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Evidence that rising population intelligence is impacting in formal education

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Abstract

Consensus is growing that rising IQ scores at least partly reflect rising population intelligence. However, there is no apparent impact in formal education, the one real world domain where it should be strongly and obviously impacting. Teachers evidently are not reporting brighter children. There is only one relevant formal study, however, which found that most Australian high school teachers surveyed did not perceive that students became brighter between 1979 and 1999. The present study investigated several possible reasons why; declining motivation in high school students masking rising intelligence, too short a time span or the wrong nation examined. The study was replicated in Australian primary school teachers who had been teaching for 20 or 30 years and in Singapore and Korea, where the environmental improvements thought to raise IQ have happened mainly in the last 40 years. Also, these nations lack the West's grave classroom motivation problems. Most Australian primary teachers did not perceive brighter children even over 30 years, but most in the two Asian nations did, particularly those in Singapore. General intelligence may have largely stopped rising in Western nations decades ago while visuospatial ability has been increasing, which with test sophistication has been pushing up IQ scores slightly. When the environmental improvements occur rapidly, teachers readily note brighter children.

Keywords: Flynn effect; Rising IQ; Population intelligence; Real world impact; Teacher perceptions; Australia; Korea; Singapore

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Raw scores on IQ tests have been rising in many nations (Flynn, 1984; 1987). Consensus is growing that this "Flynn effect" at least partly represents increasing Spearman's *g* and not just test sophistication. However, a major anomaly is that rising *g* apparently is not impacting in formal education. Teachers commonly report such trends as increasing student height and weight, earlier adolescence, and shortened attention span, but evidently are not reporting brighter students. Flynn (1987) notes rising height in his own university students, and going from being taller than most to shorter, but has seen no analogous change in intelligence. Introductory psychology textbooks use this point to argue that *g* is not significantly rising. For instance, Kalat (2002, p. 342) states, "If people really are that much smarter, teachers should have noticed that their classes are full of creative geniuses". Instead, SAT scores mostly have declined, employers complain of worsening literacy and arithmetic standards (Hunt, 1995), and educators worry about grade inflation and diminishing school achievement levels (Steinberg, 1996) and documented curriculum "dumbing down" (Hayes, Wolfer, & Wolfer, 1996).

Indeed, formal education is the one real world domain in which rising g should be strongly and noticeably impacting. *G* correlates well with relatively arbitrary, unnatural tasks such as school learning, and IQ scores correlate well with school grades (Howard, 1995). Most other real world realms may show little effect of rising g because humans have much genetic programming for such everyday tasks as language use and social behavior. Drawbacks of low *g* often only become apparent with relatively unnatural, *g*-loaded tasks. An illustration is "six hour retardation", which refers to children who seem normal but score as retarded on IQ tests and who are identified only when first meeting the complex cognitive demands of early schooling. They perform poorly in school but may function well enough outside it (Beirne-Smith, Patton, & Ittenbach, 1994, P. 122). Second, virtually everyone must attend school but can avoid almost any other realm that might show effects of rising g. Third, teachers gauge student ability well (Egan & Archer, 1985; Stevenson, Parker, Wilkinson, Hegion, & Fish, 1976; Teisl, Mazzocco, & Myers, 2001). So, while memories may fade over decades, they should note rising *g*.

The only formal study, by Howard (2001), indeed found little evidence that teachers perceive rising student intelligence. Australian high school teachers who had taught in Sydney for at least 20 years compared students in 1979 and 1999 in such factors as general intelligence and ability to do school work. Only about 10% thought the students were more intelligent, about 73% saying intelligence had stayed the same, but about 63% thought street smartness (practical *nous*) had risen. About 65% perceived declining student motivation.

So, this major puzzle needs explanation, and the present study explored several possibilities. One, suggested by Howard (2001), is that declining student motivation is masking rising *g*. Steinberg (1996) notes the widespread problem of poor motivation. Howard only surveyed high school teachers and it makes sense to survey primary school teachers. Younger children are more co-operative and intrinsically motivated, and the almost universal decline in intrinsic motivation accelerates around adolescence (Gottfried, Fleming, & Gottfried, 2001). Also, primary school teachers typically see only one class all year and so may better note changes.

