[As supplied by authors] *Selecting medical students*

Why intellectual aptitude tests probably aren't useful for selecting UK school-leaver entrants, and how A-levels could be

Supplementary Information

i). University achievement in relation to A-levels and aptitude.

a). The ISPIUA study of 1967.

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i) University achievement in relation to A-levels and aptitude.

a). *The ISPIUA study of 1967.* Initiated by the Committee of Vice-Chancellors and Principals in response to the proposed expansion of UK university education in the Robbins Report of 1963 [1], this large study looked at a random sample of 27,315 4th-term sixth-formers taking A-levels [2-4]. As well as collecting data on academic achievement and school assessments, the study also administered a three-hour Test of Academic Attitude (TAA), which separately assessed verbal ability and mathematical ability. 7,080 participants were known to have entered university in 1968, of whom 348 studied medicine. A further 2,315 participants entered university in 1969, with 118 studying medicine. The results for the 1968 entrants, shown in table 1, and the authors' conclusion, are clear: "TAA appears to add little predictive information to that already provided by GCE results [A-levels and O-lvels]and school assessment in general".

Table 1: **ISPIUA project (1967)**. Correlation of first-year degree performance (1968-69) and final degree performance (1971) with educational achievement and aptitude tests (1967). Note that medical students do not receive classed degrees, and have not finished by the third year of their course, and therefore are not included in the final column.

	First-year university performance (university tutor ratings)		Final degree
Correlation with:	Medicine (n=294)	All degree courses (n=5,985)	All degrees courses except medicine
Mean A-level grade	.35	.32	.36
Number of A-levels taken	.19	.14	.17
Number of O-levels taken	.20	.12	.16
School assessment	.23	.24	.26
Mathematical aptitude	.10	.01	.13
Verbal aptitude	.15	.01	-.02
Multiple correlation with all six predictors	*.41*	*.35*	*.42*

b). *The Westminster Study of 1975-1982.* All entrants to the clinical course at the Westminster Medical School between 1975 and 1982 were given the AH5 [5], a timed IQ test, as a measure of aptitude [6]. These students were followed up in 2002 as practising doctors, and a range of measures taken of professional attainment. Full details of correlations etc are available in the Supplementary Information of the paper (http://bmj.bmjjournals.com/cgi/content/full/327/7407/139/DC1) . A-level grades at the time of entry were predictive of professional achievement (time to Membership and Fellowship, achievement of Consultant posts, etc), although they did not predict research achievement or non-academic outcomes such as stress, burnout, and satisfaction with a medical career. The aptitude test provided little prediction of outcomes, and contributed no additional predictive power over and above that of A-level grades.

c) *The 1991 cohort study*. This study looked at 6901 applicants to UK medical schools in 1990, of whom 3333 were admitted to medical schools in 1991 or subsequently [7,8]. A subset of 786 applicants who were interviewed at three of the participating medical schools were given a series of timed psychometric tests, including an aptitude test consisting of an abbreviated version of the AH5 test [5,5]. Participants were followed-up at the end of the clinical course, as PRHOs [9],and in 2002 [10]. Outcomes for present purposes are performance in Basic Medical Science examinations at the end of year 2, finals performance (pass at expected time or delayed due to examination failure), and, in a subset of doctors who choose to take the examination, their first attempt at the first part of a UK postgraduate examination which is typically taken about 18 months after graduation.

Analyses of the aptitude test and A-levels in relation to performance on the course and afterwards have not previously been published, and are therefore provided here in somewhat more detail than for the previous two studies.

Table 2 summarises the correlations of each measure with mean A-level grade and overall AH5 performance. A-level grades were known for many more subjects than were the AH5 test results, and therefore to aid comparison, the correlations with A-level grades are provided both for all entrants and for all entrants who also took the AH5. Note that, as with the ISPIUA project, the verbal subtest of the aptitude test performs a little better than the non-verbal test.

Table 2: **1991 Cohort study (1990-2002)**. Correlations of outcome measures (Basic Medical Sciences course, Finals, and a postgraduate examination with mean A-level grade and performance on the aptitude test (abbreviated AH5, aAH5). Note that finals performance was only a binary measure, and there is relatively little power since most individuals qualified at their first sitting of the examination. Although a logistic regression is technically better for this binary measure, a correlation has been used for comparability with the other outcome measures.

