The mathematical abilities and personality of undergraduate psychology students relative to other student groups

Roy Bhakta, Clare Wood & Duncan Lawson

This study examined differences in personality and mathematical ability between students studying Business, Psychology, Sports and Nursing. There were 286 participants who each completed a mathematics diagnostics test and a Revised Eysenck Personality Questionnaire (EPQ-R) during the first term of their first year of study. There was a significant effect of subject studied on the students' performance on the maths diagnostic questionnaire and their scores on the 'psychoticism' subscale of the EPQ. Furthermore significant correlations were observed between psychoticism scores and mathematical ability within both the Business Management and Psychology groups, although the direction of those associations were different for each group (the association was positive for the business students, but negative for the psychology students). Based on these results it is suggested that there are significant differences in both psychoticism and mathematical ability between students from different courses. Furthermore, students may benefit from differing methods of teaching mathematical concepts, especially in the cases where students are averse to working in groups and collaboratively.

Keywords: *mathematics; numeracy; personality; psychoticism; extraversion; collaborative study; EPQ; EPQ-R; GCSE.*

THIS STUDY is concerned with the mathematical abilities of psychology students relative to other undergraduate students and the extent to which individual differences in the students' personality profiles are associated with mathematical competence. As Smith (2004) has highlighted, there is a constant need for a numerate workforce and this is not limited to just those who study mathematics at degree level:

> *'Advanced economies need an increasing number of people with more than minimum qualifications in mathematics to stay ahead in international competitiveness and, in particular, to effectively exploit advances in technology. An adequate supply of young people with mastery of appropriate mathematical skills at all levels is vital to the future prosperity of the UK.'*
>
> Smith (2004, p.12)

Over the past two decades the types of qualifications that have been accepted as valid for entry onto higher education courses has been relaxed by many institutions. The result of this has been increased recruitment of students into higher education, combined with greater diversity in the educational and social backgrounds of those students. A by-product of widening participation in higher education is a greater variation in current and potential attainment of the students (Hawkes & Savage, 2000). In particular, the number of students who are entering universities ill-prepared for the mathematical demands of their chosen university course has risen substantially (Williamson et al., 2003) and such students are more prone to failing or dropping out due to mathematical or numeracy issues (Bourn, 2002, 2007).

A major difference between England and other parts of the world is the non-compulsory nature of mathematics study once the compulsory phase of education has been completed (Wolf, 1997). This feature sets the English education system apart from the majority of other developed countries where

mathematics is to some extent compulsory and seen as an essential deciding factor for acceptance onto university courses. As a result, English university students may have avoided mathematics prior to entry onto the university course, but that could lead to a mismatch between students' own abilities and the demands and expectations arising from staff at universities. This problem is widespread and observable in many different disciplines (Smith, 2004).

Even though mathematical study is not compulsory after GCSEs, students still have the option of studying mathematics. However, Ruggeri et al.'s (2008) study of 196 psychology students (first year=158 and second year=38) found that only 46.7 per cent reported knowing about the compulsory statistics components of their course prior to entry. This could help explain why many students intending to take psychology do not undertake post compulsory mathematics study and as a result find the statistical components of the psychology degree challenging.

Research has shown that psychology undergraduate students have mathematical skills that are not always sufficient for their studies at university (Mulhern & Wylie, 2005). Furthermore, the mathematical skills of psychology students since 2002 is significantly lower than a similar cohort of students in 1992 (Mulhern & Wylie, 2004). Furthermore, a report by Kounine et al. (2008) suggests that the overall standard of mathematics has been declining since the mid 1970s, to the extent that students can achieve a good pass at GCSE with little conceptual understanding. Similarly, Ofsted (2009, pp.51–52) highlight that students' mathematical competencies are focused more on the performance of mathematical procedures and less on the underlying concepts involved.

It has been suggested that there may be some relationship between personality traits and academic achievement. A study conducted by Allik and Realo (1997) looked at the correlation between measures of intelligence (intelligence test, historical knowledge, writing ability, foreign language) and personality (NEO-PI, measuring Neuroticism, Extraversion, Openness to experience, Conscientiousness and Agreeableness) among Estonian speaking students (N=381) during the application process to a university. This study found weak but statistically significant correlations between the personality scales and general ability as measured by the intelligence test. In particular, the intelligence test scores were found to be negatively correlated with conscientiousness (r=–0.19, p<0.001) and agreeableness (r=–0.18, p<0.001). Extraversion was not found to be correlated with any of the measures of intelligence. Allik and Realo concluded that although personality and achievement were not directly related, students with lower intelligence scores may behave differently (thrill seeking and with the urge to explore their fantasies) than individuals who scored highly on the intelligence tests (who tended to be controlling, self-regulatory and control of their emotions). Furthermore Komarraju et al. (2009) looked at how personality could be related to both motivation and achievement (among 308 undergraduate students at an American university. Of particular note is their finding that conscientiousness, openness, neuroticism and agreeableness as measured using the NEO-FFI instrument accounted for 14 per cent in the variance of Grade Point Average (GPA) scores whilst only five per cent could be accounted for by intrinsic motivation. This suggests that personality may have a greater influence on attainment than the degree of personal motivation. Komarraju et al.'s (2009) research also showed that amongst their sample, there was a significant positive correlation between GPA scores and: conscientious (r=0.29, p<0.01), agreeableness (r=0.22, p<0.01) and openness (r=0.13, p<0.05).

