Preliminary Real-World Evidence That Average Human Intelligence Really Is Rising

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Average IQ score has been rising for several decades but researchers dispute whether population intelligence really is increasing. Clear real-world evidence of a rise may settle the issue. I first examined the domain of chess, where performance can be readily measured and tracked over decades and people of all ages compete. The young increasingly have dominated the game since the 1970's, outperforming older players at progressively earlier ages. The median age of the top 50 players dropped from 38 years old in the 1970's to 29 in 1995, and the proportion aged under 25 more than doubled. The median age of the top 10 dropped from the late-30's in the 1970's to the mid-20's in the 1990s. The median age of world championship contenders dropped from 37 in 1971 to just 26 in 1994. The Soviet team which won the 1970 Chess Olympiad had a median age of 40 and the Russian team which won the 1998 Olympiad had a median age of 22.5. The longstanding record for youngest grandmaster, set in 1958, has been broken four times since 1991. I also looked at patent and educational statistics, which have been used to suggest that intelligence is not rising. Number of U.S. patents granted largely rose from 1963 to 1996. SAT test scores overall largely have fallen from 1951, but possibly for many reasons. The chess data are the first real-world evidence that population intelligence really may be rising.

Average IQ score has been rising since the 1930's in many nations, the young scoring ever higher (Neisser, 1998). Some fine research by Flynn (1984, 1987) found that IQ tests need periodic renorming because most youngsters soon exceed the mean. In the Netherlands, for example, every male 18-year-old draftee takes the same IQ test and average score is rising about seven points a decade. The rise is found with various sample groups and tests (Lynn & Pagliar, 1994; Tasbihsazan, Nettelbeck, & Kirby, 1997). Studies suggest that fluid intelligence (mental speed, spatial reasoning, etc.) is going up more than crystallized intelligence (verbal reasoning, vocabulary, etc.; Lynn, 1990). For instance, WISC performance scores are rising faster than verbal scores (e.g., Lynn & Pagliari, 1994). The increase has sparked much interest, partly because it contradicts eugenicist alarm (Herrnstein & Murray, 1994; Itzkoff, 1994; Loehlin, 1997).

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But, exactly what is going on remains controversial. Some researchers say that humans really are getting more intelligent. They say that IQ scores measure general intelligence, tapping Spearman's g (Howard, 1993), and predict job and training performance well (Ree & Earls, 1991) and other daily life performances (Herrnstein & Murray, 1994; Gordon, 1997; Gottfredson, 1997) and correlate with physiological measures of learning and performance (Vernon, 1991; Howard, 1995). Researchers attribute the IQ rise to such factors as better diet and health (which have raised average height since 1945), more education and environmental stimulation (Howard, 1991; Flynn, 1996; Jensen, 1996), increased outbreeding, test sophistication, smaller family size (Zajonc & Mullally, 1997), and better visuospatial ability due to growing up in a more visual culture (Neisser, 1997; Greenfield, 1998).

Others deny that average intelligence is rising. Flynn himself (Flynn, 1987, 1994) argues that the increase only is in some factor specific to IQ tests, such as ''abstract problem-solving ability,'' and that IQ tests do not really measure intelligence. He argues that at face value, average scorers today would have scored in the top few percent several decades ago, which is not plausible. He also cites declining average SAT scores over the last few decades, scores that correlate with IQ.

Clear non-test, real-world evidence of a rise in intelligence may settle the issue. Various authors say that the lack of such evidence suggests that intelligence really is not rising (Neisser, 1997). Flynn (1987) argues that there is no evidence for the scientific and artistic productivity boom that the test score data would indicate. He cites an actual decrease in patents (evidently in France and the Netherlands), with 1980's rates around 65% of 1960's rates, and no sign of more gifted children.

In fact, finding such real-world evidence is very problematic. What real-world changes would occur and how could they be unequivocally measured and interpreted as due to rising intelligence? For instance, patent numbers would not necessarily go up. Though they are a sound measure of national prowess at a specific time, totals may vary over decades because of many factors unrelated to intelligence. These range from differing funds for research and very new technologies to court decisions on what can be patented (e.g., genetically engineered life forms). Scientific productivity might expand but not necessarily greatly. IQ seems to be a major factor up to a threshold of about 120, beyond which other factors become important (Howard, 1991; Jensen, 1998, Chap. 14). Doing ''genius-level'' work depends partly on motivation, personality, opportunity and being born at the right time (Simonton, 1988). Motivation and much practice are important factors in high performance in many domains (Simonton, 1988; Ericsson, Krampe, & Tesch-Romer, 1993). While the pool of people able to do high-level work would increase, only some would have other needed personal characteristics. Another problem is varying opportunities to work. Many talented people capable of high-level scientific work never found a research job at all in the last few decades, or even the chance to train for one. It also is difficult to measure and compare performance in science, architecture, law and so on across decades because fields change greatly, and different talents and amounts of knowledge may be needed to perform well. For instance, computerization has lessened somewhat the heavy load on visuospatial ability in such fields as fashion design, air traffic control and architecture. Fields also may become more complex. Much more knowledge needs to be acquired to get to the cutting edge of some fields nowadays than a few decades ago and do great

work as research shows how complex the subject matter is (e.g., in genetics and particle physics). A field even may become simpler when breakthroughs clarify the domain. A new technique (e.g., gene splicing, brain imaging, space probes) may create a burst of scientific productivity even though native talent is unchanged. A final problem is that people born in different decades also differ in interests, values, and motivations because of historical events, child rearing practices, and so on. Scientific productivity might decline though intelligence was rising, for example, simply because much young talent nowadays prefers to work in finance, which is far more lucrative. One might cite youth domination of computer programming as evidence of a rise in intelligence, but again this might be due to interest, to exposure to computers from an early age, and to company hiring preferences.

