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The Flynn effect: Smarter not faster

Ted Nettelbeck[a,*], Carlene Wilson[a,b]

[a] *Department of Psychology, University of Adelaide, Adelaide, South Australia 5005, Australia*
[b] *CSIRO, Adelaide, South Australia, Australia*

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Abstract

Inspection time (IT) and Peabody Picture Vocabulary Test (PPVT) scores from 75 school children aged 6–13 years in 2001 were compared with the performances of 70 children aged 6–13 years who had attended the same primary school in 1981 [*J. Exp. Child Psychol.* 40 (1985) 1.]. ITs for the 2001 sample were measured with the same four-field tachistoscope and identical computer-based procedures followed by Wilson in 1981. The 2001 sample completed two versions of PPVT concurrently: PPVT (1965, Form A) as used in 1981 and PPVT-III (1997, Form IIIA). Mean ITs from both samples, 20 years apart, were essentially the same (123 ± 87 and 116 ± 71 ms in 1981 and 2001, respectively). There was, therefore, no evidence that speed of processing had improved. Correlations between IT and raw PPVT scores were significant ($P < .01$) for both 1981 ($r = -.43$) and 2001 ($r = -.31$). Within the 2001 sample, concurrent PPVT scores correlated .68; however, means revealed a significant Flynn effect. Thus, scores for the 2001 cohort on the earlier PPVT were higher (*M* standardized IQ 118.52 ± 16.62) than the recently restandardized PPVT-III (113.97 ± 12.23), although, compared in terms of the most recent standardization sample, the 2001 cohort was equivalent to the 1981 sample (113.66 ± 16.72). The Flynn effect has nothing to do with speed of processing as measured by IT, despite the effect being strongest for ability tests that earn bonus scores for quick performance. Because IT correlates with IQ but appears to be stable across 20 years, whereas IQ is not, IT may have promise as a useful biological marker for an important component of cognitive decline during old age.

Keywords: Flynn effect; Inspection time; Peabody Picture Vocabulary Test

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1. Introduction

This study drew on two lines of inquiry: a steady, continuing, long-term, and worldwide improvement in IQ and the theoretical contribution of inspection time (IT), envisaged as a measure

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* Corresponding author. Tel.: +61-8-8303-5738; fax: +61-8-8303-3770.
E-mail address: ted.nettelbeck@psychology.adelaide.edu.au (T. Nettelbeck).

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of speed of processing, to an understanding of the nature of individual differences in intelligence. The critical proposition on which the study was based was that comparisons between ITs from cohorts of children separated by 20 years, made by replicating earlier research procedures, provided the means for testing whether rising IQ (the "Flynn effect") was the consequence of or accompanied by faster processing.

Flynn (1999) has clearly documented widespread rises in mean IQs from substantial samples from some 20 nations representing western European/North American cultures or technologies. These increases in mean IQ, apparently without changes in variance, are presumed to be caused by environmental influences as yet unidentified. There is considerable interest in Flynn's finding (Neisser, 1998) and ongoing debate about a range of explanations, generally covering improved physical health, nutrition and well-being, and extensive educational and technological changes within the countries involved across the 20th century. IQ has risen, despite evidence that differences in IQ are substantially influenced by genetic variation (Plomin & Petrill, 1997) and that individual IQ is generally not susceptible to improvement (Spitz, 1999). Moreover, improved IQ appears to represent gains in problem-solving abilities more than straightforward knowledge acquisition, because the largest effects involve tests designed to measure nonverbal reasoning and abstract problem-solving, like Raven's progressive matrices and the Performance subtest from the Wechsler scales. Of immediate relevance to the current study, most of these tests carry bonus points for quicker responding. By Flynn's account, average gains of about 1 IQ point every 3 years have probably been occurring since the IQ test was invented. Yet, almost no one believes that human genotypic intelligence has improved significantly during the course of the 20th century. Although the Flynn effect has thus far been demonstrated predominantly for young (male) adults (which seems to rule out earlier maturation in more recent generations as an explanation), at least one study, by Tasbihsazan, Nettelbeck and Kirby (1997), has demonstrated an improved Mental Development Index of 18 points across 25 years among infants aged 18–27 months based on concurrent Bayley's (1969, 1993) comparisons. This finding is not plausibly attributable to improved education.