The influence of conscientiousness on attainment is further highlighted by the use of the Hogan Personality Inventory (HPI) by Martin et al. (2006) who conducted a four-

year longitudinal study which looked at the effectiveness of personality measures and pre-entry academic assessments as predictors for undergraduate performance in the form of GPA scores for undergraduates (N=587) at an American university. Their study showed that there was a correlation between GPA and both Prudence (positive correlation) and Sociability (negative correlation), where Prudence was used as a measure of conscientiousness and Sociability when combined with ambition was considered a measure of Extraversion (NEO and EPQ). However, it was also shown that over the four years the strength of the correlations decreased, which suggests that tuition can attenuate the extent of any relationships between personality and attainment. Fruyt and Mervielde (1998) also found conscientiousness as measured by the NEO-PI-R (Dutch Flemish version) to be a predictor of the achievement of 934 final year undergraduate students (various disciplines).

The literature, therefore, suggests that there is an inconsistent relationship between extraversion and academic achievement, although the aspect of personality measured variously as 'conscientiousness' and 'psychoticism' would appear to have a consistent relationship with academic achievement. However, it is important to note that not all the studies use the same scales for measuring personality; for example, the *psychoticism* scale on the EPQ instrument can be thought of as an amalgamation of *conscientiousness* and *agreeableness* scales on the NEO instrument. A meta analysis by Wolf and Ackerman (2005) suggests that past research has identified statistically significant correlations between intelligence (including numerical ability) and the extraversion personality trait. Wolf and Ackerman also suggest that the magnitude of the positive correlation has decreased over time and that more recent studies imply a negative correlation. The Extraversion trait also suggests that extraverts' and introverts' behaviours when taking test taking tests were different (Eysenck, 1994); introverts being slower but being more accurate compared to extroverts who were quicker and made more errors.

Social Constructivism (Vygotsky, 1978) suggests that learning is more productive when performed as a collaborative process; individuals work with others rather than in isolation., The notion of collaborative learning has also been highlighted by Lave and Wenger's (Lave & Wenger, 1991; Wenger, 1998) work on communities of practice. However, it is important to note that the collaboration and learning as a group idea is dependent on the individuals and how they interact with each other. Personality traits such as extroversion and psychoticism (Eysenck & Eysenck, 1991) suggest how individuals may interact with their peers: introverts are more likely to prefer working alone whilst extroverts are more likely to engage with group based activities. Similarly, those scoring higher on psychoticism measures may be more inclined to work alone rather than collaborate with peers. What is not clear from the literature is if this is true in all areas of learning or just isolated to certain areas, for example, numeracy, literacy or foreign languages. Furthermore, it is unclear whether there are significant differences in the personality and mathematical competencies of students from different courses. In particular, differences in personality may influence how individuals prefer to study, for example, individually or within groups (e.g. Vygotsky, 1978; Lave & Wenger, 1991; Wenger, 1998).

By exploring the differences in personality between groups of students and the correlations with mathematics ability, it may be possible to inform discussions of how best to facilitate students' learning of mathematics related content, for example, within quantitative research methods and statistics. This study, therefore, examined the relationships between personality and mathematical competency in students from university courses where A-level mathematics is not a pre-requisite for entry, but where the course requires some element of mathematical ability. This study, therefore, aimed to assess if there were differences in personality traits

and mathematical competencies between students from different courses. The study also aimed to explore whether any relationships existed between personality variables and the mathematics competencies of undergraduate students.

Methodology

Design

This study explored the relationship between mathematics diagnostics scores and personality measures amongst undergraduate students at Coventry University. A mixed design was used such that the personality and mathematics diagnostics variables were within participant variables and the course being studied was a between participants variable. The outcome variable was the mathematics diagnostic test scores (scored between 0 and 10) while the predictor variables were the course of study (five possible courses) and personality measures (psychoticism 0 to 32, extraversion 0 to 23, neuroticism 0 to 24, lie 0 to 21, addiction, 0 to 32, criminality 0 to 34).

