski et al., 2006).

Unfortunately, highly gifted children (also described as profoundly gifted, extremely gifted, etc.) have not been studied systematically, especially concerning their emotional involvement during tests. This is partly because they are, by definition, very rare. The available studies offer mixed evidence (see Myers et al., 2017; Ruthsatz & Urbach, 2012). In addition to forming a very small proportion of the population, highly gifted children also present a marked interindividual variability (Giofrè et al., 2020), meaning that very large sample sizes would be needed to obtain robust observations. Only large populations studies may fulfill this requirement, as in the case of school surveys examining students' achievement in areas closely linked with the intelligence g-factor (e.g., Kaufman et al., 2012), such as mathematics and language.

An important school survey data set (not thoroughly studied until now) was collected by a national public assessment center in Italy, the Istituto Nazionale per la Valutazione Scolastica (INVALSI). Over the past decade, this institution has annually assessed the mathematical and reading/language abilities of the whole student population in certain school grades. In Italy, all children follow the same national curriculum for language and mathematics, so this survey offers reliable and comparable data for the entire Italian student population. As Italy's population is highly heterogeneous in many other respects (see Cornoldi et al., 2013), it also can be considered as representative of the European population. Complete information on the INVALSI assessments, including the test materials, can be obtained only for some years and only up until 2017 (the last year when identical tests were administered to the whole of the population involved in the survey).

For the present study, we focused on the scores obtained by fifth graders in the spring 2017 INVALSI assessment, when a questionnaire on the children's emotional response to the test was also administered. At this age, a child was deemed capable of perceiving the importance of the test, and consequently of feeling emotionally involved. The INVALSI assessment was administered simultaneously to all Italian fifth graders. The schools had prepared for it many weeks before, based on recommendations and simulations. Although the scores did not affect a child's final marks or any subsequent school placements, teachers presented the test to students as the most crucial assessment of the school year. The additional short questionnaire was deemed to allow valid inferences (INVALSI, 2016) and covered various aspects of the children's emotional response to being tested, that is, worry before the test, calmness, loss of emotional control, and self-monitoring during the test. The questionnaire's administration to hundreds of thousands of students generated important information on children's negative emotions experienced in a potentially stressful situation. In the present study, we examined the scores obtained in the questionnaire in relation to the children's achievement levels on its continuum, modelling the relationship with a polynomial function. We focused especially on the portions of the continuum corresponding to around +2 and +3 standard deviations above average in academic achievement scores, which we classed as corresponding to gifted and highly gifted children.

Based on previous evidence, the INVALSI questionnaire collected information concerning the children's emotional response experienced before and during the assessment. It covered the aforementioned four different aspects (worry, self-monitoring, calmness, and emotional control) reported by the children at the end of the test, thus including a particular "postdictive" function of metacognition. This postdictive function represents the opposite case with respect to the "predictive" function involved when people must predict future performance or psychological states. Postdictive judgements have been studied in the context of memory, especially in terms of confidence judgements (e.g., Ghetti et al., 2008), and also, to a lesser extent, in relation to academic tasks (Mirandola et al., 2018) and the associated emotions. Children as young as 6 years can produce reliable postdictive responses, in terms of confidence ratings at least (Ghetti et al., 2008), but when Mirandola et al. (2018) examined the postdictions of success in reading comprehension, they found that primary school children were typically overconfident of the correctness of their answers. A similar overconfidence emerged in the study by Garcia et al. (2016), involving the self-monitoring of children aged 10 years asked to judge their performance in two mathematics problems. These results support the hypothesis that typically developing children tend to be overconfident while it has been demonstrated that high-achieving students are less so than their peers. This may be because the latter foresee possible sources of error and difficulty (Garcia et al., 2016), suggesting that gifted children may anticipate the challenges of a test to a greater extent than less brilliant students.

To sum up, the present study used INVALSI data on a very large sample of children to examine the general pattern of the relationship existing between level of academic achievement and level of emotional response in the overall Italian population of fifth graders and then to test the popular assumption that gifted, and especially highly gifted children, experience more negative emotions in an important test than their typically developing peers. This latter assumption was tested by examining whether children’s negative emotional response related to their performance in the test. If gifted children had a more intense emotional response to the test, then the emotional involvement of the children sampled (as reported in the questionnaire) should be positively related to their level of achievement (in the test), whereas the relationship should be negative if gifted children had a more attenuated emotional response. For the purposes of the present study, we considered the possibility of nonlinear effects by modelling the relationship between emotional response and achievement using polynomial functions. We considered not only overall emotional response but also the four different aspects examined by the INVALSI questionnaire (i.e., worry before the test, calmness, impression of doing poorly, and loss of emotional control during the test), based on the assumption that these aspects might be independent of one another and differently affected by gender. We predicted that girls would report a greater emotional involvement overall than boys. We also expected the pattern for the four aspects to differ because girls (however gifted) might report a stronger subjective sense of emotional involvement (Mammarella et al., 2019) but not necessarily a greater objective loss of emotional control. These hypotheses were tested with reference to the children's overall test performance and with particular reference to mathematics.