Second, perhaps 20 years was too short to notice rising *g*. Here it was extended to 30 years.

Third, Howard may have looked in the wrong place. Perhaps *g* rises stopped long ago in the West as the limits of what environmental improvements could do were reached, or have been too slow to notice. The IQ gains go along with industrialisation, better diet and health, more stimulation, more education and so on (Flynn, 1998), which have improved in most Western nations

over several generations. Humans are poor at detecting slow, small, progressive changes and any recent real gains may simply be too slight to notice.

This possibility could be tested best by surveying teachers in a place where the above environmental improvements have happened very rapidly. An example is in Wheeler's (1942) classic study of Tennessee mountain children, whose initially impoverished environment improved radically between 1930 and 1940. New roads gave better access to outside areas, industry grew rapidly, school enrollments and attendance rose and schools acquired better facilities and better trained teachers. Average IQ rose more than 10 points in 10 years. Did the teachers notice brighter students?

We can use some recent, roughly analogous natural experiments. Four East Asian nations (the "Asian Tigers") have industrialised rapidly in the last 40 years and have invested heavily in education. Many of the above environmental improvements put forward as causes of rising IQ have happened very rapidly and recently in these nations. The most striking example is Singapore, which went from third world poverty in 1965 to current first world wealth in an advanced, technological society (Lee, 2000). Key factors improving over centuries in the West have improved very rapidly in Singapore. It has a high rate of computer ownership. Family size has decreased greatly. Education is highly valued and the nation has invested heavily in an extremely competitive mass system. "Hot housing" starts early and most students attend cram schools. In 2001, a "Straits Times" survey of 10–12 year olds reported that they have little time to play, the average 10 year old having 6 h of schooling a day and at least 3 h of homework. Nearly 70% receive tutoring.

Similarly, Korea mostly has been an agricultural nation and was devastated by World War II and the Korean War. But since the 1950s, South Korea has industrialised rapidly, has invested heavily in education, and has nearly reached first world status (e.g. Steinberg, 1989). For instance, in 1960, 66% of the work force was employed in agriculture while in 1986 only 23.6% was (Steinberg, 1989, p. 154).

Also, because Confucian cultures value education highly, the "Asian Tigers" lack the West's extreme motivation and classroom management problems. (However, problems are emerging. In 2001, Hong Kong's "South China Morning Post" reported increasing classroom management problems and students sleeping in lectures.) But, the students work much harder and Singapore and Korea consistently top international comparisons of school mathematics and science achievement (US National Center for Educational Statistics), outperforming Western nations (Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000). The two nations have a similar notion of general intelligence as the West, as do Kalahari Bushmen (Reuning, 1988).

So, if the environmental improvements which go along with industrialisation do raise g, teachers in Singapore and Korea should be noticing, particularly those in Singapore. If they are not, the Flynn effect may represent only test sophistication.

1. Australia

A Flynn effect has been occurring in Australia (Flynn, 1987). New South Wales has primary schooling up to about age 11 and then high school, with no intermediate level school. Schooling is compulsory until age 15.

The Howard (2001) study was replicated with primary school teachers working in the system for at least 20 years, as well as some in the system for 30. Two new questions asked whether teachers had noticed more students at the intelligence extremes.

1.1. Method

The procedure was almost identical to that in Howard (2001). Because the state education department would not permit teachers to be contacted directly, questionnaires were mailed to principals of all public primary schools in the greater Sydney metropolitan area, with a request to pass them on to teachers who had begun their first full-time job in 1981 or earlier, and then to return all questionnaires in the enclosed stamped, self-addressed envelope. The cover letter briefly explained the study's purpose and asked each principal not to reveal it until all teachers had completed the questionnaire.

The questionnaire stated that the study's aim was to get some idea of teachers's perceptions of any changes over the last few decades in the abilities of school pupils. It asked what year they had begun teaching (''Year of first full-time job'') and then featured questions all couched in one basic form, ''In general, do you believe that the average [ ] of pupils has significantly increased, decreased or has stayed about the same since around 1981?''.