	Basic Medical Sciences	Finals	Part 1 of postgraduate examination, Part 1, first attempt
Mean A-level grade (all entrants)	**.202** (p<.001, n=3112)	**.063** (p<.001, n=2510)	**.332** (p<.001, n=903)
Mean A-level grade (entrants taking aAH5)	**.210** (p<.001, n=756)	**.096** (p=.017, n=610)	**.371** (p<.001, n=239)
aAH5 (total)	**.044** (p=.227, n=766)	**.015** (p=.718, n=616)	**.123** (p=.057, n=240)
aAH5 (Verbal)	**.077** (p=.034, n=766)	**.045** (p=.262, n=616)	**.156** (p=.016, n=240)
aAH5 (Spatial)	**-.006** (p=.867, n=772)	**-.020** (p=.621, n=622)	**.048** (p=.463, n=240)

Supplementary figures 1, 2 and 3 (at the end of this **Supplementary Information)** show the relationship between A-level grades and overall aptitude test result with performance at Basic Medical Sciences, at Finals, and at the first attempt at the postgraduate examination.

We are unaware of any studies, other than the three described above, which have assessed both A-levels and aptitude tests as predictors of outcome at university, either in medicine or other subjects. We note in particular that the much cited 'pilot study' of aptitude tests in relation to A-level achievement which was carried out by the Sutton Trust [11,12]was relatively small, did not follow-up students to university, and concluded "the data provided no evidence that [the test] was able to assess potential for study at higher education, independently of a student's social and educational experiences".

iii) Statistical problems in interpreting the relationship between A-level grades and university achievement.

A major problem in interpreting the relationship between A-level grades, aptitude and university performance is what is known as 'restriction of range'. Selection often means that the range of achievement found in those selected is narrower than the range in those applying. The result is that any correlation will be attenuated from its true value for the population as a whole, with more variance due to measurement error and less due to systematic differences. To take an extreme, if one only looks at individuals gaining AAA at A-level then there can be no correlation with outcome, since there is no variance which can co-vary with outcome.

A variant argument is that since the correlation between aptitude tests and A-level grades is relatively low then they must be measuring different underlying cognitive components. That however is only the case if both are measured with high reliability and there is no restriction of range. In the Westminster study the correlation of A-level grade with aptitude was 0.285, a somewhat higher value than the 0.162 found in the 1991 Cohort Study in medical school applicants, but there was less restriction of range in the Westminster study. In the 1991 Cohort study the correlation was 0.238 in *interviewees*, not all of whom were accepted, so there was less restriction of range. In contrast in the ISPIUA project the correlation of A-levels and aptitude across *all* individuals (i.e. all of those taking A-levels) was a much higher 0.51 [13] (and that is not corrected for attenuation due to unreliability of the tests or additional restriction of range relative to the population as a whole, most of whom were not taking A-levels). It should also be remembered that very few social or psychological measures are perfectly reliable, and hence correlations of one, or even correlations above 0.5, are extremely rare, both due to the various causes of attenuation, and due to most social processes being inherently multifactorial. Correction for both measurement error and restriction of range is possible but is rarely carried out in practice, and many measures disparagingly described as 'weak', 'low' or 'poor' are actually quite good once they are corrected for such problems.

We should also add that we have recently seen data from two UK medical schools in which performance in examinations in the first three years was correlated with A-level grades, despite almost all having AAA, AAB or ABB grades; those with AAA had performed better than those with AAB who had in turn performed better than those with ABB. A-levels are still predictive of university outcome despite restriction of range.

To summarise, a low correlation between A-level grades and university outcome does not imply that A-levels are poor predictors of outcome and neither does a low correlation between A-levels and aptitude tests imply that separate cognitive processes are being measured. Both correlations suffer seriously from restriction of range, and attenuation due to unreliability, and cannot be taken at their face value.

iv. University performance of students in relation to aggregate school performance.

It has been hypothesised that the achievement of students who come from 'poorer' schools, where the aggregate level of performance at A-level is lower, will be higher at university than those with the same grades who come from schools which on average are performing at a higher level. The assumption is that academic achievement in adversity, where few students achieve well at A-level, perhaps because of lower quality teaching, will be a better predictor of success than similar achievement as a result of high quality teaching. Although a reasonable argument, it does not take into account the possibility that schools which are poorer achievers at A-level are so because the students in them are of lower intellectual ability on average. In general the hypothesis is usually put forward without any data in its support. However the recent analyses of HEFCE suggest that the hypothesis is without empirical foundation.