It is important to note that these IQ improvements are cross sectional, derived from the achievements of different cohorts on test content that has not changed or changed little across generations. There is no suggestion that individual IQs have improved longitudinally. Within generations, IQ scores remain good predictors of academic, work performance, and other life achievements (Jensen, 1998), and there is now general consensus that individual differences in IQ reflect a substantial genetic component (Neisser et al., 1996). Nonetheless, rising IQs can only be substantially explained environmentally and they therefore challenge the construct validity of the tests as measures of fundamental, inborn cognitive abilities. The Flynn effect implies that abstract reasoning abilities, previously held by many to reflect basic capacities, are influenced by as yet undetermined environmental circumstances.

Considerable speed-based research has found that speed measures correlate with IQ (Nettelbeck, 1998, 2001). IT (Vickers, Nettelbeck, & Willson, 1972) measures individual differences in threshold to detect the location (left or right) of the shorter of two vertical lines displayed in a briefly exposed target figure. The threshold measure is essentially a critical stimulus onset asynchrony (CSOA), defined as the minimum delay required, between the onset of the target figure and the subsequent onset of a backward masking figure so as to achieve predetermined high accuracy. IT correlates at about $-.5$ with nonverbal IQ (Deary & Stough, 1996; Grudnick & Kranzler, 2001; Kranzler & Jensen, 1989; Nettelbeck, 1987). The basis of this correlation has not been clearly identified, but there are strong grounds for supposing that it reflects more than application of higher-order "intelligent" strategies (Deary, 2000; Nettelbeck, 2001). It may involve IT's sensitivity to the psychometric construct "speediness" (Burns & Nettelbeck, 2003), defined by Horn and Noll (1997) as speed under relatively undemanding circumstances. However, speediness is unlikely to provide a sufficient explanation for IT–IQ correlation, because Burns and Nettelbeck (2003) also found that IT shared variance with a higher-order, orthogonal general factor and recent research has raised the possibilities that IT is sensitive to attentional capacities (Hutton, Wilding, & Hudson, 1997) and fluid abilities (Osmon & Jackson, 2002). Although it is unlikely that a single kind of mental speed could account for individual differences in IQ (Roberts & Stankov, 1999), Carroll (1993) has allowed that some fundamental aspect of processing speed could underpin the higher-order general ability factor that distinguishes his model for human intelligence from similar "multiple intelligences" models (Horn & Noll, 1997).

The current study set out to replicate with a current sample measures of vocabulary and IT initially made by Wilson in 1981 as part of a cross-sequential investigation of childhood developmental changes in processing speed (this work was published by Nettelbeck & Wilson, 1985). To this end, primary school children were recruited from the same school that was involved in 1981. This school had continued to serve the same catchment area, as 20 years previously, from upper middle-class socioeconomic suburbs.[1] As for the earlier study, vocabulary achievement was a proxy for IQ and estimated with the same test. IT was measured using exactly the same apparatus and procedures followed in the earlier study. If rising IQ is accompanied by improved processing speed as is implied by theories that have drawn heavily on the "fast is smart" assumption common to western European cultures (Brand, 1996; Eysenck, 1987; Jensen, 1998), then this would be revealed by comparison of IT measures made now with those recorded 20 years ago. On the other hand, if IQ was shown to improve but IT had not, this would rule out speed of processing as an explanation for improving IQ.

2. Method

2.1. Participants

Seventy-five school children (36 boys, 39 girls) aged 6–13 years took part, with the permission of their parents. They attended the same school as the 70 children (38 boys, 32 girls) also aged 6–13 years in the 1981 sample. As had been the case in 1981, all had normal or corrected-to-normal vision. Following Wilson in 1981, this was a sample of convenience, aiming to draw about 10 children, approximately balanced for gender, from each of seven consecutive grade levels. Response rates were high, with many more children volunteering than were required. Those participating were determined according to the children's availability and teachers' convenience at the time of testing (see Table 1).[2]

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[1] The Australian census categorizes postcodes in capital cities within quintiles for socioeconomic strata, defined by household income and other indices of relative social advantage. In 1981 and 2001, the postal districts encompassed by the school's catchment area were in the highest quintile.

