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Work Complexity and Cognitive Functioning at Midlife: Cross-Validating the Kohn-Schooler Hypothesis in an American Cohort

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CDE Working Paper No. 2007-08

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Rev. November 1, 2007

* The research reported herein was supported by the National Institute on Aging (R01 AG-9775 and P01-AG21079), by the William Vilas Estate Trust, and by the Graduate School of the University of Wisconsin-Madison. We thank Melvin Kohn and Carmi Schooler for helpful comments. The opinions expressed herein are those of the authors.
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Abstract

In an influential body of work extending across more than three decades and drawing on data from the United States, Poland, Japan, and the Ukraine, Melvin Kohn, Carmi Schooler, and their associates have found that cognitive capacities are affected by experiences on the job, specifically that working at a complex job improves cognitive functioning. These findings anticipate and parallel recent research on the relationships among social integration, leisure-time activities, and cognitive functioning among the elderly. This paper tests the Kohn-Schooler hypothesis using different measures, models, and data. Specifically, we estimate models of the reciprocal influence of work complexity and cognitive functioning at ages 53-54 among women and men who graduated from Wisconsin high schools in 1957. Even when adolescent academic ability test scores and high school rank have been controlled, we find moderate effects of the complexity of work on abstract reasoning ability at ages 53-54, and these effects are robust to reasonable assumptions about the unreliability of measurement of adolescent academic ability. Moreover, the effects of work complexity on abstract reasoning ability are virtually the same among women and men.

Recent scientific findings highlight the possible influence of work, leisure activities, and social support on cognitive functioning at midlife and beyond (Bassuk et al. 1999; Schooler et al. 1999; Friedland et al. 2001, pp. 127-31; Schooler and Mulatu 2001; Wilson et al. 2002a; Wilson et al. 2002b; Fratiglioni et al. 2004; Schooler et al. 2004). These findings are very widely cited,[1] and some have been cross-validated. They suggest potential lines of intervention to improve quality of life and reduce dependency among the elderly (Kawachi and Berkman 2001; Fillit et al. 2002; Pope et al. 2003; Fratiglioni et al. 2004; Valenzuela and Sachdev 2005; Rundek and Bennett 2006). However, many of these studies are based on short-term observations, use small or homogeneous samples, or focus separately on the several potentially influential social contexts or activities (Aartsen et al. 2002). General cognitive functioning is studied without specific reference to dementia, and *vice versa*. Some previous studies provide weak or unreliable controls for baseline cognitive functioning in adulthood, and almost none control cognitive functioning early in life (but one outstanding exception is Fritch et al. (2005)).

To date, there has been no comprehensive account of relationships among cognitive functioning and the conditions of social and intellectual engagement across the life course in a large and representative sample. Especially because of its measures of cognitive ability and academic performance[2] in adolescence and its parallel measurements on siblings, the Wisconsin Longitudinal Study (WLS) has a comparative advantage in testing and extending research on the lifelong social and environmental sources of cognitive functioning.[3] Moreover, excepting the work of Kohn, Schooler, and their colleagues, previous studies have largely ignored reciprocal

[1] We count more than 600 citations to these seven key studies. However, most cite the finding to support an assertion, not to motivate additional research about the finding. One notable exception is Salthouse's (2006, p.77) critical appraisal of Schooler's work.

[2] Academic performance (rank in high school class, courses taken in high school) is a key construct here because it includes a strong motivational and organizational component as well as intellectual functioning *per se*.

[3] See Alwin's (1993a) critique of Kohn and Slomczynski's (1990) work for failing to include an early measure of cognitive functioning, and note the importance of an adolescent cognitive assessment in Snowdon's path-breaking Nun Study (1996; 2001).

relationships between social contexts or activities and cognitive functioning. That is, they have focused on effects of contexts and activities, but ignored the influence of cognitive functioning on the location, structure, and content of social contexts and activities. Thus, much of the available evidence about relationships between social contexts or activities and cognitive functioning may be of no more than descriptive significance (National Research Council 2000: 26-29, 32-35).

Data from the WLS provide an unusual opportunity to assess key findings in a long line of American and comparative research, which has examined a broad array of interactions between social activities and psychological characteristics. Estimation of reciprocal effects of job conditions and the cognitive functioning of adults has been an especially notable feature of this work (Kohn and Schooler 1973; 1978; 1982; 1983; Kohn et al. 1990; Kohn and Slomczynski 1990; Kohn 2006). Briefly, Kohn and associates observe that jobs differing in complexity and self-direction select (require or attract) incumbents with differing levels of cognitive functioning. Over time, however, job conditions also lead to changes in "intellectual flexibility" or "cognitive functioning," terms preferred by Kohn and his associates to "ability" on the grounds that the latter term refers to an innate and inherently immeasurable trait.[4] Intellectual flexibility, they have argued, is not the same as general cognitive ability. However, in a study of older American workers, Schooler et al. (1999, pp. 483, 491) find that "it is highly correlated with more standard measures of intellectual functioning" as specified by Schaie et al. (1998).

One can trace anticipations of Kohn and Schooler's ideas at least as far back as Adam Smith (Smith 1776):

[4] We thank Melvin Kohn (personal communication) for clarifying his intention. However, in contemporary psychometric usage, "ability" refers to whatever an assessment measures, regardless of its source or content.

> “The difference of natural talents in different men is, in reality, much less than we are aware of; and the very different genius which appears to distinguish men of different professions, when grown up to maturity, is not upon many occasions so much the cause, as the effect of the division of labour. The difference between the most dissimilar characters, between a philosopher and a common street porter, for example, seems to arise not so much from nature, as from habit, custom, and education. ... But the understandings of the greater part of men are necessarily formed by their ordinary employments. The man whose whole life is spent in performing a few simple operations, of which the effects, too, are perhaps always the same, or very nearly the same, has no occasion to exert his understanding, or to exercise his invention, in finding out expedients for removing difficulties which never occur. He naturally loses, therefore, the habit of such exertion, and generally becomes as stupid and ignorant as it is possible for a human creature to become. The torpor of his mind renders him not only incapable of relishing or bearing a part in any rational conversation, but of conceiving any generous, noble, or tender sentiment, and consequently of forming any just judgment concerning many even of the ordinary duties of private life.”

Despite the wide recognition that Kohn and Schooler’s work has received (Kohn 1987), questions remain about its validity and generality. Observers have found it difficult to distinguish between the measure of intellectual flexibility and general cognitive ability. “Reciprocal causation” has had different empirical referents—cross-lagged effects, simultaneous effects, or both. Kohn and Schooler (1978, p. 40) write, “A reciprocal relationship can occur contemporaneously (albeit not necessarily instantaneously) or more gradually over time” (also, Kohn and Slomczynski (1990, pp. 127-31)). Alwin (1993a; 1993b) has criticized this line of research for ignoring the age and job-tenure of research participants. However, one earlier and two later studies have contrasted age groups (Miller et al. 1985; Schooler and Mulatu 2001; Schooler et al. 2004). The puzzling finding here is that learning generalization—the effect of job conditions on cognitive functioning—appears to be at least as large at older as at younger ages, which would appear to be inconsistent with the received knowledge that socialization occurs mainly at younger ages. To our knowledge, the theory has not been tested in the U.S. except in Kohn and associates' own data, only parts of which have been made public. Moreover, the supportive findings diverge from the reigning psychological position on the relative stability of general abilities throughout midlife (Alwin 1994).