In successive questions, the brackets had a different insert; which were:

1. General intelligence.
2. Level of pupils's reading and writing skills.
3. Level of general knowledge about the world.
4. Level of pupils's street-smartness (e.g. practical *nous*, ability to deal with practical matters).
5. Level of ability to do school work.
6. Proportion of very bright (e.g. gifted) pupils.
7. Proportion of pupils with one or more learning difficulties.
8. Level of motivation to do school work

Each question had three alternatives; ''increased'', ''decreased'' or ''stayed about the same''. The questionnaire concluded with an open ended question (''Do you have any personal observations or comments about any perceived changes in the average abilities of pupils in general over the last two [or three] decades?'').

The questionnaire had two parts, on separate sheets stapled together. The first part asked for comparisons between 1981 and 2001 students and the second between 1971 and 2001 students. The second part was only for teachers who had begun teaching in 1971 or earlier and was identical to the first part except that the year given was 1971. These teachers were asked to fill out both parts, including that for 1981. Teachers who had started later than 1971 were asked to fill out only the first part.

1.2. Results

Of 550 schools contacted, 218 schools returned one or more questionnaires, three wrote declining to participate, and the rest did not respond. As participation was voluntary, these were

not followed up. Questionnaires were discarded if only partially completed or if the year of starting was later than 1981. A total of 36 teachers filled in only the 1971 sheet and were included only in 1971 totals, and four teachers who had started in 1971 or before filled in only the 1981 sheet, and were included in that total. The final totals were relevant questionnaires from 203 teachers who had started in 1971 or earlier and 322 who had started later than 1971 but in 1981 or earlier.

Table 1 presents the responses. Teacher perceptions of students in 1971 and 1981 differ little, aside from a tendency for the percentage perceived to be increasing to be slightly higher over 30 years. The pattern is broadly similar to the Australian high school teachers in Howard (2001), except that declining motivation is less problematical. Most do not perceive that students are getting more intelligent but most perceive that children are more knowledgeable and more street smart. Most do not perceive more very bright children but most perceive more with learning difficulties.

Comments from the 1971 or earlier teachers reflected various views, but little evidence of a dominant perception of rising g or declining motivation: "(1) Ability has not changed to my mind; (2) Abilities haven't changed perceptibly. The brightest students 30 years ago would be capable of doing what the brightest students do now but the level of knowledge children have today is significantly greater; (3) Girls and boys are still very much like they were in general 30 years ago; (4) Average abilities of pupils has (sic) generally remained the same; (5) I don't believe intelligence has increased rather so many children are crammed by coaching colleges; (6) IQ, ability, giftedness or learning difficulty has been constant. (7) Students' abilities have not changed; (8) Expectations are higher generally from families who value education; (9) Children are more experienced at doing all sorts of tests; (10) More test-oriented and result-oriented; (11) General knowledge has decreased... children can't/won't learn by themselves...unless gifted; (12) Number of brighter/weaker students unchanged...motivation has decreased. (13) "Visual smart", problem solving, oracy (sic) have all increased...we are identifying a lot more LD {learning disabled} students; (14) Children are now far less imaginative, need greater stimulation and overall have poorer language skills; (15) There appears to be a much wider range of abilities in the

Table 1
Percentage of surveyed Australian primary school teachers reporting perception of change between 2001 and 1981 and 1971[a]

	Increased	Stayed same	Decreased
General intelligence	21 (28)	71 (62)	8 (10)
Reading and writing skills	48 (56)	30 (18)	22 (26)
General knowledge	55 (60)	17 (15)	28 (25)
Street smartness (practical *nous*)	56 (55)	25 (21)	19 (24)
Ability to do school work	28 (35)	46 (37)	26 (28)
Very bright	12 (16)	78 (73)	10 (11)
Learning difficulties	67 (70)	31 (26)	2 (4)
Motivation	19 (24)	38 (29)	43 (47)

$n = 525$ (1981 and earlier and all teachers). $n = 203$ (1971 or earlier).

