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# ONE SIZE FITS ALL?: PROFILES OF DIFFERENTIAL PSYCHOLOGICAL TRAJECTORIES IN OLD AGE

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# ABSTRACT

Lifespan research has long been interested in intra-individual changes within and structural relations between domains of functioning. Using a more variable-oriented approach, research in this area has revealed seminal insights into the intricacies of human development. The present study opted for a more subgroup-oriented approach using multiple-indicator information at the person level. To do so, latent profile analysis was applied to eight-year longitudinal data pooled across four Swedish studies ($N$ = 1,008; 70-95 year olds; 61% women). Results revealed four psychological profiles with distinct psychological trajectories across indicators of well-being, social, and cognitive functions. These groups were also differentiated by cross-disciplinary characteristics that may have served as antecedents, correlates, or consequences of the profile trajectories (e.g., sociodemographics, functional limitations, survival time). Discussion addresses the promises and challenges of a systemic-wholistic perspective for studying differential aging.

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# Chapter 1. Literature Review

Lifespan developmental theory and research have long provided a foundational basis for the study of differential aging. Whereas the predominant and stereotypical view of old age in society often emphasizes homogeneity and decline, much theory and research have instead shown a great deal of heterogeneity in the older population (e.g., Baltes, 1987; Birren, 1959; Dannefer, 2003; Riley, 1987). Development continues into old age and is characterized by gains as well as losses (Baltes, 1987). This multidirectionality of development is a basic tenet of lifespan research and suggests that even older adults still have the potential to experience developments characterized by different directions of change within and between domains of functioning. For example, some areas of functioning show mean-level declines early on (e.g., perceptual speed), whereas other areas remain relatively stable into old age (e.g., crystallized knowledge; Lindenberger & Baltes, 1997; Salthouse, 2004; Schaie, 2005). Moreover, these mean-level changes over age are not the same for all people. Theories of successful aging suggest that some groups of people maintain functioning across many domains throughout old age (e.g., successful agers), whereas other groups exhibit several losses in a variety of domains (Baltes & Baltes, 1990; Rowe & Kahn, 1997; Ryff & Singer, 1998).

In the following sections, the importance of the study of differential aging will be addressed as well as possible factors contributing to and implications arising from lifespan research. Approaches to the study of differential aging will then be discussed. The systemic-wholistic perspective will then be presented along with its implications for the study of differential development and heterogeneity. To illustrate this perspective, empirical examples will be provided.

## The Importance of the Study of Differential Aging

A better understanding of differential aging is of prime importance for the study of adult development. At a basic and vital level, it is essential to understand the differences occurring in the adult population in order to have a more nuanced picture of aging. Differential aging provides a more realistic picture of old age because declines in some areas are accompanied by stability or gains in other areas. This equips people with more realistic expectations for their own aging, and it motivates exploiting the potentials of old age and exploring the limitations of those potential and how these might change in historical time.

Once we recognize the differences occurring in the life trajectories of older adults, we can begin to try to understand the factors contributing to these differences. The different changes occurring for people within various domains may be meaningful differences in that they may not just be random but may surface because of different life histories. Examining these differences therefore may provide us with information about what accounts for differences in the aging processes between people. For example, relative to men, women often have higher risks of depression (Crimmins et al., 2010; Smith & Baltes, 1998). This is probably a result of accumulated status and opportunity disadvantages and limited financial resources to access healthcare (Moen, 1996). Thus, sex may be an important factor contributing to different life trajectories of older adults, particularly for well-being.

Moreover, understanding what factors account for these differences allows us to identify risk and protective factors for successful aging. Maintaining quality of life in the older population becomes extremely challenging with advancing age in part because of risks for health constraints. Understanding what can help older adults lead healthier and happier lives is an important goal for lifespan developmental research. Rowe & Kahn (1997) suggest that education, functional capacity, self-efficacy, and income may be risk factors for successful aging. Studying

how these relate to aging successfully in various areas provides us with clues for how to promote successful aging among older adults and thus increase quality of life. Whereas not all factors associated with successful aging are modifiable (e.g., genes), many factors are, and it is important to know what those are and how to best modify them (Rowe & Kahn, 1997). The study of differential aging may help educate us about what to do and what to avoid doing in order to age well.

**Factors Contributing to Differential Aging**

Now that the importance of studying differential development has been established, I will next discuss that heterogeneity can be observed in old age and possible reasons underlying the existence of heterogeneity.

Although prevalent across the lifespan, several theoretical accounts suggest that between-person differences may be particularly pronounced late in life. Much theory has postulated that development in old age is less normatively shaped than that in earlier phases of life and may instead be more affected by factors of idiographic variables and chance, thereby resulting in increased heterogeneity (Baltes & Nesselroade, 1984; Finch, 1996; Olshansky et al., 2001). This lack of normative development for older adults may be explained by the fact that historically speaking, old age is a relatively recent phenomenon, and thus, evolutionary selection did not operate in the post-reproductive stages of life. Baltes (1997) described the evolutionary incompleteness of the architecture of old age and theorized that the architecture of development is incomplete throughout life. In old age, these effects are seen more dramatically. The decrease in evolutionary selection benefits with increasing age results in fewer normative developments for older adults. In contrast, chance factors may then play a greater role in older adult development and result in greater heterogeneity (Finch & Kirkwood, 2000). From genes to cells

to the environment, chance plays a role in development across the lifespan. Not even identical twins will lead the exact same lives. Several chance factors shape all people's lives including random DNA mutations to different life opportunities. Chance continues to play a role from young ages into old age and so between-person differences may accumulate across life and become increasingly larger with advancing age.

In addition to fewer evolutionary selection processes at work in adult development, a smaller number of societal norms exist for old age. This also aids to the supposed exacerbation of between-person differences in old age (Erikson, 1959; Havighurst, 1948; Riley, 1987; Uhlenberg, 1988). For example, whereas younger people are expected to proceed through certain life events such as graduating from school, getting married, and having kids, there are not as many expectations about life events later in life. Normative age-graded events in old age include retirement and having grandchildren but not as many as younger ages. With less shaping through societal norms, earlier between-person differences may become strengthened across people's lives as they continue to have different experiences resulting in cumulative advantage/disadvantage in old age (Dannefer, 2003). With increasing age, people also tend to accumulate idiographic experiences. Heterogeneity in the older population may thus not just be a continuation of differences that existed earlier in life, but rather be quantitatively and qualitatively different from and additive to these earlier differences.

It is important to acknowledge the idea that heterogeneity may be decreasing in old age. Perhaps because of secondary aging processes (Busse, 1969), older people are actually more similar to each other than younger people. With increasing age people acquire more diseases which limit their functioning across many areas of life, and therefore, it may seem as if older adults should actually be more similar than not because of this increase in shared diseases and

decrease in functioning. However, this may not be the case. Through an extensive review of studies examining age related differences, Nelson and Dannefer (1992) concluded that variability increases with age. This was across many domains including cognition, physical functioning, and personality. However, many of these studies were cross-sectional, and so it remains an open question whether heterogeneity increases with age.

**Approaches to the Study of Differential Aging**

In order to study this diversity in the older population, a number of methods can be used. Despite the ability for differential aging to be studied in a variety of different ways, it has commonly been studied by employing a variable-oriented approach to the study of development. This approach uses variables as the main units of analysis and examines the development of single variables or the interrelationships between various ones across people (Magnusson, 1998). Problems and solutions are framed in terms of variables. A typical way to examine differential aging with this approach is to examine differences in development between variables within a single domain of functioning. Both two-component theories of adult intelligence and a myriad of empirical reports indicate that measures of fluid intelligence tend to decrease with age, whereas aspects of crystallized intelligence tend to stay relatively stable (Baltes, Lindenberger, & Staudinger, 2006; Cattell, 1971; Horn, 1982; Park, Nisbett, & Hedden, 1999; Schaie, 2005). Instead of viewing intelligence as a single construct and simply finding decline with increasing age, a more complicated picture is painted by examining multiple variables within the domain of intelligence. Decline as well as stability can be seen.

Moving beyond studying only one domain of functioning, a primary interest of the variable-oriented approach is centered on questions regarding how variables prototypically change together over time or how between-person differences in those changes are linked from

one domain to another. This can inform the study of differential aging by examining what accounts for the between-person differences in changes across domains. For example, as discussed previously, Schaie, Willis, & Pennak (2005) found that cohort differences in intelligence are linked to changes in education between cohorts. The between-person differences in the changes observed in intelligence (i.e., the cohort differences) are related to the increase in education with successive cohorts over time. The variable-oriented approach employed in that study provided important information about the observed changes in intelligence. As can be seen, lifespan developmental research employing this approach has provided valuable information about normative trajectories of change between and within domains of functioning and also information about underlying mechanisms for these changes.

The variable-oriented approach provides some valuable information about differential development in old age, but this approach overlooks the interconnectedness across domains of functioning and may also overlook higher-order or non-linear between-person differences by aggregating across people (Bergman, 1998). Common statistical models used with this approach include correlations, regressions, and factor analysis. These models assume sample homogeneity, and this suggests that all participants can be described with the average parameters and deviations from those. For instance, great decline across many domains of functioning has been found later in life by research using a variable oriented method, but within any one individual or within subgroups of individuals, decline may be evident in some but not all domains. As just discussed, it is possible that greater individual differences exist later in life, and this would stand counter to the results from a variable approach showing mainly decline across older adults. It seems that the variable approach may make too many simplifying assumptions that may not hold across people. By focusing on the relationships between variables and centering analyses on

them, the individuals represented by the data used for the analyses become lost. However, this is often the case in developmental research. One of the most commonly used statistical models is the linear model, which makes many restrictive assumptions. Magnusson (1998) nicely discusses the basic assumptions of the linear regression model such as that relationships among variables are the same for every individual and that each variable has the same weight within each individual. As will be discussed, variables may not necessarily have the same weight for each individual, and focusing on variables instead of people may lead to a narrow picture of development.

