Centre for Longitudinal Studies

CLS Cohort Studies

Guide to the Dataset

BCS70 16-year follow-up
APU Arithmetic Test

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Introduction

This document provides a brief guide to the data deriving from an arithmetic test administered to the subjects of the 1970 British Cohort Study (BCS70) in 1986 when they were 16 years of age. The data supplement those already available from the UK Data Archive (http://www.data-archive.ac.uk/) for other elements of the 1986 survey. Before using these data you are strongly advised to consult the main documentation for the 1986 survey and that for BCS70 as a whole available via the Archive and from the CLS website (http://www.cls.ioe.ac.uk/).

1970 British Cohort Study

BCS70 is a continuing, national longitudinal study which began when data were collected about the births of 17,198 babies in England, Scotland, Wales and Northern Ireland in one week in April 1970. Since the birth survey there have been seven other major data collection exercises designed to monitor their health, education, social and economic circumstances of the members of this birth cohort living in GB (England, Scotland and Wales). These were carried out in 1975 (age 5), 1980 (age 10), 1986 (age 16), 1996 (age 26), 2000 (age 30) and 2004 (at age 34). Sub-samples have also been studied at various ages: for example at age 21, a 10 per cent representative sample was assessed for basic skills difficulties.

From its original focus on the circumstances and outcomes of birth, BCS70 has broadened in scope to map all aspects of health, education and social development of their subjects as they passed through childhood and adolescence. In later sweeps, the information collected has covered their transitions into adult life, including leaving full-time education, entering the labour market, setting up independent homes, forming partnerships and becoming parents.

BCS70 1986 Follow-up

The 1986 follow-up was carried out by the International Centre for Child Studies and named "Youthscan". In this sweep, sixteen separate survey instruments were employed, including parental questionnaires, school class and head teacher questionnaires and medical examinations. The cohort members completed questionnaires, kept two four-day diaries (one for nutrition and one for general activity), and undertook educational assessments.

Much of the data gathered during this survey is already available via the UK Data Archive. Documentation is also available from Archive and the CLS website (http://www.cls.ioe.ac.uk/).

Arithmetic test administered during the 1986 BCS70 Follow-up

Origins

The test used during the 1986 follow-up is known as the APU Arithmetic Test (© 1976, multiple choice format 1986). It was designed by S.J. Closs, MA PhD, and M.J. Hutchings, MA PhD under the auspices of the Applied Psychology Unit at Edinburgh University. It was published by Hodder and Stoughton Ltd., Mill Road, Dunton Green, Sevenoaks, Kent.

A copy of the assessment as used in the survey is provided in Appendix 1.

The manual to the APU Arithmetic Test (Author, S.J. Closs 1976 *ISBN-10:* 0340174846, *ISBN-13:* 978-0340174845) gives guidance on how to interpret the results and provides look-up tables facilitating standardisation. Unfortunately, this is now out of print and, despite our best endeavours, we have been unable so far to obtain a copy. However, a commentary by B.L.M. Chapman of Bristol University Department. of Education is reproduced in Appendix 4, giving useful guidance on the reliability and validity of the test.

Administration

Survey instrumentation for the 1986 follow-up was distributed through education and health authorities. The arithmetic test was included in the materials distributed through Local Education

Authorities and, where parental consent was obtained, administered to cohort members in school with the assistance of teachers.

The arithmetic test consisted of sixty items and was included in the *Student Test Booklet.* The cohort members recorded their answers on a machine-readable *Student Score Form*.

Teachers explained the background to the study, made sure the cohort members understood what was required of them and supervised each test, ensuring that any time limits were observed. Some 30 minutes were allowed for the completion of the arithmetic test. General guidance on the administration of this and other assessments was provided in the *Information Manual for Teachers*. A copy is included in the documentation on the 1986 survey available via the Archive and from the CLS website (http://www.cls.ioe.ac.uk).

Arithmetic test data

The data for the arithmetic test administered during the BCS70 1986 follow-up consists of the response for each of the 60 test items for some 3,677 cases, plus an additional 60 derived variables interpreting the answers into 'wrong' or 'right', together with four additional variables giving details of:

- Total score (number of correct items out of 60)
- Total number of incorrect items
- Total number of items attempted
- Percentage score (i.e. total score * 100/60)

Further details are given in Appendix 3.

Data cleaning

It is important to note that the dataset has been derived from raw data transferred from the University of Bristol on behalf of the International Centre for Child Studies which was responsible for the 1986 follow-up. The data were a small part of a large volume of BCS70 data, and lack of coherent and systematic documentation and competing demands for the use of scarce resources have delayed checking and documenting of the arithmetic test.

The results of the Arithmetic Test at age 16 were part of the *Student Score Form* (Document C), which can be viewed at the UK Data Archive or the CLS website at: http://www.cls.ioe.ac.uk/studies.asp?section=00010002000200070001

Data for the vocabulary test and two spelling tests administered at age 16 have been available for some time, but data for the arithmetic, reading and matrices tests had not previously been identified. However, in 2007 the raw arithmetic data came to light when files were transferred between servers.

Finer details of the data cleaning are not provided here, but the process involved:

- eliminating cases where no data was recorded;
- eliminating apparent duplicate cases;
- matching the obsolete Youthscan 'y-number' case identifier to the BCS70 case identifier BCSID to enable longitudinal linkage to other BCS70 datasets;
- checking that all cohort members present at this arithmetic test were also present for other elements of the 16-year survey

In response to each of the 60 arithmetic questions, the cohort members were asked to choose between 5 possible answers, denoted by alternatives A-E. The variables corresponding to these responses are 'car1' to 'car60'. If the respondent chose answer 'A', this was coded as an 'A' followed by four blanks; if 'B' it was coded with 'B' in the second position, with blanks in the other four positions, and so on. If the question was not attempted, the variable was coded as 5 blank spaces.