Participants

Participants were recruited from five courses that were offered at Coventry University (Business Foundation Year, Business Management, Adult Nursing, Psychology, and Sports). Only subjects that did not require a mathematics qualification greater than a grade C at GCSE level (or equivalent) were selected. In total 288 undergraduate students at Coventry University volunteered to participate in the study (see Table 1).

Materials

Students who volunteered to participate were asked complete a questionnaire that gathered data on mathematical ability, personality and demographic data. Within the questionnaire the instruments appeared in the following order: Demographics, Mathematical ability questionnaire, Eysenck Personality Questionnaire – Revised (EPQ-R).

Mathematical ability. All students who participated in the study were required to have a GCSE or equivalent qualification as an entry criterion for their courses. It should be noted that the use of past mathematics qualifications (e.g. GCSE) as accurate measures of mathematical ability on entry has been questioned. A number of universities have found that the increasing diversity of entrance qualifications combined with the varying times between achieving the qualification and enrolment on the course has meant that past qualifications are poor measures of mathematical ability on entry (LTSN MathsTeam Project, 2003). The document

Table 1: Age, gender and university course of those involved in the study.

Course	*Male*	*Female*	*Mean Age*	*Median Age*
Business Foundation year *(SD)*	41	34	19.96 (3.87)	19
Business Management *(SD)*	20	41	20.77 (4.32)	19
Adult Nursing *(SD)*	4	46	25.10 (6.50)	23
Psychology *(SD)*	4	49	21.13 (5.55)	19
Sports *(SD)*	20	27	19.38 (2.34)	19

highlights the use of diagnostic testing (and appropriate feedback) on entry as a more accurate measure of ability and as a means to support students improve their mathematics skills. For this reason the present study opted to use a mathematics diagnostic test to assess actual mathematical skills at the point of entry on the course.

The diagnostic questionnaire was a 10-item instrument that consisted of questions relating to arithmetic, unit conversions, percentages, ratios, graph reading, transposition, straight line gradients and substitution. Individual question items were based upon a pre-existing mathematics diagnostic test used at Coventry University and developed further during a pilot work conducted five months prior to this study. Each question item in this instrument was kept as abstract as possible in order to avoid any contextual effects that may influence participants' performance either through the way in which the question is seen or perceived (Mevarech & Stern, 1997) or through contextually dependent procedures for solving mathematics problems (Boaler, 1993; Cooper, 1996). The intention was to reduce as far as possible the probability of students using prior knowledge of the context of the question and thus inadvertently answering a different question from that which was being set. In a typical contextualised mathematics problem the student could attempt to use the context to further define the problem, in which case the learner may add and create unnecessary and potentially incorrect inferences about the problem that needs to be solved. Boaler (1993) suggested that contextual questions which are familiar to the learner are those that the learner may well become more engaged with and as a result introduce properties and experiences they know of about the context to the problem and as a result perform worse. Furthermore, Van den Heuvel-Panhuizen (2005) describes this occurrence as follows:

> *'In the word problem the reality that is presented is often not in tune with the real situation… …In this word problem, the context reflects the world of textbooks. In this world, there is little space for reality with its unsolvable and multi-solvable problems.'* (p.5)

This suggests that it may not be wise to assess the students using contextualised questions. However, Clausen-May and Vappula (2005) present evidence that suggests learners do not find difficulties in transferring abstract mathematical skills to problems set in different contexts.

The aim of this research was to test their mathematical ability not their ability to transfer knowledge they may have from one context to another, it is for this reason that abstract questions were used in the diagnostic test rather than course specific contextualised questions. It was beyond the scope of this research to assess the difference that this made to the performance of students on the mathematics diagnostics test.

Personality. In choosing an instrument to measure personality, it was decided to choose the Revised Eysenck Personality Questionnaire (Eysenck et al., 1985) as it adequately measured the Extraversion personality trait which was of primary interest and was also a relatively short and simple instrument (106 question items where participants respond with 'Yes' or 'No') compared to other instruments such as the Revised NEO Personality Inventory (consisting of 240 question items on a five-point scale) or the Minnesota Multiphasic Personality Inventory, MMPI-2 (567 items). the 106-item Revised Eysenck Personality Questionnaire (Eysenck et. Al, 1985) was used. This assesses participants on six scales: psychoticism (0 to 32), extraversion (0 to 23), neuroticism (0 to 24), lie (0 to 21), addiction (0 to 32), criminality (0 to 34).