Therefore, a real-world test domain with special characteristics is needed. Performing well in it should require much knowledge and general intelligence, so that high IQ scorers excel at it. The domain should have remained essentially the same for several decades, and have objective measures of performance that can be tracked over that period. Motivational differences should not be a great factor. There should be no barriers to entry; anyone should be able to take part at any time and excel. People of all ages should participate. To test Neisser's idea as well, it might be useful to have a task that requires strong visuospatial ability.

Chess comes close to meeting these criteria. Chess-playing involves many elements of intelligence; reasoning, pattern recognition, working memory, visuospatial ability, mental speed, and use of much domain-specific knowledge that takes many years to acquire (Holding, 1985). The more intelligent excel. For instance, a sample of skilful young Belgian players had a high average IQ score of 121 and high visuospatial ability (Frydman & Lynn, 1992). Horgan and Morgan (1990) found that young chess players scored higher than average on the Raven's Progressive Matrices and that spatial ability scores correlated with chess skill level. So much knowledge must be acquired to play well that it was thought that at least 10 years training was needed to become an expert (Chase & Simon, 1973). Peak performance age is the mid to late 30's (e.g., Charness, Krampe, & Mayr, 1996), perhaps because performance is a balance between one's increasing knowledge with experience and one's inevitable post-20 age-related decline in parts of memory, mental speed, and abstract reasoning (Howard, 1995). But, because of the importance of chess knowledge, strong players may stay at the top into their 50's and 60's and many stay active into their 70's. Most chess grandmasters are still active, for example. Players of all ages compete. Chess has an international performance rating system run by the international chess federation (FIDE) that identifies the top performers and the prodigies. A player's rating varies from about 2000 to 2800 and is adjusted after every game according to result and the relative rating of each player. Inactive players are soon dropped from the list. The ratings system began in 1970 and so trends can be tracked over nearly three decades. There are few barriers to entry because most tournaments are open to all. Differences in motivation can be minimized by looking at the very top players on the international rating list. Great skill and knowledge are needed to get an international rating and only extremely highly motivated players reach the top.

If population intelligence really is rising, chess data may show several trends. Performance level is a function of knowledge steadily acquired and general intelligence,

Table 1. Some Chess Age Records by Year

Age at which Each Official World Champion First Won the Title		
Year	*Champion*	*Age*
1866	Steinitz	30
1894	Lasker	26
1921	Capablanca	33
1927	Alekhine	35
1935	Euwe	34
1948	Botvinnik	37
1957	Smyslov	36
1960	Tal	23
1963	Petrosian	34
1969	Spassky	32
1972	Fischer	29
1975	Karpov	24
1985	Kasparov	22
Grandmaster Title Age Records from Year that FIDE First Used Formal Criteria		
Year	*Player*	*Age*
1957	Tal	20 years
1958	Fischer	15 years, 6 months
1991	Polgar	15 years, 5 months
1994	Leko	14 years, 5 months
1997 (March)	Bacrot	14 years, 1 month
1997 (October)	Ponomariov	14 years, 17 days

and we would expect a steady decline in the average age of top players and also many more child prodigies. Over time, the young should reach a high performance level earlier and displace the older at progressively earlier ages.

I also took a closer look at patent and educational statistics, both mentioned by Flynn. The trends since the Flynn (1987) study were also examined.

Chess Performance Study

Aside from the Kazakhstan Chess Federation which provided a needed birth date, various national chess federations contacted and FIDE would provide no data, greatly limiting the analyses. However, some data were available from other sources. Table 1 shows the average age of each world champion first gaining the title. Obviously, the sample is too small to say much but the table shows some age decline, the youngest titleholder being the most recent. The table also shows a decline in the age record for the grandmaster title. This title itself originated in 1914 but only in 1957 did FIDE use objective, performance-based criteria to award it. The longstanding 1958 record of 15 years, 6 months old was broken four times in succession from 1991, and is now just 14 years, 17 days old.

Fig. 1 presents the average age of the top 50 players since the inaugural July, 1970 list, and of the top 10. FIDE usually publishes two rating lists a year, one in January and one in July. The ratings data were obtained from the official FIDE website which lists ratings