The WLS provides not just the opportunity for an independent examination of this theory, but one with a distinct and important methodological improvement. No study to date has controlled a general measure of cognitive ability in youth or early adulthood and rank in high school class, which the WLS contains in addition to extensive occupational information throughout the life course.

A Model of Work Complexity and Cognitive Functioning

Figure 1 shows a schematic path diagram of the evolution of the conditions of work across the life course, fashioned after Schooler et al. (1999), but referring to measures ascertained in the Wisconsin Longitudinal Study. The essential idea in the model is that there are reciprocal effects between levels of cognitive functioning and a key job characteristic – substantive complexity. Both of those measures have been ascertained at three times for working WLS graduates and their randomly selected siblings (in 1975/7, 1993/4, and 2003/6).

With reference to the relationship between job conditions and cognitive functioning –

"intellectual flexibility" in their lexicon – Kohn and Schooler (1978, p. 26) write, "intellectual flexibility obviously affects recruitment into substantively complex jobs … We should empirically test the possibility that intellectual flexibility may be responsive to the experiences of adult life." The problem here is to write a set of equations that are statistically identified, so the reciprocal effects (selection into more or less complex jobs and social learning within those jobs) can be estimated (Duncan 1975; Kohn and Slomczynski 1990, pp. 127-131).[5] The scheme in Figure 1 provides one such specification, by *assuming* the absence of cross-lagged effects of job complexity and of cognitive functioning.[6]

Let ξ_1 and ξ_3 stand for the vectors of early occupational characteristics and of early psychological variables, while ξ_2 stands for other exogenous variables. Let η_1 and η_2 be job conditions and cognitive functioning in 1993 and η_3 and η_4 be job conditions and cognitive functioning in 2004. Then, the model of Figure 1 specifies:

$$\eta_1 = \gamma_{11}\xi_1 + \gamma_{12}\xi_2 + \beta_{12}\eta_2 + \zeta_1$$

$$\eta_3 = \beta_{31}\eta_1 + \beta_{34}\eta_4 + \zeta_3$$

$$\eta_2 = \gamma_{22}\xi_2 + \gamma_{23}\xi_3 + \beta_{21}\eta_1 + \zeta_2$$

$$\eta_4 = \beta_{42}\eta_2 + \beta_{43}\eta_3 + \zeta_4$$

That is, occupational characteristics at $t_{(1)}$– 1975 or earlier – can directly affect job conditions at $t_{(2)}$ – 1993 – but they can only affect cognitive functioning at $t_{(2)}$ indirectly through job conditions

[5] Unfortunately, Kohn and Slomczynski's (1990, p. 131) heuristic example of identification confounds the structural (simultaneous) effects of occupational position and occupational self-direction with their total effects: "In models that do not estimate both cross-lagged and contemporaneous reciprocal effects, what appear to be *contemporaneous* reciprocal effects are actually *total* effects, representing both lagged and contemporaneous effects" [emphasis in the original]. In fact, the total effects of the exogenous variables are given by the reduced form coefficients, that is, the ordinary regressions of endogenous on exogenous variables.

[6] Kohn and Schooler's (1978) original models of reciprocal effects—and most of their later published work—differ in several important ways from Figure 1. Like the present analysis, they use only two waves of data. The 1978 paper does not use earlier measures of cognitive functioning or job conditions to identify simultaneous reciprocal effects, but instead relies on other exogenous variables, which, in our opinion, are weak instruments. They cite simultaneous and cross-lagged effects as equivalent evidence of "reciprocal" causation. In later work, Kohn, Schooler, and their associates rely primarily on identifying assumptions like those used here, that is, the absence of cross-lagged effects.

at $t_{(2)}$ or through their correlation with cognitive functioning at $t_{(1)}$. Obversely, cognitive functioning at $t_{(1)}$ can directly affect cognitive functioning at $t_{(2)}$, but it can only affect job conditions at $t_{(2)}$ indirectly through cognitive functioning at $t_{(2)}$ or through its correlation with occupational characteristics at $t_{(1)}$. Similar assumptions hold for the relationships between variables at $t_{(2)}$ and at $t_{(3)}$ – with one important exception: As Figure 1 shows, cognitive functioning at $t_{(2)}$ may affect job conditions at $t_{(3)}$ indirectly, either through job conditions at $t_{(2)}$, or through cognitive functioning at $t_{(3)}$. Likewise, job conditions at $t_{(2)}$ may affect cognitive functioning at $t_{(3)}$ indirectly, either through cognitive functioning at $t_{(2)}$ or through job conditions at $t_{(3)}$.

For simplicity, Figure 1 does not show the specification of all the disturbances (ζ_i) in job conditions or cognitive functioning in 1993 and 2004; one possible specification is that the disturbances in the endogenous variables are freely correlated within and between waves. Thus, ζ_1, ζ_2, ζ_3, and ζ_4 would all be freely correlated. Another possibility would be to eliminate (restrict) disturbance correlations between waves, but not within waves. Thus, only the pairs, (ζ_1, ζ_2) and (ζ_3, ζ_4) would be freely correlated. In that instance – absent lagged effects from $t_{(1)}$ to $t_{(3)}$ – there would be an additional way to identify errors of measurement in the intervening variables (job conditions and cognitive functioning in 1993).[7] The preceding example is substantively important, for Kohn and Schooler contend that jobs affect cognitive functioning even among midlife and older workers (Miller et al. 1985; Schooler et al. 1999; 2004). The present analysis is restricted to the first two waves of data depicted in Figure 1, that is, from adolescence to ages 53-54, so we have not yet examined this relationship for older workers.

Data and Measurement

[7] The latter specification is appealing because it would test our estimates of error in the limited set of cognitive indicators in the 1993 WLS.

The WLS began with a 1/3 random sample (N = 10,317) of women and men who graduated from Wisconsin high schools in 1957. After it was used to assess the demand for higher education in Wisconsin, the WLS became a premier resource for studies of social stratification in the United States, and its design and findings have had world-wide influence (Sewell et al. 2004). Since the early 1990s, the content and direction of the study have shifted from education and careers to aging, health, and retirement. Early survey data were supplemented by mental ability test scores (Henmon and Holt 1931; Froehlich 1941; Henmon and Nelson 1946; 1954), and rank in high school class. The second and third waves of survey data were collected from the graduates and their parents in 1964 and 1975, respectively. Those data provide a full record of social background, high school curriculum, youthful aspirations and social influences, schooling, military service, family formation, labor market experience, and social participation. In 1993, we conducted telephone and mail surveys of WLS graduates. These surveys updated our measurements of marital status, child-rearing, education, labor force participation, jobs and occupations, social participation, and future aspirations and plans among graduates and siblings. The one-hour graduate telephone interview covered life history data, family rosters, and job histories, which have many skips or branches. In 1993-94, we completed telephone interviews with 8493 WLS graduates out of 9741 survivors.

