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Factors That Contribute to or Hinder Academic Productivity: Comparing two groups of most and least successful Olympians

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In the 1940s, Lewis Terman (1954a, 1954b) studied "life success" of 730 gifted men at the midpoint of their careers and found that success is associated with stability and absence of disturbing conflicts. In this article, we use retrospective data ($N = 624$) from the academic Olympians in 3 countries (USA, Germany, and Finland) to study factors that are responsible for actualizing the Olympian's talent. The results, analyzed in 3 age cohorts, support the findings of the original Terman study. In the youngest age cohort (16 – 22 years), we found that most of the females were in the A group. For the second (23 – 29 years) and third (30 – 54 years) age cohorts, the findings show that the Olympians in the A group have higher motivation than those in the C group. Results showed that a conducive home atmosphere promoted best Olympians' long-term academic productivity.

Introduction

Throughout much of the 20th century, a large-scale longitudinal study of more than 1,000 gifted individuals had been underway (Terman, 1925, 1954a, 1954b; Vialle, 1994). In the 1940s, Lewis Terman (1954a, 1954b) rated the "life success" of 730 men at the midpoint of their careers (25 years or older). He labeled the 150 most successful the "A" group and the 150 least successful the "C" group. After isolating

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these groups, comparisons were made about the attitudes, values, and developmental experiences that affected their success in life. The criterion of success was the extent to which a subject had made use of his superior intellectual ability. Terman doubted Lange-Eichbaum's theory (1932) claiming that great achievement usually stems from emotional tensions that border on the abnormal. Instead, he found that success is associated with stability and absence of disturbing conflicts. This finding was later supported in a follow-up study by Oden (1968), indicating that a supportive home and school atmosphere help gifted children become adults of superior vocational achievement, generally satisfied with themselves and their lives. The effects of early experience, particularly in terms of early educational advantage, seem to be one of the most important contributory factors in later adult achievement (Oden, 1968; Terman, 1925). Other key findings of the Terman study were as follows: (1) Average grades were equal until high school; (2) 97% of the A's entered college and 90% graduated; (3) 68% of the C's entered college and 37% graduated; (4) Half of the A group's fathers but only 15% of the C group's fathers were college graduates; (5) The estimated number of books in the A group homes was nearly 50% greater than in the C group homes.

The commonly held belief is that genius is born, not made. Howe (1999) is one of the researchers who argues that the exceptional talents of those we call geniuses are the result of a unique set of circumstances and opportunities. Furthermore, in every case, the talents are pursued and exploited with a characteristic drive, determination, and focus that the rest of us rarely show. All the geniuses in his study (Charles Darwin, George Eliot, George Stevenson, the Bronte sisters, Michael Faraday, and Albert Einstein) share human qualities that set them apart from other people. These qualities are ones of temperament and personality rather than being narrowly intellectual ones (Howe, 1999). The finding that assessments of a child's capacity to resist distractions and avoid impulsive actions are better predictors of later success than measures of early intelligence is consistent with this view (Goleman, 1995). Terman (1954a, 1954b) found that individuals who were identified as being unusually intelligent in childhood often did go on to have highly successful adult careers. This result seems to confirm the predictive value of intelligence testing. However, Howe argues that it was later demonstrated that, had the children been selected on the basis of their family backgrounds and school records, without paying any attention to their intelligence test scores, equally accurate predictions could have been made about their attainments in later life (Howe, 1999, pp. 199–200).

The A and C groups in Terman's study (1954b) shared equal intellectual capacities. However, the A group accomplished more than the C group in their adulthood. The group that accomplished more shares some personality qualities that are typical of geniuses. These qualities include doggedness, persistence, the capacity for fierce and sustained concentration, as well as intense curiosity. A number of geniuses, including Darwin and Einstein, disclaimed having superior inherent intelligence, but no genius has ever denied either possessing or relying upon a capacity for diligence or a healthy curiosity. In Howe's study (1999), all the geniuses had reached high standards by frequently and regularly practicing their talents over a

period of years. Practice and preparation are shown to be vital in all fields of achievement. For example, around 10 years of sustained training are needed for a chess player to reach international levels, and it takes comparable periods of time to reach the highest standards in mathematics and the sciences. Even in music, although it is widely believed that certain gifted individuals can excel without doing the lengthy practicing that ordinary people have to engage in, the evidence contradicts that view (Howe, 1999, p. 5).

In this paper, we use retrospective data from the academic Olympians in three countries (USA, Germany, and Finland) to answer the question, "What factors are responsible for actualizing the Olympian's talent?" We use the number of publications and software products produced by this international sample as a basis for isolating the most (A's) and least (C's) productive Olympians.

The Study

Sample

The sample for this study consists of 624 academic Olympians from the USA ($n = 239$, 38.3%), Germany ($n = 228$, 36.5%), and Finland ($n = 157$, 25.2%). The following types of Olympians are present in the sample: Mathematics Olympians ($n = 233$, 37.3%), Physics Olympians ($n = 198$, 31.7%), and Chemistry Olympians ($n = 193$, 30.9%). The country-specific samples were collected between 1996 – 2000 with paper-and-pencil questionnaires (for details, see Campbell, 1994, 1996).

The original Terman study (1954b) had only male participants, but, because the Olympians are open to both genders, female participants exist in this study. In addition, we wanted to investigate if gender would make a difference in the A or C group membership. As expected, most of the participants were males ($n = 583$, 93.4%), but the female sample was also representative ($n = 41$, 6.6%). The female sample was distributed as follows: USA, $n = 23$; Germany, $n = 8$; and Finland, $n = 10$.

The sample was divided into the following age cohorts: First age cohort of 16 – 22 years ("Young", $n = 115$, 18.4%), second age cohort of 23 – 29 years ("Middle age", $n = 255$, 40.9%), and third age cohort of 30 – 54 years ("Mature", $n = 254$, 40.7%). The division was made in order to investigate productivity in a young gifted population, because the original Terman study (1954b) findings were based on a sample consisting of 25-years-olds or older men (Table 1).