In addition to the variable-oriented approach, research examining differential aging can also utilize uses a person- or subgroup-oriented approach. This approach uses individuals or subgroups of individuals as the main unit of analysis. The goal is to find subgroups of people who differ in their levels and changes in a variety of domains of functioning. Because development is shaped by multiple factors simultaneously, it is necessary to examine multiple indicator information at the individual level. Subgroups of individuals can be identified based on similar patterns of functioning in several domains. It is important to note that it may not be realistic to examine each and every level of functioning (e.g., biological, psychological, sociological) in a single analysis, but instead to focus on one level and examine multiple areas within that level (Baltes & Smith, 1997). For example, it may be enough to just look at the psychological profiles of individuals, which will be the focus of this paper. Thought must be given to the balance between obtaining complete profiles of individuals and also interpretability and complexity of the findings.

**A Systemic-Wholistic Perspective on the Study of Differential Aging**

An example of a perspective lending itself to a person- or subgroup-oriented approach is

a systemic-wholisitc perspective. This view states that development is multiply-determined and that many systems interact simultaneously within individuals (Magnusson, 1998). The systemic-wholisitic perspective views individuals as integrated totalities rather than as comprised of a combination of separate parts. The parts of a person develop together and not in isolation. Variables are important only with regards to their placement in a pattern within an individual (Bergman & Magnusson, 1997). The emphasis is on the wholeness of people as well as the interconnectedness of systems (Baltes & Smith, 1997). This approach allows for the examination of the complex interrelationships between systems within individuals over time and accommodates a variety of different configurations of the constituent variables at the individual level that may not be invariant across people. For instance, Smith and Baltes (1998) used data from the Berlin Aging Study to identify subgroups of older adults and identified some people who were low functioning across several domains including social integration, health, and well-being but then also identified people who were high functioning across domains as well as people low on some and high on others. Although a subgroup of individuals was in poor health, they were very satisfied with life. Such a pattern cannot be revealed by a variable-oriented approach.

The systemic wholistic perspective can increase knowledge about differential development in old age in several ways compared to the variable approach. Whereas the variable-oriented approach can show the normative trajectories of change for certain domains of functioning or variables within a domain, a systemic-wholisitic perspective examines multiple factors of a domain or domains within individuals simultaneously. Unique patterns of functioning can be found this way, and subgroups of individuals with similar patterns of change across these domains can be identified (Baltes & Smith, 1997). Heterogeneity in the

development of individuals unobserved before can be observed with this perspective including the non-linear interactions between domains.

In addition, the factors accounting for the continued differential development from youth to old age can be examined (Gerstorf, Smith, & Baltes, 2006). The identification of unique subgroups of individuals who differ in their patterns of change allows for the examination of the factors which differentiate them and continue to do so over time. For example, Smith and Baltes (1998) found that the subgroups of people identified in the Berlin Aging Study could be classified into desirable and less desirable profiles, and women were 1.6 times more likely to be in a less desirable profile than men. This would suggest that gender may be an important factor that differentiates functioning among groups of people in old age.

**Empirical Illustrations of the Systemic-Wholistic Perspective.** Before discussing examples of person- or subgroup-oriented research using a systemic-wholistic perspective to examine differential development in older adults, it is also important to note that this perspective can also be used to study development across the lifespan. The systemic-wholistic perspective applies to lifespan development. It is not just an artifact of old age. From birth to death, individuals are shaped by several factors as this perspective would suggest. It may be that young people have more norms for their development and are influenced more by age-graded influences than older adults (Baltes, 1987). However, differential development is possible at any age. To illustrate this, Putnam & Stifter (2005) identified groups of children at age two based on their affective (negative and positive) and behavioral (approach-inhibition) tendencies and found four distinct subgroups. This shows that even young children show different patterns of functioning. In addition, Nagin and Tremblay (1999) examined a group of boys aged six to fifteen years in order to identify subgroups with different trajectories for physical aggression,

opposition, and hyperactivity and showed that portions of this youth group differ remarkably by the patterns of these externalizing behaviors. More specifically, a group of boys experienced low levels of each of the externalizing behaviors over time, whereas a chronic offender group started off high on all of these behaviors and continued to experience high levels with increasing age. Still other boys experienced high levels of these behaviors earlier in life, but then achieved lower levels years later.

For the purposes of this paper, research using the systemic-wholistic perspective to examine differential aging will now be highlighted. A list of examples of studies using a person- or subgroup-oriented approach and employing a systemic-wholistic perspective is provided in Appendix B. Several details of the studies are specified including the name of the study and citation, the sample size, number of time points, what domain(s) are used to define subgroups along with a list of variables not used in the groupings used to further differentiate the groups (i.e., external variables), method used in the grouping analysis, and group findings. This allows for a brief summary of the studies provided. Studies highlighted in the coming pages as examples are listed in the appendix.

**Top-Down and Bottom-Up Strategies.** Studies taking a systemic-wholistic approach have used both top-down and bottom-up strategies to identify types or groups of individuals. Studies using top-down strategies identify subgroups based on explicit pre-existing, preferably theory-based criteria (e.g., Berkman et al., 1993; Jorm et al., 1998; Zarit, Johansson, & Berg, 1993). For example, much work has been done to define successful aging and what characterizes it (e.g., Rowe & Kahn, 1997). Studies wishing to identify subgroups of successful aging older adults have pre-existing criteria to classify these groups. One example comes from the MacArthur Studies on Successful Aging where Berkman and colleagues (1993) classified older

adults as successful agers (high functioning) or non-successful agers (medium and low functioning) based on predefined cut-off scores on physical health and cognition tests. Another example of a top-down classification comes from Zarit, Johansson and Berg (1993) using data from the OCTO study in order to classify a group of 84 to 90 year olds into disability groups based on performance in five domains (mobility, physical activities of daily living (PADLS), instrumental activities of daily living (IADLS), sensory, and cognition). People were classified as having zero problems in each domain, a problem with IADLS, or a problem with more than one domain.

In contrast, studies using bottom-up strategies use methods such as cluster analysis to identify groups of similar individuals empirically from the data in an exploratory manner (e.g., Aldwin, Spiro, Levenson, & Cupertino, 2001; Gerstorf, et al., 2006; Lövdén, Bergman, Adolfsson, Lindenberger, & Nilsson, 2005; Maxson, Berg, & McClearn, 1996; Neugarten, Havighurst, & Tobin, 1968; Smith & Baltes, 1997; Smith & Baltes, 1998). One example for this approach comes from Aldwin and colleagues (2001) where data from the Normative Aging Study was used to classify men into groups that differ in physical functioning, personality, and mortality. Cluster analyses were used to identify the subgroups, and a great deal of variability was found between the groups. The groups were formed by the levels and changes occurring within the domains. Another example of a study using the bottom-up approach is from Smith and Baltes (1997) where 12 measures of cognition, self related functioning, and social integration were used to obtain psychological profiles of older adults. Cluster analysis was also used in this study to find subgroups of people who differed based on their functioning within each of these domains.

**Cross-Sectional and Longitudinal Data and the Use of Multiple Domains.** Another important aspect of these studies to consider is the cross-sectional versus longitudinal design and the number of areas of functioning examined. Just as is true in many areas of study, most of these studies use cross-sectional designs with only one wave of data collection (Neugarten et al., 1968; Smith & Baltes, 1997; Smith & Baltes, 1998). Although this can provide a highly insightful snapshot of differential aging, it is important to examine differential aging over time to examine how the subgroups continue to differ over time. Few studies have indeed used longitudinal data (e.g., Gerstorf, et al., 2006; Lövdén et al., 2005; Maxson, et al., 1996).

Another important consideration is the number of the areas of functioning examined in these studies. Many studies examine only one area. For example, Lövdén and colleagues (2005) examined trajectories of cognitive development using multiple dimensions of cognition. Again, this approach provided valuable information about the progression of cognitive change with increasing age. For example, the authors demonstrated that not all individuals with dementia experience global low functioning across cognitive dimensions in the preclinical dementia phase, but some individuals experience loss in some dimensions then eventually global loss. The preclinical dementia phase is characterized by different cognitive losses for different people. However, it is an open question as to how these changes relate to changes in other domains of functioning. My premise is that it is extremely valuable to not only examine one domain of functioning, but multiple domains to comprehensively describe the psychological profiles of older adults along with possible antecedents, correlates, and consequences. Maxson and collaborators (1996) provide a great example of this through their inspection of cognitive performance, physical health, functional capacity, well-being, and social integration to identify subgroups of older adults differing based on level and change in these domains. One of their

subgroups was characterized by a profile of low functioning for social integration, well-being, and health and high functioning for cognition and functional capacity, whereas another subgroup was characterized by a profile of high functioning in all domains except for below average physical health. Examining the multiple domains simultaneously allowed for the latter group to be considered to be successfully aging, but this group would be considered to be aging poorly if physical health was just taken into account.