HEFCE's analysis of 79,005 18-year-olds entering university in 1997-1998 and followed until 2000-2001 (http://www.hefce.ac.uk/pubs/hefce/2003/03_32.htm) divided schools into four quartiles, from those with the highest aggregate A-level results to those with the lowest aggregate A-level results. Supplementary figure 4 shows the outcome at university, in terms of proportion of II.i or I degrees, in relation to individual A-level performance, and in relation to aggregate school performance. There is a small difference between those in the highest quartile and the other three quartiles, but no obvious difference between the three lowest quartiles. Further analysis of the data by HEFCE found that quartile of school achievement was strongly confounded with school type, all of the Independent schools being in the highest quartile of school achievement. When school type was taken into account, there was no effect of average level of school achievement. Therefore it has to be concluded that aggregate school achievement is not a predictor of university outcome in individual pupils, despite the seductive attractiveness of the original hypothesis.

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iv) Additional references from main text. (‘w’ superscripts).

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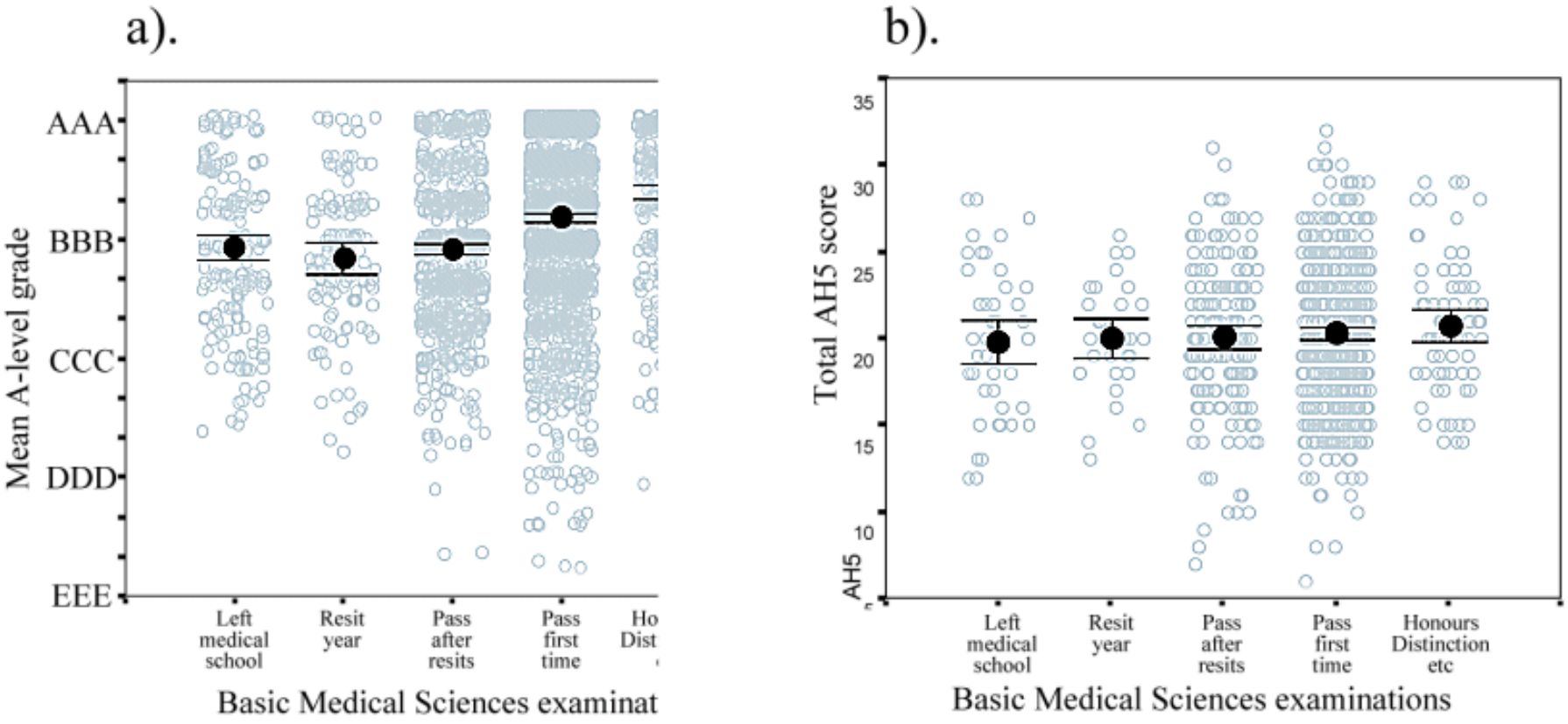
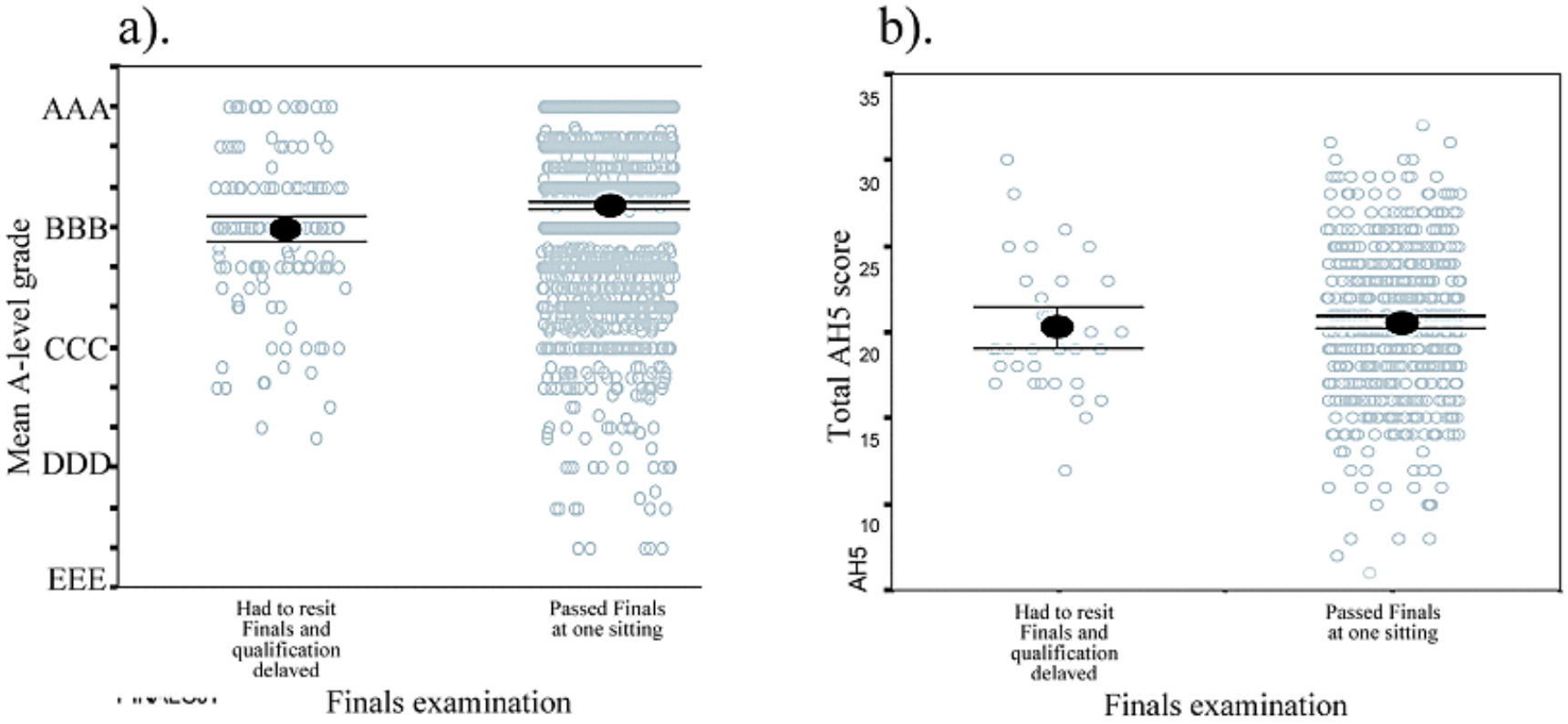
Captions for Supplementary Information Figures

Supplementary figure 1



Supplementary Figure 1. The abscissa of both figures shows performance of students in the 1991 cohort study on Basic Medical Sciences (BMS) examinations, typically reflecting performance in the first two years of the medical curriculum. BMS results are only reported in terms of five simple categories because of differences in measurement in different medical schools. The left-hand figure (a.) shows the relationship to mean A-level grade, individual subjects being shown as pale grey circles, and means (± 1 standard error) superimposed in black. The right-hand figure (b.) shows the relationship to the overall AH5 score, with pale grey circles for individual subjects, and means (± 1 standard error) superimposed in black. Individual points have been given a slight random jitter to right or left in order that points do not superimpose upon one another.