Indicators

Table 2 presents the 20 variables used in this study. Academic Olympian's country of origin (CTRY: USA, Germany, Finland), subject area (TYPE: Mathematics, Physics, Chemistry), and gender (GENDER: Male, Female) are the included categorical independent variables (IV). The 17 other indicators are dependent variables (DV).

Table 1. Representation of demographic data of the most (A's) and least (C's) productive academic Olympians by three age cohorts

	A's $n=142$			C's $n=166$			
	First 16–22 years $n=39$ n(%)	Second 23–29 years $n=50$ n(%)	Third 30–54 years $n=53$ n(%)	First 16–22 years $n=47$ n(%)	Second 23–29 years $n=62$ n(%)	Third 30–54 years $n=57$ n(%)	Total n[a]
Country							
USA	20(51.3)	33(66.0)	16(30.2)	18(38.3)	32(51.6)	17(29.8)	136[b]
Germany	16(41.0)	16(32.0)	17(32.1)	25(53.2)	16(25.8)	11(19.3)	101[b]
Finland	3(7.7)	1(2.0)	20(37.7)	4(8.5)	14(22.6)	29(50.9)	71[b]
Olympian Type							
Mathematics	8(20.5)	7(14.0)	20(37.7)	17(36.2)	22(35.5)	28(49.1)	102[c]
Physics	13(33.3)	17(34.0)	15(28.3)	14(29.8)	16(25.8)	15(26.3)	90[c]
Chemistry	18(46.2)	26(52.0)	18(34.0)	16(34.0)	24(38.7)	14(24.6)	116[c]
Gender							
Male	28(71.8)	46(92.0)	51(96.2)	45(95.7)	59(95.2)	54(94.7)	283[d]
Female	11(28.2)	4(8.0)	2(3.8)	2(4.3)	3(4.8)	3(5.3)	25[d]

[a] $N=624$.
[b] USA ($n=239$, 38.3%), Germany ($n=228$, 36.5%), and Finland ($n=157$, 25.2%).
[c] Mathematics ($n=233$, 37.3%), Physics ($n=198$, 31.7%), and Chemistry ($n=193$, 30.9%).
[d] Males ($n=583$, 93.4%), and females ($n=41$, 6.6%).

Table 2. Variables in the study

Variable	Description
CTRY	1 = USA, 2 = Germany, 3 = Finland
TYPE	1 = Mathematics, 2 = Physics, 3 = Chemistry
GENDER	1 = Male, 2 = Female
PUB_T	Academic Productivity Composite (publications, patents, software products)
AB_CO	High School Ability Composite (GPA, SAT, GRE, high school ranking)
SES	Socioeconomic Status (Nam & Powers, 1983)
COMP	Computer Literacy Composite (number of computer languages known and software products developed, self-report of computer literacy)
CC_PR	Pressure factor (incl. mother's and/or father's factors)
CC_SU	Support factor (incl. mother's and/or father's factors)
CC_HE	Help/Supervision factor (incl. mother's and/or father's factors)
CC_TG	Monitoring TV & Homework factor (incl. mother's and/or father's factors)
CC_RE	Reading Emphasis factor (incl. mother's and/or father's factors)
CC_FAIL	Lack of Motivation (Individual)
CC_AB	Importance of Ability (Global)
CC_PE	Performance Related to Effort (Individual)
CC_ES	Importance of Effort Needed for Success (Global)
SA	Olympians Conducive Home Atmosphere
PA	Parents Conducive Home Atmosphere
C_SHO	Olympians School Shortcomings
C_AFF	Olympians Negative Affect in School

The first four DV's are composite variables. Academic productivity (PUB_T) is a composite variable measuring the total number of publications, patents, and software products created by these Olympians. Academic ability (AB_CO) is a synthesis of the grade point average, standardized test scores (SAT, GRE), and the Olympian's high school ranking at graduation. Socioeconomic status (SES, see Nam & Powers, 1983) utilizes five variables including mother's and father's occupational status, mother's and father's educational level of schooling, and family income. Computer literacy (COMP) synthesizes the Olympian's computer use reports, the number of computer languages used, the number of software products developed, and a self-reported estimation of their computer literacy.

The rest of the DV's presented in Table 2, namely 13 variables, are components produced in the Principal Components Analysis (PCA). For further information, see Campbell and Verna (2004) for the mothers' and fathers' perceived reports of pressure, support, help/supervision, monitoring, and reading emphasis factors (CC_PR, CC_SU, CC_HE, CC_TG, CC_RE) and Campbell, Heller, and Feng (2004) for the attribution factors (CC_FAIL, CC_AB, CC_PE, CC_ES).

The Conducive Home factors (SA, PA) were derived from 12–14 family/school items related to the academic atmosphere of the home (for details, see Campbell, 1994, 1996). The first conducive factor was derived from the parents' reports (PA) and the second was derived from the Olympians' reports (SA). It must be pointed out

that the items from both sources did not factor together as a single Conducive Home factor. The parents' report of their home academic atmosphere was different than the Olympians' reports. It must also be pointed out that these factors were not statistically dependent on the parental pressure, support, help, monitoring, or reading emphasis factors.

Two school-related factors (C_SHO, C_AFF) were derived from 11–13 items dealing with hindrances that the Olympians reported (for details, see Campbell, 1994, 1996). One factor (C_SHO) summarizes the shortcomings of the schools, and the other (C_AFF) deals with the negative affect experienced by the Olympians during their elementary and secondary school years.

We isolated the most (the A's, $n = 142$) and the least (the C's, $n = 166$) productive Olympians. The group sizes were determined on the basis of the original Terman study (1954b). We used Academic Productivity (variable PUB_T) and the standardized High School Ability Composite variable (AB_CO) to adjust cut-off points for the A or C group membership (Figure 1).