**Predecessor Studies of the Current Work**

Next, I describe two studies exemplifying the systemic-wholistic perspective to the study of differential aging. Both use subgroup-oriented approaches and will provide the basis for the current study. The first by Smith and Baltes (1997) was cross-sectional in nature and provided a foundation for the next study to be discussed by Gerstorf and colleagues (2006). Smith & Baltes (1997) used one wave of data from the Berlin Aging Study (BASE) to identify psychological profiles in older adults (aged 70 to 103). Data from 516 people were used on 12 measures of cognition, personality and self related functioning, and social integration. These domains were chosen to provide a comprehensive psychological profile of individuals across key domains of functioning in old age. Through cluster analysis, nine subgroups were identified who differed considerably in levels across the three domains. The number of subgroups found provides support for the differential development that occurs into and throughout old age. In addition, the subgroups differed significantly in the levels of functioning across domains. For instance, some had low levels of cognitive fitness but high social integration. Having identified such a profile runs counter to variable-oriented findings of a positive manifold among the profile-defining dimensions, suggesting that people with low levels in one domain tend to show low levels of functioning in the other domain as well. Finally, the subgroups also differed on cross-

disciplinary factors not included in the cluster analysis including demographics, physical functioning and life history, and successful aging outcomes. This allows for the identification of factors associated with more desirable profiles, be it as precursor, correlate, or consequence of the psychological profile. For example, people who were in the best health, had the highest levels of education, and were young were in the most desirable profiles.

Whereas Smith & Baltes (1997) did not address how the subgroups differ over time or in regards to changes across the psychological domains, Gerstorf and colleagues (2006) were able to get a step closer to this. This study used six-year longitudinal data from three waves of BASE. The same domains were used to identify the subgroups. In order to examine the change in subgroups over time, baseline clusters were used as the reference for change analyses to see how many people remained in the same cluster wave to wave or changed clusters. Three subgroups were identified. Specifically, one subgroup was characterized by high functioning in all domains whereas another subgroup was average across domains, and a third group was highly cognitively fit but had low self related functioning and social integration. The authors found that subgroup classification was fairly consistent over time with an average of two-thirds of the participants remaining in their original subgroup. At the same time, some people did move between groups. This again provides support for the continued differential development that occurs in old age. Also like Smith & Baltes (1997), this study found that the subgroups differed on variables that were not part of the subgroup definition, namely sensory functioning, health, life history, and demographics. For example, individuals in the high functioning subgroup were younger and in better health especially when compared to the high cognition, low self related functioning and social integration subgroup. One aspect of this study that was different from the Smith & Baltes report (1997) was the capability of examining the predictive ability of the subgroups for

subsequent outcomes of successful aging. Two long-term outcomes of well-being and mortality were found to differ between subgroup of individuals. In particular, the desirable subgroup (high functioning across all three areas) reported higher well-being six years later and also lived longer at the end of the study than people in the less desirable profiles. This pattern provides further evidence for the validity of the subgroup formations. More importantly, the subgroups revealed robust and predictive effects for these outcomes, whereas the subgroup-defining variables individually did not. This pattern once again highlights the utility of examining multiple factors simultaneously at the individual level to study development.

**The Present Study**

Taken together, these studies clearly illustrate the utility of the systemic-wholistic perspective. Although Gerstorf and colleagues (2006) provided greater insight into the differences of subgroups of older adults over time, they did not model change directly, which will be the goal of the current study. This study aims to answer two overarching questions. First, can I identify groups of old and very old adults who differ in developmental trajectories over time in the domains of well-being, social integration, and cognition? These domains are chosen to represent key psychological domains to provide comprehensive psychological profiles. The goal is to identify different psychological profiles based on these variables. Latent profile analysis will be used to obtain the subgroups through the use of individual intercepts and linear slopes over time in each psychological domain for every participant. After identifying these subgroups, I seek to validate the groupings through the use of external variables not included in the profiles. Thus, secondly, can these subgroups be differentiated by other variables not included in the groupings such as sociodemographics (age, educational level, sex, marital status, and living arrangement) and health indicators (functional limitations and survival time)?

Differences found between profiles for these correlates will add additional evidence for the validity of the groupings.

# Chapter 2. Method

## Participants and Procedure

I make use of data pooled together from four Swedish studies of aging: GENDER (Gold, Malmberg, McClearn, Pedersen, & Berg, 2002), OCTO (Johansson & Zarit, 1995), OCTO-TWIN (McClearn et al., 1997), and NONA (Fauth, Zarit, Malmberg, & Johansson, 2007). In the GENDER and OCTO-TWIN studies, beginning in 1995 and 1990, respectively, representative samples of twin-pairs in their 70s and 80s were recruited from the Swedish Twin Registry, a population-based registry of all multiple births in Sweden. In the OCTO and NONA studies, beginning in 1987 and 1999, respectively, participants in their 80s and 90s were recruited from the population registry (which contains names and birth dates of all residents) of the municipality of Jonkoping. Initially, at the baseline assessment, OCTO participants were age 84, 86, 88, and 90 years and NONA participants were age 86, 90, and 94 years. All four longitudinal studies assessed individuals on at least three occasions (OCTO-TWIN on five occasions) at two year or four year (GENDER) intervals. The current analysis uses longitudinal data from the subsample of participants who provided data on at least two occasions for the profile defining measures (well-being, social integration, and cognition). These 1,008 participants (61% women) provided an average of 3.4 occasions of data, and at their first assessment (T1) were aged between 69 and 95 years ($M$ = 81, $SD$ = 5.6).

## Measures

**Profile Defining Measures.** Measures from three domains representing key areas of psychological functioning (cognition, well-being, and social integration) were used to identify subgroups defined by differential trajectory profiles. Each measure was administered in the same

way across waves and studies unless otherwise noted. Appendix C contains the full listing of the items for each measure.

***Well-Being.*** 10 items from the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977) provided information on depressive symptoms. Participants were asked how often during the past week they had experienced a variety of depressive symptoms (e.g., thought life had been a failure, felt fearful, felt depressed). An average score was calculated, and responses range from zero (rarely or never) to three (most of the time) (T1: $M$ = 0.5, $SD$ = 0.4). The scale was found to be highly reliable ($\alpha$ = .79).

***Social Integration.*** Measures of subjective support (three items) and loneliness (two items) were adapted from the UCLA Loneliness Scale (Malmberg, 1990; Russell, 1982). Participants were asked how often they felt the way described in the items (e.g., feeling like there is someone to talk to, feeling a part of a circle of friends). Responses range from one (not at all) to four (nearly always). An average score was calculated across items (T1: $M$ = 3.4, $SD$ = 0.5). Reliability of the scales has been established in a number of studies (e.g., Femia, Zarit, & Johansson, 2001).

***Cognition.*** Individuals' cognitive ability was measured using a recall memory subtest of the Memory in Reality test (Johansson 1988/1989). Participants were presented and asked to memorize a list of 10 common objects (keys, medicine, wrist watch, comb, pencil, matchbox, ring, eyeglasses, scissors, and glass). The number of words from the list that they were able to recall when prompted 30 minutes later was taken as a measure of their memory ability. At the initial assessment (T1) scores ranged from 0 to 10 ($M$ = 6.8, $SD$ = 2.5). This measure has been found to be a reliable and valid measure of recall memory (Fiske & Gatz, 2007).

**Correlates**. An additional set of variables were used to examine possible differences between the profiles to further validate the subgroups. Specifically I examined how the profile subgroups differed on a range of sociodemographic characteristics and health indicators. *Sociodemographic* variables included initial assessments of age, educational level (total years of education), sex (0 = man, 1= woman), marital status (0 = married, 1 = not married), and living arrangement (0 = ordinary housing, 1 = living in institution). *Health indicators* included measures of functional limitations and survival time. Functional limitations were assessed using a subset of the personal activities of daily living (PADLs) and instrumental activities of daily living (IADLs) scales. Participants were asked how much disability they had performing a variety of activities from zero (completely independent) to three (unable to do the activity at all). Sum scores of PADLs and IADLs were averaged to obtain a final functional limitation score. Finally, survival time was assessed as distance-to-death (years to death). See Table 1 for descriptive information on all variables.

**Statistical Analysis**

Data analysis proceeded as follows. In a preliminary step, growth models were used to obtain six measures (two for each outcome) that quantified interindividual differences in intraindividual change for the three profile defining measures (depressive symptoms, social integration, and memory). Then, latent profile analysis (LPA) was used to identify the subgroups of individuals with differing developmental trajectories, as defined by the six model-derived measures obtained in the preceding step (depressive symptom intercept and linear change, social integration slope and linear change, and memory intercept and linear change). Finally, a variety of regression-based methods were used for examining differences among profile groups in relation to sociodemographic and health indicator variables. Specifically, analysis of variance

(ANOVA) was used to examine group differences on the continuous correlates (e.g., age, educational level); cross-tabs to examine extent of relation between group membership and the categorical correlates (e.g., sex, marital status, living arrangement); multi-level models to examine group-level differences in longitudinal trajectories of functional limitations; and Cox-Regression for group-level differences in survival time.