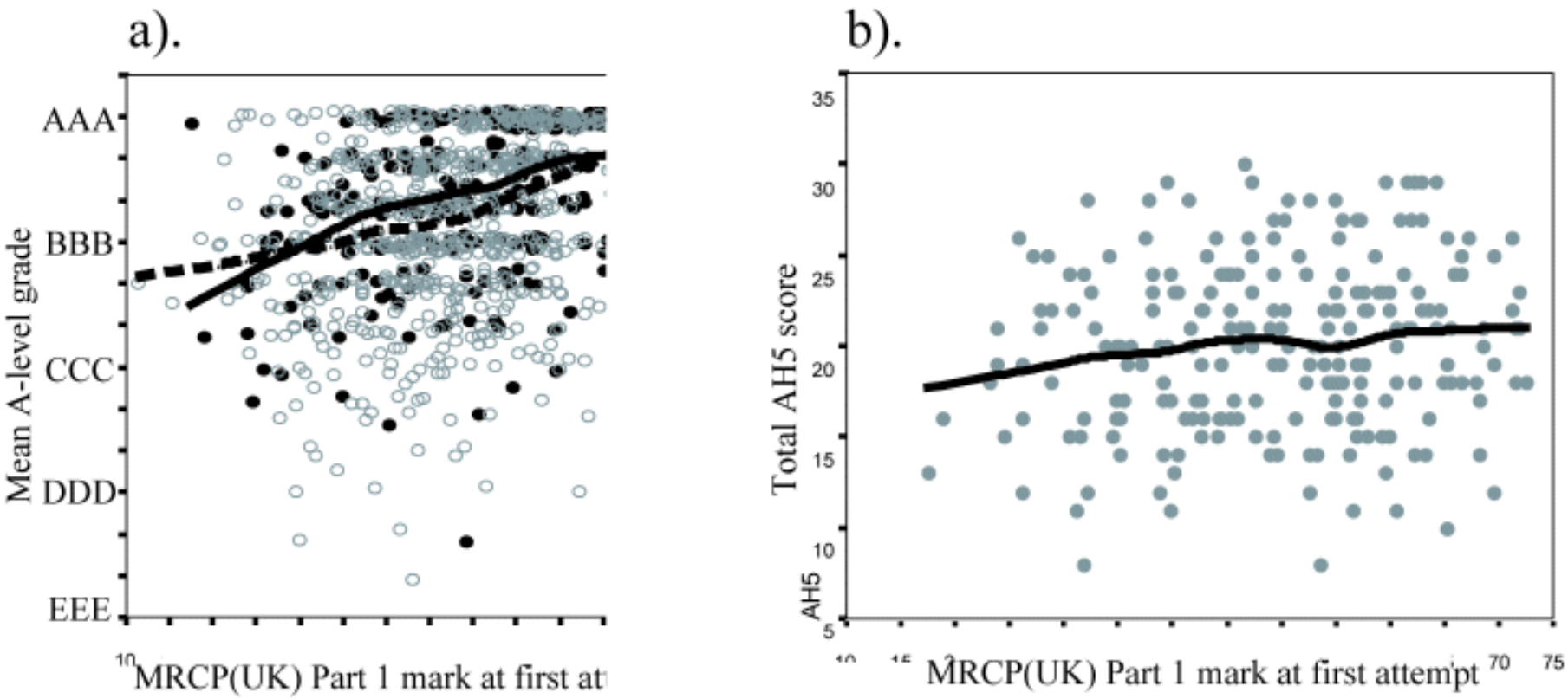
Supplementary figure 2



Supplementary Figure 2. The abscissa of both figures shows performance of students in the 1991 cohort study at their final examinations. Because of differences

in method of examining between medical schools, the results are merely expressed as whether candidates passed their finals at the first sitting, and hence qualified, or instead had to resit finals six months or so later, and hence qualified late. The left-hand figure (a.) shows the relationship to mean A-level grade, individual subjects being shown as pale grey circles, and means (± 1 standard error) superimposed in black. The right-hand figure (b.) shows the relationship to the overall AH5 score, with pale grey circles for individual subjects, and means (± 1 standard error) superimposed in black. Individual points have been given a slight random jitter to right or left in order that points do not superimpose upon one another.