[a] Figures in parentheses are the comparison between 1971 and 2001 students. The 1981 perceptions are those of all teachers surveyed.

average primary school class than in the past; (16) Abilities, I don't think, have changed but decreased concentration, ability to stay on tasks is very evident; (18) With the increased population of Chinese families into Australia, there has been an increase in abilities levels of children. (19) Average abilities of pupils have definitely increased over the last 20–30 years due to better resources...specialist teachers...parents much better informed and educationally aware ...students are expected to do more."

Two accuracy checks on the dominant perceptions were possible. First, the state education department has been closing special schools and integrating children with various learning difficulties in normal classrooms, so the perception of more such children is accurate. Some teachers also commented that more such children are being identified because of special education services. Similarly, the education department introduced an annual basic skills test (measuring reading, writing and arithmetical skills) in 1988, which all pupils take at about age 11. It shows that reading and writing skills have improved slightly since 1988, but not spectacularly.

2. South Korea

South Korea has primary school to about age 11, intermediate to about age 14, and high school to about age 17 or 18. The education system is extremely competitive.

We tried to get some IQ data from Korea and Singapore to see if there has been a clear Flynn effect. One would be expected since rising IQ evidently goes along anywhere with industrialisation (Flynn, 1987, 1998). Flynn (1987) reports a fast rate of IQ gain in Japan. Gao, Qian, and Wang (1998) report a Flynn effect in Raven's scores in China between 1987 and 1996, which they attribute to improving environmental, educational and social conditions. However, relevant studies in Korea and Singapore are few. Hyun, Park and Lee (1994) report a large increase in Korean secondary school students's scores on tests of logical thinking between 1982 and 1994. The Singapore Ministry of Education evidently has longitudinal IQ data but we could not get access.

However, the Korean Ministry of Education posts some interesting relevant data on its official website. It shows significant increases in average height and weight of students from 1970 to 1995. For example, in 6 year olds from 1970 to 1995, average height rose from around 112 to 119 cm and average weight from around 19 to 22 kg. These gains only began to level off around 1995 or so. The growth in average height largely halted much earlier in various Western nations (Martorell, 1998).

2.1. Method

The questionnaire was translated into Korean. Because of cultural differences, simply mailing questionnaires to all school principals would have yielded little or no data. Teachers were recruited from the Seoul metropolitan area in various ways; from local schools and through various contacts of three of the authors. Two separate and completely independent samples were surveyed, one gathered by one of the present authors and the other sample by two other authors. The samples are not random but are independent and results are very similar in each. There was no other way to gather data. Teachers in all three levels of schooling were surveyed.

2.2. Results

Tables 2 and 3 present the results. Data are combined for intermediate and high school teachers.

Table 2 shows that most Korean primary school teachers perceived that students are becoming more intelligent; 61% for the 1981–2001 comparison and 64% for 1971–2001. Most perceived that students were more knowledgeable and about half that they were more street smart. However, most did not perceive more very bright students or increasing ability to do school work (though the 1971 teachers did). Most perceived declining student motivation and this could partly explain the latter, if this includes ability to sit still and concentrate for long periods.

Table 3 shows a different picture for the intermediate and high school teachers. Most actually perceived that general intelligence, general knowledge, street smartness, and ability to do school

Table 2
Percentage of surveyed Korea primary school teachers reporting perception of change between 2001 and 1981 and 1971[a]

	Increased	Stayed same	Decreased
General intelligence	61 (64)	11 (11)	28 (25)
Reading and writing skills	48 (53)	14 (14)	38 (33)
General knowledge	69 (77)	10 (9)	21 (14)
Street smartness (practical *nous*)	49 (57)	18 (14)	33 (29)
Ability to do school work	33 (52)	18 (13)	49 (35)
Very bright	28 (41)	51 (44)	21 (15)
Learning difficulties	24 (28)	28 (19)	48 (53)
Motivation	15 (25)	16 (13)	69 (62)

$n = 425$ (1981 and earlier and all teachers). $n = 107$ (1971 or earlier).