Method

Participants

The study involved 468,423 fifth graders (51% males, from a total of 28,404 classes and 6,753 primary schools), mainly aged between 10 and 11 years, who took part in the INVALSI assessment in the spring of 2017. As the INVALSI assessment is mandatory in the Italian school system, this sample represented nearly all the children attending fifth grade in Italian State schools. Children were administered a language and a mathematical test on two close days. At the end of the second test, they were administered a short questionnaire comprising four questions about their emotions and metacognitive feelings experienced during the assessment: 460,688 children completed the questionnaire and were considered in the present analysis.

Test Materials

Mathematics and Language Tests

The tests were the INVALSI tasks developed for fifth graders in the school year 2016-2017. These tasks are inspired by similar international assessment procedures such as the TIMSS, PIRLS, and PISA (OECD, 2016). The children take the tests in their own classrooms, taking about 2 hours altogether, split over 2 days. In 2017, the mathematics test for fifth graders included 33 questions in various formats on arithmetic, interpretation of diagrams, and geometry. For the language test, there were 29 reading comprehension questions concerning both fictional and informational texts, and 10 grammar questions. More information about the test is available on the INVALSI website (https://invalsi-areaprove.cineca.it/). The scores for mathematics and language achievement were derived using Rasch models. Note that the Rasch scores were practically isomorphic to the average item accuracy; however, for mathematics, r = .98, and for language, r = .99.

Although the development of the INVALSI tasks is based on item response theory, for descriptive purposes, we calculated Cronbach's α as an index of consistency across accuracy of responses. As the responses are represented by binomial scores (correct/incorrect), the ordinal Cronbach's α was calculated based on the tetrachoric correlation matrix. The consistency was very high for both mathematics, α = .94, 95% confidence interval [CI: 0.94, 0.94], and language, α = .93, 95% CI [0.93, 0.93]. The correlation between the mathematics and language scores was also high, r = .67, 95% CI [0.67, 0.67], suggesting that a basic analysis could be run combining the two scores.

Questionnaire on the Children's Emotional Response to the Test

The questionnaire included four items scored on a Likert scale. It was the final revised version of a longer previous questionnaire prepared on the strength of the psychological literature available in the field (INVALSI, 2011) and subsequently validated (INVALSI, 2016). The children were asked to rate on a scale of 1 to 4 how worried they were before the test (Item 1: "Before taking the test, I felt worried"), whether they had experienced an emotional block during the test (Item 2: "I was so nervous that I couldn't find the answers"), the results of their online self-monitoring (Item 3: "During the test I had the impression I was having difficulty"), and whether they were calm during the test (Item 4: "I felt calm while taking the test"). An overall score of emotional response was obtained via confirmatory factor analysis (CFA) as described below.

Data Analysis

All analyses were performed with the R software, version 4.1.0 (2021-05-18; R Core Team, 2021).

Controlling Children’s Achievement for Geographical Region, Parents’ Education, Family’s Socioeconomic Status, and Citizenship

First, we checked whether test scores in mathematics and language varied across—and thus had to be corrected for—several demographic factors. We considered: geographical area (i.e., the 22 Italian regions and territories coded by the INVALSI system); fathers’ and mothers’ education (six education levels coded by the INVALSI system); fathers’ and mothers’ professions, used as a proxy of socioeconomic status (nine levels coded by the INVALSI system); and citizenship/ethnicity, Italian versus not Italian (further details on the countries of origin were available, but they were scattered; the main factor considered as potentially relevant in the Italian education system is whether a child has Italian citizenship; 12.6% participants had foreign citizenship).

To obtain corrected test scores for mathematics and language, these two variables were entered as the dependent variables in two linear models, with the above factors entered as predictors, and the residuals were extracted for subsequent analyses. Unfortunately, although there were no missing data for geographical area, missing data represented 3% for citizenship and between 15% and 18% for each of the other variables. Overall, 25% of all observations had missing data on at least one variable. Listwise deletion of such a large share of observations could undermine the representativeness of the sample. Therefore, we chose to handle missing data via multiple imputation, using the multivariate imputation by chained equations method implemented in the “mice” package of R (van Buuren & Groothuis-Oudshoorn, 2011). We conducted multiple imputation on a data set with all these covariates, plus reading and mathematics scores. Five multiple imputations were obtained, each with 10 iterations. The linear models were then calculated on all the data sets with multiple imputations, and the residual values were averaged across them to obtain the corrected test scores for mathematics and language.

To assess whether all demographic factors considered contributed to explain the test scores, a stepwise model selection using Bayesian information criterion (*BIC*; lower is better; c.f. Burnham & Anderson, 2004; Wagenmakers, 2007) was preliminarily performed. For simplicity, this model selection was conducted only on the full data set without missing data. The model selection confirmed that the best-fitting models included all the demographic predictors for both mathematics and language test scores (removing any of them resulted in a substantial loss of fit, all $\Delta BICs > 300$). When considered over and above the others, however, none of the predictors independently explained a large portion of variance in the scores for either test, all ΔR^2s < .02, but all combined in the final models, they explained a nonnegligible portion of the variance: for mathematics, $R^2 = .08$; for language, $R^2 = .10$.