[2] Grade levels in 2001 were different from those in 1981. Today's children aged 6–13 years were located in Grades 1–7, whereas in 1981 these age groups were in Grades 2–8.

Table 1
Means ± S.D.s for grade levels, chronological ages, standardized PPVT scores, and ITs from children in 1981 and 2001

Grade level	*n*	Age (years-months)	Gender (M/F)	PPVT[a]	IT
1981					
1	10	7-4 ± 0-6	6/4	101 ± 19	231 ± 171
2	10	7-10 ± 0-3	5/5	116 ± 19	133 ± 45
3	10	8-8 ± 0-2	5/5	116 ± 9	125 ± 48
4	10	9-10 ± 0-5	4/6	115 ± 18	115 ± 46
5	10	10-11 ± 0-4	6/4	117 ± 14	101 ± 40
6	10	11-11 ± 0-3	6/4	107 ± 7	70 ± 42
7	10	13-2 ± 0-3	6/4	123 ± 22	86 ± 24
2001					
1	14	6-9 ± 0-5	7/7	116 ± 11	151 ± 64
2	12	7-9 ± 0-5	6/6	113 ± 16	135 ± 120
3	10	8-8 ± 0-2	4/6	122 ± 12	132 ± 85
4	10	9-9 ± 0-2	5/5	110 ± 8	114 ± 53
5	10	10-8 ± 0-4	4/6	115 ± 11	91 ± 29
6	10	11-7 ± 0-2	5/5	109 ± 11	96 ± 28
7	9	12-9 ± 0-5	5/4	113 ± 14	74 ± 18

[a] Original PPVT norms were applied in 1981, while PPVT-III norms were applied in 2001.

2.2. Materials and apparatus

Vocabulary was measured with the Peabody Picture Vocabulary Test (PPVT) using both the original version (Dunn, 1965; Form A) and the most recent PPVT-III (Dunn & Dunn, 1997; Form IIIA). IT was measured using the same Gerbrands tachistoscope, previously modified in-house to provide four fields so that the four stimulus cards could be set undisturbed throughout the study, following appropriate initial alignments. These cards displayed in turn an initial visual fixation cue, the two alternative targets with the shorter vertical line to left or right, and the backward masking figure. The tachistoscope was set at the same field luminances, employing the same stimulus cards, the same sequence for lighting the fields, and the same presentation technique used by Wilson in 1981. Thus, the two vertical lines in the target were 24 and 34 mm, were 10 mm apart, and aligned at the top by a horizontal line. The backward mask that subsequently overlaid each target display had both vertical bars 44 mm long and 5 mm wide, centered at 10 mm apart. The software that controlled onset and offset of the four fields and recorded responses as correct or not was the same program used by Wilson in 1981. It was an early version of the Parameter Estimation by Sequential Testing (PEST) program (Taylor & Creelman, 1967), an adaptive staircase algorithm that estimated the CSOA with an associated probability of 85% correct responding. The response keypad was that used by Wilson in 1981. Further details for these pieces of equipment are to be found in Nettelbeck and Wilson (1985) (Study 3).

2.3. Procedures

All children were tested individually, first completing both versions of PPVT concurrently at a single session, with ∼ 10 min break between. Order of completion was balanced across children. A single estimate of IT was made at a second session, following exactly the same instructions used by Wilson in

1981. These emphasized accuracy of responding, not speed. The same practice routines and staircase algorithms were used. Nettelbeck and Wilson (1985) provided a full description of these.

3. Results

As can be seen from Table 1, the age sample in 2001 (overall $M = 9\text{-}5 \pm 2\text{-}4$ years-months) closely matched the 1981 cohort (9-11 ± 2-6 years-months) [$t(143) = 1.49$, $P > .05$, two-tailed]. The numbers of children and gender balances within age levels were similar for both cohorts. There were 48% boys in 2001 compared with 54% in 1981. Thus, the two samples drawn from the same school 20 years apart were age and gender equivalent for comparison purposes.