Figure 1 shows how aforementioned cut-off points for Academic Productivity and Ability composite variables classified Olympians into A and C groups. The upper part of the figure presents Academic Ability variance for both the A's within the total sample ($n = 624$, $Me = 1.3$, $-2.6 - 6.5$) and three age cohorts (Cohort 1, $n = 115$, $Me = 1.6$, $-2.6 - 6.5$; Cohort 2, $n = 255$, $Me = 1.4$, $-1.5 - 6.4$; Cohort 3, $n = 254$, $Me = 0.8$, $-1.1 - 3.8$) and C's within the total sample ($n = 624$, $Me = -0.4$, $-2.6 - 0.0$) and three age cohorts (Cohort 1, $n = 115$, $Me = -0.4$, $-2.3 - 0.0$; Cohort 2, $n = 255$, $Me = -0.4$, $-2.3 - -0.1$; Cohort 3, $n = 254$, $Me = -0.4$, $-2.6 - 0.0$). The lower part of Figure 1 presents Academic productivity variance for both the A's within the total sample ($n = 624$, $Me = 18$, $0 - 1500$) and three age cohorts (Cohort 1, $n = 115$, $Me = 0$, $0 - 115$; Cohort 2, $n = 255$, $Me = 12$, $0 - 302$; Cohort 3, $n = 254$, $Me = 164$, $0 - 1500$) and C's within the total sample ($n = 624$, $Me = 0$, $0 - 20$) and three age cohorts (Cohort 1, $n = 115$, $Me = 0$, $0 - 20$; Cohort 2, $n = 255$, $Me = 0$, zero variance; Cohort 3, $n = 254$, $Me = 5$, $0 - 18$).

Design

Figure 2 presents the measurement design of the study. Demographic and other variables are on the left-hand side in the figure. A total number of 308 Olympians out of 624 (49.4%) were selected to represent high (A's, $n = 142$) and low (C's, $n = 166$) academic productivity. Both groups were further divided into three age cohorts (16–22 years, $n = 86$; 23–29 years, $n = 112$; 30–54 years, $n = 110$) for more specific analyses. The right-hand side of Figure 2 presents the statistical techniques applied in this study (Figure 2).

Statistical Procedure

In this study, we apply nonparametric statistical techniques instead of parametric ones (e.g., Pearson product moment correlation, Student's *t* test, linear discriminant

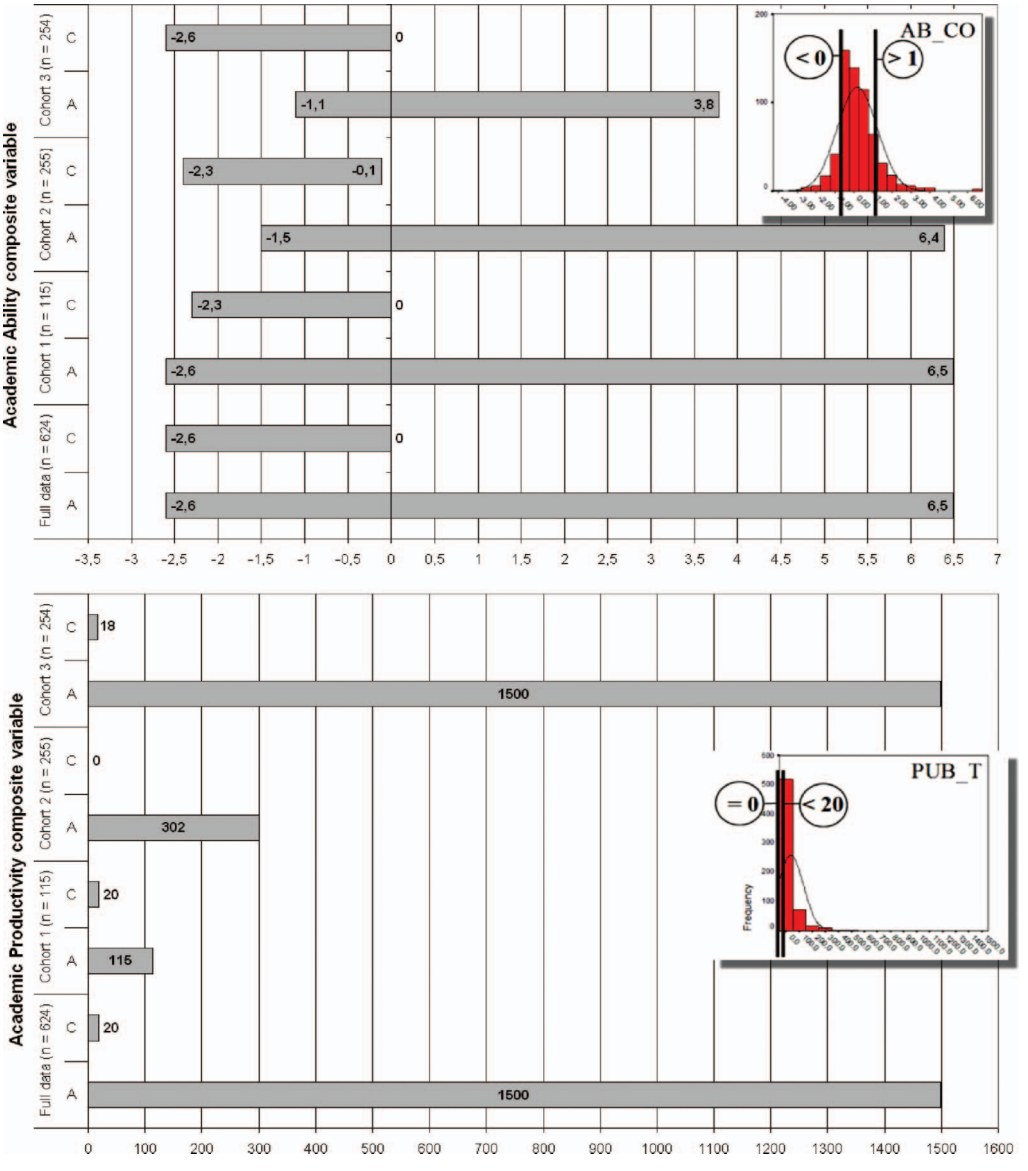

Figure 1. Cut-off points of the Academic Productivity (PUB_T) and the High School Ability Composite (AB_CO) variables