All the analyses presented below were run on the test scores corrected for the demographic predictors examined in this section (i.e., on the residuals of the linear models outlined in this section). That said, the uncorrected scores yielded virtually the same results and prompted the same interpretations (see supplementary online material, Figure S1).

Factorial Score of Emotional Response

A CFA was conducted using the “lavaan” package of R (Rosseel, 2012) on the four items of the emotional response questionnaire as the observed variables, with emotional response as the latent factor. The items were treated as ordinal. The model fit was assessed using the following four indices (Jöreskog & Sörbom, 1993): root mean square error of approximation, standardized root mean squared residual, comparative fit index, and normed fit index. The model had optimal fit: root mean square error of approximation = .05, standardized root mean squared residual = .02, comparative fit index = .99, normed fit index

= 1.00. The overall measure of emotional response was extracted as the factorial score from the CFA and standardized to obtain a z-score for ease of interpretation. Reliability of the factorial scores was assessed using the omega value calculated from the CFA parameters (McDonald, 1999), and it was adequate, $\omega = .72$ (Cronbach's α for ordinal variables, calculated using polychoric correlations, was $\alpha = .76$, 95% CI [0.76, 0.76]).

Factorial Score of Overall Achievement

An index of overall success on the tests was obtained by extracting the factorial scores from a model obtained using CFA, taking the standardized scores in the mathematics and language tests as the observed variables loading on the "achievement" latent factor (this is practically identical to averaging the standardized scores in the mathematics and language tests). As there were only two observed indicators, their loadings had to be constrained to be equal for model identification. We report no fit indices because, with only two observed indicators, there cannot be a discrepancy between the observed covariances and those implied by the model, so $\chi2 = 0$, with no loss of fit. To facilitate subsequent interpretation, the extracted factorial scores for overall achievement were standardized to obtain a z-score.

Modelling the Relationship Between Emotional Response and Achievement

The relationship between emotional response to the test and overall achievement was examined using linear models with emotional response as the dependent variable and achievement level as the independent variable. To examine possible nonlinearities in this relationship, and to focus especially on its nature at one tail of the achievement distribution, we tested polynomial terms (e.g., quadratic, cubic) in the linear models. Alternative linear models were fitted with polynomials of different degrees (from 1, indicating a linear relationship, to a maximum of 10). Once again, the best-fitting model was selected using the *BIC* (Wagenmakers, 2007), where lower is better, and interpreted a ΔBIC >10 as very strong evidence (e.g., Raftery, 1995). The best-fitting model (with the lowest BIC) was taken to indicate the optimal degree of the polynomial describing the relationship between emotional response and achievement. We used the *BIC* instead of the likelihood ratio (significance testing with the p value) to ascertain the best-fitting model because the former balances the complexity of the model with its parsimony, especially when very large sample sizes are involved, as in our case. Finally, we did not model schools or classes as random effects for two reasons. First, we did not sample the random effects (i.e., schools or classes) from a larger population of effects, but we examined the whole population at once. Second, modeling complex polynomial effects with random effects would have led to convergence issues because several single classes and schools did not have enough observations to support the fitting of complex polynomial effects.

Results

Relationship Between Overall Emotional Responses and Overall Achievement

We first focused on the factorial score for overall performance in mathematics and language, calculated as mentioned above. In a preliminary analysis, we examined whether males and females differed in average level of overall achievement. The standardized difference was found to be practically 0, Cohen's $d = 0.01$, 95% CI [0.01, 0.02].

Then we applied the model selection procedure described above (in the data analysis section) to establish the degree of the polynomial that best described the relationship between overall emotional response and overall achievement. The best-fitting model had a degree-5 (quintic function) polynomial. This model was supported by strong evidence against any alternative model: all ΔBICs >10.

The regression formula for the best-fitting model was:

$$y \sim -7.96 * x^5 - 3.99 * x^4 + 18.50 * x^3 + 14.38 * x^2 - 105.11 * x + 0.00$$

where y is the emotional response and x is the academic achievement.

Such a high-degree polynomial function suggests that the relationship between achievement and emotional response is complex. A simpler linear model could result in a substantial loss of fit, but interpreting the model coefficients above the second polynomial degree is challenging from a theoretical standpoint. The difficulty involved probably reflects the great complexity of the real phenomenon, which may extend along a continuum and be impossible to bring down to a few simple parameters representing linear or quadratic effects. We consequently interpreted our data relying on a visual inspection of the predicted mean values for emotional response at different levels of achievement. The predicted values were calculated using the “effects” package (Fox, 2003) of the R software. To ensure that the selected model fit the data well, we also recorded the observed mean emotional response scores grouping the children by their z-scores in achievement, rounded up or down to the nearest integer for the sake of simplicity (see Figure 1). The range of z-scores for achievement was limited to between −3 and 3.5, as this included nearly all the population. The portions of the curve representing the gifted children (with an overall achievement between 1.5 and 2.5 standard deviations above the mean; N = 26,426), and the highly gifted children (more than 2.5 standard deviations above the mean for overall achievement; N = 4,662) are highlighted with a gray shaded background. Figure 1 shows the 95% confidence bands as shaded areas, and the 95% CIs of the observed mean values as error bars to enable a comparison of the predictions at focal points of interest. The very large sample size means that statistical inference was practically meaningless, however, and any consideration was limited to the effect size. It is easy to derive the effect sizes of the differences, as standardized z-scores were used. The pattern shown in Figure 1 strongly suggests a negative association between the two variables, a lower emotional response coinciding with a higher achievement.