Psychoticism can be thought of as a personality trait that measures the tendency of an individual to behave or display psychotic tendencies. For the purposes of this paper, those who score highly on the scale and are classed as susceptible to psychotic tendencies will be defined as follows (Eysenck & Eysenck, 1991, p.6):

> *'…the high scorer, then, may be described as being solitary, not caring for people; he is often troublesome, not fitting in anywhere. He maybe cruel and inhumane, lacking in feeling and empathy, and altogether insensitive, He is hostile to others, even his own kith and kin, and aggressive, even to loved ones. He has a liking for odd and unusual things, and a disregard for danger; he likes to make fools of other people, and to upset them. Socialisation is a concept which is relatively alien to high P scorers; empathy, feelings of guilt, sensitivity to other people are notions which are strange and unfamiliar to them.'*

Extraversion, however, is a measure of an individual's tendency to be concerned with issues outside of the self and the need to seek out stimulus and enjoyment through engagement and interactions with others. For this paper the Extravert and Introvert as measured using the Eysenck Personality Questionnaire will be defined as (Eysenck & Eysenk, 1991, p.4):

> *'The typical extrovert is sociable, likes parties, has many friends, needs to have people to talk to, and does not like reading or studying by himself. He craves excitement, takes chances, often sticks his neck out, acts on the spur of the moment, and is generally an impulsive individual. He is fond of practical jokes, always has a ready answer, and generally likes to take charge; he is carefree, easy going, optimistic, and likes to 'laugh and be merry'. He prefers to keep moving and doing things, tends to be aggressive and lose his temper quickly; although his feelings are not kept under tight control, and he is not always a reliable person […] The Typical introvert is a quiet, retiring sort of person, introspective, fond of books rather than people; he is reserved and distant except to intimate friends. He tends to plan ahead, 'looks before he leaps' and distrusts the impulse of the moment. He does not like excitement, takes matters of everyday life with proper seriousness, and likes a well-ordered mode of life. He keeps his feelings under close control, seldom behaves in an aggressive manner, and does not lose his temper easily. He is reliable, somewhat pessimistic, and places great value on ethical standards.'*

Procedure

With the co-operation from the relevant university departments, data were collected either during or after timetabled lectures and workshops. Each group of students was visited once during the beginning of the first term of their first year of study at the university. Prior to participation, each class/lecture group of students was informed of the aims of the study, especially that participation was entirely voluntary and that they had the right to withdraw at any time. Informed consent was obtained from all students who wished to participate. Those who did not wish to participate were able to leave the session while those who volunteered were able to stay. No rewards were given for participation, although psychology students were able to receive research participation credits for taking part. Participants were all given the questionnaires, which they were asked to complete during the session without consultation or discussion with other students. All participants were given 50 minutes to complete the questionnaire after which they were free to leave the room. Most students completed the questionnaire in approximately 30 to 40 minutes.

Ethical considerations

This study was approved by the Coventry University Ethics Committee. As part of the data gathering process, all students were given an overview of the research and informed that participation was voluntary. Prior to completing the questionnaires it was made clear that withdrawal was possible at any point up to a month after completing the questionnaire. Furthermore participants were assured that responses would be kept anonymous and would in no way be used as part of the assessment process of their chosen university course.

Results

Kolmogo-Smirov and Shapiro-Wilk tests of normality were performed on the predictor

variables associated with personality and mathematics diagnostic scores for the whole group (see Table 1 in the Appendix) and within subject groups (see Table 2 in the Appendix). In all cases both the Kolmogorov-Smirnov and Shapiro-Wilk tests suggest distributions that are far enough away from being normal to suggest the use of non-parametric methods when performing analysis on the whole group of students.

Various transformations were used to address the negative and positive skew in addition to the leptokurtic and platykurtic distributions; unfortunately these transformations did not adequately address the normality issues. Transformations which did make data sufficiently normal for some subgroups caused other sub groups of data to deviate further from normal. Based on the normality tests and transformations, non-parametric methods were used as it was felt unwise to use parametric testing.

As shown in Table 2, there appear to be small differences in personality and mathematical ability across the five subject groups. Non-parametric tests were conducted to assess whether personality traits and mathematical competency differed across courses and whether there were significant relationships between personality and performance on mathematical diagnostics test.

Differences between the groups

A Kruskal-Wallis test was conducted to test if the personality traits (Psychoticism, Extraversion, Neuroticism, Lie, Addiction and Criminality) and mathematics diagnostics scores were different between the subject groups. A significant difference between the groups was found on the mathematics diagnostic test, H=33.088, p<0.01 and psychoticism scores, H=33.568, p<0.01 between the six course groups. Post-hoc testing consisted of 10 Mann-Whitney U tests to compare all the possible parings of subject groups. As 10 tests were performed, a Bonferroni correction was used such that significant effects occurred when p<0.005 rather than p<0.05. The results of the Mann-Whitney testing are presented in Tables 3 and 4.