analysis) as our indicators (see Table 2 for details) are neither continuous nor normally distributed. Nonparametric techniques allow discrete, ordinal, and non-normal indicators (Nokelainen, Silander, Ruohotie, & Tirri, in press).

In the following results section, we first present the overall summary of the findings for the total sample and then proceed to analyze the differences between the A and C groups according to the demographic and dependent variables in three phases. In the

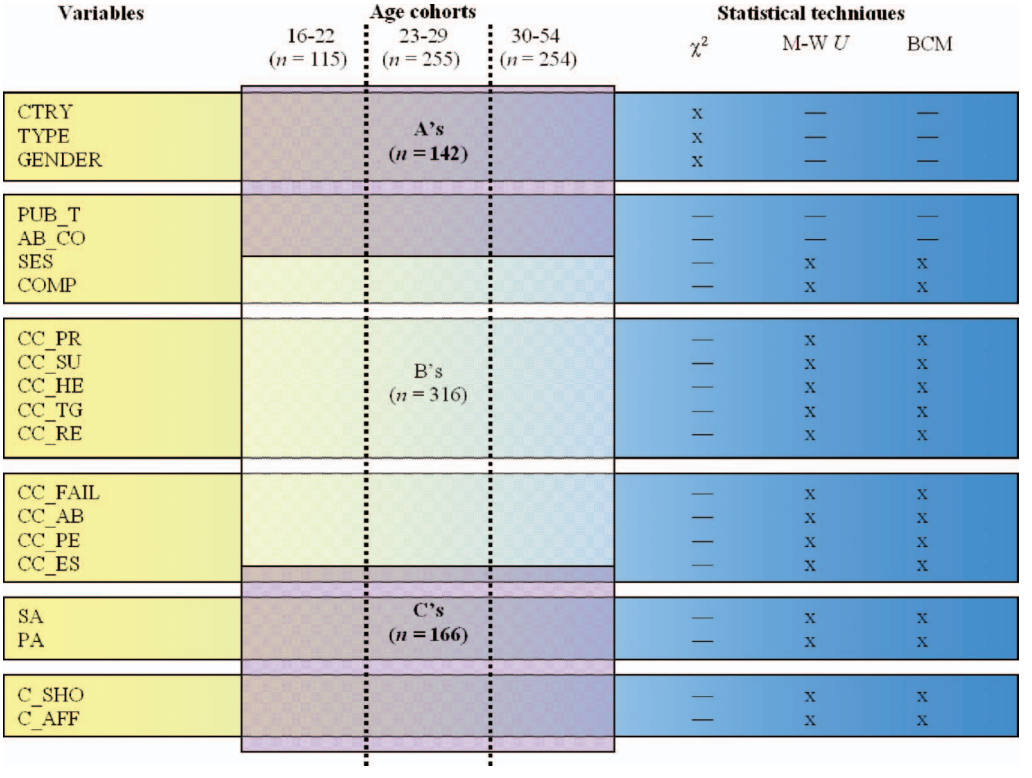

Figure 2. The design of the study

first phase, demographic differences (country of origin, area of interest, and gender) within age cohorts are analyzed with cross tabulation and χ^2 test. The second phase of the analysis involves examination of the cohort-specific differences between DV's (school- and home-related factors, attributions) with the Mann-Whitney U test. The third phase describes the best predictors for the A and C group memberships, amongst all 20 indicators, with a sophisticated discriminant analysis technique, Bayesian classification modeling (Nokelainen & Tirri, 2004; Silander & Tirri, 1999).

When performing k multiple independent significance tests each at the alpha (α) level, the probability of making at least one Type I error, the error of incorrectly declaring a relationship to be true due to chance producing the observed state of events, is $1 - (1 - \alpha)^k$. For the mothers' and fathers' perceived reports of pressure, support, help/supervision, monitoring, and reading emphasis factors (see Table 2), with $k = 5$ and $\alpha = .05$, the effective group-wise Type I error rate is actually 22.6% ($1 - (.95)^5 = .226$) instead of 5% ($1 - (.95)^1 = .05$). To compensate this, we applied the Bonferroni correction (Miller, 1981, pp. 6–8) for the alpha level by dividing the test-wise significance level by the number of tests: $\alpha_\beta = \alpha/k$. For the aforementioned parental scale $\alpha_{\beta\_parental}$ is 0.01 (alpha level of 0.05 divided by the number of items in

the scale; five), and for the attribution scale (items CC_FAIL, CC_AB, CC_PE, CC_ES; see Table 2 for details) $\alpha_{\beta\_attribution}$ is .013. It follows, for example, that if we apply a significance level of .01 to each of the five tests in the parental scale, there is now only a 5% chance that any of them will be declared significant under the null hypothesis. We acknowledge that MANOVA has certain advantages over univariate tests, such as the Mann-Whitney U test (e.g., multiple DV's increase chance of finding effect and protection against Type I error rate inflation). However, in this study we prefer to use solely nonparametric methods, as we have ordinal indicators that are not guaranteed to have univariate and, thus, multivariate normal distribution.