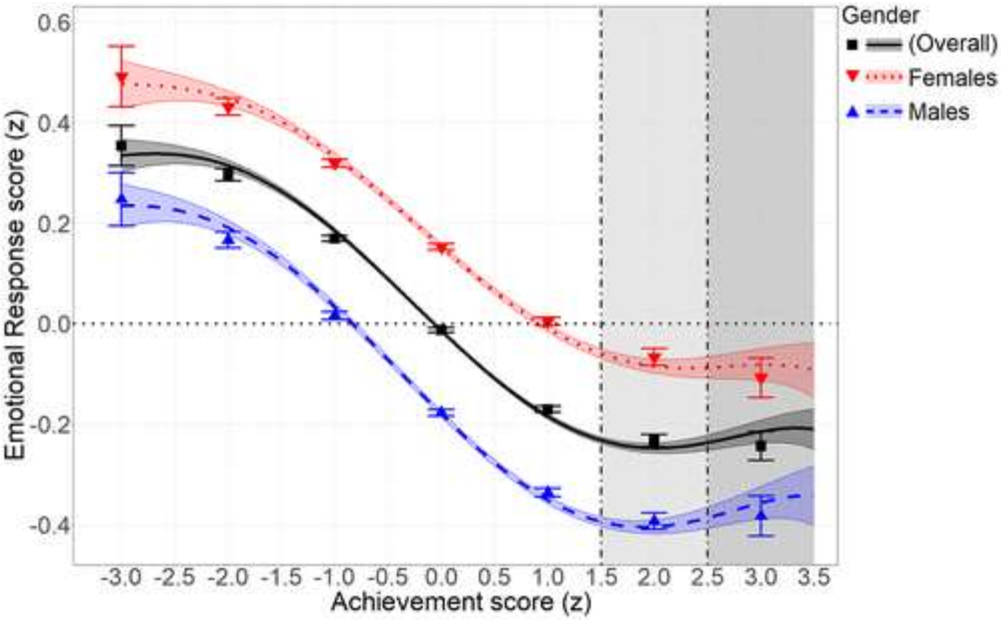

Figure 1. Estimated mean emotional response as a function of overall achievement in the sample as a whole, and separately for females and males.

Note. Shaded areas represent 95% confidence bands. Dots represent the mean emotional response of children grouped by achievement z score rounded up or down to the nearest integer (error bars represent 95% confidence intervals). Vertical shaded areas highlight the estimated emotional response in gifted (light gray) and highly gifted (dark gray) children.

Overall, across a range of almost 7 standard deviations in achievement, the average decrease in emotional response was about 0.70 standard deviations. This means that, on average, there is a decrease of about 0.10 standard deviation in emotional response for every 1 standard deviation increase in achievement.

Relationship Between Overall Emotional Response and Overall Achievement in the Gifted Population

The present study focused on the case of gifted children. There were 26,426 who were considered gifted (with a standardized score between 1.5 and 2.5 standard deviations above the mean) and 4,662 children who were considered highly gifted (with a standardized score more than 2.5 standard deviations above the mean in overall achievement). A first analysis concerned the male-to-female ratio in this population. The proportions of boys among the gifted and highly gifted children (51.0% and 49.5%, respectively) roughly corresponded to the proportion of boys in the whole population examined (50.5%).

Although the relationship between emotional response and academic achievement was nearly monotonic, the decreasing emotional response with increasing achievement was not entirely steady. The curve seemed to be steeper in the middle range of the achievement distribution but flattened for high levels of achievement. Between about −2 standard deviation and +1 standard deviation in achievement, there was a steep decrease of nearly 0.20 standard deviation in emotional response for every 1 standard deviation increase in achievement. On the other hand, the further decrease in emotional response coinciding with between +1 and +2 standard deviation in achievement amounted to only 0.06 standard deviation, and there was virtually no additional decrease beyond +2 standard deviation, despite some minor oscillations.

As shown in Figure 1, the inverse relationship between emotional response and achievement was apparent in both males and females. These data were extracted from a model that included an interaction term between overall achievement and gender. Once again, a five-degree polynomial represented the best-fitting model describing the relationship between emotional response and achievement (all $\Delta BICs$ >10). Figure 1 shows that males reported a lower emotional response than females, with a difference of about 0.30 standard deviation on all levels of academic achievement: the model coefficient describing the effect of gender at the intercept (i.e., at an achievement z-score of 0) was $B = 0.32$, $p < .001$. The relationship between emotional response and achievement was basically much the same in males and females. This relationship seems to decrease monotonically in girls, while there appears to be a slightly rising trend for boys above $z = +2.5$. This impression should be taken with caution, however, as the variation is within the margin of uncertainty (confidence bands). Among males and females alike, the highly gifted children's emotional response showed no marked differences compared the groups of boys or girls of above average achievement.