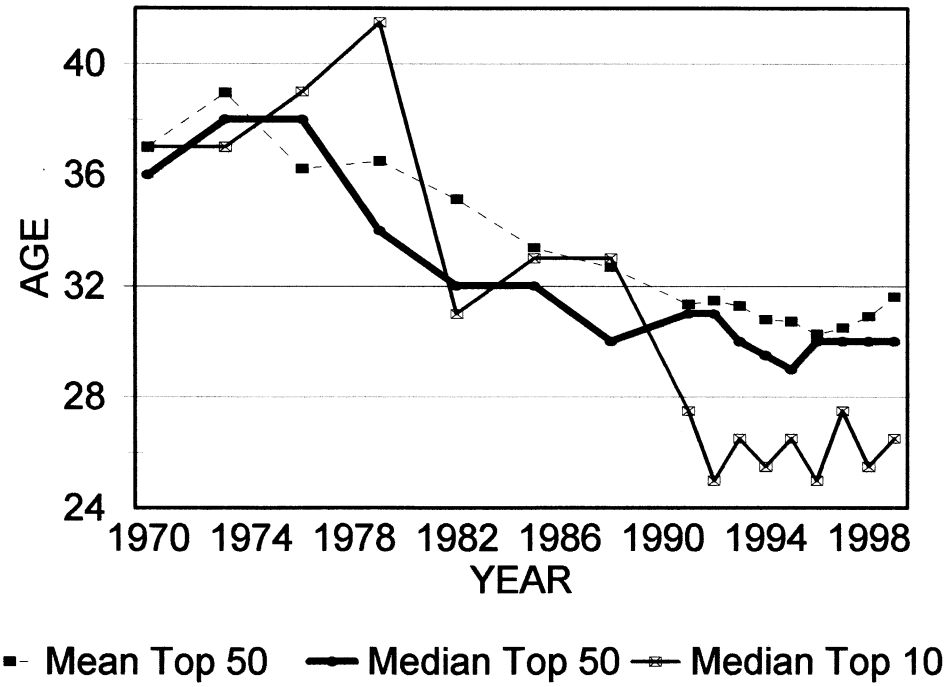

Figure 1. Average age of the top 50 and top 10 chess players on the international rating list from the inaugural 1970 list. Averages were calculated every 3 years until 1991 and every year thereafter.

from 1990 and from the July official list published in the periodical *Sahovski Informator* (Chess Informant). Almost every top 50 player was from a Western or former Soviet bloc nation. Birth dates were obtained from the FIDE website, from Gaige (1987) and in one case from a chess federation and the age of each player on July 1 of the year cited was computed. Because of the difficulty of obtaining ratings data, the initial plan was to survey only every 3 years, but, to determine the trough of a clear trend, data were determined for every year from 1991. No July ratings list was published in *Sahovski Informator* in 1976 and 1979 so the January list was used and age of each player on January 1 of that year was calculated. The 1999 data point is from the January, 1999 list (with age computed as on January 1, 1999), as the July list was not published at the time of writing. Some years had a tie for 50th place (e.g. several players on the same rating) so then all in the tie were included, as also occurred with the top 10. FIDE removed number 1 player Garry Kasparov (born in 1963) from several lists after a purely political dispute but I replaced him and dropped the 50th place player (who really was 51st) then.

Fig. 1 mainly shows a steady decline in the average age of the top 50, from a peak median age of 38 years in 1973 and 1976 to just 29 in 1995. Fig. 2 shows that the age drop largely was due to an increasing proportion of very young (under-25 years) players, from about 14% in 1970 to 32% in 1997. The number of teenagers on the list also mainly rose; two in 1970, none in 1973–1979, four in 1993 and 1994 and five in 1995. The decrease

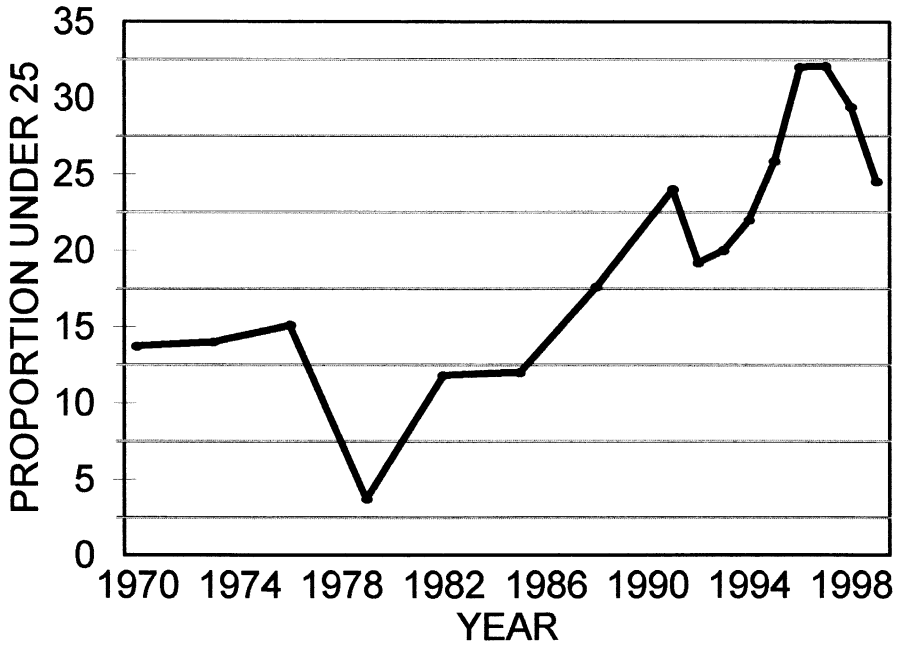

Figure 2. Proportion of very young players (under 25 years old) of the top 50.

is even more striking for the top 10, from a median age around the late-30s in the 1970s down to around the mid-20s in the 1990s.