It was necessary to derive a corresponding series of 60 variables carx1 to carx60 coded 1 for ‘right answer’ and 0 for ‘wrong answer’. These were then totalled in a variable ‘mscore’, and a corresponding variable ‘mincorct’ added up the incorrect responses.

Normally only one character had been keyed in each item score, but for about 2-3% of cases, two or more characters appear, which seems to indicate the student 'hedged their bets'. All these multiple answers were coded as 'incorrect'.

It was noticeable that very few people achieved correct answers to questions 48-50. This may be attributable to an unfortunate fault in the printing of the histogram they were asked to analyse, which has no labels on the X axis, making it very difficult to understand the questions.

References

Closs, S. J. and Hutchings, M. J. (1976) *APU arithmetic test*. London: Hodder and Stoughton. ISBN: 0340174838

Closs, S. J. and Hutchings, M. J. (1976) *APU arithmetic test: Instruction manual*. London: Hodder and Stoughton, ISBN: 0340174846 (sd)

Levy, P & Goldstein, H, (eds) (1984) *Tests in Education: A book of critical reviews*, London: Academic Press

Appendix 1 The Arithmetic Test Booklet

ARITHMETIC TEST

YOUTHSCAN TEST NUMBER **3**

YOU WILL BE TOLD WHEN TO START – please read the instructions on this page first.

INSTRUCTIONS

This is a test of arithmetic. You can work out the answers in your head or use spare paper for any rough work.

Please remember to enter your choice of answer on the separate Student Score Form.

Please look first at the two examples shown below. You will see that for each question there are five answers to choose from. Only one answer is correct.

1st example

	(a)	(b)	(c)	(d)	(e)
2 × 2 =	1	2	3	4	5

The correct answer is 4, so the **d** space has been filled in for you on the Score Form opposite "1st example". Look at the answer sheet and check this.

Now proceed to do the next example for yourself.

2nd example

	(a)	(b)	(c)	(d)	(e)
4 + 4 =	2	4	8	10	15

You should have filled in space **c** opposite the "2nd example" on the Score Form, since the correct answer is 8 in column **c.**

There are 60 questions in this test. Try to answer as many of them as you can. If you cannot answer a question don't waste too much time on it but go on to the next one. When you have finished one page, go on to the next page. There are three pages of questions altogether. You have 30 minutes to do this test. If you finish before then, you can go back over your answers to check them.

DO NOT TURN OVER THIS PAGE UNTIL YOU ARE TOLD TO DO SO

	(a)	(b)	(c)	(d)	(e)
1. 2 + 3 =	1/5	3	4	5	7
2. 2 × 4 =	6	8	12	16	24
3. 12 ÷ 3 =	4	6	9	12	36
4. 359 − 126 =	103	113	133	213	233
5. 57 + 135 =	78	182	192	642	705
6. What number multiplied by itself gives 81?	7	8	9	10	11
7. Add half of 26 to twice 24	61	74	100	101	124
8. Choose in figures "fourteen hundred and three"	103	143	403	1403	1430
9. 1·85 − 0·45 =	1·2	1·4	1·45	1·65	2·3
10. 4 × 6 ÷ 3 =	3	4	5	6	8
11. 44×11 =	55	88	444	484	584
12. Subtract a quarter of 12 from half of 12	3	4	5	6	8
13. 27·85 + 15·32 =	33·17	43·17	43·27	44·17	44·77
14. 196 ÷ 14 =	6	8	10	12	14
15. 6 × 0.33 =	1·88	1·98	2	2·05	2·19
16. 1·25 + 0·875 =	1·875	1·9	2·125	2·215	2·225
17. What is the square root of 36?	3	4	6	12	16
18. What is the average of 2, 4 and 12?	6	7	8	9	10
19. What is the average of 43, 37, 125 and 35?	30	35	40	45	60
20. **25, 24, 22, 19?** What number comes next?	16	15	14	13	12
21. 12^2 =	24	122	144	148	156
22. 2^4 =	48	32	24	16	8
23. 4^3 =	12	43	56	64	143

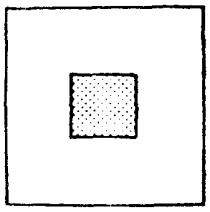
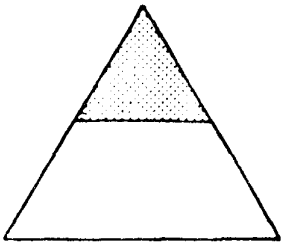
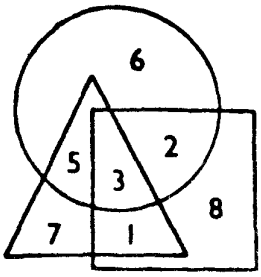
24-26. A letter is to be chosen at random from the word "ARITHMETIC". What is the probability that it will be:

	(a)	(b)	(c)	(d)	(e)
24. The letter 'R'?	0·1 or 1/10	0·2 or 1/5	0·3 or 3/10	0·4 or 2/5	0·5 or 1/2
25. The letter 'T'?	0·1 or 1/10	0·12 or 3/25	0·15 or 3/20	0·18 or 9/50	0·2 or 1/5
26. A vowel?	0·2 or 1/5	0·4 or 2/5	0·5 or 1/2	0·6 or 3/5	1·0 or 1