We selected graduate men and women who completed telephone interviews in 1993. We further restricted the analyses to participants who reported having a current or last job in both 1975 and 1993. This selection primarily eliminated women who had never worked. Our final sample includes 3886 men and 3137 women.[8] Table 1 presents the means and standard deviations of the variables used in the analyses.

[8] At ages 53-54, very few individuals had retired. Almost all of those with “last,” but not “current” jobs were between jobs.

Measures of psychological background include high school rank, educational aspirations, occupational aspirations, and academic ability (IQ), usually measured during the junior year in high school. High school rank is a normalized transformation of the graduates' rank percentile. Educational aspirations are measured by a simple dichotomous variable, which takes on the value 1 if the graduate planned on attending a four-year college or university in the fall of 1957 and 0 if they had other plans. Our measure of occupational aspirations is the 1970-basis Duncan SEI score for the occupation they eventually hoped to enter, as reported in the original 1957 survey (Duncan 1961). Finally, academic ability is taken either from the graduate's junior or freshman year score on the Henmon-Nelson IQ test.

The 1993 interviews included a subset of the abstract reasoning (similarity) items in the Wechsler Adult Intelligence Scale (1981), hereafter, WAIS. The prototypic item is, "How is an orange like a banana." Two points are awarded for an abstract response, e.g., "They are both fruit," and one point is awarded for a concrete response, e.g., "They both have skins." Many transcribed scores could be assigned by computer, and in the remaining cases, specially trained coders assigned the scores. In the latter case, scoring was carried out in batches by item, to avoid respondent-specific biases.

Our next set of measures captures education and occupational background. Education is measured as the number of years of regular education, where, for example, 12 indicates a high school diploma and 16 indicates a baccalaureate degree. We have measures for the amount of time the respondent spent doing three types of tasks on their current or most recent *job* as of the 1975 and 1993 interviews. We asked the average number of hours per week that the respondent spent: "reading, writing, and dealing with written materials;" "working with hands, tools, or equipment;" and "dealing with people about work—not just passing the time of day." These measures differ from those used by Kohn, Schooler, and their associates because they do not map directly into DOT job ratings.

In addition, measures of the complexity of respondents' occupations were drawn from the Dictionary of Occupational Titles (DOT) (U. S. Department of Labor 1977), specifically, from a computer file of aggregated characteristics of 574 expanded occupational categories of the 1970 U.S. Census (1981). This file was created by the Committee on Occupational Classification and Analysis of the National Research Council (1981). It allows researchers to link the characteristics of occupations (as provided in the DOT) to the characteristics of individuals in those occupations (as available in Census and survey data). Aggregated DOT scores were assigned to occupation lines using the April 1971 Current Population Survey (CPS), a source of data that includes both the 1970 U.S. Census occupation codes and the fourth edition DOT codes. This yielded enough cases to produce reliable estimates for detailed occupational categories. The resulting file contains aggregated information about the characteristics of jobs for each of 574 expanded job and occupation categories. We link WLS jobs—classifications of current or last occupations in 1975 and 1993—to the aggregated 1970 DOT characteristics through common 1970 Census occupation and industry codes. The DOT data include three measures of work complexity, how the worker functions in relation to data, people, and things. These "scales" (displayed in Figure 2) are arranged so that relatively simple tasks are denoted by high numbers, while more complex functions are assigned lower numbers. Each code corresponds to an action verb, or verbs, such as "compiling" or "handling" (U. S. Department of Labor 1977).

We imputed missing data using the ICE command (Imputation with Chained Equations) in Stata 9. Although most variables had very little missing data, a few measures—occupational aspirations (34 percent for men, 19 percent for women), high school rank (seven percent for men, six percent for women), and the number of hours spent on each specific task (six percent for men, five percent for women)—had a substantial number of missing cases.

Measurement Models of Work Complexity and Cognition

Figure 3 is a schematic path diagram of the measurement of substantive complexity. Each of the six indicators—three based on self-reported job characteristics and three from DOT scores linked to Census occupation lines—depends upon a common factor that represents the complexity of work.[9] Using LISREL 8.8 (Jöreskog and Sörbom 1993; Jöreskog et al. 1996), we estimated four instances of this model by maximum likelihood, that is, once for each combination of gender and year of observation. The best-fitting models are more complicated than Figure 3 would suggest for two reasons. First, within each sample and year, there are correlations between errors of indicators. For example, in every instance there are positive correlations between the errors in time spent reading and time spent dealing with people. That is, those two indicators are more highly correlated than one would expect from their common dependence on the complexity of work. Second, there are positive correlations between errors in corresponding indicators across years. Thus, the error in time spent reading in 1975 is positively correlated with the error in time spent reading in 1993. That is, between 1975 and 1993, each indicator is more persistent than one would expect from the combination of their dependence on the complexity of work and the persistence of overall work complexity across the 18 year period.

Table 2 displays standardized loadings of each indicator of cognitive functioning and work complexity on its latent variable. For convenience in reading, we have reversed the signs of loadings of the DOT variables relative to their original coding. Each of the indicators of abstract reasoning ability loads positively, but no more than moderately, on the general factor for

[9] Hereafter, we use "job" to refer to the specific set of activities of an employee and "occupation" to refer to a collection of similar jobs. Since complexity is indicated both by characteristics of jobs and of occupations, we refer to it as "the complexity of work."

cognitive functioning. In addition, in both the female and male samples, cognitive functioning in 1993 loads negatively on the number of hours per week that the participant spends "working with hands, tools, and equipment." This in itself is an indication that less complex work is associated with lower cognitive functioning. Consistent with this finding, each indicator of work with data or people loads positively on work complexity for women and men and in both years, but each indicator of manual work loads negatively on the complexity of work.

It is striking that in these measurement models, the individual reports of time spent on data, people, and thing have low loadings on work complexity, especially in comparison to those of the aggregate occupational characteristics. Kohn, Schooler and their associates find higher loadings for their individual measures, which are tied directly to DOT ratings. This raises the question—which we cannot completely resolve—whether our work complexity factor is measuring the same thing as theirs. Since we do have appropriately signed loadings on the individual reports, we think that our work complexity factor is appropriately measured. It may be that aggregate occupational characteristics are simply more reliable than our measures, as reported by individuals. Of course, while aggregate occupational characteristics may be reliable, they may also be invalid by dint of aggregation, that is, because they pertain to heterogeneous jobs. However, we have not made strong assumptions about the validity of the aggregate DOT measures; on the contrary, our model treats each job and occupational characteristic as an imperfect indicator of a latent level of job complexity.