Fig. 3 presents average age over the same period of the world championship candidates. FIDE used to select the candidates in a 3-year cycle, but began a new format after 1994. The winners of a series of zonal tournaments competed in an interzonal tournament/s and varying numbers of the top placers then played knockout matches, the winner of which challenged the world champion in a match. Numbers of candidates varied from eight to 16. The data are average age (on January 1 of the year given) of candidates seeded into the initial matches, which sometimes included the seeded-in loser of the previous cycle's championship match. The median rose from 37 years in 1971 to 42.5 in 1980 and dropped to just 26 in 1994.

Fig. 4 presents average age over the same period of the players on the Soviet Chess Olympiad team (or Russian team from 1992). The Olympiad is held every 2 years, and features six-player teams, usually the best each nation can field. Usually the USSR won. The Olympiad runs for some weeks, at a variable time in the year (but typically late in the year), and so the data are for age on July 1 of the year each was held. There is no data point for 1976 because the USSR boycotted that year's event. The figure shows a precipitous age drop, from a median of 40 years in 1970 (when the USSR won) to 23 years in 1994, 24 years in 1996 and just 22.5 years in 1998 (all years in which Russia won). In 1994, Russia had a second string team in the competition (under Olympiad rules the nation on whose territory the event is held, Russia in 1994, may field two teams). That team came third and its median age was only 18.5 years.

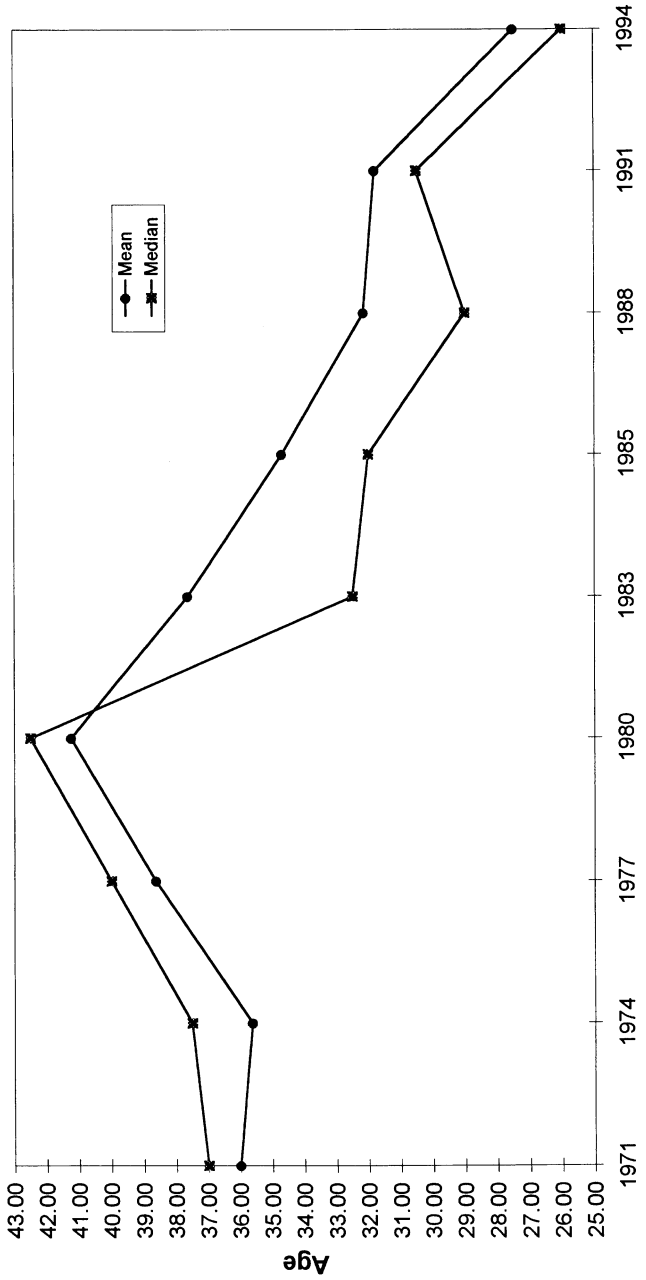

Figure 3. Average age of the world championship candidates in each 3-year cycle.