Results

The results of nonparametric mean rank comparison (full sample, $n = 624$) of the most (A's) and least (C's) productive academic Olympians by the 15 predictor variables are presented in Table 3. The results regarding Olympian's computer literacy, interpreted with the aforementioned Bonferroni correction, show that the

Table 3. The results of nonparametric mean rank comparison of the most (A's) and least (C's) productive academic Olympians by the 15 predictor variables

		A's $n = 142$ *M*(*SD*)	C's $n = 166$ *M*(*SD*)	*U*(*p*)
SES	Socioeconomic Status[a]	67.9(19.862)	67.1(24.608)	11451.0(.667)
COMP	Computer Literacy Composite[b]	4.8(1.852)	4.2(1.786)	7206.5(.004)
CC_PR	Pressure[c]	1.8(0.518)	1.9(0.477)	3821.5(.141)
CC_SU	Support[c]	3.4(0.719)	3.5(0.685)	4237.0(.613)
CC_HE	Help/Supervision[c]	2.7(0.808)	2.5(0.711)	3761.5(.113)
CC_TG	Monitoring TV & Homework[c]	2.4(0.871)	2.3(0.728)	4074.0(.619)
CC_RE	Reading Emphasis[c]	3.3(0.857)	3.3(0.824)	4275.0(.878)
CC_FAIL	Lack of Motivation	2.9(0.667)	3.1(0.625)	6312.0(.001)
CC_AB	Importance of Ability	3.3(0.734)	3.4(0.592)	8063.5(.706)
CC_PE	Performance Related to Effort	3.2(0.786)	3.2(0.661)	7962.5(.825)
CC_ES	Effort Needed for Success	3.1(0.752)	3.0(0.737)	7619.5(.420)
SA	Olympians Conducive Home Atmosphere	2.9(0.935)	2.5(0.922)	6836.5(<.001)
PA	Parents Conducive Home Atmosphere	3.4(0.714)	3.3(0.763)	6207.0(.521)
C_SHO	Olympians School Shortcomings	2.3(0.974)	2.2(1.001)	8123.5(.626)
C_AFF	Olympians Negative Affect in School	1.7(0.905)	1.5(0.891)	6547.5(.046)

[a]Nam & Powers, 1983.
[b]Computer use reports, the number of computer languages used and software products developed and self-evaluation of computer literacy.
[c]Including mother's and/or father's factors.

members of the A group have reported a higher skill level than C group members, $U(1, n = 624) = 7206.5$, $p = .004$. Further, members of the A group reported a clearly higher level of motivation, $U(1, n = 624) = 6312.0$, $p = .001$, and a conducive home atmosphere, $U(1, n = 624) = 6836.5$, $p < .001$. They had also experienced more negative affect in school than their lower productive peers, $U(1, n = 624) = 6547.5$, $p = .046$.

First Age Cohort (16–22 years, n = 115)

The first age cohort, ''the young Olympians'' ($n = 151$), had 99 male (86.1%) and 16 female (13.9%) participants. The country of origin was distributed in this age cohort as follows: USA ($n = 47$, 40.9%), Germany ($n = 61$, 53.0%), and Finland ($n = 7$, 6.1%). The Olympian types were represented as follows: Mathematics ($n = 33$, 28.7%), Physics ($n = 37$, 32.2%), and Chemistry ($n = 45$, 39.1%).

Differences between the IV's (demographic variables in the study: Olympians' country of origin, area of interest, and gender) within the youngest age cohort were analyzed with cross tabulation and χ^2 test. Investigation of the contingency table showed that female Olympians were more likely to be members of the most productive A group ($n = 11$) than the least productive C group ($n = 3$) in this youngest cohort. The Chi square test indicated that the finding was statistically significant, $\chi^2(1) = 9.528$, $p = .002$.

Cohort-specific differences between DV's (school- and home-related factors, attributions, see Table 2 for details) were analyzed with the Mann-Whitney U test. The results showed that the A's had better self-rated computer literacy skills than the C's, $U(1, n = 115) = 471.500$, $p = .014$.

The results of Bayesian classification modeling showed that the estimated classification accuracy of the best model found was 60%. The left-hand side of Figure 3 shows that only three variables, Olympians Conducive Home Atmosphere (SA), Olympians School Shortcomings (C_SHO), and Computer literacy composite (COMP), were successful predictors for the A or C group membership. All the other variables that were not accepted in the model are to be considered as connective factors between the two groups. The middle section of Figure 3 shows that the two strongest predictors were Olympians Conducive Home Atmosphere (20.9%) and Olympians School Shortcomings (22.6%). The confusion matrix shows that most of the A (25 correct out of 39) and the C (29 out of 47) group members were correctly classified. The matrix also shows that nine participants of the group A were incorrectly classified into group C and vice versa.

Figure 4 presents predictive modeling of the A and C groups (''A_C'', A or C group membership) by Olympians Conducive Home Atmosphere (SA), Olympians School Shortcomings (C_SHO), and Computer Literacy Composite (COMP). The left-hand side of the figure presents the initial model with no values fixed. The model in the middle presents a scenario where all the A group members are selected. When we compare this model to the one on the right-hand side (i.e., presenting a situation where all the C group members are selected), we notice, for example, that conditional

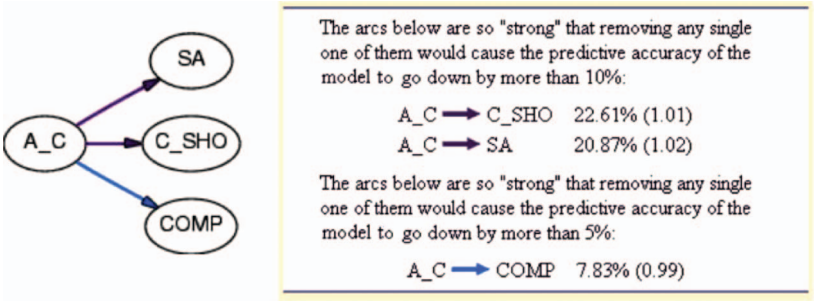

Figure 3. Results of Bayesian classification modeling of the first age cohort (16–22 years)