Relationship Between Single Items Investigating Emotional Response and Overall Achievement in Language and Mathematics

Although the scores on the four-item scale exhibited good internal consistency, we were aware that the items concern substantially different aspects of emotional involvement, which might have different implications for males and females. We therefore examined the relationship between each item of the emotional response questionnaire and overall achievement. We computed the children's mean ratings in the questionnaire (in which answers were given on a Likert-type scale from 1 to 4).

The above-described model selection procedure was adopted. For Questions 1, 3, and 4, fifth-degree polynomials represented the best-fitting models, but for Question 2 a fourth-degree polynomial had the best fit. In all cases, the best-fitting models were supported by strong evidence against all alternative models (all ΔBICs >8). Once again, we based our interpretation on a visual inspection, as the parameters of 3- to 5-degree polynomial functions are difficult to interpret analytically. The predicted values are shown in Figure 2. The regression formulas of the polynomial functions in Figure 2 (overall sample, black solid line), are as follows:

Question 1: $y \sim -5.21 * x^5 - 4.69*x^4 + 15.02*x^3 + 5.07*x^2 - 47.80*x + 2.48$

Question 2: $y \sim -3.84*x^4 + 0.28*x^3 + 28.38*x^2 - 80.53*x + 1.52$

Question 3: $y \sim -8.68*x^5 + -3.86*x^4 + 21.00*x^3 + 10.86*x^3 - 112.05*x + 2.34$

Question 4: $y \sim +6.15*x^5 + 0.95*x^4 - 13.61*x^3 - 2.95*x^2 + 58.60*x + 2.60$

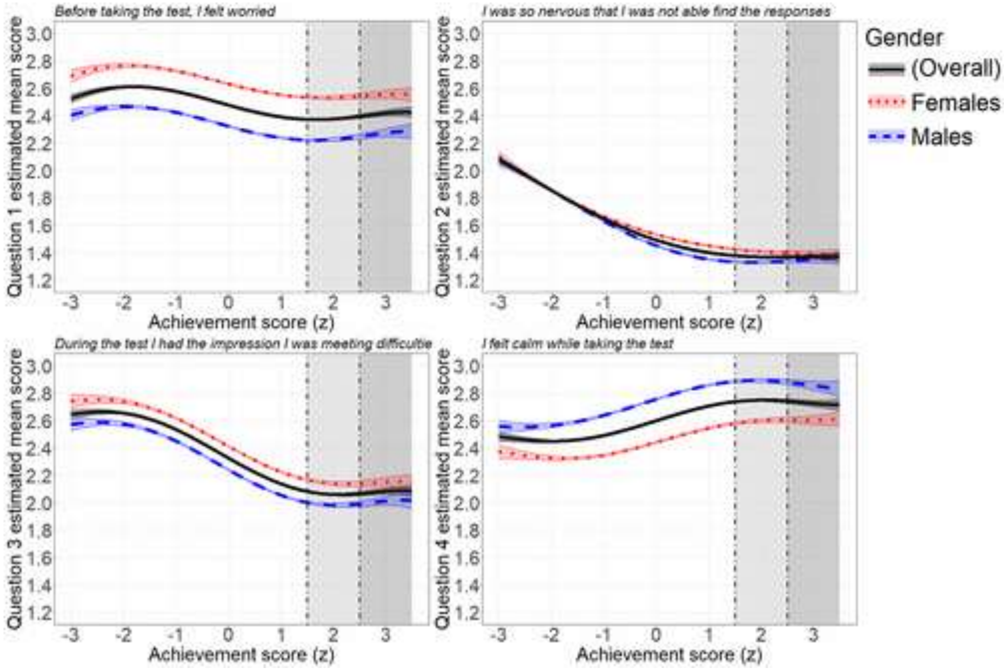

Figure 2. Estimated mean ratings on each item in the emotional response questionnaire as a function of achievement, in the sample as a whole and separately for females and males. *Note*. Shaded areas represent 95% confidence bands. Dots represent the mean emotional response of children grouped by achievement z score rounded up or down to the nearest integer (error bars represent 95% confidence intervals). Vertical shaded areas highlight the estimated emotional response in gifted (light gray) and highly gifted (dark gray) children.

Separately examining the answers to the four different questions generated some interesting findings. The first question, about worrying before a test, pointed to a clear difference between males and females whatever their levels of academic achievement and a generally negative association between achievement and emotional response. That said, there was no average decrease in emotional response (as measured by Question 1) associated with achievement scores higher than $z = +1$. In addition, the maximum predicted emotional response was reported by children with a low achievement, around $z = -2$, while there was no further increase in negative emotions (and even a slight decrease) for the children with an even lower academic achievement ($z = -3$).