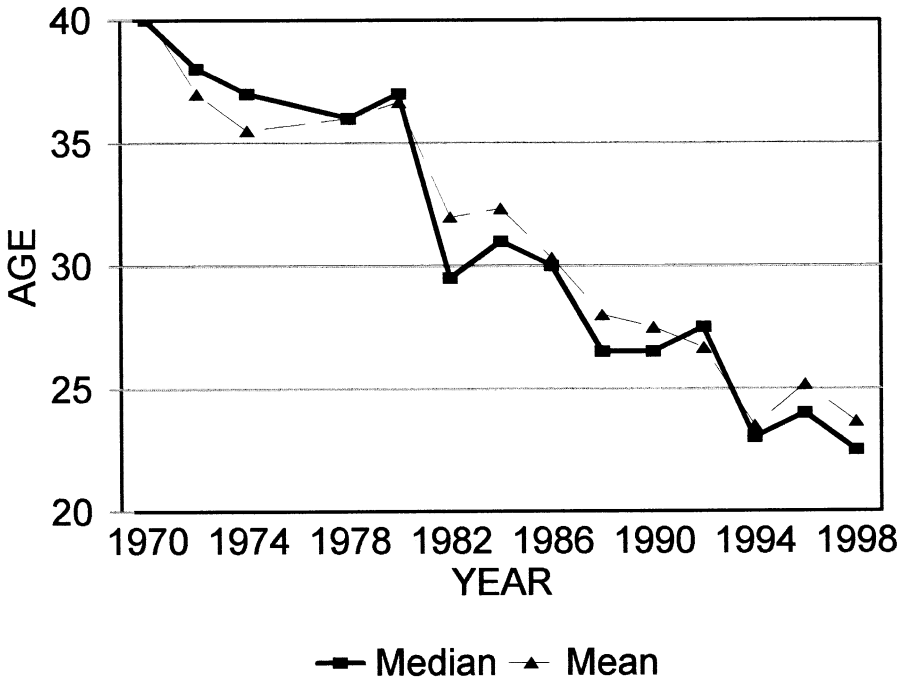

Figure 4. Average age of the players in the Soviet (Russian from 1992) Chess Olympiad teams. The Olympiad is held every 2 years. There is no 1976 data point because the USSR boycotted the 1976 Olympiad.

Patent Study

As noted, patent data have problematic significance for questions about rising intelligence. However, Flynn mentions a decline and I took a closer look. Fig. 5 shows total patents granted by the U.S. Patent Office since 1963. Overall, the absolute number actually rose; from 48,971 in 1963 to 121,697 in 1996. However, the number declined from 1971 to 1979, and thereafter largely increased. The proportion of foreign grantees rose (from 18% in 1963 to 43% in 1996), perhaps because of decreasing U.S. technological dominance, and the U.S. and world population has increased in that period. But, while world population has approximately doubled, the number of patents has increased two and a half times. If we just examine the number granted to U.S. sources only, per hundred thousand of U.S. population in each year (Fig. 6), 1960's rates indeed exceed 1980's rates. But, they declined to a trough in 1979 and since largely have risen. The 1996 figure exceeds the 1963 figure. Therefore, patent numbers overall have risen since 1963.

Educational Statistics

Finally, I examined some educational data. Until 1995, the SAT was normed in relation to a group which took the test in 1941, so performance can be tracked ever since. It gives verbal and mathematical scores, with a mean score of 500 on each and standard deviation

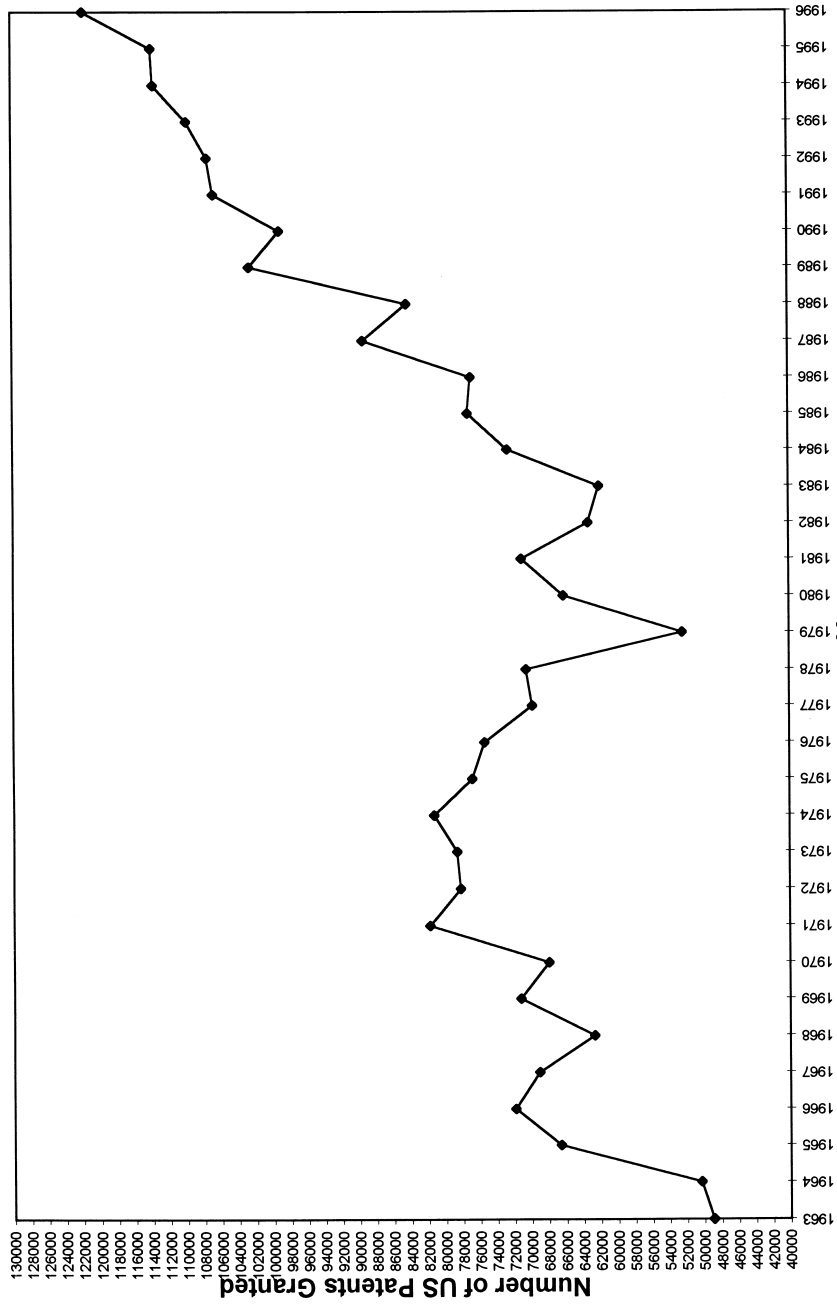

Figure 5. Total number of U.S. patents granted each year to U.S. and foreign sources. Source: U.S. Patent Office.