[a] Figures in parentheses are comparisons between 1971 and 2001 students. The 1981 perceptions are those of all teachers surveyed.

Table 3
Percentage of surveyed Korea intermediate and high school teachers reporting perception of change between 2001 and 1981 and 1971[a]

	Increased	Stayed same	Decreased
General intelligence	30 (34)	12 (15)	58 (51)
Reading and writing skills	25 (25)	10 (11)	65 (64)
General knowledge	30 (48)	12 (10)	58 (42)
Street smartness (practical *nous*)	32 (30)	13 (16)	55 (54)
Ability to do school work	17 (25)	11 (9)	72 (66)
Very bright	19 (21)	33 (34)	48 (45)
Learning difficulties	49 (47)	19 (24)	32 (29)
Motivation	7 (12)	10 (8)	83 (80)

$n = 400$ (1981 and earlier and all teachers). $n = 87$ (1971 or earlier).

[a] Figures in parentheses are comparisons between 1971 and 2001 students. The 1981 perceptions are those of all teachers surveyed.

work had declined! About half perceived more students with learning problems. Most perceived declining student motivation.

Several possibilities could explain this reversal. One is declining motivation. Primary school teachers also mostly perceived declining motivation, but the decline may have accelerated after adolescence. Another is a similar explanation for declining SAT scores; the sample in intermediate school and high school got less selected. Indeed, Teasdale and Owen (1994) compared IQ test scores of Danish school leavers over the decades from around 1960 and found that the later year students scored lower. But a greater proportion finished school and the data were consistent with overall rising population scores.

Data from the Korea Ministry of Education website suggests that the latter is a likely reason. In 1970, 66.1% of students progressed from primary to intermediate school and of those, 70.1% went to high school. In 1980, 95.8% went from primary to intermediate school and 84.5% of those went to high school. By 1996, the figures were respectively, 99.9 and 98.6%. In 1970, only 26.9% of high school graduates went to college or university but by 1996, 54.9% did.

This interesting switch-over between primary and later school levels at first suggested a way to estimate roughly the size of the perceived rise. For instance, consider the intermediate level school population from 1971 to 2001. Adding the approximate bottom 34% (as a working assumption) of school children to the intermediate level population made most teachers perceive that average intelligence had declined, suggesting that *g* rose much less than a standard deviation.

However, asking some high school teachers to explain their answers further suggested another interpretation. They said that they really thought that average intelligence was rising but the children were "less intelligent because they are behaving more stupidly in class"; for example, misbehaving, not working, not concentrating, and so on.

Teacher comments from all three levels noted rising ability and declining motivation; "(1) Read and write better; (2) Creative power has increased. (3) Students's average or scholar ability has increased; (4) Average abilities and skills have increased; however, their respect for others has decreased; (5) Our living conditions have improved. Students get many things. However, school facilities have not followed; (6) Individual abilities have increased but ability to work in groups and help others has declined; (7) Because of the dramatic change in society, students want more variety; (8) Motivation to succeed has declined because society has become richer; (9) Students have more ideas; (10) Home discipline has decreased so patience and willingness to work hard has declined. Everything is fast, fast, fast; (11) Motivation to study has declined; (12) Students are hyperactive. They do not like reading. Speaking ability has increased but reading ability has decreased; (13) Patience has decreased. Students do not want to think deeply; (14) Concentration has decreased. (15) Achievement motivation has decreased′Students only think about today. They have no respect for home, school, or society; (16) Need more motivation; (17) Need more teacher's motivation; (18) Bored easily and discouraged."

3. Singapore

Primary school lasts up to about age 11. Most students attend some form of post-secondary schooling.

3.1. Method

The questionnaire was given in English to teachers in various local primary schools known to two of the authors. Two separate and completely independent samples were surveyed, one by each author. The samples are not random but are independent and the results were very similar in each. Unfortunately, it was possible to survey only primary school teachers, and then only a small sample. However, their perceptions are quite consistent, and much like those in Korea.