Figure 4 is a schematic path diagram of the measurement of cognitive functioning in 1993. Here, there are just two instances of the model, one for women and the other for men. In each case, there are three positive correlations among errors: between those of orange-banana and table-chair, between those of orange-banana and eye-ear, and between those of table-chair and fly-tree. That is, graduates are more likely to have responded correctly (or incorrectly) to each of the paired items than would be expected from their joint dependence on the common factor for abstract reasoning ability. However, we are unable to offer a substantive rationale for those specific relationships.

None of these models fits satisfactorily if one considers only nominal statistical significance. This is to be expected in light of the large sample sizes. However, fit is very good when judged by the Bayesian Information Criterion (*BIC*) (Raftery 1995; Weakliem 1999) and the Root Mean Square Error of Approximation (*RMSEA*) (Loehlin 2004, pp. 67-70). That is, the ratios of the likelihood-ratio test-statistic, χ^2, to the degrees of freedom of the models are less than *ln*(N), the natural log of the sample sizes, and RMSEA < .05.

Structural Models of Work Complexity and Cognition

Figure 5 shows a reduced form model of the effects of the exogenous variables on cognition (WAIS abstract reasoning) and the complexity of work among WLS participants in 1993. For convenience, neither the correlations among the exogenous variables nor the measurement models are shown in the figure. The unrestricted reduced form model simply regresses each of the endogenous variables (WAIS, 1993, and complexity of work, 1993) on all of the exogenous variables, and it does not attempt to explain the correlation between the disturbances of those two outcomes. All of the lack of fit of the model here is attributable to restrictions in the measurement models, both within and between constructs.

Table 3 shows selected coefficients of the reduced form models of cognition and work complexity for women and men in the WLS. The findings make sense intuitively. For example, cognitive functioning in 1993 is strongly affected by Henmon-Nelson IQ, but only weakly affected by high school class rank. Complexity of work in 1993 is moderately affected by complexity in 1975. Note, however, that the persistence of work complexity is greater among men than among women. Educational attainment has moderate effects both on cognitive functioning and work complexity in 1993.

For present purposes, the most important information in Table 3 is the size of effects that are postulated to occur only indirectly in the structural model. Thus, we should like to see statistically significant effects of Henmon-Nelson IQ and high school class rank on complexity of work in 1993 and of complexity of work in 1975 on cognitive functioning in 1993. One variable fails to support these hypotheses; high school rank has negligible effects on complexity of work in the reduced form equations. However, the significant effects of Henmon-Nelson IQ are large enough to support estimation of the model of reciprocal effects.

Figure 6 shows a structural model of the reciprocal influences of cognition (WAIS abstract reasoning) and the complexity of work among WLS participants in 1993. Again, for convenience, neither the correlations among the exogenous variables nor the measurement models are shown in the figure. However, the coefficients reported here are based on simultaneous estimation of the measurement and structural models. Again, the fit of the full models is satisfactory when they are estimated separately for women and for men.

The structural model specifies that WAIS (abstract reasoning) performance in 1993 is affected by Henmon-Nelson IQ, high school class rank, high school aspirations, educational attainment and the complexity of work in 1993, but not by the complexity of work in 1975. The complexity of work in 1993 is also affected by high school aspirations and by educational attainment, the complexity of work in 1975, and by WAIS in 1993, but not by Henmon-Nelson IQ or high school class rank. Since two of the exogenous variables are excluded the structural equation for job complexity in 1993, that equation is over-identified.[10]

Table 4 shows fit statistics for the reduced-form and structural models for women and men in the WLS. Since there are two omitted variables in the structural equation for complexity of work in 1993, there is one more degree of freedom for error in the structural models than in the corresponding reduced form models. For men and for women, the restriction fits extremely well. The increase in chi-square between the reduced form and structural models is negligible in size and statistically insignificant.

Table 5 shows selected coefficients of the structural models for women and for men. There is remarkable similarity between women and men in the estimated reciprocal effects between cognitive functioning and the complexity of work. The (social learning) effect of work complexity on cognition is roughly twice as the (selection) effect of cognitive functioning on work complexity. There is substantial persistence of work complexity among men between 1975 and 1993, but that effect is about twice as large as the effect among women. The effects of Henmon-Nelson IQ on cognitive functioning across a 36 year period are larger than either reciprocal effect and almost as large as the persistence of work complexity among men across an 18 year period. However, the effects of high school rank on later cognition are quite small. The effects of high school aspirations on later cognition and work complexity are also very small.

We began this study with the observation that a better control for prior cognitive functioning could reduce or eliminate the appearance of an effect of later work complexity on later cognitive functioning. The estimates in Table 5 are based on the assumption that Henmon-Nelson IQ was measured without error. Thus, we have asked whether a reasonable adjustment for unreliability in that variable would materially alter our findings. First, based on a prior

[10] We had originally supposed that educational attainment could be excluded from the structural equation for work complexity in 1993, but this yielded exceptionally poor fit of the model for men.

estimate of the random error variance in Henmon-Nelson IQ (Hauser and Sewell 1986), we re-estimated the structural model.[11] Among women, the effect of work complexity on cognitive functioning declined from 0.209 to 0.148, and among men, it declined from 0.236 to 0.187. Thus, while our initial observation is correct—that the effect of work complexity on cognitive functioning declines with improvement in the measurement of prior cognition, a reasonable estimate of unreliability in the Henmon-Nelson test does not eliminate the effect.

In addition, we asked how large an estimate of the error variance in Henmon-Nelson IQ would completely eliminate the effect of work complexity on cognition. These estimates are 85.3 for women and 106.0 for men, corresponding to reliabilities of 0.58 for women and 0.54 for men in the present samples. We think that these reliability estimates are unreasonably low and thus conclude that our estimates of the effect of work complexity on cognition are robust with respect to error in the measurement of prior cognition.

Discussion

We think that, for several reasons, the present analysis provides compelling evidence favoring the Kohn-Schooler hypothesis. First, our measures and data are entirely independent of those developed and used by Kohn, Schooler, and their associates. Second, our measures of academic ability and high school rank provide a better baseline assessment of cognitive functioning than those available in any of the research by Kohn, Schooler, and their associates (see, for example, Alwin's (1993a) critique of Kohn and Slomczynski (1990)). Third, we have estimated similar effects in two independent samples, namely, women and men in the Wisconsin Longitudinal Study. Fourth, we have strong evidence that our findings are robust with respect to unreliability in the adolescent measure of cognitive functioning.

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[11] Specifically, we used the valued 50.9 for the error variance in H-N IQ, corresponding to a reliability of 0.78 in a sample of male WLS participants.