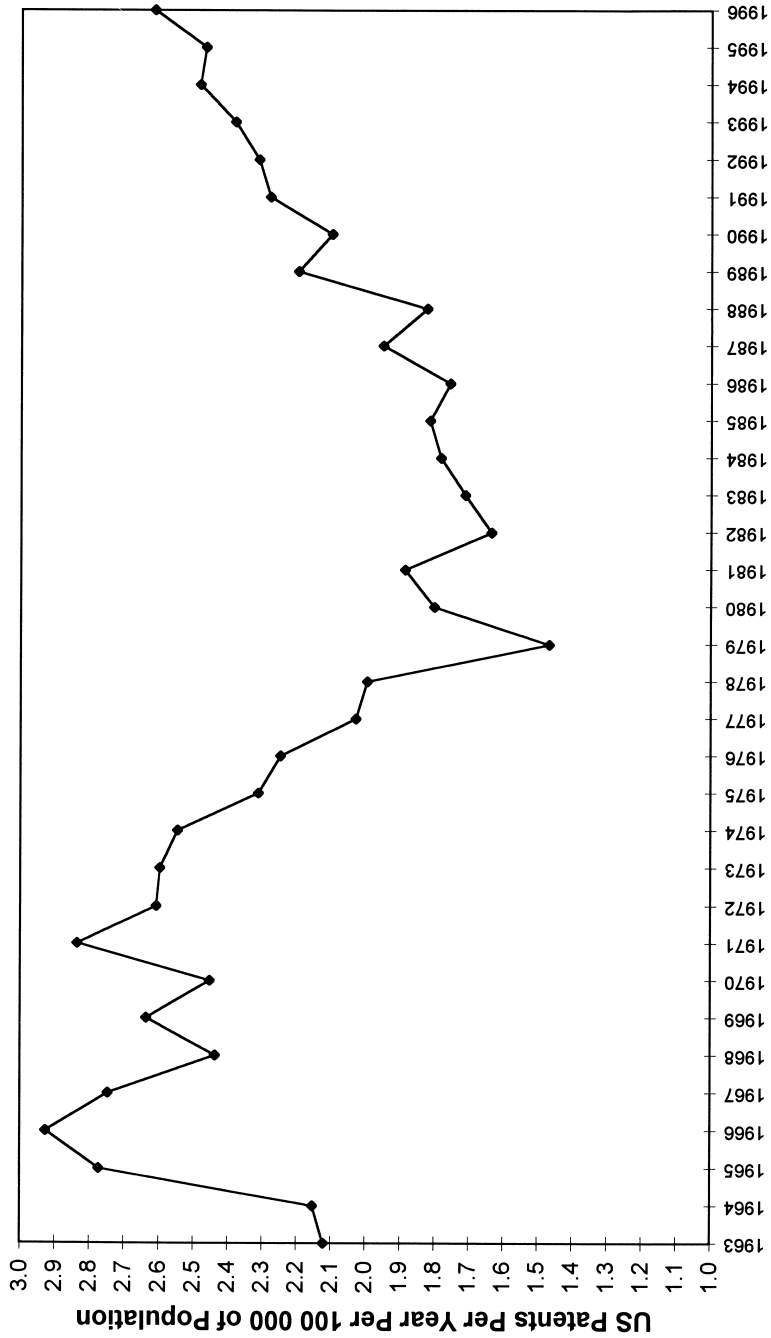

Figure 6. Total U.S. patents granted each year to U.S. sources per 100,000 of U.S. population.