Distributions of standardized PPVT scores within the current and the 1981 sample, based on age norms applying in 1981 and 2001, were also essentially the same. The overall mean in 1981 (initial PPVT age norms) was 113.66 ± 16.72 compared with 113.97 ± 12.23 in 2001 (PPVT-III age norms). The difference was not statistically significant ($t < 1.0$), and correcting scores according to the extent to which norms for both versions of PPVT had become obsolete at time of testing (see Flynn, 1987) did not change this outcome. Nonetheless, although samples were equivalent for verbal achievement for their respective times, the current sample demonstrated a clear Flynn effect. Thus, although concurrent scores for the 2001 children with original and recent versions of PPVT were highly correlated [$r(73)=.68$, $P < .01$, two-tailed], these children were significantly advantaged on the early PPVT ($M = 118.52 \pm 16.62$) compared with PPVT-III ($M = 113.97 \pm 12.23$) [$t(74) = 3.22$, $P < .01$, two-tailed]. This within-subjects outcome was confirmed by between-subjects analysis, comparing the earlier version PPVT scores from the 2001 sample with the earlier version PPVT scores from the 1981 sample [$t(143) = 1.76$, $P < .05$, one-tailed]. This rise of almost 5 points across 20 years was lower than but consistent with 20 years' improvement in Wechsler Verbal IQ (7 points), estimated by comparing WISC with WISC-R standardization samples (Wechsler, 1949, 1974). (The improvement for word knowledge was also smaller than the Flynn effect of ∼ 8 Performance IQ points across 20 years embedded in the WISC/WISC-R norms.)

Despite the Flynn effect for vocabulary achievement, Table 1 demonstrates that there was no evidence of improvement in IT from 1981 (overall $M = 123 \pm 87$ ms) to 2001 ($M = 116 \pm 71$ ms). Of course, this conclusion amounts to accepting a null hypothesis, but the effect size of only about 0.09 would require more than 2000 cases in both cohorts to achieve $\alpha=.05$ (two-tailed) at power = 0.80. Overall, the 1981 and 2001 distributions were remarkably similar, being positively skewed to the same extent (2.26 and 2.94, respectively) around the same medians (103 and 102 ms) and with similar minima (18 and 33 ms) and maxima (450 and 500 ms). Two-way ANOVA found no cohort (1981 vs. 2001) effect [$F(1,131) < 1.0$]; as expected, there was a highly significant age effect [$F(6,131) = 6.20$, $P < .001$] but no Cohort × Age interaction [$F(6,131) = 1.24$, $P > .05$]. Visual inspection of the IT distributions across age and cohorts confirmed that the longer mean IT in the youngest 1981 subsample, compared with 2001, was the consequence of three children aged 6/7 years whose low PPVT scores and long IT estimates made them outliers. Nonetheless, correlations within both cohorts between raw PPVT scores and IT (1981) and raw PPVT-III scores and IT (2001) were significant and similar: 1981 $r(68) = -.43 \pm .24$ (95% confidence limits), $P < .01$; 2001 $r(73) = -.31 \pm .23$, $P < .05$. These coefficients did not differ significantly ($z = 1.07$, ns). Both outcomes were, of course, confounded by strong age effects.

4. Discussion

The current study aimed to replicate Wilson's 1981 study (Nettelbeck & Wilson, 1985) and succeeded to a remarkable degree. Word knowledge outcomes derived from 1981 and 2001 norms provided an excellent match. As predicted by Flynn's observations, concurrent testing of word knowledge in the 2001 sample, using both current and earlier Peabody test versions and norms, found that word knowledge had risen significantly by about 5 points across 20 years. This result was statistically significant and consistent with restandardizations of the Wechsler scales across this period, which have found a Flynn effect of 7 Verbal IQ points (cf. about 8 points for nonverbal aspects). However, most importantly, estimates of IT were essentially the same from both cohorts, results for 1981 and 2001 demonstrating the expected significant age and IQ effects to the same extent. The monotonic reduction in mean IT with age was marked and not consistent with Anderson's theory that IT does not change with development (Anderson, 1992; Anderson, Reid, & Nelson, 2001).