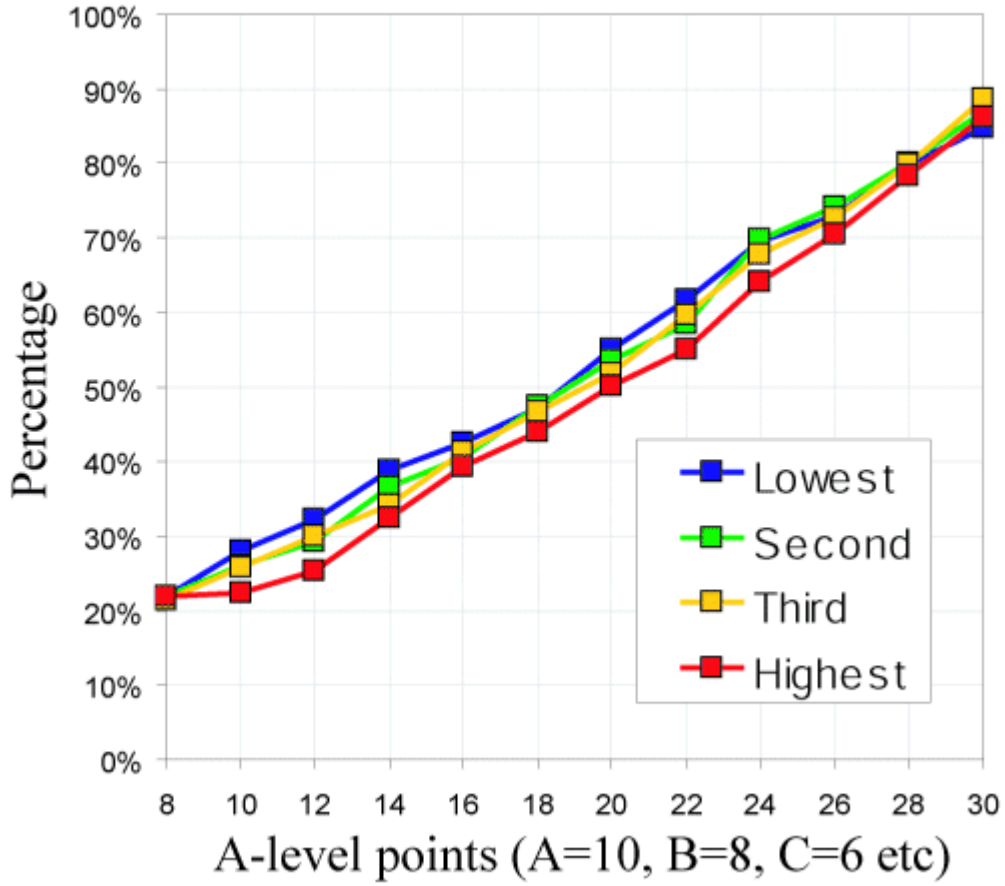
Supplementary figure 3



Supplementary Figure 3. The abscissa of both figures shows performance of those students in the 1991 cohort study who had taken the 1st Part of the postgraduate examination on their first attempt at the examination. The left-hand figure (a.) shows the relationship to mean A-level grade, individual subjects

being shown as circles. The superimposed lines are lowess curves. The solid black circles and the solid line are for those subjects for whom AH5 results were available, whereas the open grey circles and dashed line are for subjects who had not taken the AH5 test. Individual points have been given a slight vertical jitter to prevent subjects with exactly the same A-level grades being superimposed upon one another.

Supplement



Supplementary Figure 4. The proportion of university entrants with particular A-level grades who gained a II.i or I degree, in relation to the overall performance of their secondary school at A-level. School performance is ordered from the highest quartile (schools with the highest average grades), through to the lowest quartile (schools with the lowest average grades). Redrawn from the HEFCE data reported at www.hefce.ac.uk/pubs/hefce/2003/03_32.htm.