The second question was about a sense of mental block in test situations due to nerves. Here again, there was a monotonic decrease in emotional response with increasing achievement levels; and, once again, the highly gifted students did not feel much better, on average, than the other students performing above the mean. It is worth noting that the children's answers to Question 2 differed from the overall pattern because their ratings were lower than in the other three questions and there was virtually no difference between the average ratings of boys and girls, whatever their level of achievement. These lower ratings may mean that the experience of an emotional block is relatively rare. The absence of a gender-related difference cannot be attributed to a floor effect for two reasons: because the item was still clearly associated with achievement (the difference in the absolute values of the most and least brilliant students' ratings was particularly relevant, at approximately 0.70), and because there were no gender-related difference at low levels of achievement, where the emotional response ratings for Question 2 were far from the floor.

The third question examined the feeling of doing poorly in a test. Once again, we found effects of both achievement level and gender. The pattern was very similar to the case of Question 1 but much more marked.

Finally, Question 4 was about whether the children felt calm during the test. In this case, the ratings were higher for the more gifted children because, unlike the other items, a higher rating indicated a more positive response. We again found the effects of both achievement level and gender, but there was a direct relationship in this case between the reported emotional response (calmness) and achievement. Here too, there were minimal differences between students who were highly gifted, students who were gifted, and the other students in the groups of above-average academic achievement.

Relationship Between Emotional Response and Mathematical Achievement

The case of mathematical achievement was considered separately because mathematics typically represents the situation children find more stressful. Unfortunately, no separate questionnaire was administered to address the specific emotions experienced during the mathematical test, so our analyses are based on the general questionnaire.

In a preliminary step, a difference was observed between the boys' and girls' average mathematical achievement, with the former scoring higher, although the standardized difference was small, Cohen's d = 0.15, 95% CI [0.14, 0.15]. This difference was evident in the proportions of highly gifted children (due to the nature of the INVALSI test, corresponding with those children who made no mistakes in the test) and gifted children. In fact, the males who were gifted (56.8%) and highly gifted (55.0%) were more numerous than their female counterparts. That this difference was not evident when overall performance in both mathematics and language was considered suggests that a pattern, opposite to the pattern observed in mathematics, was present in the case of language and that more females than males could be linguistically gifted.

To investigate the relationship between mathematical achievement and emotional response, we adopted the same data analysis strategy as for overall achievement and used the same model selection procedure. The patterns of results for mathematical achievement were all very similar to those previously discussed for overall achievement, so they are not reported in detail here but can be found in the supplementary online material, Figures S2 and S3.

Discussion

This study obtained some interesting results from a very large sample of children attending school in Italy. The heterogeneity of the sample, which includes children coming from areas that differ in socioeconomic status, culture, and dialects, makes it also more generally representative of a relevant proportion of European children. Our results concerning academic achievement resemble findings in other countries, as Giofrè et al. (2020) reported after comparing the patterns emerging from the Italian INVALSI tests and other international assessments on schoolchildren. For example, the proportion of males among the gifted children (considering overall performance in mathematics and language) roughly corresponded to the overall proportion of males in the population examined, but gifted males outnumbered gifted females when achievement in mathematics was considered alone.

When we examined the relationship between overall academic achievement and emotional response (overall and separately for the four questions), we found a general tendency for a lesser emotional response to coincide with a greater achievement. The very large body of INVALSI test data then enabled us to focus on the relationship between giftedness (as a portion on a continuum of achievement scores) and emotional response to testing. The results of these analyses are important and partly new.

First, high achievers reported fewer negative emotions in test situations, on average, than the other children. We found an inverse relationship between achievement and the negative emotional impact of tests, even in the right tail of the achievement distribution indicating the most gifted children. Previous research had found that the more competent students felt more confident than the others about their performance after being assessed on their reading comprehension (e.g., Mirandola et al., 2018), but this phenomenon had not been thoroughly studied in the case of gifted children. We identified a clear pattern that contrasts with the notion that gifted children are more sensitive, perfectionist and critical (e.g., Gaesser, 2018), and consequently experience more negative emotions during a test. On the contrary, our gifted children reported that they worried less before the test and felt calmer during the test than the other children reported. On average, they reported not having the impression of encountering particular difficulties and not experiencing a mental block during the test. For the case of fifth graders at least, this corroborates claims (e.g., Scholwinski & Reynolds, 1985) that gifted children may experience less test anxiety than other children. Separate analyses on the four items in our questionnaire showed that for the gifted children the inverse relationship between achievement and emotional impact was more marked regarding the impression they had done poorly in a test.

The trend describing an inverse correspondence between achievement and negative emotions virtually flattened out, however, near the end of the right tail of the ability distribution. It is worth noting the comparison between the gifted and the highly gifted children. It has been claimed that the extremely gifted differ in some respects from other gifted children, showing a greater degree of negative emotionality (Roedell, 1984). Our results do not point in this direction: the emotional response of the highly gifted children in our sample was neither high, nor especially low. Their average emotional response did not correspond to the level that might be predicted if the relationship between achievement and emotional response were simply linear. These very gifted children’s emotional response was roughly the same as in other gifted children and only slightly lower than in other children whose academic achievement was only just above average. This may be due to combination of factors including a prevailing linear relationship between achievement and emotional response in most of the population and the concurrent presence of high emotionality in some (but clearly not all) children in the highly gifted group (Ackerman, 1997).