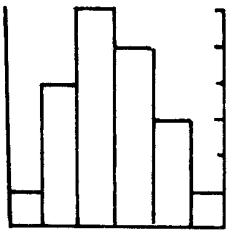
	(a)	(b)	(c)	(d)	(e)
27. 20% of 50 =	10	15	20	25	30
28. 0·5 × 0·25 =	0·105	0·115	0·125	0·75	1·25
29. If we multiply a number by 9, subtract 8 and divide by 7 we get 13. What is the number?	8	9	10	11	13
30. What is the cube root of 27?	1	2	3	4	9

31-33. A box contains 25 black marbles, 35 white marbles and 40 red marbles. If one marble is taken at random from the box, what is the probability that it will be:

	(a)	(b)	(c)	(d)	(e)
31. A red marble?	0·35 or 7/20	0·4 or 2/5	0·45 or 9/20	0·5 or 1/2	0·75 or 3/4
32. A white marble?	0·2 or 1/5	0·25 or 1/4	0·3 or 3/10	0·35 or 7/20	0·4 or 2/5
33. A marble that is not black?	0·35 or 7/20	0·4 or 2/5	0·65 or 13/20	0·7 or 7/10	0·75 or 3/4

	(a)	(b)	(c)	(d)	(e)
34. What is $\frac{17}{1000}$ expressed as a decimal fraction? . .	10·7	1·7	0·7	0·17	0·017
35. $(7 \times 1000) + (8 \times 100) + (9 \times 10) = 100 \times ?$ . .	78·9	79·8	789	798	71890
36. 10% of the seats in a cinema with 1700 seats were empty. How many people were in the cinema?	170	1170	1530	1570	1630
37.  Look at this figure, then work out what fraction of the whole area is shaded.	1/10	1/9	1/5	1/4	1/3
38.  Now look at this figure and work out what fraction of the whole area is shaded.	(a) 1/4	(b) 1/5	(c) 1/6	(d) 1/7	(e) 1/8
39. **99, 97, 93, 85, 69,** ? What number comes next?	53	43	39	37	35
40. If we cube a number greater than 0 and divide the result by 16 we get the number we started with. What is the number?	0	1	2	3	4
41-42. Two children had to be chosen from a group of three boys and four girls: **B_1 B_2 B_3 G_1 G_2 G_3 G_4**	(a)	(b)	(c)	(d)	(e)
41. In how many ways could two girls be chosen? .	3	4	6	9	10
42. In how many ways could a boy and a girl be chosen?	3	4	6	9	12
43. 27% of 30 − 17% of 30 = ...	2	3	13	17	25
44. The sum of two numbers is 89 and the difference between them is 23. What is the **smaller** number?	(a) 16	(b) 29	(c) 31	(d) 33	(e) 57
45-47. The total in the circle is 16 The total in the triangle is 16 The total in the square is 14 	(a)	(b)	(c)	(d)	(e)
45. Which number must be increased if all the totals are to be equal?	1	2	3	7	8
46. Which number must be changed if the totals in the circle, in the triangle and in the square are all to be changed equally?	3	5	6	7	8
47. Which number must be increased if the totals in the circle and the triangle are to be 6 greater than the total in the square?	2	5	6	7	8

48-50. A group of 100 people were asked to estimate the length of a line. It's true length was 5 cms. The histogram shows the distribution of their estimates. . . . . .



Estimated length of line in cms

	(a)	(b)	(c)	(d)	(e)
48. How many people guessed correctly?	5	15	20	25	30
49. What percentage of the group were only one centimetre out in their estimate?	35	40	45	50	55
50. What is the mean of the group's estimates? . .	4·4	4·5	4·7	4·9	5
51. 0, 3, 10, 21, 36, ? What number comes next? . .	41	45	55	57	61
52. $14·9 \times 5·4 \div 2·7 =$	29·8	31·2	32·8	39·8	46·8
53. Divide 200 in the ratio 7:3	110:90	120:80	130:70	140:60	150:50

54. Divide 600 in the ratio 3:2:1

(a)	(b)	(c)	(d)	(e)
200:150:100	200:200:100	200:200:200	300:100:100	300:200:100

55. Divide 300 in the ratio 3:4:2:6

(a)	(b)	(c)	(d)	(e)
50:80:40:120	60:80:40:120	60:70:50:120	60:80:50:110	70:80:30:120

	(a)	(b)	(c)	(d)	(e)
56. How many rectangular blocks 30 cms long, 20 cms wide and 6 cms deep will fit into a rectangular box 90 cms long, 80 cms wide and 72 cms deep?	144	154	156	164	166
57. The line round a football pitch is 350 metres long. The pitch is 35 metres longer than it is broad. How many metres long is it?	85	95	105	125	135
58. What is the radius in cms of a circle of 62·8 cms circumference? (Take $\pi = 3·14$)	5	6	8	9	10
59. What is the area in cm^2 of a circle of 3 cms radius? (Take $\pi = 3·14$)	(a) 31·46	(b) 31·4	(c) 30·28	(d) 30·26	(e) 28·26
60. If a two figure number is written backwards it makes a number that is 72 smaller. What is the number?	(a) 68	(b) 75	(c) 86	(d) 91	(e) 97