There are also many additional questions to pursue in this line of research using data from the WLS. A high priority is to extend our models to all three waves of data displayed in Figure 1. Of necessity, given the age of WLS participants, this will reduce the size of the samples by about half. As an additional check on the robustness of our findings, we should repeat the present analysis for subgroups of participants defined by labor market experience. One obvious step is to use data only for current job-holders, eliminating cases where the participant held a "last" job, but was not employed at the survey date. A second possibility is to look separately at subsamples defined by duration of the current job or current occupation; we would expect to find larger estimates of the effect of work complexity on cognition among persons with long experience in a single line of work. Also, the present analysis is limited to one aspect of cogntitive functioning, namely, abstract reasoning as measured in the WAIS. However, in the three-wave models, we can use the wider array of cognitive measures assessed in the 2004 wave of the WLS—adding verbal fluency, word recall, and digit ordering.

Finally, we see the present analysis as a template for a more comprehensive investigation of the interaction between social activities and cognitive functioning. We think that similar models and methods will be useful in improving our understanding of the relationships between leisure and volunteer activities and cognition among the elderly. Here, too, the Wisconsin Longitudinal Study will have much to contribute.

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Table 1: Means and Standard Deviations

	Males		Females	
	Mean	Std. Dev	Mean	Std. Dev.
Psychological Background				
High School Grades Percentile (rank-normalized)	97.80	(14.57)	104.81	(14.33)
Plans to attend college/university?	0.37	(0.48)	0.29	(0.45)
Occupational Aspiration Score	54.94	(28.51)	48.38	(14.70)
High School IQ (raw Henmon-Nelson test score)	101.37	(15.15)	101.48	(14.33)
Cognitive Functioning 1993				
In what way are an orange and a banana alike?	1.82	(0.47)	1.88	(0.39)
In what way are a table and a chair alike?	0.91	(0.91)	1.01	(0.93)
In what way are an eye and an ear alike?	1.27	(0.73)	1.27	(0.73)
In what way are an egg and a seed alike?	1.03	(0.77)	0.89	(0.73)
In what way are a fly and a tree alike?	0.63	(0.85)	0.62	(0.81)
In what way are praise and punishment alike?	0.51	(0.75)	0.43	(0.71)
Educational and Occupational Background				
Years of regular education	13.86	(2.46)	13.08	(1.84)
1975 average hours/week R spends reading/writing/written materials	18.94	(14.88)	16.09	(14.60)
1975 average hours/week R spends working with hands/tools/equipment	22.88	(19.23)	20.59	(15.33)
1975 average hours/week R spends dealing with people	23.62	(16.57)	19.72	(15.18)
1975 Complexity of Work with Data	2.36	(1.52)	3.19	(1.35)
1975 Complexity of Work with People	5.51	(1.92)	5.87	(1.73)
1975 Complexity of Work with Things	4.50	(2.17)	4.59	(2.03)
Job Conditions 1993				
1993 average hours/week R spends reading/writing/written materials	19.65	(14.62)	21.51	(15.05)
1993 average hours/week R spends working with hands/tools/equipment	22.41	(18.76)	24.15	(15.92)
1993 average hours/week R spends dealing with people	22.74	(16.23)	24.51	(15.40)
1993 Complexity of Work with Data	2.33	(1.52)	2.81	(1.38)
1993 Complexity of Work with People	5.44	(1.89)	5.58	(1.84)
1993 Complexity of Work with Things	4.72	(2.17)	4.86	(2.01)
Sample Size	3886		3137	

Table 2 Factor Loadings of Cognitive Functioning (WAIS Abstract Reasoning) and Complexity of Work

	Women		Men	
	1975	1993	1975	1993
WAIS (Abstract reasoning)				
In what way are an orange and banana alike?	-	0.235	-	0.257
In what way are a table and a chair alike?	-	0.341	-	0.355
In what way are an eye and an ear alike?	-	0.415	-	0.443
In what way are an egg and a seed alike?	-	0.441	-	0.389
In what way are a fly and a tree alike?	-	0.510	-	0.500
In what way are praise and punishment alike?	-	0.269	-	0.267
Hours/week R spends working with hands/tools/equipment, 1993	-	-0.249	-	-0.277
Work complexity				
Hours/week R spends reading/writing/written materials	0.197	0.185	0.450	0.382
Hours/week R spends working with hands/tools/equipment	-0.406	-0.242	-0.857	-0.416
Hours/week R spends dealing with people	0.233	0.169	0.325	0.216
Complexity of Work with Data	0.672	0.691	0.745	0.738
Complexity of Work with People	0.981	0.963	0.782	0.785
Complexity of Work Things	-0.448	-1.005	-0.549	-0.633

Note: Effects pertain to variables in standard form.

Table 3. Reduced Form Coefficients: Model of Cognitive Functioning and Complexity of Work

	Women		Men	
	WAIS, 1993	Complexity of work, 1993	WAIS, 1993	Complexity of work, 1993
Henmon-Nelson IQ	0.442	0.077	0.425	0.064
	0.037	0.021	0.032	0.017
High school class rank	0.157	-0.020	0.047	-0.019
	0.029	0.019	0.024	0.016
Educational aspiration	0.072	-0.010	-0.046	0.052
	0.032	0.022	0.026	0.018
Occupational aspiration	-0.022	0.036	0.098	0.073
	0.027	0.019	0.026	0.018
Educational attainment	0.236	0.329	0.302	0.106
	0.037	0.041	0.030	0.020
Complexity of Work, 1975	0.060	0.292	0.131	0.556
	0.029	0.042	0.026	0.031
Percentage of variance	0.561	0.357	0.596	0.510

Note: Effects pertain to variables in standard form. The entry below each estimated coefficient is its standard error.

Table 4 Fit of Reduced Form and Structural Models of Cognitive Functioning and Complexity of

Population and model	Chi-square	Degrees of Freedom	BIC	RMSEA
Women				
Reduced form model	895.8	183	-577.5	0.036
Structural model	899.6	184	-581.8	0.036
Difference	3.8	1	-4.3	---------------
Men				
Reduced form model	1131.4	184	-389.4	0.036
Structural model	1133.6	185	-395.5	0.038
Difference	2.1	1	-6.1	---------------

Table 5. Structural Coefficients: Model of Cognitive Functioning and Complexity of Work

	Women		Men	
	WAIS, 1993	Complexity of work, 1993	WAIS, 1993	Complexity of work, 1993
WAIS, 1993	--------------------	0.113	--------------------	0.123
		0.033		0.035
Complexity of work, 1993	0.209	--------------------	0.236	--------------------
	0.101		0.047	
Henmon-Nelson IQ	0.438	--------------------	0.416	--------------------
	0.038		0.032	
High school class rank	0.145	--------------------	0.039	--------------------
	0.028		0.023	
Educational aspiration	0.075	-0.020	-0.057	0.055
	0.033	0.023	0.026	0.018
Occupational aspiration	-0.028	0.037	0.082	0.060
	0.027	0.019	0.027	0.019
Educational attainment	0.169	0.300	0.280	0.064
	0.058	0.040	0.032	0.024
Complexity of Work, 1975	--------------------	0.283	--------------------	0.540
		0.042		0.031
Percentage of variance	0.537	0.350	0.573	0.506

Note: Effects pertain to variables in standard form. The entry below each estimated coefficient is its standard error.