**Growth Models.** Growth curve models (e.g., McArdle & Nesselroade, 2003; Singer & Willett, 2003) were used to obtain six trajectory-based measures that would then be used to define profiles. Specifically, our objective was to summarize and extract information about individuals' initial levels and trajectories (i.e., rates of change) in three measures of psychological functioning (depressive symptoms, social integration, and memory). Using a multilevel modeling framework, growth models for each variable were specified as

$$Domain_{ti} = \beta_{0i} + \beta_{1i}(time_{ti}) + e_{ti}\,, \qquad (1)$$

where person *i*'s score in a particular domain (e.g., depressive symptoms, social integration, memory ) at time *t*, $Domain_{ti}$, is a function of an individual-specific intercept parameter, $\beta_{0i,}$ and an individual-specific linear slope parameter, $\beta_{1i}$, that captures the linear rate of change per year of time, and residual error, $e_{ti}$. Following standard growth curve modeling procedures, individual specific intercepts, $\beta_{0i}$, and linear slopes, $\beta_{1i}$, (from the Level 1 model give in Equation 1) were modeled as

$$\beta_{0i} = \gamma_{00} + u_{0i}\,, \qquad (2)$$

$$\beta_{1i} = \gamma_{10} + u_{1i}\,,$$

(i.e., Level 2 model) where $\gamma_{00}$ and $\gamma_{01}$ are sample means, and $u_{0i}$ and $u_{1i}$ are individual deviation from those means. Using SAS PROC MIXED with restricted maximum likelihood estimation and standard missing at random assumptions (Little & Rubin, 1987; Singer & Willett, 2003), I

fitted the model separately for each of the three domain measures to obtain, through calculation of Bayes empirical estimates (see Littell, Milliken, Stroup, Wolfinger, & Schabenberger, 2006), individual-level measures of level, $\beta_{0i}$, and rate of change, $\beta_{1i}$, for each domain based on up to eight years of time. These measures were then carried forth into the next step.

**Latent Profile Analysis.** The intercept and linear slope estimates for depressive symptoms, social integration, and memory extracted through the above procedure were transformed to Z-scores (to alleviate concerns of differential weighting) and used to obtain a set of subgroups defined by their trajectory profiles. Specifically, latent profile analysis (LPA), a latent mixture model for the identification of latent classes based on mean differences in continuous, manifest variables, was used to determine and describe the characteristics of the optimal number subgroups that best represented the data (Ko, Berg, Butner, Uchino, & Smith, 2007; Lanza, Flaherty, & Collins, 2003). Advantages o this approach include the simultaneous estimation of profiles and of group membership probabilities and the ability to test alternative models (e.g., means differing, variances differing between groups; see Hill, Degnan, Calkins, & Keane, 2006; Lanza et al., 2003). A series of LPA models with different numbers of classes (1 to 10) and possible group differences (means, variances) were fitted to the data using *MPlus* (Version 4: Muthen & Muthen, 2006) with maximum likelihood estimation and standard missing at random assumptions (Little & Rubin, 1987).

To compare LPA models with different numbers of profile groups, several criteria and statistics can be used. Ram and Grimm (2009) outline a series of steps to use when determining the optimal model which will be adopted here. First, model parameters were examined for any peculiarities with estimates (e.g., unable to be estimated, out of bounds) and to check the interpretability of the groupings and estimates. If a model provided groups that seemed

inappropriate (e.g., because of convergence problems), then these model solutions were not considered further.

Second, models were compared using model fit criteria including the Bayesian Information Criteria (BIC) and Adjusted BIC. These fit statistics allow for the comparison of models with different numbers of parameters and penalizes for overfitting or having too many parameters in a model. Good fitting models minimize the BIC and ABIC. When comparing two models, the better model is the one with a smaller BIC and ABIC (Nagin, 1999; Nylund, Asparouhov, & Muthen, 2007).

Third, the entropy value of each model was examined. Entropy is a measure of the precision of individual profile membership and provides a summary of the conditional probabilities of group membership for individuals. Values range from zero (individuals have an equal chance of being in any profile) to one (individuals have probability of being assigned to only one class). Entropy values greater than or equal to .80 are typically considered to be adequate and indicate that individuals are likely to be grouped in profiles best suited to them (Muthen, 2004).

Finally, the Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR-LRT) was used to compare models to models with one fewer group. This test applies a corrected likelihood ratio distribution when comparing differences in model fit and provides a p-value to test if there is significant improvement in fit between a model with c and c-1 groups. A p-value of less than .05 indicates that the current model should be used over a model with one less group (Lo, Mendell, & Rubin, 2001; Nylund et al., 2007; Ram & Grimm, 2009).

After determining the optimal number of profile groups and their characteristics, model parameters and individual probability estimates were imported to SAS for further examination, interpretation, and plotting.

**Group Differences.** Profile groups were further differentiated through a series of group difference analyses. Group membership was used as the predictor variable whereas sociodemographic characteristics and health indicators were used as outcomes. Analyses used included ANOVAs, t-tests, multi-level models, and Cox-Regression.

# Chapter 3. Results

Results are organized into two sections. First, the findings of the latent profile analysis are presented along with the final profile solution. These findings are focused on identifying the proper number of profile solutions and showing the differences between the final chosen profile solutions with regards to their developmental trajectories of the profile defining measures. Second, additional analyses then further examined the validity of the profiles by examining their differences in relation to external measures not included in the measures.

## Subgroup Identification

The first goal of our study was to identify subgroups of individuals differing in their developmental trajectories across depressive symptoms, social integration, and memory. After obtaining the individual level intercepts and linear slopes of depressive symptoms, social integration, and memory from the MLM, the LPA was then performed on these six variables. Models discussed here only allowed for the means for each variable to vary across profiles. However, similar results were obtained from models where the variances of variables were allowed to differ in addition to the means.

To choose the ideal number of profiles, the steps outlined in the data analysis section (taken from Ram & Grimm, 2009) were utilized. Balancing fit and interpretability, models with two to ten profile solutions were compared to determine the optimal solution. Models with eight and ten subgroups were immediately eliminated due to convergence problems. After checking the rest of the models for any peculiarities with and interpretability of the estimates and finding nothing out of the ordinary, statistical indicators were then used to help decide upon the final solution. Table 2 displays the statistical indicators of the BIC, Adjusted BIC, entropy, and VLMR-LRT. First the BIC and adjusted BIC were examined for model fit. The nine-group

solution offered the best relative fit, but did not provide much in terms of interpretability. Entropy values were greater than .80 for each remaining model indicating that all profile solutions had adequate precision of individual profile membership. Finally, the VLMR-LRT was utilized to examine differences in model fit between a model and a model with one less profile. The significance test p-value attached to this statistic should be less than be .05 to indicate that a model fits better than a model with one less profile. Models with two to four profile solutions had significant p-values. Because the BIC and adjusted BIC were smallest for the four profile solution along with the highest entropy value (.88), this model was chosen as the final model.

In sum, our LPA analyses indicated that a four class model of mean differences provided an optimal description of the data. Parameter estimates, converted back to T-score units are shown in Table 3. As stated previously, the LPA was used to obtain the profile membership of each individual participant included in the study. The data was then put back into SAS to examine the actual differences between the profiles on the profile defining variables. This was done by using profile membership as a correlate in growth curve models discussed previously. Separate growth curves were ran for each of the three profile defining variables of depressive symptoms, social integration, and memory, which were T-scored ($M$ = 50, $SD$ =10). The fourth group (preserved system integrity group), which was the largest, was used as the reference group for the analyses. Table 3 displays the results from the growth curve models and provides an overview of differences between groups in levels and linear changes of the psychological variables. Corresponding group-level trajectories based on the six means (levels and rates of change for each of the profile defining variables) are shown in Figure 1.

As displayed in the first panel, the first profile was the largest consisting of 639 individuals (63% of sample). I labeled this profile group the *preserved system integrity group*.

This group maintained average or above average trajectories across all domains. Depressive symptoms were around average at baseline (48.124) and increased at a minor linear rate of change per year (0.295). Social integration and memory were around a half standard deviation above average at baseline (54.655 and 54.627, respectively). However, social integration had a slight average linear rate of decline (-0.324) whereas memory remained stable (linear slope parameter of -0.026 not significantly different than zero).

The second profile group consisted of 176 individuals (18% of sample) and was characterized by relatively low functioning across all domains, particularly in social integration. This group was labeled the *aging in isolation group.* At baseline, this subgroup was about one standard deviation above the total sample mean depressive symptom level (48.124 + 11.962 = 60.086), two standard deviations below average in social integration (54.655 – 22.970 = 31.685), and a half standard deviation below the mean in memory (54.627 – 8.747 = 45.88). On average, this group maintained their high levels of depressive symptoms over time (linear slope = 0.295 – 0.669 = -0.374), while their social integration scores increased substantially (linear slope = -0.324 + 1.701 = 1.377) over time, and their memory scores decreased slightly (linear slope = -0.026 – 0.436 = -0.462).

Figure 1 also displays the third profile consisting of 39 individuals (4% of sample) referred to as the *memory failing group*. The group remained fairly average in their depressive symptoms and declined around a half standard deviation in social integration. The distinguishing factor of the memory failing group was the severe loss in memory. This group started off about a half standard deviation above average in memory at baseline but then proceeded to decline around three standard deviations throughout the eight years of study. The individual memory

trajectories of the 39 group members are plotted in Figure 2. Most trajectories declined drastically as would be expected from the average group memory trajectory.

The fourth profile contained 154 individuals (15% of sample) and is referred to as the *compromised memory group*. This profile's trajectories of depressive symptoms and social integration are what would be characterized as fairly normal aging. Depressive symptoms and social integration were around average at baseline and remained fairly stable. On the other hand, memory began at around one and a quarter standard deviations below average at baseline which is what really characterized this profile. The change in memory thereafter is fairly average, but the low level initially is not.