The results of the tests summarised in Table 3 suggest that the students from Adult Nursing, Psychology and Sports (Mdn=6) scored significantly higher than students from both Business Management and Business Foundation year courses (Mdn=4) on the mathematics diagnostic test, U=6707.5, z=5.610, p<0.001, r=–0.327. There was no significant difference in mathematics diagnostic scores between Business Foundation Year and Business Management students (U=2195.0, r=–0.035). There was also no significant difference between Adult Nursing and both Psychology (U=1349, r=–0.018) and Sports (U=1074, r=–0.091) students. Similarly there was no difference between Psychology and Sports students' scores (U=1129.5, r=–0.096). Furthermore, the data suggest that the students from Adult Nursing, Psychology and Sports scored significantly higher than those from both Business Foundation year and Business management.

The results of the tests summarised in Table 4 suggest that on the psychoticism scale, Business Management and Business Foundation year students (Mdn=8) scored significantly higher than both Psychology and Adult Nursing students (Mdn=6), U=4256.5, z=–5.439, p<0.001, r=–0.350 There was no significant difference in psychoticism scores between Business Foundation Year and Business Management students (U=2222.5, r=–0.002), there was also no significant difference in the scores of Sports when compared to Business Foundation Year (U=1010.5, r=–0.182) and Business Management students (U=1045.5, r=–0.189). Similarly it was found that there was no significant difference in the scores of Sports when compared to Adult Nursing (U=891.5, r=–0.178) and Psychology (U=1054, r=–0.035), and there was also no difference between Psychology and Adult Nursing scores (U=1071, r=–0.138).

Table 2: Mean mathematics diagnostics and EPQ-R scores across different subject groups at Coventry University.

Course	*N=Maths Diagnostic/ EPQ-R*	*Maths diagnostic*	*Psychoticism*	*Extraversion*	*Neuroticism*	*Lie*	*Addiction*	*Criminality*
Business Foundation Year	*75/73*	4.61	8.86	15.86	11.61	9.86	10.92	13.00
(S.D)		(1.94)	(4.20)	(4.36)	(5.33)	(4.46)	(4.84)	(5.01)
Business Management	*61/61*	4.51	8.54	17.38	12.28	8.98	11.79	14.25
(S.D)		(2.20)	(3.66)	(3.49)	(4.63)	(3.91)	(3.80)	(4.61)
Adult Nursing	*51/51*	5.80	5.82	16.18	12.85	10.71	10.27	12.39
(S.D)		(1.74)	(3.05)	(4.17)	(6.06)	(4.22)	(5.10)	(5.12)
Psychology	*54/50*	5.75	6.52	16.34	14.34	8.58	12.14	13.50
(S.D)		(2.25)	(2.65)	(4.63)	(5.12)	(3.79)	(4.60)	(4.87)
Sports	*47/44*	6.17	7.59	17.72	11.68	8.30	10.93	12.93
(S.D)		(1.87)	(4.56)	(3.57)	(5.04)	(4.14)	(4.72)	(4.48)
All Courses	*288/279*	5.27	7.64	16.63	12.48	9.35	11.21	13.24
(S.D)		(2.11)	(3.88)	(4.12)	(5.30)	(4.19)	(4.63)	(4.85)

Table 3: Results from the Mann-Whitney tests that show the estimate effect size for each comparison of maths diagnostic score between students from different courses.

		Effect size of comparison (comparing maths diagnostic scores)				
Course *(N)*	Mathematics Diagnostic (Median)	Business Foundation Year	Business Management	Adult Nursing	Psychology	Sports
1 (75)	5		–0.035	–0.308*	–0.263*	–0.362*
2 (61)	4			–0.329*	–0.284*	–0.388*
3 (51)	6				–0.018	–0.091
4 (54)	6					–0.096
5 (47)	6					

*Significant at $p<0.005$ level

Correlations between personality and mathematics diagnostic scores

To test the relationships between mathematics diagnostics performance with personality traits measured using the EPQ-R instrument, Kendall's tau (two-tailed tests) correlation coefficients were examined. The results can be seen in Table 5.

From Table 5 it can be seen that when looking at data from all of the participants there is a significant but weak correlation between psychoticism and diagnostic performance, r=–0.08, p<0.05. However, there was no significant correlation between extraversion and diagnostic test scores. The same result was not found within individual subject groups, a summary of which is given in Table 6.

From Table 6 there seems to be a significant correlation between maths diagnostic scores and psychoticism for students from Business Management (r=0.226, p<0.05) and Psychology (r=–0.306, p<0.01) but not for

Table 4: Results from the Mann-Whitney tests that show the estimated effect size for each comparison of psychoticism score between students from different courses.