A further important finding concerns gender differences. Although the general pattern of findings was similar for boys and girls, the intensity of their emotional response differed. At every level of achievement, females reported a greater mean emotional response than males. This confirms prior findings (e.g., Mammarella et al., 2019) and also applied to our gifted and highly gifted boys and girls. When the four questions on emotional response were considered separately, however, there was no such gender difference for one item. This concerned the experience of a mental block due to emotions interfering during a test—a situation that best describes the actual consequences of an emotional response. Our results suggest that girls may be more inclined than boys to express and emphasize their emotions, regardless of the consequences on their behavior.

Finally, we considered the separate case of mathematics tests, which are often seen as the most representative situation prompting negative emotions at school and test anxiety in particular (Mammarella et al., 2019). In the present study, the portions of the curve concerning the gifted children included more males than females, replicating previous observations (Giofrè et al., 2020). The effect of gender on emotional response was not due to boys performing better in the mathematics test, however, because the comparison between genders took mathematical ability into account. The results concerning the relationship between mathematical achievement and emotional response closely replicate the results for overall achievement, suggesting that mathematical test performance predicts a child's general emotional reactions to testing. On the other hand, we found a slightly greater difference in emotional response between the very high and the very low achievers when considering mathematical achievement vis-à-vis overall achievement. Although the effect was minimal, this is consistent with the notion that mathematics may emphasize differences in emotional response (Mammarella et al., 2019).

In conclusion, with the aid of a large sample including many gifted children, the present study offers robust evidence of the emotional response of children performing exceptionally well in mathematics and language tests. We found that gifted children reported low levels of worry before a test, and high levels of wellbeing during a test. That said, the highly gifted children did not reflect the linear negative association between academic achievement and emotional response observed in the other children (especially those of around-average performance). These findings are important for practitioners and families, as they show that gifted children tend to have a better attitude to tests at school than other children, so their emotional response should not be overestimated.

The present results can be interpreted in different ways. It may be that the relationship between achievement and negative emotions is bidirectional. Some individuals whose abilities should have placed them in the right tail of the distribution might have been affected by negative emotions severe enough to prevent them from obtaining high scores in the test administered here (see Devine et al., 2018). This issue could be further studied by assessing very capable students on low-stakes tests that are less anxiety-provoking.

Our results need to be replicated, extended, and more systematically studied in relation to the large number of variables that substantially affect both academic achievement and emotional response (Ceci et al., 2009). We also have several limitations to mention. In particular, the questionnaire on emotional response included only four questions, neglecting some aspects of a child’s emotions during a test. Our data were also based on subjective responses, and no objective measures (such as physiological data) were obtained. Children completed the questionnaire after (not before or during) the test, so their answers may have been influenced by their recall and especially by their thoughts about their test performance.

Finally, we only considered fifth graders, and it may be that younger and especially older children would answer the questionnaire differently. Further research is therefore needed.

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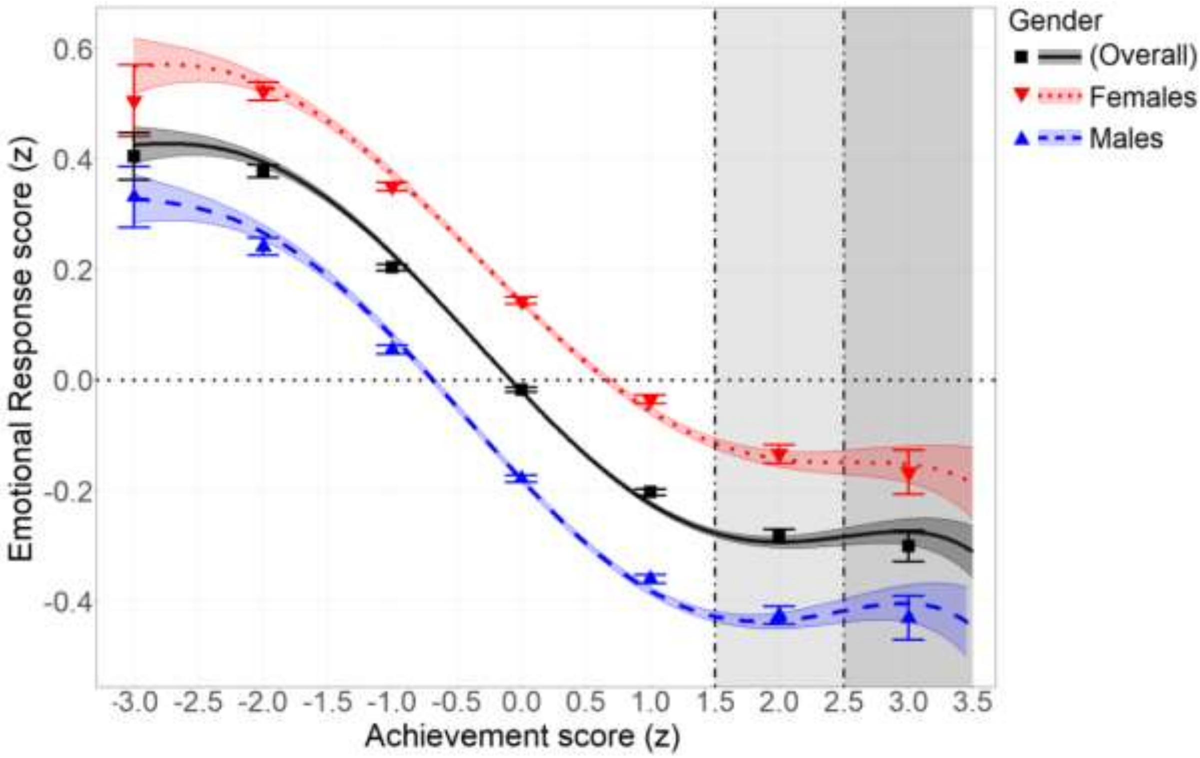
Supplementary Material for:

Emotional Response to Test by Intellectually Gifted and Highly Gifted Children

Figure S1. Estimated mean emotional response as a function of achievement z-scores not adjusted by region, parental education, parental profession, or citizenship (see the manuscript and its Figure 1 for comparison).



When mathematical achievement was considered alone, the exact same degrees of the polynomial functions emerged for the best fitting models. All best fitting models were supported by very strong evidence against any alternative (i.e., against any model with a different polynomial degree).

Figure S2. Estimated mean emotional response as a function of mathematical achievement in the overall sample and separately by females and males. Shaded areas represent the 95% confidence bands. Dots represent the mean emotional response of children grouped to have an achievement z score rounded to the nearest integer (error bars represent their 95% confidence intervals). The vertical shaded areas highlight the estimated values of emotional response for gifted (light gray) and highly gifted (dark gray) children.

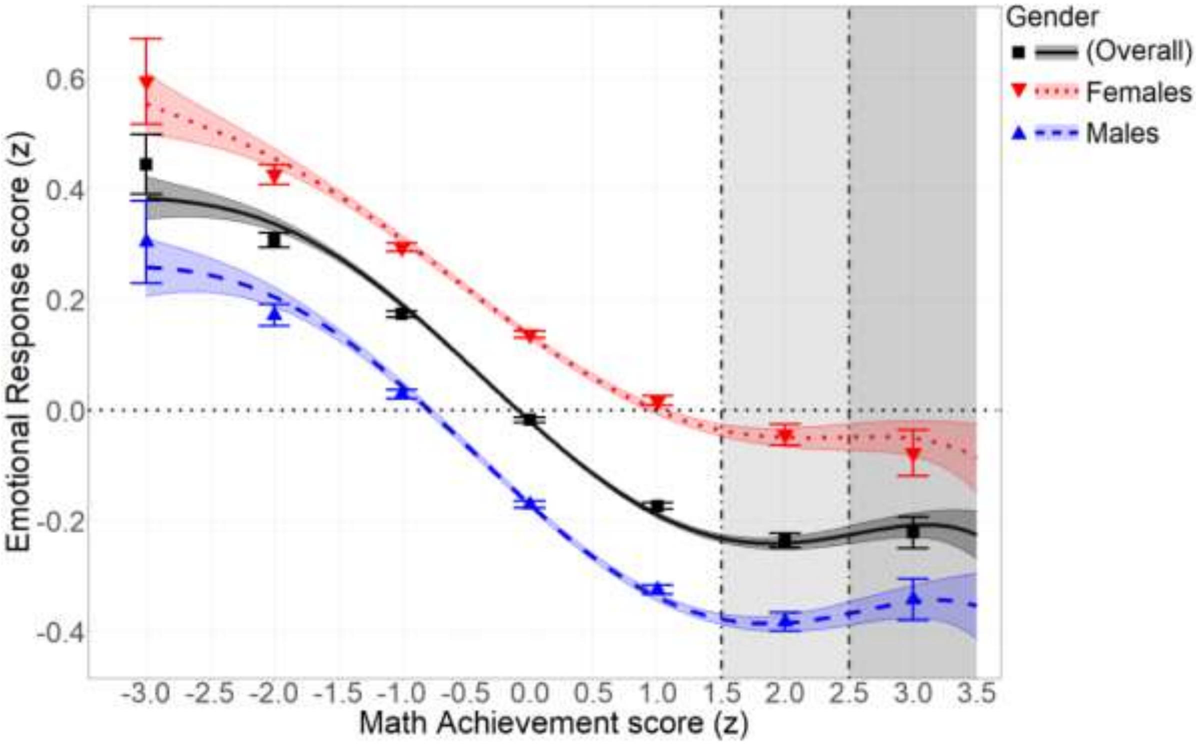


Figure S3. Mean estimated rating in each emotional response question as a function of mathematical achievement in the overall sample and separately by females and males. Shaded areas represent the 95% confidence bands. Dots represent the mean emotional response of children grouped to have an achievement z score rounded to the nearest integer (error bars represent their 95% confidence intervals). The vertical shaded areas highlight the estimated values of emotional response for gifted (light gray) and highly gifted (dark gray) children.