END OF TEST 3

Appendix 2 Syntax used to derive scores from the BCS70 16-year arithmetic dataset

```
* Delete cases where all 60 item scores are blank (i.e. test not attempted at all).

select if (not(car1='    ' and car2='    ' and car3='    ' and car4='    ' and car5='    '
and car6='    ' and car7='    ' and car8='    ' and car9='    ' and car10='    '
and car11='    ' and car12='    ' and car13='    ' and car14='    ' and car15='    '
and car16='    ' and car17='    ' and car18='    ' and car19='    ' and car20='    '
and car21='    ' and car22='    ' and car23='    ' and car24='    ' and car25='    '
and car26='    ' and car27='    ' and car28='    ' and car29='    ' and car30='    '
and car31='    ' and car32='    ' and car33='    ' and car34='    ' and car35='    '
and car36='    ' and car37='    ' and car38='    ' and car39='    ' and car40='    '
and car41='    ' and car42='    ' and car43='    ' and car44='    ' and car45='    '
and car46='    ' and car47='    ' and car48='    ' and car49='    ' and car50='    '
and car51='    ' and car52='    ' and car53='    ' and car54='    ' and car55='    '
and car56='    ' and car57='    ' and car58='    ' and car59='    ' and car60='    ')).

execute.

* Derive arithmetic 'total score' variables from the item scores.
* The raw arithmetic variables car1 to car60 are coded with the alphabetic digit (A-E) of the
* alternative that was selected as correct, which varies with each question.
* Need to recode the correct alternative in each case to '1' and incorrect to '0', then total up
* the correct and incorrect responses ('not answered'=-1).

* Create vector MATHS, with 60 slots for the arithmetic items.

vector #maths (60).

* Initialise all 60 slots to zero (i.e. incorrect), with intention of replacing by '1' if found to be
* correct, or' -1' if no answer (i.e. 5-char string is blank).

loop #i=1 to 60.
compute #maths(#i)=0.
end loop.

* Proceed through all 60 test items, re-coding slot to '1' if found to be correct, or' -1' if no
* answer (i.e. 5-char string is blank)

If (car1='   D ')#maths(1)=1.
If (car1='    ')#maths(1)=-1.

If (car2=' B   ')#maths(2)=1.
If (car2='    ')#maths(2)=-1.

If (car3='A    ')#maths(3)=1.
If (car3='    ')#maths(3)=-1.

If (car4='    E')#maths(4)=1.
If (car4='    ')#maths(4)=-1.

If (car5='  C  ')#maths(5)=1.
If (car5='    ')#maths(5)=-1.

If (car6='  C  ')#maths(6)=1.
If (car6='    ')#maths(6)=-1.

If (car7='A    ')#maths(7)=1.
If (car7='     ')#maths(7)=-1.
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If (car8='   D ')#maths(8)=1.
If (car8='     ')#maths(8)=-1.

If (car9=' B   ')#maths(9)=1.
If (car9='     ')#maths(9)=-1.

If (car10='    E')#maths(10)=1.
If (car10='     ')#maths(10)=-1.

If (car11='   D ')#maths(11)=1.
If (car11='     ')#maths(11)=-1.

If (car12='A    ')#maths(12)=1.
If (car12='     ')#maths(12)=-1.

If (car13=' B   ')#maths(13)=1.
If (car13='     ')#maths(13)=-1.

If (car14='    E')#maths(14)=1.
If (car14='     ')#maths(14)=-1.

If (car15=' B   ')#maths(15)=1.
If (car15='     ')#maths(15)=-1.

If (car16='  C  ')#maths(16)=1.
If (car16='     ')#maths(16)=-1.

If (car17='  C  ')#maths(17)=1.
If (car17='     ')#maths(17)=-1.

If (car18='A    ')#maths(18)=1.
If (car18='     ')#maths(18)=-1.

If (car19='    E')#maths(19)=1.
If (car19='     ')#maths(19)=-1.

If (car20=' B   ')#maths(20)=1.
If (car20='     ')#maths(20)=-1.

If (car21='  C  ')#maths(21)=1.
If (car21='     ')#maths(21)=-1.

If (car22='   D ')#maths(22)=1.
If (car22='     ')#maths(22)=-1.

If (car23='   D ')#maths(23)=1.
If (car23='      ')#maths(23)=-1.

If (car24='A    ')#maths(24)=1.
If (car24='     ')#maths(24)=-1.

If (car25='    E')#maths(25)=1.
If (car25='     ')#maths(25)=-1.

If (car26=' B   ')#maths(26)=1.
If (car26='     ')#maths(26)=-1.

If (car27='A    ')#maths(27)=1.
If (car27='     ')#maths(27)=-1.
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If (car28='  C  ')#maths(28)=1.
If (car28='     ')#maths(28)=-1.

If (car29='   D ')#maths(29)=1.
If (car29='     ')#maths(29)=-1.

If (car30='  C  ')#maths(30)=1.
If (car30='     ')#maths(30)=-1.

If (car31=' B   ')#maths(31)=1.
If (car31='     ')#maths(31)=-1.

If (car32='   D ')#maths(32)=1.
If (car32='     ')#maths(32)=-1.

If (car33='    E')#maths(33)=1.
If (car33='     ')#maths(33)=-1.

If (car34='    E')#maths(34)=1.
If (car34='     ')#maths(34)=-1.

If (car35='A    ')#maths(35)=1.
If (car35='     ')#maths(35)=-1.

If (car36='  C  ')#maths(36)=1.
If (car36='     ')#maths(36)=-1.

If (car37=' B   ')#maths(37)=1.
If (car37='     ')#maths(37)=-1.

If (car38='A    ')#maths(38)=1.
If (car38='     ')#maths(38)=-1.

If (car39='   D ' )#maths(39)=1.
If (car39='      ' )#maths(39)=-1.

If (car40='    E')#maths(40)=1.
If (car40='     ')#maths(40)=-1.

If (car41='  C  ')#maths(41)=1.
If (car41='     ')#maths(41)=-1.

If (car42='    E')#maths(42)=1.
If (car42='     ')#maths(42)=-1.

If (car43=' B   ')#maths(43)=1.
If (car43='     ')#maths(43)=-1.

If (car44='   D ')#maths(44)=1.
If (car44='     ')#maths(44)=-1.

If (car45='    E')#maths(45)=1.
If (car45='     ')#maths(45)=-1.

If (car46='A    ')#maths(46)=1.
If (car46='     ')#maths(46)=-1.

If (car47=' B   ')#maths(47)=1.