		Effect size of comparison (comparing psychoticism scores)				
Course *(N)*	Psychoticism (Median)	Business Foundation Year	Business Management	Adult Nursing	Psychology	Sports
1 (73)	8		−0.002	−0.363*	−0.268*	−0.182
2 (61)	8			−0.394*	−0.297*	−0.189
3 (51)	5				−0.138	−0.178
4 (50)	6					−0.035
5 (44)	7					

*Significant at $p<0.005$ level

Table 5: Kendall's tau coefficients showing the correlations between predictor variables and mathematics diagnostic scores.

	Gender	*Psychoticism*	*Extraversion*	*Neuroticism*	*Lie*	*Addiction*	*Criminality*
Business Foundation Year *(N)*	0.249* (75)	0.002 (73)	0.015 (73)	−0.159 (73)	0.159 (73)	−0.022 (73)	−0.11 (73)
Business Management *(N)*	0.074 (61)	0.226* (61)	0.203* (61)	−0.011 (61)	−0.242* (61)	0.082 (61)	0.074 (61)
Adult Nursing *(N)*	0.217 (51)	−0.103 (51)	−0.193 (51)	−0.169 (51)	0.014 (51)	−0.094 (51)	−0.203 (51)
Psychology *(N)*	0.052 (54)	−0.306** (50)	0.099 (50)	−0.128 (50)	−0.025 (50)	−0.141 (50)	−0.131 (50)
Sports *(N)*	0.102 (47)	−0.095 (44)	−0.038 (44)	−0.119 (44)	0.078 (44)	−0.159 (44)	−0.203 (44)
All Courses *(N)*	0.019 (288)	−0.088* (279)	0.034 (279)	−0.030 (279)	−0.013 (279)	−0.041 (279)	−0.067 (279)

*Significant at the $p<0.05$ level **Significant at the $p<0.01$ level

others. With regards to correlations between mathematics diagnostics performance and extraversion only Business Management students showed a significant result, $r=0.203$, $p<0.05$. However, the initial idea that there is some connection between the psychoticism scale scores and mathematics diagnostics scores only seems to hold true within some student groups (Business Management and Psychology).

Discussion

Analysis of the data showed that there was a significant difference between the student groups on both the psychoticism and mathematics diagnostic scales. It was also found that groups of students who scored highly on the mathematics diagnostic test generally scored lower on the psychoticism scale than those groups who scored lower on the mathematics diagnostics test. However, the nega-

Table 6: Summary table of the correlations which were and were not found between mathematics test scores with psychoticism and extraversion (using Kendall's tau).

Course	*Psychoticism with mathematics diagnostic scores (Kendall's tau)*	*Extraversion with mathematics diagnosticscores (Kendall's tau)*
All students	Yes (–0.088)*	No
Business Foundation Year	No	No
Business Management	Yes (0.226)*	Yes (0.203)*
Adult Nursing	No	No
Psychology	Yes (–0.306)**	No
Sports	No	No

*significant at the p<0.05 level **significant at the p<0.01 level

tive correlation between mathematics diagnostic score and psychoticism score was not found to be consistent across the range of courses involved in the study. A significant positive correlation was found for Business Management students and a significant negative correlation was found amongst the Psychology students only. This seems to go against the literature, which suggests that this correlation should have been observed to some degree within all groups that were assessed.

Before discussing the level of psychoticism it is important to revisit the notion of psychoticism as measured using the EPQ-R. Psychoticism as described by Eysenck and Eysenck (1991, p.6) suggests that a high scorer may exhibit antisocial tendencies, including an inability to form meaningful relationships with those around the individual. However, they also state that the instrument is designed to measure the tendency of the general population to exhibit psychotic tendencies. As such, it is only applicable in cases where the behaviours are non-pathological (as is assumed of the participants in the reported study). Within this study psychoticism does not primarily refer to the anti-social tendencies of the participants as suggested by Eysenck and Eysenck (1991) but rather to academic and study related dispositions and tendencies. To clarify this, psychoticism can be thought of as being a combination of scales i.e. conscientiousness and agreeableness and openness (Matthews et al., 2003, pp.21–36). A study conducted by Lodhi, Deo and Belhekar (2002) involving 300 undergraduate students at a university in India explored the relationship between the big five factors as measured by NEO-FFI and the three factors of EPQ-R; it was found that there were significant correlations between psychoticism and both agreeableness (r=–0.42, p<0.001) and conscientiousness (r=–0.33, p<0.001). Significant correlations were also found by Lodhi and Belhekar between Lie and both agreeableness (r=0.51, p<0.001) and conscientiousness (r=0.46, p<0.001). Their study also found very small but significant correlations between psychoticism and openness which seemed only significant due to the large sample size.

