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COMMENTARY: INTERDISCIPLINARY LONGITUDINAL STUDIES OF AGEING

If one is interested in exploring the antecedent variables that differentiate groups of individuals with different demographic characteristics such as age, gender, or region of residence, one needs to look for data sets that have followed such groups over time. Hence, multi-disciplinary studies are increasingly common and two prime examples the ILSE and KAROLA studies are described in this volume (Rothenbacher, Rott, Jopp, & Brenner; Schmitt, Oswald, Jopp, Wahl, & Brenner). Before commenting on these studies, I will raise some issues common to interdisciplinary studies in general, and show a conceptual framework from my own Seattle Longitudinal study to illustrate how any major longitudinal study investigating aging processes is likely to become interdisciplinary whether it started in that manner or not. I then comment on some design issues relevant to both ILSE and KAROLA. Finally, I comment briefly on the power of interdisciplinary longitudinal studies of aging.

1. ISSUES IN INTERDISCIPLINARY STUDIES

1.1. Different Levels of Reductionism

One of the major issues in the design of interdisciplinary studies is to deal with the levels of reductionism involved. The principal initiator of the study will generally perceive the data of his discipline to provide the basic dependent variables. Nevertheless, as soon as other disciplines are added, one or more of the original dependent variables may well be perceived by another discipline instead as the their independent variables. While there may be many levels of potential influences (e.g. environmental, societal, individual, physiological system or cellular levels), the use of more than two or three levels of reductionism may be problematic, especially when each level may exert direct and/or indirect influences or may serve as a moderator of influences at other levels.

1.2. Communication Problems

Most interdisciplinary studies include scientists whose technical vocabulary may differ widely. Hence, one of the first issues for effective collaborative relationships across disciplines consists of gaining a full understanding of the technical terms of neighbouring disciplines. The same terms may denote rather different constructs.

H.-W. Wahl et al. (eds.), The Many Faces of Health, Competence and Well-Being in Old Age, 223–230.

1.3. Asymmetrical Advances in State-of-the-Art

Different disciplines advance in an asymmetric fashion. Constructs that remain at a taxonomic level in one field may have attained precise and reliable measurement in another. Sampling strategies at a macro-societal level may aspire to obtain representative populations while studies of individual differences may instead call for sampling the entire range of the phenomenon studied. Likewise, state-of-the-art statistical analyses will differ markedly across different disciplines. Hence, compatibility of data across different disciplines may be compromised with respect to reliability of measurement, comparability of sampling approaches as well as precision of data analyses. Most of these issues, of course, require some compromises in order to enable interdisciplinary research approaches.

2. EXAMPLE FROM THE SEATTLE LONGITUDINAL STUDY

Figure 1 shows a conceptual framework for the Seattle Longitudinal Study (Schaie, 2005) that illustrates both the advantages and disadvantages of operating within an interdisciplinary framework of longitudinal research. The Seattle study began as a narrow inquiry on the relationship of age differences in cognitive abilities to age differences in personality and cognitive styles (Schaie, 1958). Given the scientific climate of the times it was seen as a strictly intra-disciplinary inquiry. It soon became clear that the questions raised required a longitudinal approach that allowed definition of alternative patterns of antecedents of change in cognitive function across adulthood. These concerns soon led to the recognition that data collection and analysis strategies had to move beyond those available to a single discipline.

To understand intellectual development from early adulthood to old age we tried to embed what we know about such development within the context of changing environmental influences and changes in individuals' physiological infrastructure. Figure 1 contains two endpoints: The first is concerned with those influences that affect the level of late-life cognitive functioning. A second endpoint of interest, however, is the

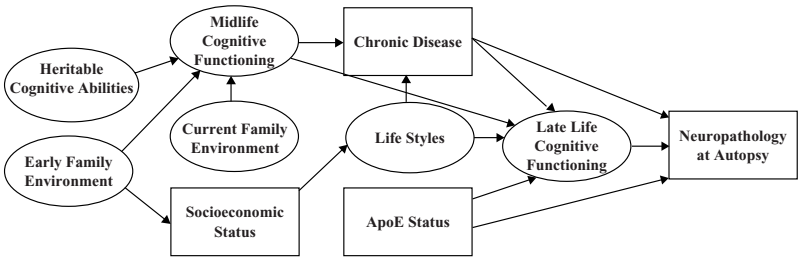

Figure 1. Conceptual framework for the Seattle Longitudinal Study (adapted from Schaie, 2005, p. 8)

status of the cortex at life's end that would describe the neural infrastructure required for the maintenance of cognitive functioning; often determinable only at post mortem. Figure 1 should be interpreted as a conceptual path model; rectangles are used to identify indicators that are observed directly while ovals indicate the latent constructs that would be inferred from measurement models for sets of observed variables.