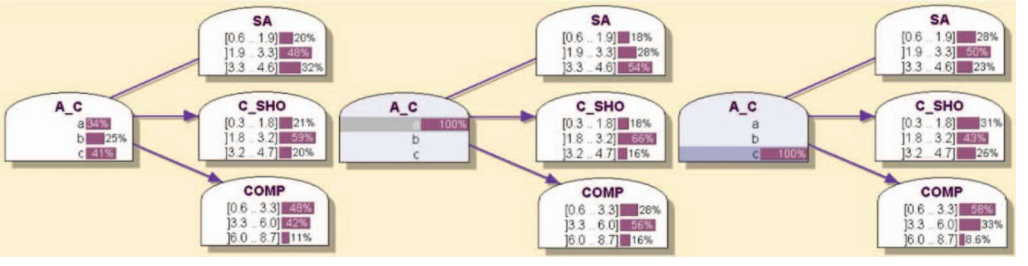

Figure 4. Predictive modeling of A's and C's by Olympians Conducive Home Atmosphere (SA), Olympians School Shortcomings (C_SHO), and Computer Literacy Composite (COMP)

distribution of the Olympians Conducive Home Atmosphere (SA) has changed. It shows that highly productive Olympians have reported more Conducive home atmosphere (54.0%) than the members of the low productivity group C (23.0%). This finding is also supported by the nonparametric mean rank comparison, although the result is not statistically significant, $U = 608.000$, $p = .091$. Figure 4 shows that the members of group A have at least modest (56.0%) or high (16.0%) self-reported computer literacy, and most members of group C have low (58.0%) or modest (33.0%) computer literacy.

Second Age Cohort (23–29 years, n = 255)

The second age cohort, "the middle age Olympians" ($n = 255$), had 241 male (94.5%) and 14 female (5.5%) participants. The country of origin was distributed in this age cohort as follows: USA ($n = 117$, 45.9%), Germany ($n = 92$, 36.1%), and Finland ($n = 46$, 18.0%). The Olympian types were represented as follows: Mathematics ($n = 79$, 31.0%), Physics ($n = 90$, 35.3%), and Chemistry ($n = 86$, 33.7%).

The results of the Chi square test showed that 93.3% of the Finnish Olympians were in the low productive C group, $\chi^2(2) = 10.112$, $p = .006$. Seventy-six percent of

the Mathematics Olympians were also members of the same low productive group, $\chi^2(2) = 6.660$, $p = .036$.

The results of the Mann-Whitney U test showed that home atmosphere was more conducive in the high productive A group than it was in the low productive C group, $U = 498.500$, $p < .001$. The A's had better computer literacy skills than the C's, $U(1,\ n = 255) = 796.000$, $p = .029$. C's had lower levels of motivation than A's, $U(1,\ n = 255) = 630.500$, $p = .020$.

The estimated classification accuracy of the best Bayesian classification model found was 62.4%. The left-hand side of Figure 5 shows that the following seven variables were successful predictors (i.e., discriminating factors) for the A or C group membership: (1) Country (1 = USA, 2 = Germany, 3 = Finland, CTRY); (2) Type of Olympians (1 = Mathematics, 2 = Physics, 3 = Chemistry, TYPE); (3) Support factor, including mother's and/or father's factors (CC_SU); (4) Olympians Conducive Home Atmosphere (SA); (5) Parents Conducive Home Atmosphere (PA); (6) Lack of Motivation (C_FAIL); (7) Computer Literacy Composite (COMP).

The middle section of Figure 5 shows that the three strongest predictors for group membership were Country (7.8%); Support factor including mother's and/or father's factors (6.7%); and Parents Conducive Home Atmosphere (5.9%). The confusion matrix shows that it was easier to classify members of group A (22 correct out of 50) than members of group C (17 out of 62).

Figure 6 presents predictive modeling of A and C groups by seven predictor variables. Comparison of the models shows that when the class variable (''A_C'', A or C group membership) is fixed to the A, most of the members of that group are U.S. and German chemistry and physics Olympians. The results also show that both

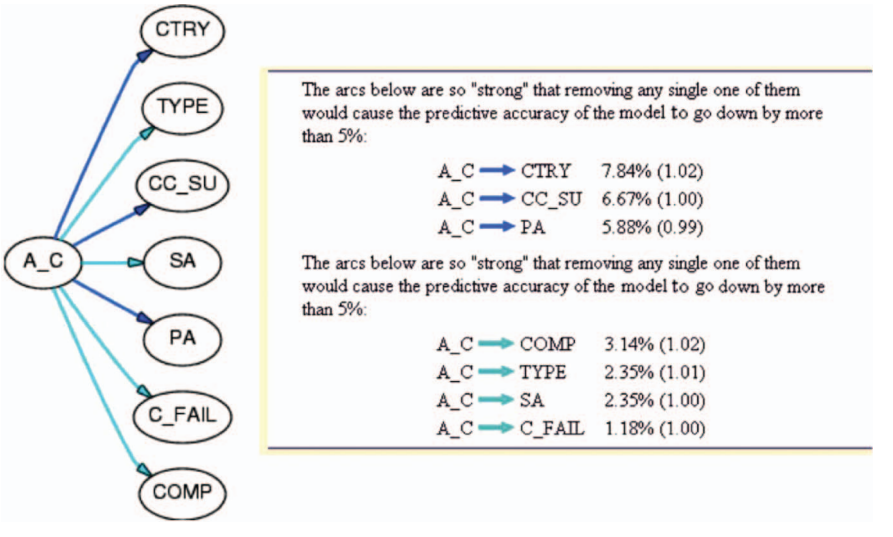

Figure 5. Results of Bayesian classification modeling of the second age cohort (23 – 29 years)