It is thus assumed based on the evidence in the literature that psychoticism is negatively correlated with both agreeableness and conscientiousness. Agreeableness scales measure how individuals interact with those

around them, in particular empathy, sympathy and tough mindedness. The agreeableness scale suggests that high scoring individuals could be more able to use peer to peer and group study strategies. Conscientiousness, however, is of more interest as it relates more directly with an individual's personal study behaviours, beliefs and possibly academic achievement. High scorers on the conscientious scale tend to be more meticulous, organised, better at planning and also more able to self-motivate towards a goal. The literature described earlier in this paper suggests that conscientiousness is positively correlated with academic achievement suggesting that high scorers on the conscientiousness scale are more likely to score higher in intelligence tests than those who score lower on the conscientious scale. In light of this and the contributions of Matthews et al. (2003) and Lodhi and Belhekar (2002), it would be expected that participants who scored lower on the psychoticism scale would score higher on an intelligence test (such as a mathematical diagnostics test as used in this study). However, as reported earlier in this paper, this correlation was only found to be true within some groups of students (see Table 5). Those groups scoring lower on the psychoticism scale scored higher on the mathematics diagnostic test than higher scoring groups, which to some extent would support the literature on the relationship between psychoticism and academic achievement.

However, the literature suggests that the relationship between extraverison and achievement is harder to identify. Allik and Realo (1997), for example, found no significant correlation between extraversion and intelligence tests, only finding correlations with language related tasks. Furthermore research by Martin et al. (2006) (using scales for ambition and sociability that could be considered proxies for extraversion) suggests that extraversion is correlated with achievement. From the analysis of the study carried out for this paper, the evidence would suggest that there is no significant correlation between extraversion and mathematics achievement.

These results can be used to provide information about the types of learners who were involved in the study, in particular those who scored lower on the mathematics diagnostic test and higher on the psychoticism scale. As was discussed earlier, the literature suggests that conscientiousness is negatively correlated with psychoticism. It is suggested that those who tended to score higher on the psychoticism scale were more inclined to work individually, less able to work in groups and find it harder to follow through with personal study intentions and schedules. Learning through group work, collaboration and the formation of communities of learning have been shown to be important in the learning process, for example, Social Constructivism (Vygotsky, 1978) and Communities of Practice (Lave & Wenger, 1991; Wenger, 1998). Furthermore the ability to adhere with personal study intentions and schedules is important in allowing students to undertake effective private study, not just of mathematics but with their whole course of study.

It is beyond the scope of this paper to ascertain if either psychoticism or extraversion can be used as predictors for mathematical ability either within or across disciplines. However, the data does suggest that students from different disciplines would appear to have significantly different psychoticism scores and mathematics scores, with those groups who scored higher on the psychoticism scale tending to have lower mathematics scores. Unfortunately the design of the study did not allow for a causal relation to be identified (if one exists). Importantly, it should be noted that these conclusions are based on one assumption and that is the validity of a mathematical test or assessment being a proxy for mathematical aptitude or intelligence. As this cannot be taken as fact, the maths diagnostic test is only taken as a proxy that indicates how well a student would perform when taking a

mathematical test as part of their course and to some small extent their knowledge. However, undertaking tests and assessment is an important part of an individual's university study and as such the diagnostic test can still be though of as a useful tool for predicting performance under similar conditions. If the results from this study were to be generalised to students from other disciplines then there are implications for how students from different subjects are assisted in not only developing their mathematical abilities and examination technique, but also on the effectiveness and value that the assistance would provide.

Implications

The results of this study have several implications for how mathematics related content is taught to undergraduate students not just within practical workshops but also through supplementary support services offered by the university. Firstly the correlation between psychoticism and mathematical achievements was not consistent between subject groups and suggests that there is a significant difference between the personalities of the groups. Where psychoticism was correlated to mathematical ability it is proposed that increased efforts must be made to ensure those who ordinarily are not inclined to work collaboratively (i.e. those groups who scored higher on psychoticism) are assisted in doing so in a supportive environment where their group working skills are encouraged and developed. Furthermore those students from courses that score significantly higher than most on the psychoticism scale may consequently spend less time addressing self diagnosed mathematical problems due to increased difficulties in organisation, planning and sticking to personal study goals (again suggested by higher scores on the scale). However, as the correlations were weak it is sensible to assume that there are other factors that contribute to low attainment including peer influences (constructive and detrimental), personal issues, family commitments. These students may benefit from peer support strategies, which could help initiate and maintain their personal study behaviours. Secondly the observed difference between groups on psychoticism and mathematics especially the correlation between the two scales suggests that teaching strategies aimed at taking account of students who are less able to collaborate with others may not be equally effective with students from different disciplines, the importance of being able to collaborate and work with peers was shown to be of importance in the effectiveness of the learning process (Vygotsky, 1978; Lave & Wenger, 1991; Wenger, 1998).