3.2. Results

Table 4 presents the findings. Most teachers perceive that students are getting brighter, more knowledgeable, and better at school work. Interestingly, most perceive more very bright students and increasing student motivation. The added comments reflected perceptions of brighter children but in some cases, motivational problems: "(1)...brighter, with more ideas...more sociable and explain work better; (2). ...smarter and streetwise due to exposure to television and books; (3) Students are more intelligent but are under greater pressure to perform well...They are more intelligent and are more knowledgeable; (4) ...easier to teach and learn faster; (5) Average students seem to have slightly higher achievement level; (6) Students of average ability have higher achievement; (7) Hot-housed from early age; (8) Understand work better, need motivation to work; (9) Pupils are smarter as they are exposed to multimedia, IT, etc... Things we did not enjoy in our time; (10) I believe the average abilities of pupils in general have gone up. This can be attributed to better nutrition, greater exposure, availabilities of resources, etc; (11) Pupils' ability to grasp IT skill and knowledge is stronger; (12) Express ideas better; (13) Ability in mastering the IT skills has increased; (14) Able to do better work, but can't handle stress at work; (15) Able to write faster, can explain work better; (16) Easier to teach as students...but need to motivate them more; (17) Knowledge has increased, but still need guidance to do better; (18) Students more vocal, less obedient; (19) Children get bored easily; (20) Pupils are too active; (21) Pupils tend to get bored very easily these days. They always seem to have this need to be entertained. Work that

Table 4
Percentage of surveyed Singapore primary school teachers reporting perception of change between 2001 and 1981 and 1971[a]

	Increased	Stayed same	Decreased
General intelligence	83 (78)	16 (22)	1 (0)
Reading and writing skills	86 (84)	11 (14)	3 (2)
General knowledge	87 (87)	4 (13)	9 (0)
Street smartness (practical *nous*)	61 (58)	17 (20)	22 (22)
Ability to do school work	79 (84)	19 (9)	2 (7)
Very bright	64 (56)	33 (42)	3 (2)
Learning difficulties	34 (33)	38 (45)	28 (22)
Motivation	63 (76)	21 (13)	16 (11)

$n = 96$ (1981 and earlier and all teachers). $n = 45$ (1971 or earlier).

[a] Figures in parentheses are comparisons between 1971 and 2001 students. The 1981 perceptions are those of all teachers surveyed.

takes effort is something they would walk away from; (22) Easily bored, need motivation to get work done.''

Fig. 1 presents 1981–2001 comparisons on some key questions for primary teachers in the three nations. Most teachers surveyed in the two ''Asian Tigers'' clearly are perceiving that students are getting more intelligent, particularly in Singapore, but most in Australia are not.

4. Discussion

Most Australian primary school teachers surveyed are not perceiving brighter students, but most in two ''Asian Tigers'' are. The rise is most obvious in Singapore. Indeed, some further anecdotal evidence suggests this perception is common in teachers in another Asian Tiger, Taiwan, too, ''The students are better today''. So, at last there is some clear evidence that rising *g* is impacting where most expected.

However, the present study has various limitations. The data are subject to memory biases, cross-cultural differences, and so on. Also, a problem with this methodology is that some teachers may shift between schools in different socio-economic areas or their school's catchment area and demographics may alter. The Singapore sample is small and the samples are not random and it is not clear how representative they are of the relevant teacher populations. However, for the two