**Profile Differences in External Baseline Variables**

The second goal of this study was to examine if and how the profile groups differed on sociodemographic (age, education, sex, marital status, living arrangements) and health indicator (functional limitations, survival time) variables. Results suggested differences between profiles on these external measures and provided more validity to the profiles. The differences were paralleled in the psychological differences between groups.

One-way ANOVAs were used to examine group differences in mean age and educational level. Results, along will group-level descriptive are provided in Table 4. Graphical representations of the difference, relative to the overall sample means are shown in Figure 3. Significant group differences were found for age $F(3, 1004) = 82.19$, $p < .001$, and educational level, $F(3, 998) = 5.24$, $p < .001$. Scheffé post hoc tests revealed that the preserved system integrity group was, on average, younger ($M = 79.2$, $SD = 5.7$) than the other groups. As well, this group had a significantly higher educational level ($M = 7.4$ $SD = 2.4$) than the compromised memory group ($M = 6.8$, $SD = 1.6$).

Cross-tabulations along with chi-square tests of independence were used to examine if group assignment was associated with sex, marital status, and living arrangement. Significant associations were found for all three variables: sex, $\chi^2(3, N = 1008) = 11.35$, $p < .01$, marital status, $\chi^2(3, N = 1008) = 44.28$, $p < .001$, and living arrangement, $\chi^2(3, N = 1008) = 41.88$, $p < .001$. Follow-up analyses indicated that the preserved system integrity group had a lower percentage of women (57%) and of institutionalized individuals (5%) and a greater percentage of married individuals (49%) than both the aging in isolation and compromised memory groups (see Table 4 and Figure 3).

A conditional growth model was used to examine group differences in how functional limitations changed over time. Specifically, dummy variables (with the preserved system integrity group as the reference group) were introduced as predictors into a growth model to isolate differences in both initial levels and rates of change for functional limitations. Results are presented in Table 5. Significant differences between average levels at baseline are suggested, but no significant linear change differences are found. Figure 4 displays the different functional limitations trajectories for each group (all parameters used for plots but no significant linear change differences between groups). The preserved system integrity and memory failing groups start off around a half standard deviation below average at baseline with number of functional limitations (44.981). In comparison, the aging in isolation and compromised memory groups begin slightly above average with more functional limitations at baseline (respectively, 44.981 + 9.357 = 54.338, 44.981 + 8.589 = 53.570). Projecting over eight years, the rank-order differences were maintained over the study period.

In the final analysis, Cox (1972) proportional hazards regression models (implemented via the PHREG procedure from the SAS software package (SAS Institute, 1997; see also Allison,

1995) were used to examine group differences in survival time, both not controlling and then controlling for age, education, and sex. Results from these two models are shown in Table 6. I found that the that the relative risk of dying was higher for the aging in isolation group, $\chi^2(1, N = 1008) = 28.30$, $p < .001$ (RR = 1.60, confidence interval [CI] = 1.34, 1.89); the memory failing group, $\chi^2(1, N = 1008) = 14.00$, $p < .001$ (RR = 1.87, CI = 1.35, 2.60); and for the compromised memory group, $\chi^2(1, N = 1008) = 32.32$, $p < .001$ (RR = 1.70, CI = 1.42, 2.04) as compared to the preserved system integrity group. The noted group differences remained when controlling for sex, education, and age (Model 2). The Kaplan-Meier survival curves over the 16 year follow-up shown in Figure 5 illustrate the differences in survival probability. People in the preserved system integrity group lived an average of ten years after baseline assessment, compared to eight years for the memory failing group, six years for the aging in isolation group, and five years for the compromised memory group.

## Chapter 4. Discussion

Whereas much research on differential aging has utilized a variable-oriented approach, this study adopted a systemic-wholistic perspective to the study of heterogeneity in old age. This perspective uses multiple-indicator information at the person or subgroup level in order to gain insights into differential development that may not be possible using a variable-oriented approach. The results reported here illustrate the unique understanding of the intricacies of human development that is possible by adopting this perspective and using person- or subgroup-oriented methods in the study of differential aging.

This study pursued two research questions. First, I used multiple indicator information at the individual level to identify profiles of differential psychological trajectories for old and very old individuals. The domains of well-being [depressive symptoms], social integration, and cognition [recall memory] were chosen to provide psychological profiles of a pooled sample of 1,008 older adults from four Swedish longitudinal studies spanning eight years. Using latent profile analysis, I found four subgroups of individuals differing in their profiles of trajectories across the chosen psychological constructs. This provides support for my expectation of finding these subgroups differing in their psychological profiles and also speaks to the heterogeneity in the development of older adults, which can be further explored using methods such as those used in this study. It is important to note that latent profile analysis generates many possible solutions with somewhat ambiguous and often disagreed upon selection criteria. However, I used systematic evaluation steps and many statistical indicators to arrive at my final and arguably best solution of four profiles.

Second, I asked if the subgroups could be differentiated by other constructs not included in the profiles. These external constructs consisted of sociodemographic variables (age, sex,

marital status, educational level, and living arrangement) and health indicators (functional limitations and survival time). The subgroups were found to differ on these external variables. Differences in the profiles on these cross-disciplinary factors add further validity to the groupings and can begin to provide insight into possible precursors or consequences of profile membership (Smith & Baltes, 1997). This can help aid our understanding of possible factors contributing to differential aging.

**Subgroups**

**Preserved System Integrity Group.** The largest profile group consisting of 639 individuals (63% of sample) was uniquely characterized by average to above average trajectories across all psychological domains. This group was called the preserved system integrity group to highlight the fact that the different systems of functioning changed together in a way that provided optimal psychological functioning for the individuals. Further evidence of this was provided with the fact that the individuals in this group experienced fewer functional limitations and lived longer on average than the other groups. Additionally, this profile included the youngest, most educated, highest percent married, and lowest percent women and institutional living individuals. Most significant differences found between profiles were between this group and the others. It may be that the characteristics of this group may be considered protective factors for successful aging (e.g., greater educational attainment and marriage).

The high levels of functioning in the preserved system integrity group echo the high functioning of overall positive profiles found in several other subgroup-oriented studies, and these groups tend also to contain the largest portion of individuals in the studies (e.g., general positive profile in Smith & Baltes, 1997; overall positive profile in Gerstorf et al., 2006; generally positive group in Ko et al., 2007; high cognitive/high social/high well-being group in

Maxson et al., 1996). For example, the overall positive group discussed in Gerstorf and colleagues (2006) was at least half a standard deviation above average in the group defining domains of cognition, self and personality, and social integration. The individuals in this group were also found to live longer than the less positive profiles in the study. The table in Appendix B provides a further overview of the study.

Findings of an overall positive profile in this sample of old and very old adults provide a deeper understanding of successful aging for this age group. Successful aging is possible even in the oldest ages and not just in a small subsample of individuals but in many people. The preserved system integrity group best illustrates successful aging through the maintenance of functioning across all domains and is the largest group of the four profiles. Contrary to popular notions of old age as a time of great decline, my findings suggest that a large portion of individuals are maintaining functioning across a variety of domains and successfully aging.

**Aging in Isolation Group.** Compared to the preserved system integrity group, the aging in isolation group ($N$ = 176, 18% of sample) experienced poor functioning across all domains. Well-being and cognition continued at low levels throughout the study. Social integration was the lowest for this profile, and thus, the profile name emphasizes the isolation of its individuals. Further features of this less than desirable profile were the lowest percentage of married individuals and the highest percentage of institutionalized individuals in addition to the greatest number of functional limitations compared to the other profiles.

This group is similar to many groups in other subgroup-oriented studies. It best resembles the overall negative profiles obtained in these studies (e.g., general negative profile in Smith & Baltes, 1997; extremely frail, lonely, depressive group in Smith & Baltes, 1998; overall negative group in Maxson et al., 1996). These negative profiles contain individuals with low

functioning across most or all group defining domains. However, social integration is not the profile defining domain as it is in the aging in isolation profile. An example where the social domain is the profile defining component is provided by the general positive profile: high social embeddedness group found in Smith and Baltes (1997) (see Appendix B for further study details). The social integration domain best characterizes this profile also but in the opposite direction with its extreme high levels of two standard deviations above the sample average.

Theories of successful aging would refer to the aging in isolation group as the unsuccessful aging group of the four profiles. Particularly with such low social integration, individuals in this group are unable to maintain desirable levels of functioning. Lack of social support and feelings of loneliness may be the driving force behind the poor trajectories in the other domains and the overall poor psychological profile. It seems that a subgroup of older individuals require interventions perhaps aimed at increasing feelings of social integration. However, it is an important point that this unsuccessful aging group is not the largest group and thus helps to dispel the misconception of old age as only a time of poor functioning.

**Memory Failing Group.** Individuals in the memory failing group ($N$ = 39, 4% of sample) were characterized by their drastic decline in cognition. They were experiencing such severe declines in cognition that it was possible that they were experiencing some form of dementia, which they most likely they would not come back from or stop from further declines. Furthermore, the memory failing group had comparable characteristics on the external variables to the preserved system integrity group, but the small sample in the group may have made it impossible to obtain significant group differences.