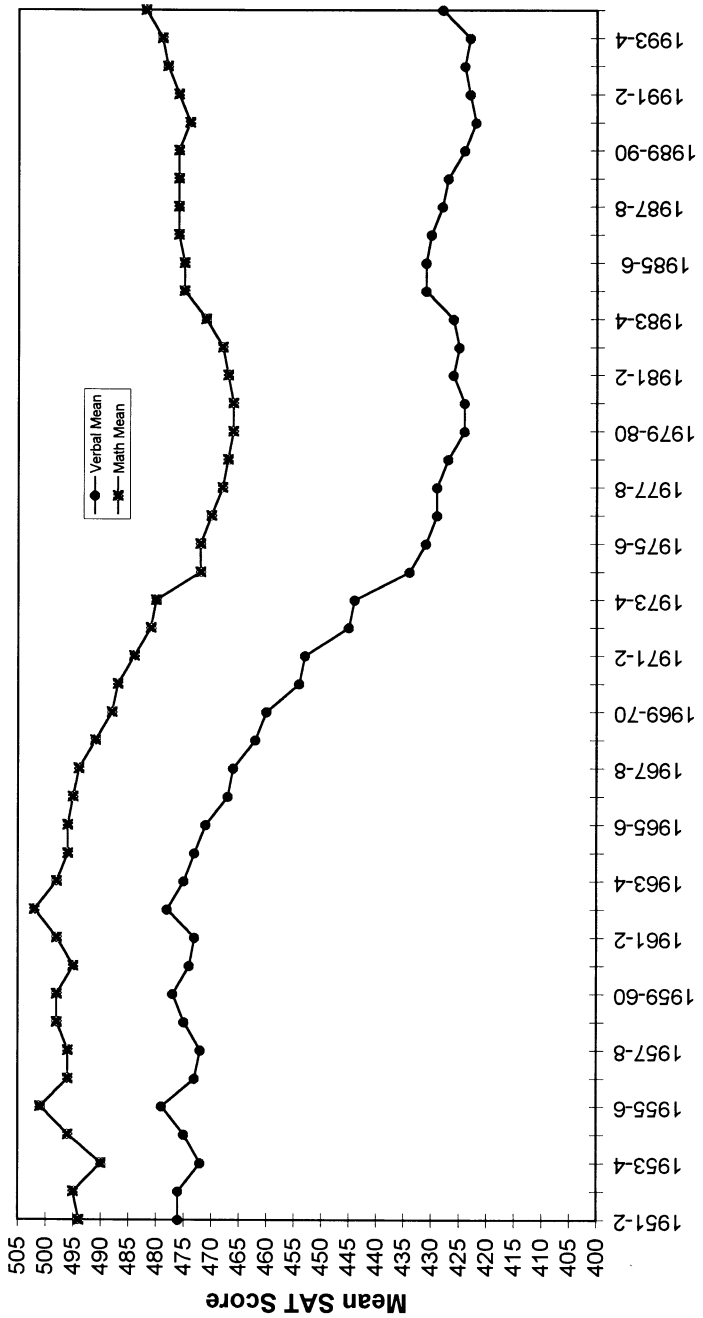

Figure 7. Mean SAT verbal and mathematical scores each year. Source: College Board.

of 100 for the normative group. Indeed, as Fig. 7 shows, the overall average score has mainly declined since 1951. College Board studies suggest that the decline partly was due to more persons taking the test, including many more U.S. minorities (e.g., Hunt, 1995; Steinberg, 1996).

The SAT data, as Flynn argues, suggest that average intelligence is not rising. However, another explanation is that the SAT is not a pure IQ test. Performance depends heavily on knowledge and skills acquired in the classroom and from print (e.g., Brody & Benbow, 1990). Studies suggest decreasing academic skills and general knowledge among American school children, partly because of widespread poor motivation, simplification of course material and diminishing school workload expectations (Sizer, 1984; Steinberg, 1996). Indeed, Hayes, Wolfer, and Wolfer (1996) link much SAT verbal score decline from 1963 to 1979 to a simplification of textbooks published between 1919 and 1991. Many American universities run remedial reading and writing programs and surveys find that U.S. employers say that entry-level employees are generally deficient in basic language and mathematics skills (Hunt, 1995). The young today also may be reading less and so practicing reading skills less: Fewer youngsters read newspapers than did a generation ago, for instance. The average U.S. newspaper reader today is aged over 40 (Stevenson, 1994). Stanovich, West, and Harrison (1995) and Cunningham and Stanovich (1991) link amount of exposure to print to extent of an individual's vocabulary and general knowledge base, which are tapped by the SAT. These trends may be masking an intelligence rise.

Flynn also suggests that we should see many more gifted children and are not. However, this is not clear, especially since academic skills and motivation have been falling. I checked with various U.S. gifted child associations and research centers but none knew of any longitudinal statistics being collected on numbers of gifted children. They also pointed out that widely varying criteria for categorizing a child as gifted and varying willingness and ability of schools to identify them would make any such statistics difficult to interpret. Finally, a logical problem with this index is that a gifted child is a relative thing. A common definition is a child in the top 2% of the IQ distribution and by definition only 2% will be identified each year. And, with the diminishing proportion of children in the aging Western population, fewer total numbers would be identified each year, anyway.

Discussion

The overall results are consistent with the view that average human intelligence really is rising. The chess player age drop and its pattern are what would be expected from a rise and the real-world data cited by Flynn against the idea of a rise do not hold up well on close examination.

However, there are various alternative accounts of the chess data. Causation often is difficult to pinpoint in real-world, correlational studies and some factor/s other than rising intelligence may well be responsible. Chess players are self-selected and many more people may be interested in playing. More women play chess nowadays, for instance, though only one has ever made the top 50. Chess now could be attracting relatively more intelligent people. Players may be learning the rules earlier and studying and practicing more and coaching may be better. In fields dominated by the young such as swimming, for instance, children now may begin extensive practice much younger.

Indeed, one might cite as evidence analogous apparent age trends in some physical sports (e.g., female tennis players seem to be getting younger) and that world sports records keep being broken. There are reports that athletes in such sports as sprinting even are showing peak performance at later ages. One might also cite studies that suggest the apparent potency of such factors as amount of practice and coaching in attaining expert performance and claims that native talent (e.g., general intelligence) is unimportant (e.g., Ericsson & Lehmann, 1996). (However, without legislating on this issue, the practice versus native talent debate is very controversial. In sports and chess, most experts assume that native talent is important. Sternberg (1996) severely criticizes the notion that native talent has little role and the retrospective studies cited as evidence. Bloom (1982) studied 25 individuals who had attained world class status in such fields as mathematics, swimming, and piano playing and found strong evidence that each had great innate talent in their area. Feldman (1979) found this in chess players.