If (car47='     ')#maths(47)=-1.
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If (car48='   D ')#maths(48)=1.
If (car48='     ')#maths(48)=-1.

If (car49='  C  ')#maths(49)=1.
If (car49='     ')#maths(49)=-1.

If (car50='A    ')#maths(50)=1.
If (car50='     ')#maths(50)=-1.

If (car51='  C  ')#maths(51)=1.
If (car51='     ')#maths(51)=-1.

If (car52='A    ')#maths(52)=1.
If (car52='     ')#maths(52)=-1.

If (car53='   D ')#maths(53)=1.
If (car53='     ')#maths(53)=-1.

If (car54='    E')#maths(54)=1.
If (car54='     ')#maths(54)=-1.

If (car55=' B   ')#maths(55)=1.
If (car55='     ')#maths(55)=-1.

If (car56='A    ')#maths(56)=1.
If (car56='     ')#maths(56)=-1.

If (car57='  C  ')#maths(57)=1.
If (car57='     ')#maths(57)=-1.

If (car58='    E')#maths(58)=1.
If (car58='     ')#maths(58)=-1.

If (car59='    E')#maths(59)=1.
If (car59='     ')#maths(59)=-1.

If (car60='   D ')#maths(60)=1.
If (car60='     ')#maths(60)=-1.

compute carx1=#maths(1).
compute carx2=#maths(2).
compute carx3=#maths(3).
compute carx4=#maths(4).
compute carx5=#maths(5).
compute carx6=#maths(6).
compute carx7=#maths(7).
compute carx8=#maths(8).
compute carx9=#maths(9).
compute carx10=#maths(10).
compute carx11=#maths(11).
compute carx12=#maths(12).
compute carx13=#maths(13).
compute carx14=#maths(14).
compute carx15=#maths(15).
compute carx16=#maths(16).
compute carx17=#maths(17).
compute carx18=#maths(18).
compute carx19=#maths(19).
compute carx20=#maths(20).
```

```
compute carx21=#maths(21).
compute carx22=#maths(22).
compute carx23=#maths(23).
compute carx24=#maths(24).
compute carx25=#maths(25).
compute carx26=#maths(26).
compute carx27=#maths(27).
compute carx28=#maths(28).
compute carx29=#maths(29).
compute carx30=#maths(30).
compute carx31=#maths(31).
compute carx32=#maths(32).
compute carx33=#maths(33).
compute carx34=#maths(34).
compute carx35=#maths(35).
compute carx36=#maths(36).
compute carx37=#maths(37).
compute carx38=#maths(38).
compute carx39=#maths(39).
compute carx40=#maths(40).
compute carx41=#maths(41).
compute carx42=#maths(42).
compute carx43=#maths(43).
compute carx44=#maths(44).
compute carx45=#maths(45).
compute carx46=#maths(46).
compute carx47=#maths(47).
compute carx48=#maths(48).
compute carx49=#maths(49).
compute carx50=#maths(50).
compute carx51=#maths(51).
compute carx52=#maths(52).
compute carx53=#maths(53).
compute carx54=#maths(54).
compute carx55=#maths(55).
compute carx56=#maths(56).
compute carx57=#maths(57).
compute carx58=#maths(58).
compute carx59=#maths(59).
compute carx60=#maths(60).

variable labels carx1 'derived variable from item response car1'.
variable labels carx2 'derived variable from item response car2'.
variable labels carx3 'derived variable from item response car3'.
variable labels carx4 'derived variable from item response car4'.
variable labels carx5 'derived variable from item response car5'.
variable labels carx6 'derived variable from item response car6'.
variable labels carx7 'derived variable from item response car7.
variable labels carx8 'derived variable from item response car8'.
variable labels carx9 'derived variable from item response car9'.
variable labels carx10 'derived variable from item response car10'.
variable labels carx11 'derived variable from item response car11'.
variable labels carx12 'derived variable from item response car12'.
variable labels carx13 'derived variable from item response car13'.
variable labels carx14 'derived variable from item response car14'.
variable labels carx15 'derived variable from item response car15'.
variable labels carx16 'derived variable from item response car16'.
variable labels carx17 'derived variable from item response car17'.
variable labels carx18 'derived variable from item response car18'.
variable labels carx19 'derived variable from item response car19'.
```

```
variable labels carx20 'derived variable from item response car20'.
variable labels carx21 'derived variable from item response car21'.
variable labels carx22 'derived variable from item response car22'.
variable labels carx23 'derived variable from item response car23'.
variable labels carx24 'derived variable from item response car24'.
variable labels carx25 'derived variable from item response car25'.
variable labels carx26 'derived variable from item response car26'.
variable labels carx27 'derived variable from item response car27'.
variable labels carx28 'derived variable from item response car28'.
variable labels carx29 'derived variable from item response car29'.
variable labels carx30 'derived variable from item response car30'.
variable labels carx31 'derived variable from item response car31'.
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variable labels carx33 'derived variable from item response car33'.
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variable labels carx35 'derived variable from item response car35'.
variable labels carx36 'derived variable from item response car36'.
variable labels carx37 'derived variable from item response car37'.
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variable labels carx48 'derived variable from item response car48'.