Figure 1. Job Conditions and Cognitive Functioning across the Life Course: A Schematic Model

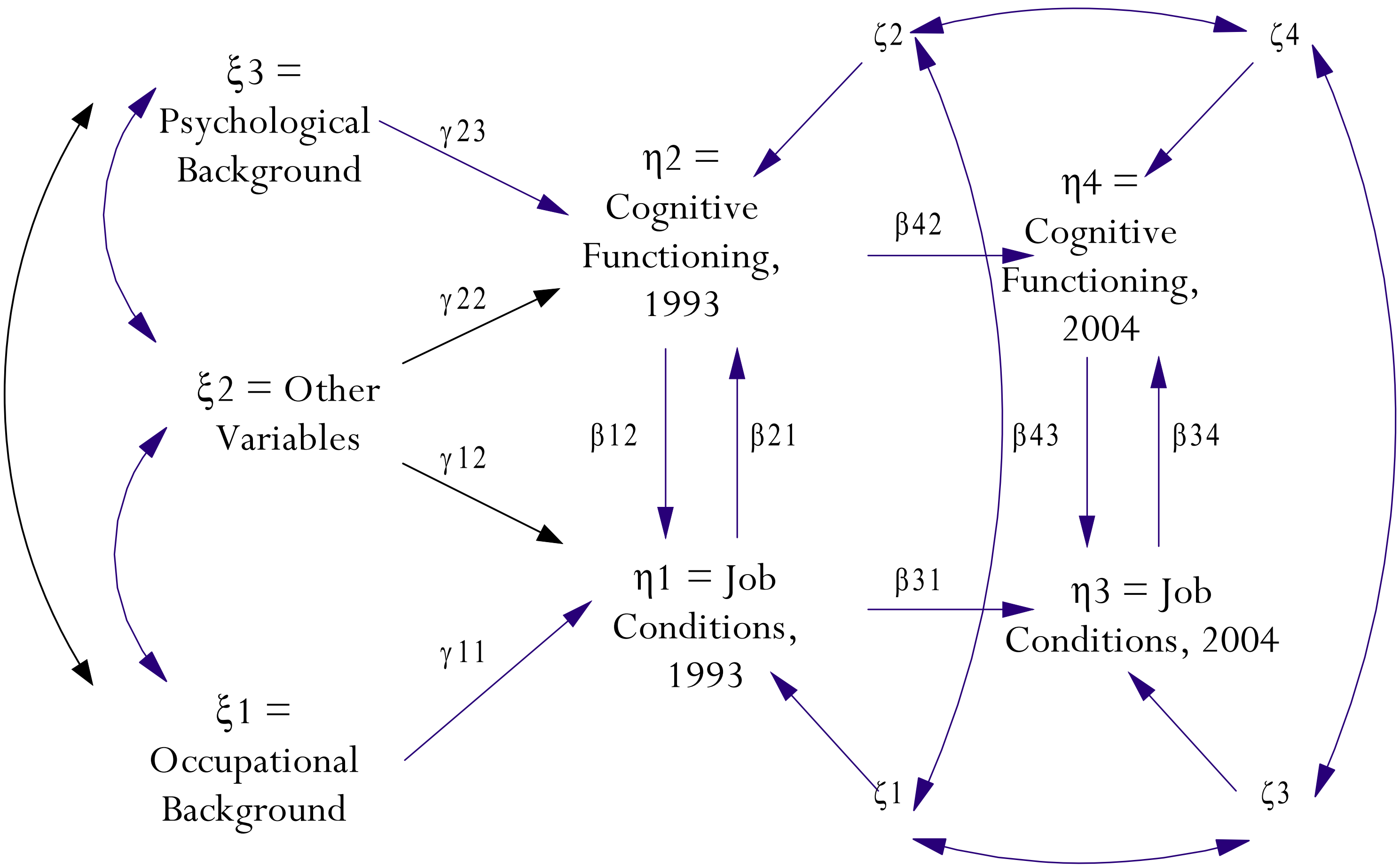


Figure 2. Definitions of the Worker Function Scales in the Dictionary of Occupational Titles

Data
0 – Synthesizing
1 – Coordinating
2 – Analyzing
3 – Compiling
4 – Computing
5 – Copying
6 – Comparing

People
0 – Mentoring
1 – Negotiating
2 – Instructing
3 – Supervising
4 – Diverting
5 – Persuading
6 – Speaking-Signaling
7 – Serving
8 – Taking Instructions – Helping

Things
0 – Setting-up
1 – Precision Working
2 – Operating – Controlling
3 – Driving Operating
4 - Manipulating
5 – Tending
6 - Feeding – Off bearing
7 – Handling

Note: Lower numbers indicate higher complexity.

Figure 3. A Measurement Model of the Substantive Complexity of Jobs and Occupations