However, rising intelligence still is the likely cause of the chess player age decline. The above arguments from physical sports trends fail on close examination. First, some factors that may be raising IQ scores probably also are raising sports performance, and at earlier ages. Better diet and health are producing taller and heavier children who reach adolescence earlier, and thus get to needed physical milestones for sports sooner. Weight-lifters, for example, only attain the bone development needed for serious competition after adolescence. Second, sports skills depend on mental abilities, too. For instance, tennis demands much hand–eye co-ordination and anticipation of the opponent's movements. G affects cognitive, perceptual and motor skill acquisition and performance (Howard, 1995). Hall and Buckolz (1992) link visuospatial ability to the acquisition of motor skills in sports. If g is rising in the young, they should acquire needed sports skills faster and perform better at earlier ages.

Third, physical sports performance has improved largely because of many known factors that do not affect chess performance. A few such factors are better equipment (shoes, running tracks, rackets), use of sports psychology (rare or nonexistent in chess), new coaching and training techniques such as mental practice and, perhaps most important, performance-enhancing drugs (Laura & White, 1991; Singer, 1993). Great improvements in weight lifting records followed the introduction of steroids in the 1960's and of growth hormone in the late 1980's. Coaching is not universal in chess; many top players mainly studied individually (Charness et al., 1996). There is no evidence that chess instruction has improved over the years or that more players get coaching or that this would produce the current findings. Charness et al. even present some data that suggests that chess coaching has little effect on performance.

Perhaps the strongest evidence that the age decline is due to an intelligence rise is the four new grandmaster age records set since 1991. Other chess age records are being broken in the 1990's. In 1998, Hikaru Nakamura at just 10 years and two months old became the youngest-ever U.S. Chess Federation master (a prestigious performance-based title that few players attain). In 1997, another 10-year-old won a major section at the prestigious New York Open. Previous chess history has nothing like this consistent record breaking.

In fact, there is something close to a natural experiment on the effect of such factors as coaching, amount of practice and (probably) age of learning the rules. The USSR was slower to industrialize than Western nations and since 1914 has been devastated by famines and wars. One might expect an intelligence rise due to diet, health, stimulation

and so on to start much later. However, since the 1920's, chess was the national sport. Many millions played; the chess participation rate was very high (Charness & Gerchak, 1996) . Factories and schools had chess sections and chess even was taught in schools. Talent was identified early and given much special training. Top players got great prestige, sizeable government salaries, and overseas travel. We would expect many players of those millions to have learned the rules as early as they could and to have spent much time studying and practicing. Such factors evidently had an impact in that the USSR dominated the chess world. But, there is no evidence up to 1970 in the USSR of the age trends shown since. Let us assume that average intelligence has stayed constant since say, 1930. If the chess age drop is due only to such factors as practice and interest, we should see many Soviet prodigies in the 1950's and 1960's, as in the 1990's, and a much lower average age of top players. But, we do not. Indeed, the USSR won a major team match in 1970 against the rest of the world, and the Soviet team's median age was around 41 years old. The Soviet team which won the 1970 Chess Olympiad had a median age of 40 and the Russian team which won in 1998 had a median age of 22.5. In 1970, the average age of the top 50 was in the late 30's (around the expected peak age) and prodigies in the decades before emerged only occasionally.

Finally, there is a plausibility argument. The chess player age drop and its continuous pattern is exactly what we would expect from the IQ rise and the fact that the abilities important in chess (e.g., visuospatial ability) are rising most. The results are exactly the opposite of what we would expect from educational score declines, the apparent lessening inclination of the young to read and study (Stevenson, 1994; Steinberg, 1996), their increasingly short attention spans, and from demographics. The aging Western population had proportionately fewer youngsters in the 1990's than in the 1970's, and all other things being equal, we would expect fewer youngsters in the top 50. So, we know that average IQ is rising, that spatial ability is rising, and that these correlate with chess skill. We do not know that chess coaching is improving or that amount of practice is increasing or is more widespread or that players are learning the rules earlier or that these could produce the chess age drop. (Indeed, even if studies showed such effects, there would be another problem of assigning causation. If top players learned the rules earlier and got more practice, did that alone make them better players or was it that they were more intelligent and became interested in intellectual games and could profit from chess instruction earlier?). So, the likely explanation is that young players today have higher general intelligence. They can acquire chess knowledge faster and more easily and are more adept at using it. Otherwise, the average age of the top 50 would be expected to have risen.

A recent study (mentioned by a reviewer) also is consistent with an actual population intelligence rise. Rosenau and Fagen (1997) had skilled raters gauge the "integrative complexity" of text, scoring texts on such factors as number of dimensions used in arguments, whether other viewpoints are considered, and whether competing ideas are integrated, to get a numerical complexity score. They compared texts of elite persons (e.g., given in Congressional debates and newspaper editorials) between 1916 and 1932 with those of different elite persons written between 1970–1993. Text complexity rose over time, suggesting that discourse became more sophisticated. Of course, such factors as improved education or different types of elite members may be responsible, though.

Finally, the present findings are only preliminary. More research is needed to settle the issue. One research strategy is use of converging evidence; to examine trends in as many domains as possible that meet the criteria listed earlier. Chess could be examined further, using larger samples and national federation data, such as national championship winners. Researchers might also look at real-world measures used to validate IQ tests.

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