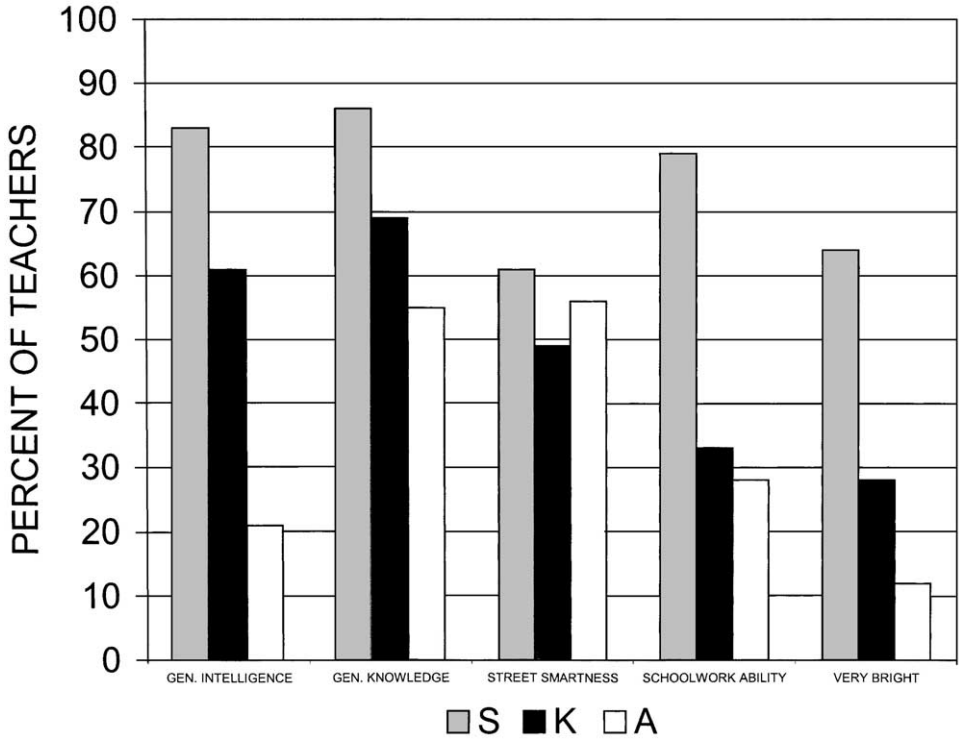

Fig. 1. Percentage of primary school teachers reporting a perceived increase in five key qualities between 1981 and 2001 in students in Singapore (S), Korea (K), and Australia (A).

Asian nations, two completely independent samples in each nation yielded similar results, and the overall results are roughly similar in the two Asian nations. Furthermore, key perceptions in each nation are quite consistent and it seems very unlikely that sampling bias could have produced the overall results. The teachers were asked to make a judgment (analogous to "Is one line longer than another?") rather than state a preference ("Will you vote for X or Y?") so a random sample is not critical. Also, there is little sign that the results were due to a positive or negative "gloss" about students because perceptions of particular traits differ considerably.

By integrating the present results along with longitudinal test score data reported elsewhere and speculating a bit, we can propose a possible account of what has actually been going on. Now in Western nations in the last decade or more, the pattern of score increases has mostly been in fluid intelligence measures. For instance, Teasdale and Owen (1989, 1994, 2000), using test scores of Danish draftees and school leavers, present evidence that the IQ score rise in the last decade has been quite modest, and mainly due to increasing visuospatial ability.

An interpretation is that improvements in nutrition, amount of education and so on and decreases in family size do raise average *g*, as they evidently have in Singapore and Korea, and brighter students then are obvious to teachers. However, the *g* rise has been much slower in Western nations and largely halted a long time ago, at least in primary school children, as the limits of what environmental improvements could do were reached. In the West particularly, visuospatial ability may still be increasing due to the great amount of visual stimulation children get nowadays, as Neisser (1997) and Greenfield (1998) propose. This rise may have come on top of a rise in g. Indeed, neuroscience has shown the brain to be very plastic, responding to such environmental demands even in adulthood. For instance, Maguire et al. (2000) found that London taxi drivers studied had an enlarged hippocampal area in the region thought to be involved in spatial representation, consistent with the job's huge demands on spatial memory.

Increased visuospatial ability may push up IQ scores further because it helps in some item types, such as Raven's items. However, it is not the only reason for the Flynn effect. Test sophistication must also be a factor but *g* must also have risen. Otherwise, teacher perceptions between nations should differ little in the present study, as their students have been exposed to the same improved visual environments. Spatial ability correlates with chess performance (Frydman & Lynn, 1992) and improving visuospatial ability may partly explain the decreasing age of top chess players reported by Howard (1999), at least of Western players.