When attempting to link this profile to similar ones found in other subgroup-oriented studies, it becomes challenging because of the lack of longitudinal studies in this area. For the

memory failing group, the great decline in cognition requires a profile from a longitudinal study in order to make the best comparison. One exception is Lövdén and colleagues (2005) who examined the change in multiple cognitive areas in a cluster analysis and found that it is possible for cognition to decline drastically from average to below average levels as it does in the memory failing group, but it is fairly rare. The authors found that dementia or death would often result from such a decline if it was to occur. The small size of the memory failing group is similar to the small size of the sample with a similar trajectory in Lövdén and colleagues (2005) suggesting that it is possible that this group represents a small subsample of participants who experienced dementia or were in a pre-dementia phase.

Stereotypes of old age as a time of cognitive loss and high dementia risk lack much supporting evidence from the size of the memory failing subgroup. Only a very small percentage of the sample possessed membership in the profile suggesting that severe cognitive loss is not as common as may be conceived stereotypically. Dementia and related cognitive illnesses are not a part of normal aging and do not best describe development in old age. A small percentage of individuals will suffer from great cognitive impairment and require care to meet their different functional demands, but this group accounts for only a small proportion of older adults.

**Compromised Memory Group.** The compromised memory group ($N$ = 154, 15% of sample) maintained very low cognition levels throughout the course of the study, which its name illustrates. Well-being and social integration trajectories were fairly average, leaving poor cognition to stand out as the profile defining characteristic. Compared to the memory failing group, this group did not decline drastically in cognition but instead began with low levels at baseline and continued at similar levels. On average, the oldest individuals in the sample were in

the compromised memory group, and group members had the shortest survival time compared to the other profiles.

Additionally, this group is not solely a product of this analysis but resembles groups from other subgroup-oriented studies. Other groups are also characterized by somewhat average functioning groups with low cognitive abilities (e.g., cognitively impaired and high external control group in Baltes & Smith, 1997; low cognitive group in Ko et al., 2007; low cognitive group in Maxson et al., 1996). To illustrate, the low cognitive group found in Maxson and colleagues (1996) was characterized by extremely low cognition but average physical health, well-being, social contact, and functional capacity. This study is detailed more in Appendix B.

Through the maintenance of average well-being and social integration despite their cognitive limitations, it is suggested that perhaps individuals in the compromised memory group felt socially supported and were able to maintain psychological functioning in other domains thus keeping their cognitive abilities from declining even more. Moreover, this group provides a different configuration of variables than would be hypothesized using a variable oriented approach, which would more likely predict low levels for all variables. Through the use of multiple domain information, I was able to examine the average trajectories of well-being and social integration in addition to the poor cognition leading me to conclude that the profile was not negative overall. Thus the compromised memory group is an excellent example of a unique insight into differential development in old age through the methods used in this study.

**Limitations and Outlook**

I acknowledge that the profile analysis applied in this study is not without limitations. Profile analyses are dependent on the sample and measures used. The domains and measures used to indicate them were restricted by the constructs included in the utilized studies. Using

other constructs may provide dissimilar findings as would using other measures as indicators of the profile defining domains of well-being, social integration, and cognition. For instance, using another indicator of cognition such as crystallized intelligence, which is not prone to as much decline as recall memory, may have changed the findings. Two of the subgroups identified here were characterized by their poor cognition (the memory failing and compromised memory groups), but results may not have found this with another cognition measure. Future research in this area should use multiple measures of the same domain in order to provide a deeper understanding of differential aging within that domain and its relation to other domains.

My findings may also suffer from lack of generalizability because of my use of data from a Swedish sample of older adults aged 70 and over whom possessed high levels of functioning overall. The solution may differ if using another study with a larger age range or people from another geographic area, which is why these findings should be replicated in order to ensure their validity. Importantly a more diverse sample of older adults from a variety of ethnic backgrounds and with varying resource constraints would be important to use in future studies. In addition, a study following individuals from earlier in life to old age may provide more clues about mechanisms leading to the different group memberships which can provide insight into risk and protective factors for successful aging.

A final source of limitations lied within the occasions of measurement. Participants provided up to five occasions, but with the pooled studies used, only a small subset of participants actually provided data five times. With the data, I was able to model change directly through the use of not only level but also linear change scores, which is something that few person- or subgroup-oriented studies have done. However, a greater number of occasions, more closely spaced would allow for analyses which consider possible transitions in group

membership and non-linear trajectories. Future work should continue to model differential change through the use of long-term longitudinal studies but those with more closely spaced and numerous measurement occasions.

Despite the limitations and issues to be addressed in future research, the results of the subgroup analysis provide additional evidence of the heterogeneity possible in the development of older adults. Even with much theory supporting the notion of differential aging (e.g., Baltes, 1987; Birren, 1959; Dannefer, 2003; Riley, 1987), research in this area is still continuing to develop through the use of longitudinal studies and contemporary statistical methods. In particular, this study illustrates the heterogeneity which can be observed in the older population through the use of person- or subgroup-oriented analyses and by adopting a systemic-wholistic perspective. For example, I was able to find two subgroups of individuals with average functioning in well-being and social integration but with below average cognitive functioning (memory failing and compromised memory groups). Having identified such profiles runs counter to variable-oriented findings of a positive manifold among the profile-defining dimensions, suggesting that people with low levels in one domain tend to show low levels of functioning in the other domains as well. The systemic-wholistic perspective allows for research to identify subgroups that go against the common beliefs about old age development and further shows the heterogeneity in the older population.

Findings from this study also provide suggestions about risk and protective factors for successful aging. The examination of the relationships between group membership and a number of sociodemographic characteristics and health indicators allows for the identification of factors associated with more and less desirable profiles. These factors may be precursors, correlates, or consequences of the psychological profile. Factors which may be precursors to the profiles are of

particular interest as possible risk and protective factors for successful aging. For instance, the preserved system integrity group provides an example of a successful aging group of individuals. Group members were found to possess the greatest levels of education on average. Education may be an important factor for successful aging and has been suggested as such in the literature (e.g., Rowe & Kahn, 1997). This and other factors associated with group membership can help give clues about what contributes to successful aging and what to do and not to do in order to age well.

Additionally, the results of this study can be used in support of the use of adaptive interventions. These are interventions with flexible protocol tailored to the needs of individuals. The results reported here suggest that older adults experience a great deal of heterogeneity such that one intervention protocol may not be as beneficial for one group of individuals compared to another group. Adaptive interventions can more easily recognize and work with these differences in order to provide the best possible intervention for an individual.

Through the use of a person- or subgroup-oriented approach and the systemic-wholistic perspective, results indicated subgroups of individuals exhibiting differential change across various psychological constructs and further differences in cross-disciplinary factors. Results should be taken to indicate the differential aging which can be observed when moving towards using multiple indicator information at the person level in analyses. This speaks to the utility of a systemic-wholistic perspective when examining differential aging.

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# Appendix A

## Tables and Figures

Table 1
*Means, Standard Deviations, and Intercorrelations Among the Profile Defining Constructs and Correlates*

| Construct | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| Profile defining | | | | | | | | |
| 1. Memory | 6.8 | 2.5 | - | | | | | |
| 2. Depressive symptoms | 0.5 | 0.4 | -.08* | - | | | | |
| 3. Social integration | 3.4 | 0.5 | 0.25* | -.41* | - | | | |
| Correlates | | | | | | | | |
| 4. Age | 81.1 | 5.8 | -.45* | .04 | -.22* | - | | |
| 5. Years of education | 7.2 | 2.3 | .15* | -.05 | .08* | -.14* | - | |
| 6. Functional limitations | 1.1 | 1.8 | -.39* | .20* | -.31* | .37* | -.11* | - |
| 7. Sex (% women) | | 61.3 | | | | | | |
| 8. Marital status (% married) | | 41.2 | | | | | | |
| 9. Living arrangement (% institutionalized) | | 8.8 | | | | | | |

*Note.* $N = 1{,}008$. *$p < .05$.

Table 2
*Fit Statistics for Profile Solutions*

| Profile solution | BIC | ABIC | Entropy | VLMR-LRT p-value |
|---|---|---|---|---|
| 2 | 16445 | 16385 | 0.84 | 0.00 |
| 3 | 16253 | 16170 | 0.84 | 0.00 |
| **4** | **16077** | **15972** | **0.88** | **0.00** |
| 5 | 15939 | 15812 | 0.88 | 0.11 |
| 6 | 15825 | 15676 | 0.86 | 0.09 |
| 7 | 15742 | 15571 | 0.87 | 0.62 |
| 8* | 15667 | 15474 | 0.88 | 0.09 |
| 9 | 15619 | 15403 | 0.88 | 0.41 |
| 10* | 15631 | 15393 | 0.89 | 0.73 |

*Note*. BIC = Bayesian information criterion. ABIC = Adjusted Bayesian information criterion. VLMR-LRT = Vuong-Lo-Mendell-Rubin likelihood ratio test. Bold profile solution is the final solution. An asterisk indicates convergence problems.