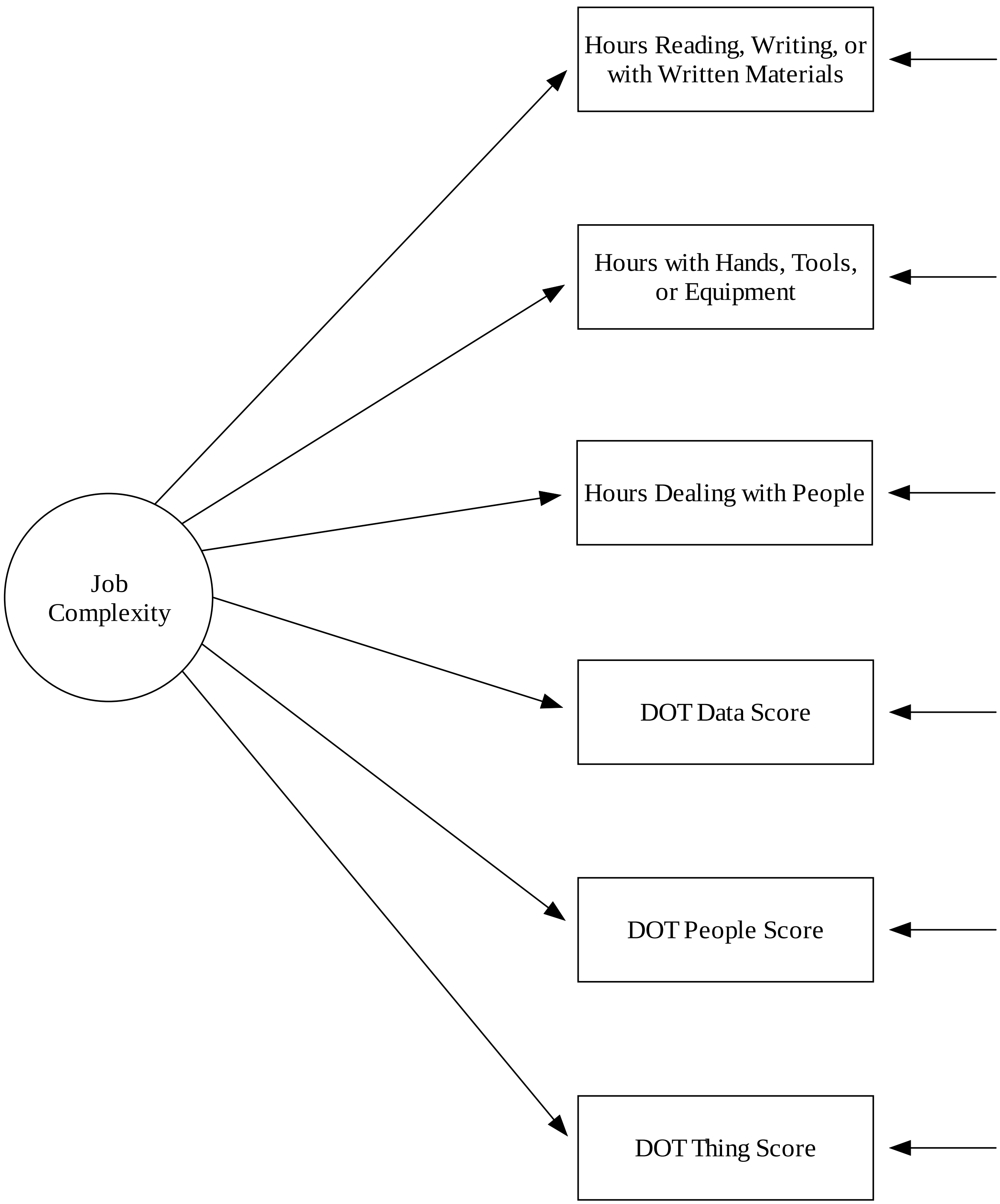


Figure 4. A Measurement Model of Cognitive Functioning
(from WAIS Abstract Reasoning Items)

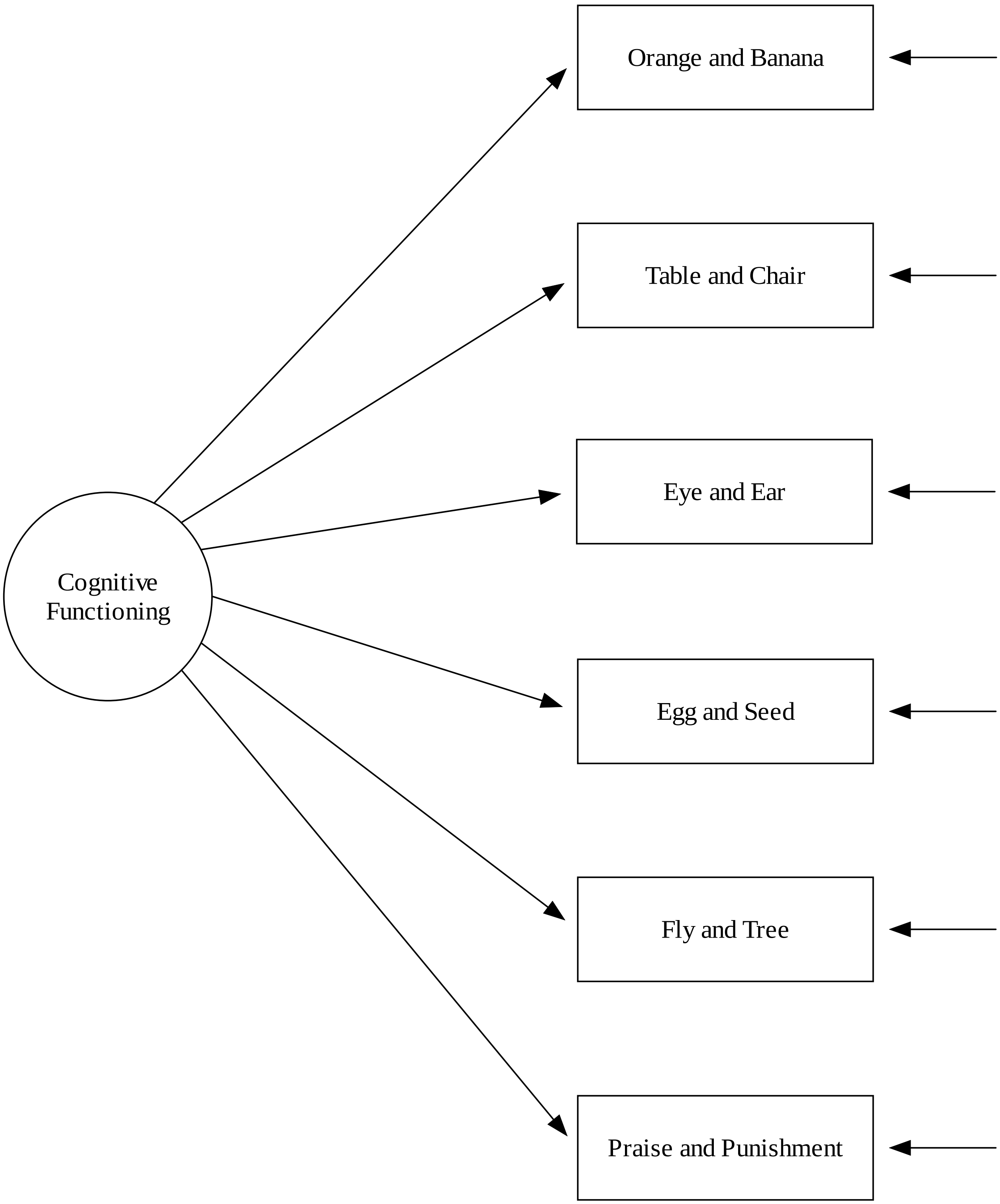


Figure 5. A Reduced Form Model of Cognitive Functioning and the Complexity of Work