Teasdale and Owen (1989) suggested that the IQ rise mostly is occurring below the mean. However, the Singapore teachers perceived more very bright students too, and Howard's chess data suggests that the very top is being affected. Rising *g* does impact where we would most expect it too, in formal education, when the environmental changes are rapid and in living memory. Western teachers probably have not been reporting that students are becoming brilliant because the *g* rises occurred more slowly and mostly halted decades ago, as has the rise in average height. As well, a much greater proportion of the population now finishes secondary school and university. All this may be why Flynn and most Western teachers are not noticing brighter students. The situation may be different in subjects that rely heavily on visuospatial ability, however, such as architecture and technical drawing, and this could be investigated.

Several key questions remain. One is the magnitude of the effect. How large a rise in *g* has occurred and, indeed, is possible with environmental improvements? The usual estimate of three IQ points a decade is tricky for several reasons. First, the IQ gains must be due partly to

increasing test sophistication. Test practice can quickly add several IQ points (Kulik, Kulik, & Bangert, 1984) but extensive coaching, now commonplace, can add much more (Bunting & Mooney, 2001). Some purported intelligence-raising regimes mainly teach how to do test items, and rising achievement test scores in some US states have been attributed to such coaching. Second, some studies report much faster IQ gains. Wheeler reported 10 points in a decade and Flynn (1987) shows gains at varying rates in different nations, and the rate in Singapore must be greater than three points a decade. One way to gauge the magnitude is to ask teachers to estimate it and the ''Asian Tiger'' nations are good places to investigate this and other issues further.

Another key issue is the physiological basis. One view is that brain size is increasing in response to improved nutrition and/or complex environmental demands (Lynn, 1990, 1998; Storfer, 1999), but this is controversial. The question may only be answered when all genes for intelligence are identified and their action understood.

Finally, recent work has shown various other Flynn-type effects. The brain's amenability to environmental influences and the many changes in technological society are altering various other population parameters. These include (probably) average visuospatial ability, height, weight, myopia level, life span and attention span. China's one-child policy instituted in 1979 apparently has produced a generation with a characteristic personality type; self-centred and intolerant of frustration (Rosenberg & Jin, 1996). Twenge (2001) presents evidence that average extraversion level in American students has risen almost a standard deviation since the 1960s, perhaps partly due to increased family mobility and industry's emphasis on cooperation and teamwork. Student motivation is declining in various nations. Steinberg (1996) attributes declining motivation in American high school students to various national factors, such as most being in paid employment after school, not valuing education, believing that grades are unimportant, and so on. However, this trend is occurring elsewhere, even in a culture (Korea) with an extremely competitive education system in which results really do matter, education is highly valued, and few children are employed or even have much leisure time. The trend needs further study.

Some of these parameter changes are related. Improved nutrition and public health measures have raised average height, life span, and probably *g*, and evidently have lowered average age of adolescence. Declining motivation may be linked to shortened attention spans and childrens's increased need for entertainment, and perhaps increased extraversion. Storfer (1999) linked rising IQ and increased myopia to expanding brain size, though others attribute the myopia rise to increased close work. Parameter changes also may cascade and interact. For example, rising IQ scores may induce people to seek more complex environments, which may further raise IQ (e.g. Dickens & Flynn, 2001). Shortening attention spans and increased need for entertainment may spur the entertainment industry to cater to this in customers, further reducing attention spans. Raine, Reynolds, Venables, and Mednick (2002) link sensation-seeking to IQ, proposing that young stimulation seekers create an enriched environment for themselves which enhances cognitive development. If sensation-seeking is rising, this may prompt IQ rises, too.

Such cohort effects are well-known but have been relatively little studied (Twenge, 2001). These changes are interesting for the study of individual differences and for social policy reasons. Genetic population trends were of great concern in the twentieth century (Lynn, 1996) but these environmentally induced ones occur much more rapidly and strongly. They need more study. We propose that a specific research area be set up to catalogue and study these parameter changes in

depth; their causes, their interrelations, their interaction with genetic trends, and their real-world impact.

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