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variable labels carx50 'derived variable from item response car50'.
variable labels carx51 'derived variable from item response car51'.
variable labels carx52 'derived variable from item response car52'.
variable labels carx53 'derived variable from item response car53'.
variable labels carx54 'derived variable from item response car54'.
variable labels carx55 'derived variable from item response car55'.
variable labels carx56 'derived variable from item response car56'.
variable labels carx57 'derived variable from item response car57'.
variable labels carx58 'derived variable from item response car58'.
variable labels carx59 'derived variable from item response car59'.
variable labels carx60 'derived variable from item response car60'.

value labels carx1 to carx60
0 'wrong answer'
1 'right answer'
-1 'not attempted'.

missing values carx1 to carx60 (-1).
format carx1 to carx60 (f3.0).

variable labels car1 'response to question 1'.
variable labels car2 'response to question 2'.
variable labels car3 'response to question 3'.
variable labels car4 'response to question 4'.
variable labels car5 'response to question 5'.
variable labels car6 'response to question 6'.
variable labels car7 'response to question 7'.
variable labels car8 'response to question 8'.
variable labels car9 'response to question 9'.
variable labels car10 'response to question 10'.
```

```
variable labels car11 'response to question 11'.
variable labels car12 'response to question 12'.
variable labels car13 'response to question 13'.
variable labels car14 'response to question 14'.
variable labels car15 'response to question 15'.
variable labels car16 'response to question 16'.
variable labels car17 'response to question 17'.
variable labels car18 'response to question 18'.
variable labels car19 'response to question 19'.
variable labels car20 'response to question 20'.
variable labels car21 'response to question 21'.
variable labels car22 'response to question 22'.
variable labels car23 'response to question 23'.
variable labels car24 'response to question 24'.
variable labels car25 'response to question 25'.
variable labels car26 'response to question 26'.
variable labels car27 'response to question 27'.
variable labels car28 'response to question 28'.
variable labels car29 'response to question 29'.
variable labels car30 'response to question 30'.
variable labels car31 'response to question 31'.
variable labels car32 'response to question 32'.
variable labels car33 'response to question 33'.
variable labels car34 'response to question 34'.
variable labels car35 'response to question 35'.
variable labels car36 'response to question 36'.
variable labels car37 'response to question 37'.
variable labels car38 'response to question 38'.
variable labels car39 'response to question 39'.
variable labels car40 'response to question 40'.
variable labels car41 'response to question 41'.
variable labels car42 'response to question 42'.
variable labels car43 'response to question 43'.
variable labels car44 'response to question 44'.
variable labels car45 'response to question 45'.
variable labels car46 'response to question 46'.
variable labels car47 'response to question 47'.
variable labels car48 'response to question 48'.
variable labels car49 'response to question 49'.
variable labels car50 'response to question 50'.
variable labels car51 'response to question 51'.
variable labels car52 'response to question 52'.
variable labels car53 'response to question 53'.
variable labels car54 'response to question 54'.
variable labels car55 'response to question 55'.
variable labels car56 'response to question 56'.
variable labels car57 'response to question 57'.
variable labels car58 'response to question 58'.
variable labels car59 'response to question 59'.
variable labels car60 'response to question 60'.

* Initialise and label two variables which will keep track of the number of correct and incorrect
* answers.

compute mscore=0.
compute mincorct=0.
format mscore mincorct (f3.0).
missing values mscore mincorct(-1).

variable lables mscore 'BCS70 16-year Arithmetic scores (out of 60)'.
```

```
value labels mscore
-1 'Test not attempted'.

variable lables mincorct 'BCS70 16-year Arithmetic - no. incorrect scores'.
value labels mincorct
-1 'Test not attempted'.

* Loop through all 60 test items, increasing total each time a correct answer is encountered,
* whilst correspondingly logging incorrect responses.

loop #i=1 to 60.
if (#maths(#i)=1)mscore=mscore+1.
if (#maths(#i)=0)mincorct=mincorct+1.
end loop.

* If no correct nor incorrect replies, assume test was not attempted and set total to missing.

if (mscore=0 and mincorct=0)mscore=-1.

* Derive total number of questions attempted (i.e. correct plus incorrect).

compute manswred=-1.
if (mscore + mincorct ge 1)manswred=mscore+mincorct.
format manswred (f3.0).
missing values manswred (-1).

variable lables manswred 'BCS70 16-year Arithmetic test - no. of questions attempted'.
value labels manswred
-1 'Test not attempted'.

* Display frequency counts of total score and total questions attempted.

fre mscore manswred.
```