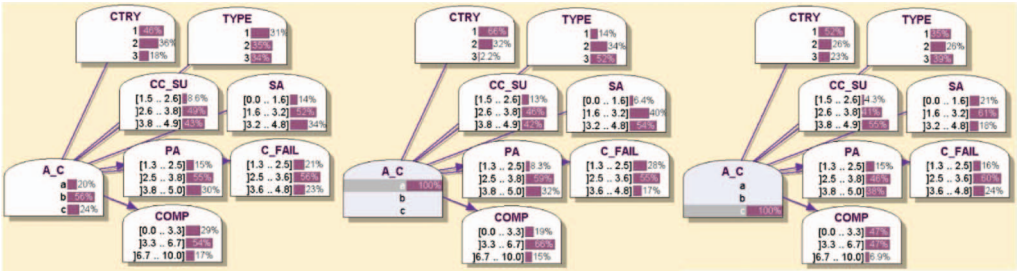

Figure 6. Predictive modeling of A's and C's by seven predictor variables

Olympians Conducive Home Atmosphere (SA) and Parental Conducive Home Atmosphere (PA) have higher values in the A than in the C group. Members of group A have high computer skills and no lack of motivation.

When we fix the class variable to C, most group members are U.S., Germany, and Finland chemistry and math Olympians. Olympians in this group have higher support factor (CC_SU) than the A's, but the difference is quite small. Members of the C group have lower levels of motivation (C_FAI) and computer skills (COMP).

Third Age Cohort (30–54 years, n = 254)

The third age cohort, ''the mature Olympians'' ($n = 254$), had 243 male (95.7%) and 11 female (4.3%) participants. The country of origin was distributed in this age cohort as follows: USA ($n = 75$, 29.5%), Germany ($n = 75$, 29.5%), and Finland ($n = 104$, 40.9%). The Olympian types were represented as follows: Mathematics ($n = 121$, 47.6%), Physics ($n = 71$, 28.0%), and Chemistry ($n = 62$, 24.4%).

The results of the nonparametric mean rank comparison showed that the C's were less motivated than the A's, $U(1, n = 254) = 855.000$, $p = .014$.

The estimated classification accuracy of the best classification model found was 58.7%. The left-hand side of Figure 7 shows that four variables, Country (1 = USA, 2 = Germany, 3 = Finland, CTRY), Help and Supervision (CC_HE), Olympians Conducive Home Atmosphere (SA), and Importance of Ability (CC_AB) were the best predictors for the A or C group membership. The middle section of Figure 7 shows that the strongest predictor for the group membership was Importance of Ability (CC_AB, 4.7%). The confusion matrix shows that it was impossible to classify members of group A (0 correct out of 53). The model also had great difficulties classifying the members of group C because only 8 out of 57 were correctly classified.

Predictive modeling presented in Figure 8 shows only minor differences between A's and C's. This is mostly due to weak classification performance. When the class is fixed to the A group, the help and supervision factor, including mother's and/or father's factors (CC_HE), and Olympians Conducive Home Atmosphere (SA) have slightly higher values for the A than for the C group.

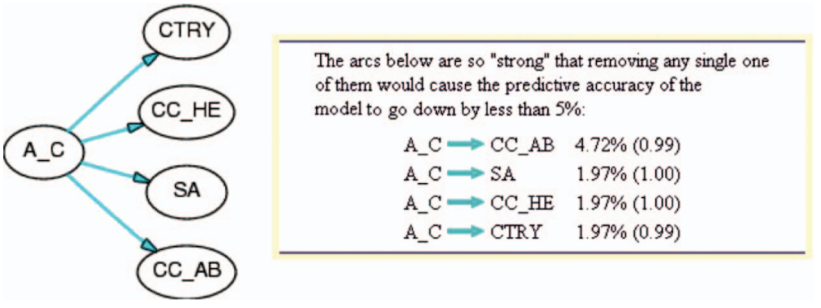

Figure 7. Results of Bayesian classification modeling of the third age cohort (30 – 54 years)

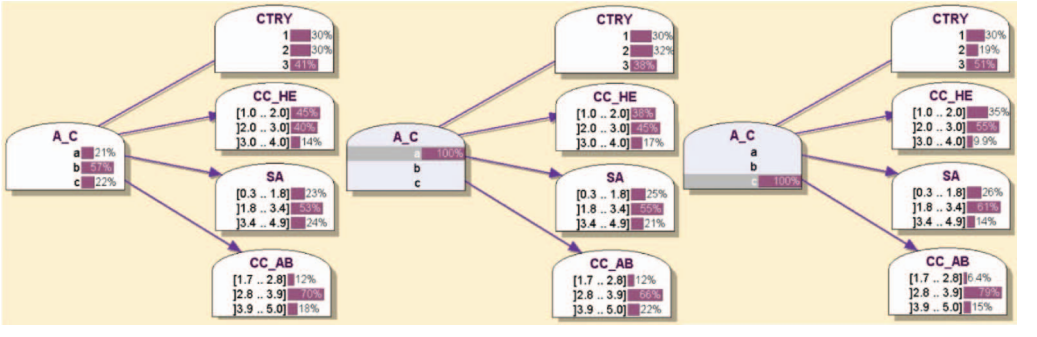

Figure 8. Predictive modeling of A's and C's by Country (CTRY), Help and Supervision (CC_HE), Olympians Conducive Home Atmosphere (SA), and Importance of Ability (CC_AB)

Conclusions

The intent of the original Terman study (1954b) was to examine two groups of equally talented men and tease out the factors that were different for the most and least successful. In other words, accounting for ability, what differences separate the two groups? For our study, we started with the same premise. Our objective was to isolate the factors that account for productivity (publishing) among the most and least successful Olympians. But we must remind the reader that our *design* differs from the original Terman study. Terman collected longitudinal data over decades and synthesized these data for the A's versus C's study, whereas our data are retrospective. We asked the Olympians and their parents to think back to the developing years. Terman had many more variables to analyze. But instruments used in the 1920s and 1930s did not possess the psychometric qualities that are possible today. Consequently, the factors that we use are much more reliable and replicable.