Table 3

*Linear Growth Models for Profile Defining Measures*

| | Measure | | | | | |
|---|---|---|---|---|---|---|
| Effect (SE) | Depressive symptoms | | Social integration | | Memory | |
| Fixed | | | | | | |
| Intercept | 48.124* | (0.486) | 54.655* | (0.403) | 54.627* | (0.358) |
| Slope | 0.295* | (0.090) | -0.324* | (0.092) | -0.026 | (0.068) |
| Preserved system integrity (reference group) | - | - | - | - | - | - |
| Aging in isolation | 11.962* | (0.990) | -22.970* | (0.798) | -8.747* | (0.722) |
| Memory failing | -2.906 | (1.754) | -0.476 | (1.396) | 4.822* | (1.269) |
| Compromised memory | -0.916 | (1.084) | -6.338* | (0.891) | -17.611* | (0.772) |
| Preserved system integrity X slope (reference group) | - | - | - | - | - | - |
| Aging in isolation X slope | -0.669* | (0.224) | 1.701* | (0.220) | -0.436* | (0.164) |
| Memory failing X slope | -0.278 | (0.302) | -0.669* | (0.323) | -4.024* | (0.214) |
| Compromised memory X slope | -0.620* | (0.276) | 0.482 | (0.269) | -1.010* | (0.183) |
| Random | | | | | | |
| Variance of intercept | 48.920* | (6.757) | 22.640* | (5.883) | 24.893* | (3.522) |
| Variance of slope | 0.224 | (0.239) | 0.416* | (0.179) | 0.089 | (0.124) |
| Covariance of intercept, slope | 0.089 | (1.148) | 1.674* | (1.435) | 0.131 | (0.603) |
| Residual variance | 36.434* | (1.938) | 42.858* | (1.583) | 19.783* | (1.032) |
| -2LL | 15217 | | 15757 | | 13851 | |
| Pseudo $R^2$ | 0.193 | | 0.142 | | 0.380 | |

*Note*. Measures were T-scored ($M$ = 50, $SD$ =10). $N$ = 1,008. *-2LL* = -2 Log Likelihood. *$p < .05$.

Table 4
*Descriptives of Sociodemographic Measures not Involved in Defining the Profiles*

| | Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Preserved system integrity (n=639) | | Aging in isolation (n=176) | | Memory failing (n=39) | | Compromised memory (n=154) | |
| Construct | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Age | $79.2_{a}$ | 5.7 | $84.3_{b}$ | 4.6 | $83.2_{b}$ | 2.9 | $85.0_{b}$ | 3.3 |
| Education | $7.4_{a}$ | 2.4 | $6.9_{a,b}$ | 2.2 | $6.7_{a,b}$ | 1.6 | $6.8_{b}$ | 1.6 |
| % women | $57_{a}$ | | $68_{b}$ | | $69_{b}$ | | $69_{b}$ | |
| % married | $49_{a}$ | | $26_{b}$ | | $28_{b}$ | | $28_{b}$ | |
| % institutionalized | $5_{a}$ | | $19_{b}$ | | $15_{b}$ | | $15_{b}$ | |

*Note*. *M* = mean, *SD* = standard deviation. Means in the same row that have different subscripts were found to differ at $p < .05$ after running ANOVAs and Sheffe's post-hoc tests. Percentages in the same row that have different subscripts were found to differ at $p < .05$ after running cross tabulations with chi-squared tests.

Table 5
*Linear Growth Model for Functional Limitations: The Role of the Profiles*

| Effect (SE) | Functional limitations | |
|---|---|---|
| Fixed | | |
| Intercept | 44.981* | (0.460) |
| Slope | 0.922* | (0.093) |
| Preserved system integrity (reference group) | - | - |
| Aging in isolation | 9.357* | (0.929) |
| Memory failing | 1.199 | (1.665) |
| Compromised memory | 8.589* | (1.012) |
| Preserved system integrity X slope (reference group) | - | - |
| Aging in isolation X slope | 0.265 | (0.223) |
| Memory failing X slope | 0.378 | (0.325) |
| Compromised memory X slope | -0.054 | (0.263) |
| Random | | |
| Variance of intercept | 51.983* | (5.799) |
| Variance of slope | 1.492* | (0.281) |
| Covariance of intercept, slope | 0.091 | (1.116) |
| Residual variance | 28.281* | (1.511) |
| -2LL | 16543 | |
| Pseudo $R^2$ | 0.410 | |

*Note.* Functional limitations measure was T-scored ($M$ = 50, $SD$ =10). $N$ = 1,008. *-2LL* = -2 Log Likelihood.
*$p < .05$.

Table 6
*Cox Regressions Predicting Mortality Status of the Profiles*

| | Baseline model | | Covariates included | |
|---|---|---|---|---|
| | *HR* | 95% CI | *HR* | 95% CI |
| Preserved system integrity (reference group) | - | - | - | - |
| Aging in isolation | 1.60* | 1.34-1.89 | 1.32* | 1.10-1.58 |
| Memory failing | 1.87* | 1.35-2.60 | 1.62* | 1.16-2.25 |
| Compromised memory | 1.70* | 1.42-2.04 | 1.28* | 1.05-1.55 |
| Age | | | 1.05* | 1.04-1.06 |
| Education | | | 1.00 | 0.97-1.03 |
| Sex | | | 0.91 | 0.80-1.04 |

*$p < .05$

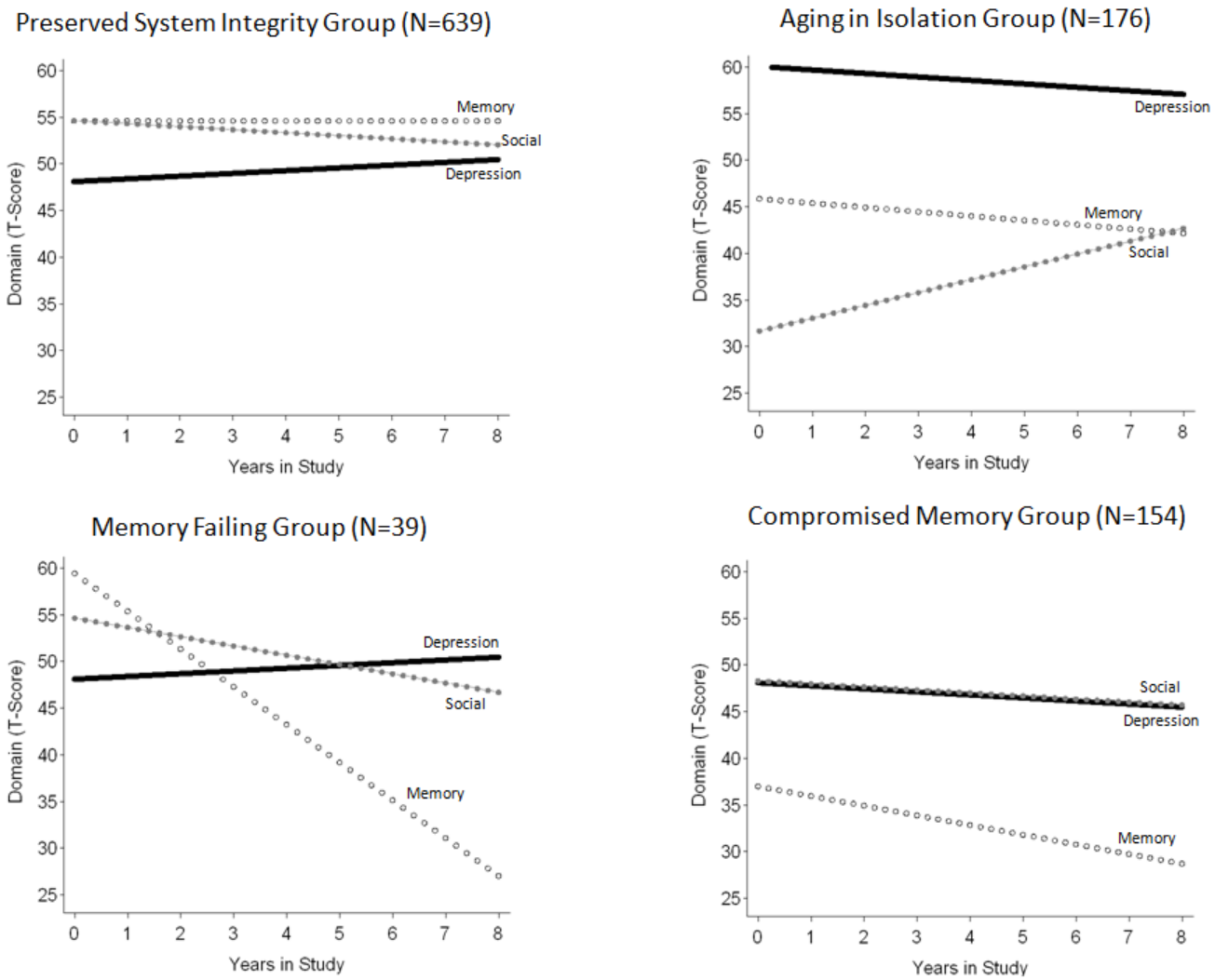


*Figure 1.* The four subgroups identified from latent profile analysis. Each graph represents a different subgroup's depressive symptoms, social integration, and memory trajectories. Measures were T-scored ($M$ = 50, $SD$ = 10).