Let me now try to explicate some of the attributes of the heuristic model in Figure 1 in terms of their implications for the need of interdisciplinary inquiry. First, the initial bases for the development of adult intelligence must be attributed to both heritable (genetic) influences as well as to early environmental influences typically experienced within the home of the biological parents. Although some of the behaviour genetic literature suggests that much of the early environmental variance is non-shared (e.g. Plomin & Daniels, 1987), there is recent retrospective evidence of some early shared environmental influences upon later cognitive performance (Schaie & Zuo, 2001). Both generic and early environmental factors influence midlife cognitive functioning. Early environmental influences also exert influences on midlife social status (Nguyen, 2000). By contrast, virtually no correlations have been found between retrospective accounts of family environments in the family of origin and the current family, although the current family environment does influence midlife cognitive performance (Schaie & Willis, 1995). Genetic factors are also likely to be implicated in the rate of cognitive decline in adulthood. The best-studied gene in this context is the *Apo-E* gene, one of whose alleles is thought to be a risk factor for Alzheimer's disease. *Apo-E* status is therefore also added as a factor in midlife; the expression of this gene is probably not important prior to midlife.

A number of causal influences can be specified that determine level of intellectual functioning in late life as well as cortical status at autopsy. The direct influences to be implicated in addition to genes that are turned on in late life, most likely originate in midlife. They include level of cognitive functioning in midlife, midlife life styles and the incidence and severity of chronic disease. There are also indirect influences attributable to the effects of midlife cognitive function and life styles upon chronic disease, as well as shared family influences on midlife cognition and of social status upon midlife life styles.

Recognition of these relationships in the Seattle study was largely influenced by the investigators being imbedded in interdisciplinary settings and being influenced by colleagues in other disciplines. Our work on to the impact of social structures and individual micro-environments on cognitive change (cf. Schaie & O'Hanlon, 1990) was influenced early on by the writing of Matilda Riley (Riley, 1985; Riley, Johnson, & Foner, 1972) and later on by the work of Schooler (1972, 1987, 1990), as well as many other sociologists, anthropologists and epidemiologists. Colleagues conducting research on chronic disease furthermore convinced us that we needed to consider the relation between chronic disease and cognitive change (Bosworth & Schaie, 1997, 1999; Gruber-Baldini, 1991; Hertzog, Schaie, & Gribbin, 1978, Schaie, 2005).

Collaboration with Robert Plomin, a noted developmental behaviour geneticist, allowed us to take advantage of our longitudinal database to collect data to implement a study of cognitive family resemblance in adulthood. We did this adding a large

number of adult offspring and siblings of our longitudinal panel members (Schaie, Plomin, Willis, Gruber-Baldini, & Dutta, 1992; Schaie et al. 1993; Schaie & Willis, 1995; Schaie & Zuo, 2001).

Collaboration with Sherry Willis, an educational psychologist, resulted in mounting a major intervention study to implement educational training as a procedure designed to slow or reverse loss in cognitive function with age (Schaie & Willis, 1986; Willis & Schaie, 1986, 1988).

Finally, we expanded into the fields of neuropsychology and neuropathology to consider end-of-life outcomes by expanding our efforts into the clinical assessment of cognitive impairment and collaborative work on neural correlates of behaviour change involving collaboration with colleagues in neuropsychology, neurology, neuro-imaging and neuropathology (cf. Schaie et al. 2005, for an early example of this work).

Each of the expansions into adding the expertise of additional disciplines has raised new problems in trying to bridge assumptions and methods of different disciplines. Nevertheless, we could not have fully exploited the potential of our work without taking the interdisciplinary approach.

3. THE ILSE STUDY

I will first comment briefly on the particular advantages and limitations of the ILSE study design and then address some of the substantive issues.

3.1. Design Issues

The ILSE Study represents an application of the minimal requirements of the *cross-sequential* design (Schaie, 1977). It includes two birth cohorts differing on average by 16 year who were followed over the same time period (i.e. 4 years on average, from 1993/1996 to 2000/2003). It should be noted that this design confounds age with both cohort and time. Although it is not possible in this design to resolve this confounds, conclusions will be valid when comparing intra-cohort changes over time, while disregarding age. In other words, differences in change over 4 years observed in the study cannot be directly attributed to the age difference between the two cohorts, but are more likely attributable to the differential prior experience of these cohorts ILSE.

The *cross-regional sampling* is one of the major strengths of the ILSE Study. Because of the natural experiment of differential prior experiences across the two regions for one of the two cohorts, it would be possible to conduct an independent test of the age vs. cohort differences hypothesis. To do so one would merely need to enter the age group by region interaction into the regression analyses.