We conclude that these results support the findings of the original Terman study (1954b). Of course, both studies started with exceptionally gifted people, but we had no trained judges (like Terman), and our "evidence" is based on Olympians' reports

of publications. However, we think that the basic idea of comparison was captured in this study satisfactorily.

One of the main findings is that in the A group of the youngest Olympian cohort there are 11 women (out of 14 women in the cohort). This result was opposite in the two other cohorts (cohort 2: 4 of 11 and cohort 3: 2 of 6). Terman (1954b) also reported that the A group was more motivated, and we came up with the same result for the A groups in all three cohorts.

The overall results showed that the members of the A group had clearly a higher level of motivation, and they have had a more conducive home atmosphere in their past than their less productive peers.

First Age Cohort (16–22 years, n = 115)

- Gender equity – most women were members of the A group.
- A's had better computer literacy skills than C's.
- The Bayesian classification model with 60% classification accuracy showed that:
  - Olympians with high levels of conducive home atmosphere predicted the A group membership.
  - Olympians with high computer literacy predicted the A group membership.
  - Olympians with both high and low reports of school shortcomings predicted the C group membership.

Second Age Cohort (23–29 years, n = 255)

- A's had a more conducive home atmosphere than C's.
- A's had better computer literacy skills.
- C's lacked motivation.
- The C group contained an overrepresentation of Mathematics Olympians.
- The C group had more Finnish Olympians because in Finland it usually takes more time to graduate than in the USA and Germany.
- The Bayesian classification model with 62% classification accuracy showed that:
  - A's had higher motivation than C's.
  - Most of the A's are U.S. and German chemistry and physics Olympians.
  - A's have more conducive home atmospheres.
  - Olympian parents report higher levels of conducive home atmospheres in the A group.
  - A's had higher computer literacy skills than C's.
  - C's had slightly more supportive families than A's.

Third Age Cohort (30–54 years, n = 254)

- C's lacked motivation.
- The Bayesian classification model with 59% classification accuracy showed that:
  - A's had higher motivation than C's;

- the help and supervision factor, including mother's and/or father's factors, is slightly higher for the A group;
- Olympians with more conducive home atmospheres had slightly higher values in the A group.

The findings from the last cohort are less clear, but the results emphasized above are important. For all three Olympian cohorts, the A groups had better motivation. It is surprising to still find that a conducive home atmosphere contributes to the Olympians productivity even during their middle age years. Furthermore, those parents that provided closer supervision during the school years obviously helped the Olympians to establish better work habits that continue to yield benefits even decades later in their lives.

Discussion

Our research group conducted a series of gender studies with the academic Olympians and found that traditional stereotypes and attitudes undermine gender equity (Campbell, 2002; Cho & Lee, 2002; Feng, Campbell, & Verna, 2002; Lengfelder & Heller, 2002; O'Connor, 2002; Tirri, 2002; Verna & Feng, 2002). Therefore, to find that most of the females in the first cohort are in the A group is an encouraging finding. This result shows that gender equity in technical areas may finally be changing for women.

A related finding concerns the fact that the most productive Olympians in this cohort had high levels of computer literacy (both males and females). This finding makes sense because computer programs have become more central for researchers. Furthermore, computer skills are needed in writing manuscripts and submitting them to publishers and journals. Everything in the publishing industry is increasingly computerized. Consequently, those with higher computer literacy would have an advantage. In an earlier study of all of the American Math Olympians, we found that those who spent the most time with computers had lower GPA (Campbell, 1997). With a better-constructed latent variable (COMP), we are now able to derive more accurate results.

The Olympians that were more productive reported having higher levels of Conducive Home Atmospheres during their formative years. This finding holds true for all three cohorts. This factor summarizes 10 items about the academic atmosphere of the family. Some of these items deal with the family's literacy and others are concerned with the mother's and the father's recognition and encouragement. In the youngest cohort, the Olympians reporting schools with the most severe shortcomings are in the C group. Therefore, the schools that presented obstacles to the Olympians sabotaged their long-term productivity.

For the second Olympian cohort, one important set of findings concerns the motivational attribution factors. The Olympians in the A group have higher motivation (C_FAIL) than those in the C group. The same finding occurs in the third Olympian cohort.

Again, those Olympians coming from homes with a more Conducive atmosphere and those who acquired higher computer literacy were the most productive. For this cohort, reports from both parents and Olympians describing conducive home atmosphere are found in the A group. One related finding concerns the fact that in the C group the parents report supplying more support to their child when he/she was growing up. It could be that this support undermines the Olympians' motivation and their willingness to persevere when things get tough later in their careers.

One finding that puzzled us was the overrepresentation of Mathematics Olympians in the less productive group. It seems that the field of mathematics requires fewer publications, or in mathematics it is more important to publish a weighty work.

The one clear implication from this study is that parents need to supply a Conducive home atmosphere that will promote academic achievement. The fact that this factor emerges again and again for each cohort is striking. It is even more important to recognize that child-rearing practices used by effective parents pay dividends when their children grow up. Such parents were able to encourage the Olympians to develop functioning attitudes and work habits that are still in operation 20 or 30 years later.

The topic of this paper is strongly related to the Olympians' careers. Thus, developmental models (e.g., Heller & Perleth, 2004) have an obvious application to the A's versus C's study.

Finally, we would like to mention that this study employed only instruments that were constructed with qualitative and quantitative cross-cultural methods (Campbell, 1994, 1996). The results are therefore more replicable than other cross-national studies where mostly American instruments are used or where one-item constructs are used.

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