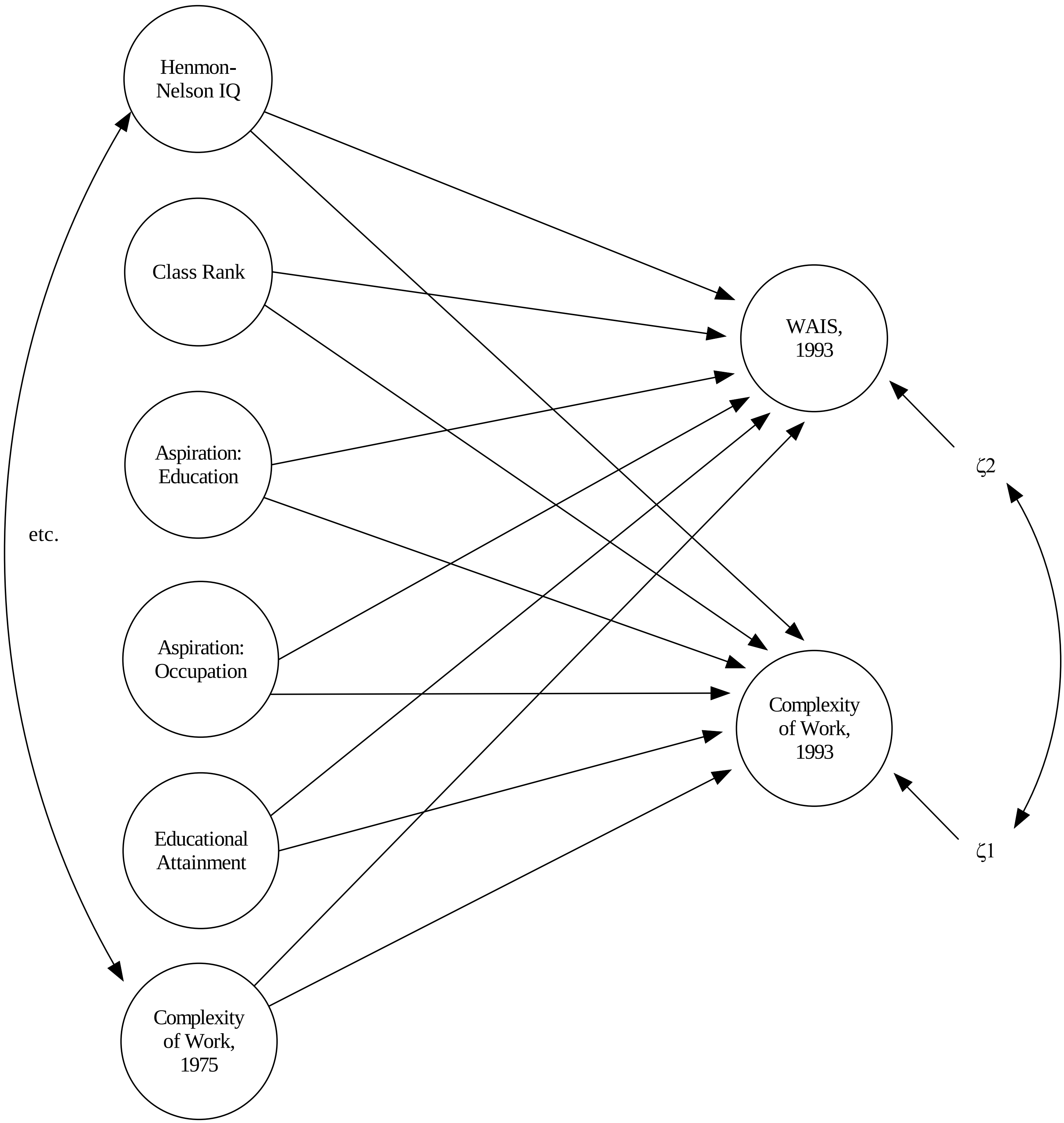
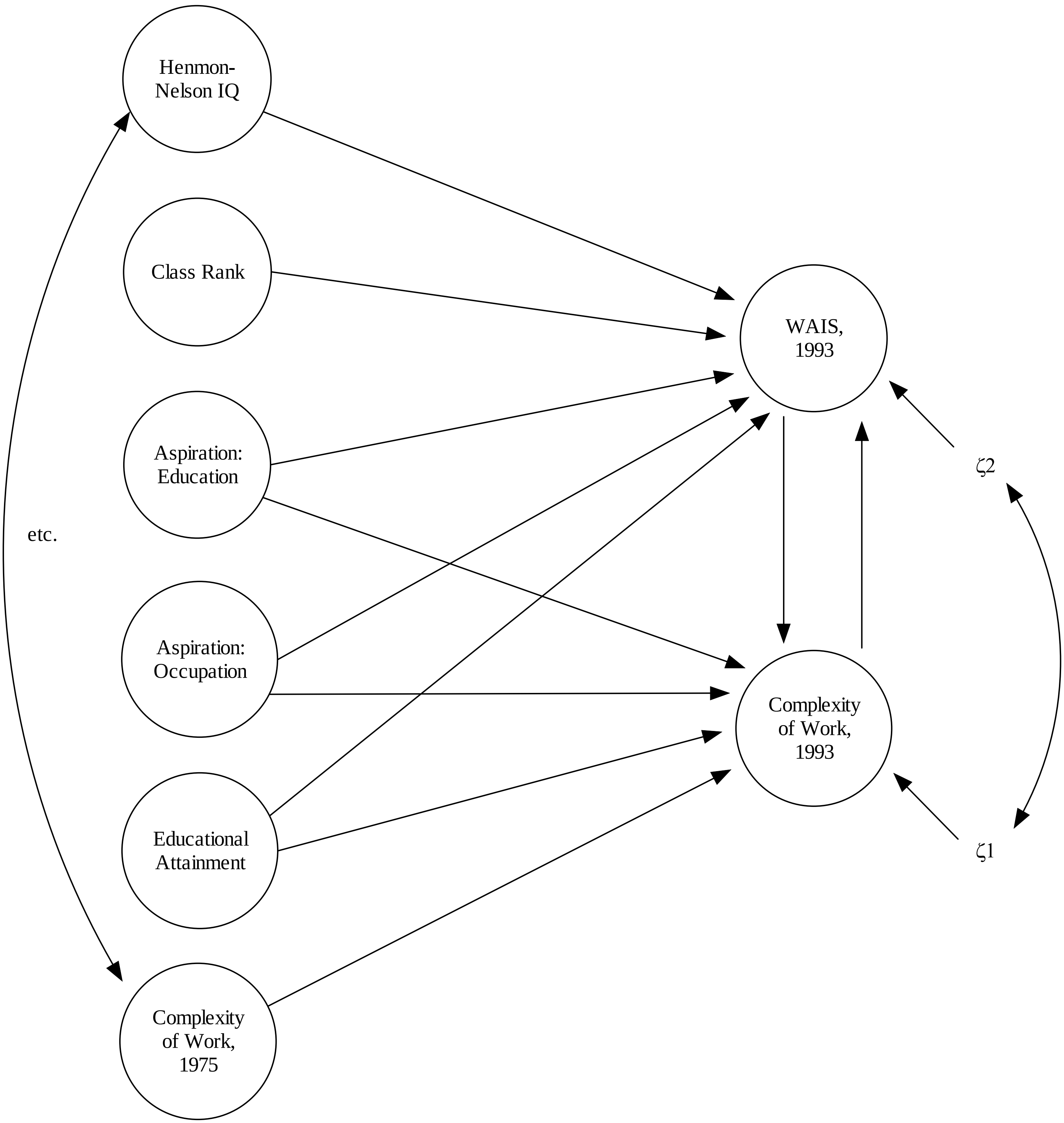


Figure 6. A Structural Model of Cognitive Functioning and the Complexity of Work



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