Appendix 3: 1986 Survey Arithmetic Test data

Variable		Description
bcsid		BCS70 case identifier
mscore		BCS70 16-year Arithmetic scores (out of 60)
mincorct		BCS70 16-year Arithmetic - no. incorrect scores
manswred		BCS70 16-year Arithmetic test - no. of questions attempted
car1	carx1	2+3=
car2	carx2	2x4=
car3	carx3	12÷3=
car4	carx4	359-126=
car5	carx5	57+135=
car6	carx6	What number multiplied by itself gives 81?
car7	carx7	Add half of 26 to twice 24
car8	carx8	Choose in figures "fourteen hundred and three"
car9	carx9	1.85-0.45=
car10	carx10	4x6/3=
car11	carx11	44x11=
car12	carx12	Subtract a quarter of 12 from half of 12
car13	carx13	27.85+15.32=
car14	carx14	196÷14=
car15	carx15	6x0.33=
car16	carx16	1.25+0.875=
car17	carx17	What is the square root of 36?
car18	carx18	What is the average of 2, 4 and 12?
car19	carx19	What is the average of 43, 37, 125 and 35?
car20	carx20	25, 24, 22, 19? What number comes next?
car21	carx21	12^2=
car22	carx22	2^4=
car23	carx23	4^3=
car24	carx24	A letter is chosen at random from the word ARITHMETIC. What is the probability that it will be: The letter 'R'?
car25	carx25	A letter is chosen at random from the word ARITHMETIC. What is the probability that it will be: The letter 'T'?
car26	carx26	A letter is chosen at random from the word ARITHMETIC. What is the probability that it will be: A vowel?
car27	carx27	20% of 50=
car28	carx28	0.5x0.25=
car29	carx29	If we multiply a number by 9, subtract 8 and divide by 7 we get 13. What is the number?
car30	carx30	What is the cube root of 27?
car31	carx31	A box contains 25 black marbles, 35 white marbles and 40 red marbles. If one marble is taken at random from the box, what is the probability that it will be: A red marble?
car32	carx32	A box contains 25 black marbles, 35 white marbles and 40 red marbles. If one marble is taken at random from the box, what is the probability that it will be: A white marble?
car33	carx33	A box contains 25 black marbles, 35 white marbles and 40 red marbles. If one marble is taken at random from the box, what is the probability that it will be: A marble that is not black?
car34	carx34	What is 17÷1000 expressed as a decimal fraction?
car35	carx35	(7x1000)=(8x100)+(9x10s)=100x?
car36	carx36	10% of the seats in a cinema with 1700 seats were empty. How many people were in the cinema?

Variable		Description
car37	carx37	Look at this figure, then work out what fraction of the whole area is shaded
car38	carx38	Now look at this figure and work out what fraction of the whole area is shaded
car39	carx39	99, 97, 93, 85, 69, ? What number comes next?
car40	carx40	If we cube a number greater than 0 and divide the result by 16 we get the number we started with. What is the number?
car41	carx41	Two children had to be chosen from a group of 3 boys and 4 girls: B1 B2 B3 G1 G2 G3 G4: In how many ways could the girls be chosen?
car42	carx42	Two children had to be chosen from a group of 3 boys and 4 girls: B1 B2 B3 G1 G2 G3 G4: In how many ways could a girl and a boy be chosen?
car43	carx43	27% of 30-17% of 30=
car44	carx44	The sum of 2 numbers is 89 and the difference between them is 23. What is the smaller number?
car45	carx45	The total in the circle is 16. The total in the triangle is 16. The total in the square is 14. Which number must be increased if all the totals are to be equal?
car46	carx46	The total in the circle is 16. The total in the triangle is 16. The total in the square is 14. Which number must be changed if the totals in the circle, in the triangle and in the square are to be changed equally?
car47	carx47	The total in the circle is 16. The total in the triangle is 16. The total in the square is 14. Which number must be increased if all the totals in the circle and the triangle are to be 6 greater than the total in the square?
car48	carx48	A group of 100 people were asked to estimate the length of a line. It's true length was 5cms. The histogram shows the distribution of their estimates. How many people guessed correctly?
car49	carx49	A group of 100 people were asked to estimate the length of a line. It's true length was 5cms. The histogram shows the distribution of their estimates. What percentage of the group were only one centimetre out in their estimate?
car50	carx50	A group of 100 people were asked to estimate the length of a line. It's true length was 5cms. The histogram shows the distribution of their estimates. What is the mean of the groups estimates?
car51	carx51	0, 3, 10, 21, 36, ? What number comes next?
car52	carx52	14.9x5.4÷2.7=
car53	carx53	Divide 21 in the ration 7:3
car54	carx54	Divide 600 in the ratio 3:2:1
car55	carx55	Divide 300 in the ratio 3:4:2:6
car56	carx56	How many rectangular blocks 30cms long, 20cms wide and 6cms deep will fit into a rectangular box 90cms long, 80 cms wide and 72cms deep?
car57	carx57	The line round a football pitch is 350 metres long. The pitch is 35 meters longer than it is broad. How many metres long is it?
car58	carx58	What is the radius in cms of a circle 62.8 cms in circumference? (Take π=3.14)
car59	carx59	What is the area in cms2 (square centimetres) of a circle of 3cms radius. (Take π=3.14)
car60	carx60	If a two figure number is written backwards it makes a number that is 72 smaller. What is the number?

Appendix 4: Review of APU Arithmetic Test

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(Reproduced here by kind permission of Prof. Harvey Goldstein from 'Tests in Education: A book of critical reviews' (Levy, P & Goldstein, H, eds), Academic Press, London 1984)

Test content

This is a single timed test in arithmetic, covering the age-range 11-18 years, which the Manual stresses is an achievement test and not an aptitude test. The 50 questions begin by testing a straightforward evaluation of arithmetic expressions mixed with evaluations of simple problems specified in sentential form. Subsequent questions then deal with knowledge of proportion, percentage, estimation of area and simple probability. In the main, questions can be solved mentally by sequential processing of partial results, but a few may be most quickly solved by resort to simple algebra which may lead the testee to using 'rough-working' procedures.

For the most part the test makes little demand upon a knowledge of units of measure although some of the questions on mensuration refer to metric measures of length. All of these could be answered correctly without a specific knowledge of those units. To this extent the test is reasonably free of local cultures within the western scientific community. It may be, however, that the patterns of correlation with mathematics results in the General Certificate and Scottish Certificate of Education, which are discussed later, are due to this freedom from particular curricular fashion.