In other words, whereas average IQs of 6–13-year-olds are known to have risen appreciably across 20 years, including on a pencil-and-paper marker test for "speediness" (the Coding subscale from Wechsler), IT was not subject to cohort improvement. IT, which as expected correlated significantly with word knowledge scores within both the 1981 and the 2001 cohort, did not change at all on average. Thus, based on current results, IQ gains are not explicable in terms of improved processing speed, as operationalized by IT. This result suggests, moreover, that IT measures some fundamental aspect of mental functioning that is relevant to understanding of human intelligence, which is not influenced by whatever environmental circumstances are responsible for rising IQ scores. What this function is, however, is not clear. Debate continues around what psychological processes are tapped by IT (Nettelbeck, 2001), and the nature of processing speed appears to be complex (Roberts & Stankov, 1999). Moreover, it is necessary, though difficult, to replicate this result. The samples in both the original 1981 study and the 2001 replication were small, with only about 10 children in each age group. Insofar as a major assumption underpinning current conclusions is that the 1981 and 2001 cohorts were demographically equivalent, it would have been desirable to confirm this more precisely, e.g., by recording parents' educational levels, occupations, and salaries. Without more evidence to the contrary than the broad census data available here, it is always possible that the increased word knowledge found was the consequence of idiosyncratic improvement to the socioeconomic circumstances of the children involved, beyond those that speculation has linked with the Flynn effect (Neisser, 1998). It is also important that future research of this issue should test the stability of IT across time for a much wider range of ages than the 6–13 years included here.

If the current result is confirmed, two future directions for research are suggested. The present result for IT begs the question as to whether different kinds of processing speed, similarly known to correlate with IQ although not necessarily appreciably with each other (Kranzler & Jensen, 1991), are stable or improve across time. For example, existing large data sets derived for parameters of Decision time and Movement time (Jensen, 1987) might be used to explore this question by replicating these earlier procedures with current samples.

A second suggestion is that IT may provide a useful biomarker for cognitive aging. The causes of aging are not known. Nonetheless, there is considerable evidence to support a conclusion that normal aging beyond the mid-1960s is, on average, accompanied by cognitive decline that, although different abilities change at different rates, is largely attributable to slowing of information processing speed (Deary, 2000; Salthouse, 1996; Schaie, 1994). Although gradually slowing processing speed and declining cognitive abilities may be ongoing beyond early adult years, considerable evidence points to relative stability before the sixth decade but a marked shift in rate beyond. However, there are marked individual differences in the onset and progress of age-related changes, so that chronological age is an unreliable marker for functional aging. Obviously, individual differences in functional aging have implications of considerable practical importance for those involved, and reliable biomarkers, capable of predicting functional change as a consequence of aging, particularly any accelerated decline in cognitive integrity, would therefore be extremely useful (Stern & Carstensen, 2000).

Much aging research has relied on the Digit Symbol test (Wechsler) to measure processing speed (Salthouse, 1996). Although longitudinal studies leave little doubt that aging effects are real (Salthouse, 2000; Schaie, 1994), it is possible that effect sizes from cross-sectional designs have been exaggerated by the Flynn effect, which would tend to favor younger cohorts on Digit Symbol. Thus, a measure of processing speed, known to be stable across age cohorts, would be desirable for researching age-related cognitive decline.

At the very least, IT appears to tap "speediness" (Nettelbeck, 1994) and may also be relevant to general ability (Burns & Nettelbeck, 2003). Moreover, on current evidence, IT is stable across generations, at least among children, unlike conventional psychometric tests. We suggest that these attributes, together with its noninvasive measurement procedure, may make IT an attractive prospect as a biomarker to monitor cognitive changes that accompany aging, providing that it meets other essential criteria. These should include sensitivity to cognitive change within a short period, predicting important life changes ahead of time (e.g., decline in workplace competence or the onset of driving difficulties) and predicting longevity. It is also desirable that a biomarker should be measurable in other species (McClearn, 1997) and therefore available for animal modeling of functional aging. IT is certainly sensitive to cross-sectional age comparisons among elderly people (Nettelbeck, 1987) and to age-related differences in cognitive functioning (Nettelbeck & Rabbitt, 1992; see also Deary, 2000, pp. 244–246 for a relevant reanalysis of these data), but nothing is known currently about whether IT is subject to longitudinal slowing. In principle, the discrimination required to estimate IT is simple and should be achievable with animals; however, IT's utility as a lead biomarker, capable of predicting accelerated decline in cognitive integrity, would be a more immediate priority for future research.

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