Significant correlations between mathematics and psychoticism were observed for the first year psychology students, which suggests that for those students with higher levels of conscientiousness and agreeableness there is a likelihood of having higher mathematics ability on entry. However, without data on their end of year results it is not possible to conclude if psychoticism is a measure of mathematical performance or aptitude over the year. However, it is worth noting that no correlation was found between psychoticism and mathematical ability for some groups of students and if it is assumed that their ability to plan, organise and follow through with goals has no effect on their academic performance then it could be concluded that such an intervention aimed at improving these skills may have no beneficial effect. No data was gathered to suggest that psychology students were unaware of the mathematical components of their chosen course. However, it was concerning that even though all of the participants had in the past achieved a grade C or equivalent in mathematics, the scores on the mathematics diagnostic test suggest that many students lack basic numeracy skills that they should already possess. Further research is needed to ascertain why there was a significant difference in psychoticism scores between groups. Was this due to certain courses attracting students of certain dispositions, i.e. ability to work in groups,

ability to plan, or are there other underlying factors which were not captured using the instruments in this study which could account for the differences between the groups?

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Correspondence

Roy Bhakta
E-mail: roy.bhakta@coventry.ac.uk

Clare Wood
E-mail: clare.wood@coventry.ac.uk

Duncan Lawson
E-mail: duncan.lawson@coventry.ac.uk

Mulhern, G. & Wylie, J. (2004). Changing levels of numeracy and other core mathematical skills among psychology undergraduates between 1992 and 2002. *British Journal of Psychology, 95*, 355–370.

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Appendix Table 1: Normality tests performed on data from all of the participant data.

	*Kolmogorov-Smirnov**			*Shapiro-Wilk*		
Variable	*Statistic*	*Df*	*Significance*	*Statistic*	*df*	*Significance*
Mathematics Diagnostic	0.112	284	0.000	0.972	284	0.000
Marlowe Crowne	0.077	284	0.000	0.986	284	0.008
Psychoticism	0.129	284	0.000	0.945	284	0.000
Extraversion	0.117	284	0.000	0.955	284	0.000
Neuroticism	0.073	284	0.001	0.984	284	0.000
Criminality	0.074	284	0.001	0.987	284	0.000
Addiction	0.072	284	0.001	0.988	284	0.016
Lie	0.075	284	0.001	0.985	284	0.014

* Lilliefors Significance Correction

Appendix Table 2: Tests for normality from within individual subject groups

	Course enrolled on	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Marlowe Crowne	1	.078	72	.200*	.986	72	.579
	2	.115	61	.044	.968	61	.116
	3	.096	51	.200*	.987	51	.835
	4	.097	50	.200*	.980	50	.545
	5	.126	44	.075	.955	44	.086
Maths diagnostic score	1	.133	72	.003	.954	72	.011
	2	.149	61	.002	.960	61	.043
	3	.142	51	.012	.959	51	.074
	4	.107	50	.200*	.966	50	.166
	5	.146	44	.019	.947	44	.044
Psychoticism	1	.147	72	.001	.943	72	.003
	2	.160	61	.001	.950	61	.015
	3	.136	51	.020	.942	51	.015
	4	.118	50	.081	.976	50	.399
	5	.188	44	.000	.887	44	.000
Extraversion	1	.115	72	.019	.952	72	.008
	2	.118	61	.034	.954	61	.022
	3	.166	51	.001	.914	51	.001
	4	.120	50	.069	.969	50	.210
	5	.208	44	.000	.920	44	.005
Neuroticism	1	.071	72	.200*	.982	72	.378
	2	.084	61	.200*	.976	61	.287
	3	.149	51	.006	.943	51	.016
	4	.116	50	.089	.977	50	.434
	5	.097	44	.200*	.981	44	.667
Lie	1	.112	72	.026	.977	72	.211
	2	.090	61	.200*	.976	61	.282
	3	.088	51	.200*	.977	51	.423
	4	.082	50	.200*	.979	50	.509
	5	.074	44	.200*	.967	44	.235
Addiction	1	.080	72	.200*	.968	72	.067
	2	.123	61	.023	.976	61	.265
	3	.143	51	.011	.966	51	.146
	4	.108	50	.200*	.975	50	.380
	5	.112	44	.200	.977	44	.533
Criminality	1	.058	72	.200*	.983	72	.464
	2	.084	61	.200*	.976	61	.283
	3	.118	51	.073	.963	51	.107
	4	.101	50	.200*	.969	50	.206
	5	.094	44	.200*	.956	44	.096

[a] Lilliefors Significance Correction * This is a lower bound of the true significance.
(1 = Business Foundation Year, 2 = Business Management, 3 = Adult Nursing, 4 = Psychology, 5 = Sports)