Purpose

The test was designed as one of general arithmetic attainment, not tied to particular curricula, but clearly by its use of arithmetic symbolism it is specific to the familiar form of western educational culture. It is designed to test arithmetic concepts through calculation yet not to impose difficulty of calculation nor to test perseverance in calculation. Quite explicitly it does not seek to test algebra, geometry, trigonometry, matrices or calculus. The acronym APU might suggest that it is a product of the Assessment of Performance Unit set up by Department of Education and Science in Britain to study educational attainment on a national basis. This is not the case, however, and as the Manual makes clear the acronym refers to Applied Psychology Unit at the University of Edinburgh whose test predates the setting up of the Assessment of Performance Unit.

Item preparation

No details of any kind are given about item selection although the Manual is very specific about standardization procedures.

Administration

The instructions on administration in the Manual are exemplary in their attention to detail and general advice to the examiner. The test is administered as a group test with one expendable test form for each pupil and the time allowed for the completion is 25 minutes.

Standardization

Standardization was carried out using pupils drawn from a random sample of secondary schools throughout the UK. In drawing this sample considerable care was exercised to maintain a balance between schools of different size and to obtain a sample of schools which were geographically representative of the UK. The final sample consisted of 14 schools which, despite the care exercised, may be regarded as rather a small number to properly represent the attributes among which a balance was sought.

Sampling of pupils within these schools was carried out by age-group and a very comprehensive table

of distribution statistics for the sample is published.

In the 11-17 years age group the sample sizes vary from 294-1591 but in the 18 years age group the sample is down to 130 pupils. The Manual includes a caveat for the interpretation of percentile scores for the 16-18 years age group because these children are by definition those who are staying on to take leaving certificates and are thus a self selected group. Although the meticulous reporting of the standardization procedure inspires confidence it is unfortunate that there is no comment on the distribution of ages by sex or of any difference in the means for the sex groups. Date of standardization is not reported.

Scoring

Layout of the test form is extremely clear for the pupil with a bold answer column on the right of each page and good regular alignment of questions with answers. Marking is equally straightforward with one double page of the test Manual devoted to answer keys matching each of the pages on the test form. In the few cases where alternative answers are acceptable these are also clearly marked. It is difficult to envisage any improvements to this procedure short of machine-readable code.

Total scores of correct answers are converted to percentile ranks for each age year-group using tables of norms derived from the standardization procedure.

Reliability

Two indices of reliability are given, one being a measure of internal consistency based on a part-whole (item-test) correlation similar in assumptions to those of KR-20, and the other from test-retest correlation. The first was carried out only for the 15-16 years age group while the second was reportedly only done with a sample of 13 year-old pupils. The reliability indices are respectively 0.91 and 0.96. There is some confusion in the text, however, because elsewhere a table of standard errors of measurement is given for each of the age ranges 11-18 years and this claims to be based upon test-retest results for which no details are given. The test-retest which is described for the 13 year-old pupils involved tests given only one week apart which for this kind of test would seem to be rather too short an interval.

The Manual is at pains to point out the meaning and inference to be drawn from the standard error of measurement though it falls into the very common error of failing to state whether this is for the raw score or the derived score. Because, in this case a percentile scale is used, it is reasonably safe to assume that the standard error of measurement refers to the raw score.

Validity

As the Manual correctly indicates, in a test of this kind, the content is so closely related to what one seeks to measure that validity can be assessed in terms of the extent to which the test content samples the curriculum. Nevertheless, a series of figures for concurrent validity are quoted. Perhaps the most relevant comparison in terms of similarity of test aims is the Vernon Graded Arithmetic-Mathematics Test which yields a correlation with the APU Arithmetic of 0.88. Also of great interest is a table of correlations with various papers on the Scottish Certificate of Education and the General Certificate of Education. The highest figure in this table is the correlation between APU Arithmetic and the arithmetic paper of the SCE which is 0.75. In terms of predictive validity this is not very useful in that neither paper adds substantially to a prediction the other made upon a knowledge of age alone. Among the other subjects, however, the relative magnitudes of the correlations follow a familiar pattern with all of the sciences being correlated with APU Arithmetic but the coefficients becoming progressively smaller as the subjects become more applied in the vocational sense.

What is most striking about this table is the comparison, subject by subject, between the SCE and the GCE. For each of the three subjects maths, physics and chemistry at ‘0’ level the correlation coefficient with APU Arithmetic is about half for the GCE what it is for the SCE. This suggests very strongly that

there is an attribute of the Scottish curriculum which, irrespective of subject speciality, forms a common element not shared by curricula in the rest of the UK. It is impossible to guess what this may be but there is no doubt that on the figures presented the APU is a much better predictor of success on these three subject areas in SCE than it is in GCE.

Interpretation

A table provides percentile equivalents of raw scores for each year group 11-18.

General evaluation

In terms of the well-defined aims of the test there is no doubt that this is, both administratively and in terms of standardization, one of the most satisfactory tests available. Its avoidance of particular fashionable procedures in education and adherence to basic competence makes it attractive as a test likely to withstand the erosion of time. In some respects, however, this same centrality of approach which avoids curricular differences makes it less satisfactory as an index of mathematical attainment, particularly in the context of testing pupils against national expectations.

Despite the protestations of the Manual this implies that when given in the context of a body of pupils who have been subject to similar treatment the test has much to commend it as an index of aptitude for arithmetic learning. It does little to test transfer of training or lateral thinking with arithmetic concepts but essentially tests the ability to reproduce that which is common to all arithmetic processes.

Without doubt the quality of the administrative Manual as an instrument for educating the test user is very high and having consideration for the context of use of many educational tests this is a very desirable asset.

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