The methods section of this paper indicates that only study participants who were available at both T1 and T2 entered the analyses. Unfortunately, no data were provided on participant attrition. Unless attrition is trivial (say <5% of original participants) it would be important to consider attrition differences in initial performance with respect both age group and region.

3.2. Substantive Issues

Internal resources appear to be rather narrowly restricted to four of Costa and McCrae's (1992) personality factors and a single omnibus measure of cognitive functioning. In particular, it should be noted that the first factor extracted from a WAIS type intelligence scale has generally been identified as being overdetermined by *Gf* (fluid intelligence) in prior research. However, previous studies of the relationship between cognitive abilities and health and/or well-being outcomes (cf. Bosworth, Schaie, & Willis, 1999) have found that measures of *Gc* (crystallized intelligence) involving culturally acquired skills are the best outcome predictors. It is likely, therefore, that an index based on the WAIS sub-scales that reflect *Gc* would account for a greater proportion of outcome variance than the single-factor score entered into the analyses reported in this paper. Other intrinsic psychological factors that warrant further investigation might involve variables such as ego-strength and group dependency, or Costa and McCrae's fifth factor a*greeableness.*

The variables chosen to define external resources are not unreasonable. They vary, however, from items where respondents should be expected to have adequate information to provide semi-objective information (e.g. education, income, housing characteristics), to rather subjective scales where each respondent has to form their own scale reference (e.g. health, well-being). As a consequence scales must vary substantially in reliability (nor reported in this paper), which along could account for some of the low or non-significant predictive value of these resource characteristics.

It is not clear why well-being, measured in this study, was not used as an outcome criterion. All the more curious is the decision to characterize participation in leisure activities as a measure of "competence," and use this measure as an outcome variable. Recently there has been an interest in studying participation in leisure activities as a possible mechanism of maintaining "cognitive competence" in the elderly (cf. Wilson et al., 2002). However, leisure activities are typically used as an independent rather than as an outcome variable. In a normal well functioning population sample such as ILSE it seems more likely that high involvement in leisure activities could be an expression of "busyness" or of an extroversive temperament, as is suggest by the reported values in Table 2 (Schmitt et al., this volume).

The ILSE Study is a useful example of the added power obtained when different disciplines (in this case behavioural and social scientists as well as epidemiologists interact with each other). It could, however be strengthened markedly, if more objective health and behavioural outcomes were investigated directly.

4. THE KAROLA STUDY

As a cognitive psychologist I feel a lot less comfortable in providing substantive comments on the KAROLA study. However, there are a number of design and analysis issues that seem important of attention.

Design Issues. The KAROLA study is a large longitudinal follow-up of patients with coronary heart disease participating in two German rehabilitation clinics. The

population ranges from 30 to 70 years of age. The data reported in this volume (Rothenbacher, Rott, Jopp, & Brenner) come from a 1-year follow-up and are limited to the prognostic relevance and the development of anxiety and depression over this period. Given the well-known age differences in depression, it might have been advantageous to divide the group into several age/cohort sub-sets, rather than including age as a control variable. It would also have been desirable to control for participation in the two different rehabilitation clinics. Such a design would then be rather similar to that used in ILSE except for the much shorter follow-up period.

Analysis Issues. The appropriate analyses of the data presented in this report, of course, depend largely on the underlying assumptions. As I understand the current design, there is an implicit specification of reciprocal causal paths. That is, on the one hand anxiety and depression are treated as independent variables, that as prognostic predictors of rehabilitation success. On the other hand, anxiety and depression are seen as possible dependent variables given alternative severity of the coronary problem. It occurs to me, that this system of hypothesized relationships would benefit from the application of structural equations modelling (SEM) with nested models that would involve both initial level of depression and anxiety as well as change over the observed period as mediators and/or moderators. Testing of reciprocal vs. directional models of causation seems a particular strength in inter-disciplinary projects of the kind for which KAROLA is a noteworthy example.

5. POWER OF INTERDISCIPLINARY STUDIES

In this paper I reviewed studies that help illustrate the power of interdisciplinary studies but also identified a number of cautions regarding the problems of communication and proper selection of predictor and outcome variables that would maximize cross-disciplinary interaction. I conclude with a number of points that contemporary researchers of human aging need attend to for maximally affective outcomes. The first conclusion is that serious researchers must always attend to the fact that aging is a multi-dimensional process. Hence, the mechanism for any aging process can always be found in a sub-stratum explored by a different discipline. Second, in contrast to those studying child development, aging researchers must attend to the fact that adults are agents of their own development. That is, identical outcomes may occur due to different combinations of causal mechanisms, since individuals respond to the challenges of the aging processes in different ways. And finally, it has become evident that individual aging must be studied within the context of the physiological infrastructure and the environment (physical and cultural) thus mandating interdisciplinary collaboration.

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