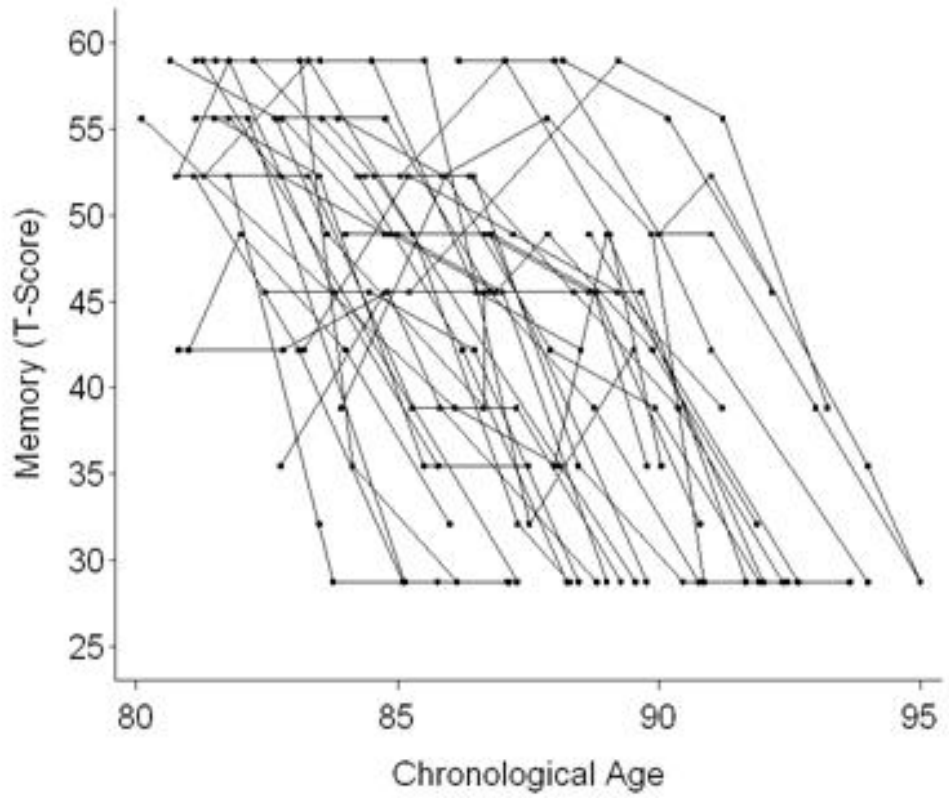


*Figure 2.* Individual memory trajectories for the 39 members of the memory failing group. Most trajectories decline drastically as would be expected from the memory failing group average memory trajectory.

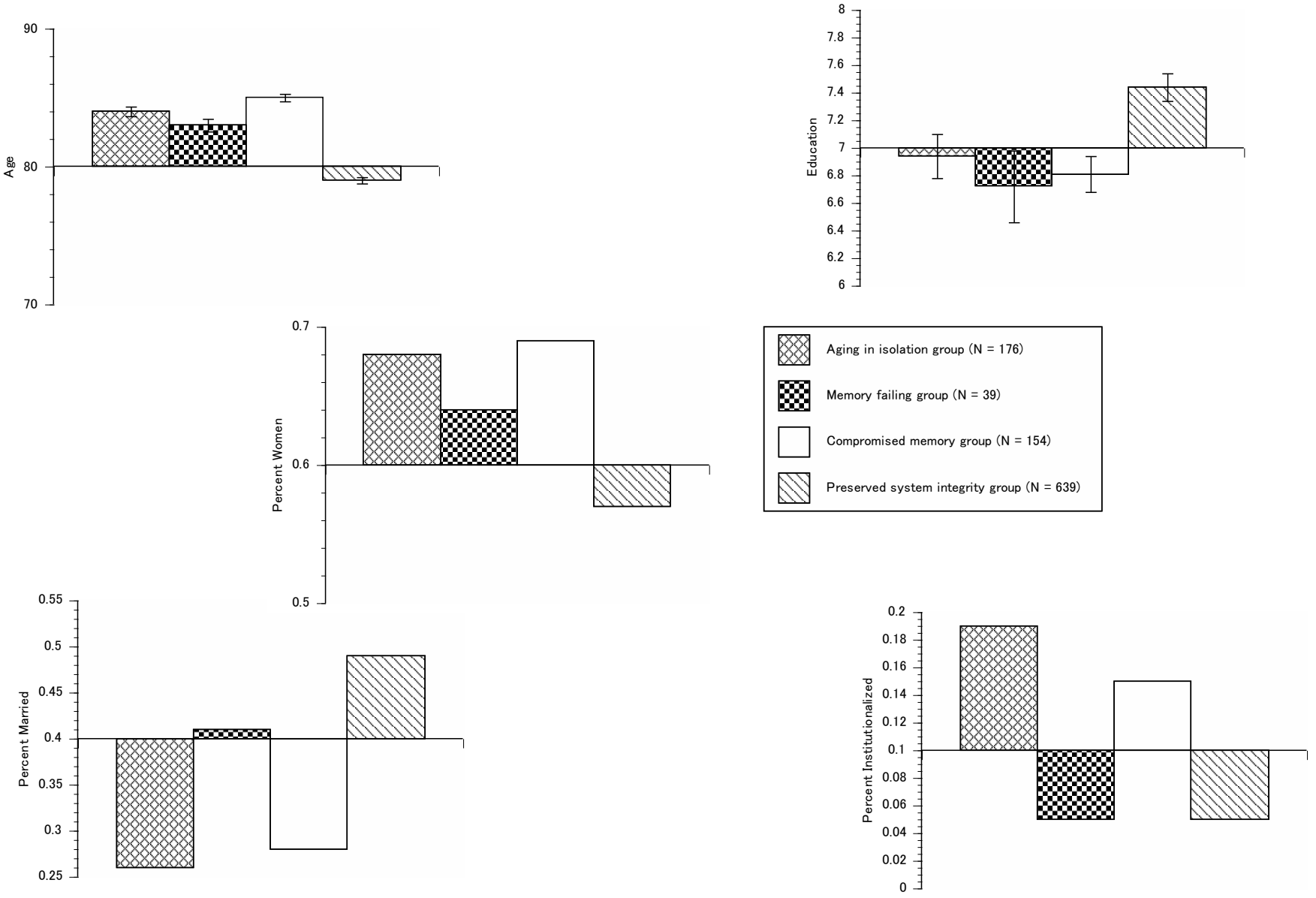


*Figure 3.* Differences in subgroups for sociodemographic correlates. The preserved system integrity group contained the youngest, most educated, least percent women and institutional living, and greatest percent married individuals.

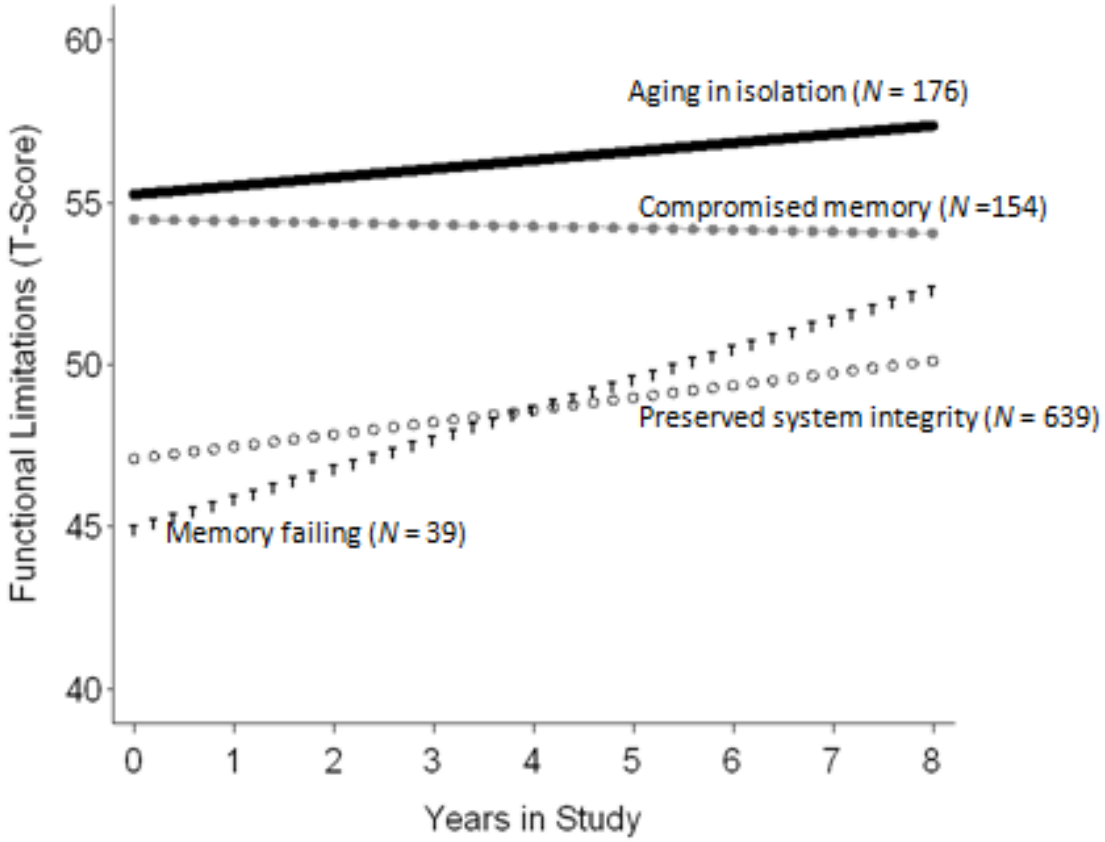


*Figure 4.* Time related change in functional limitations for subgroups. The plot suggests linear change differences between subgroups; however, this simply reflects plotting the trajectories with all parameters. There are no actual significant change differences but only level differences between the groups. Individuals in the preserved system integrity and memory failing group experienced the fewest functional limitations over time.

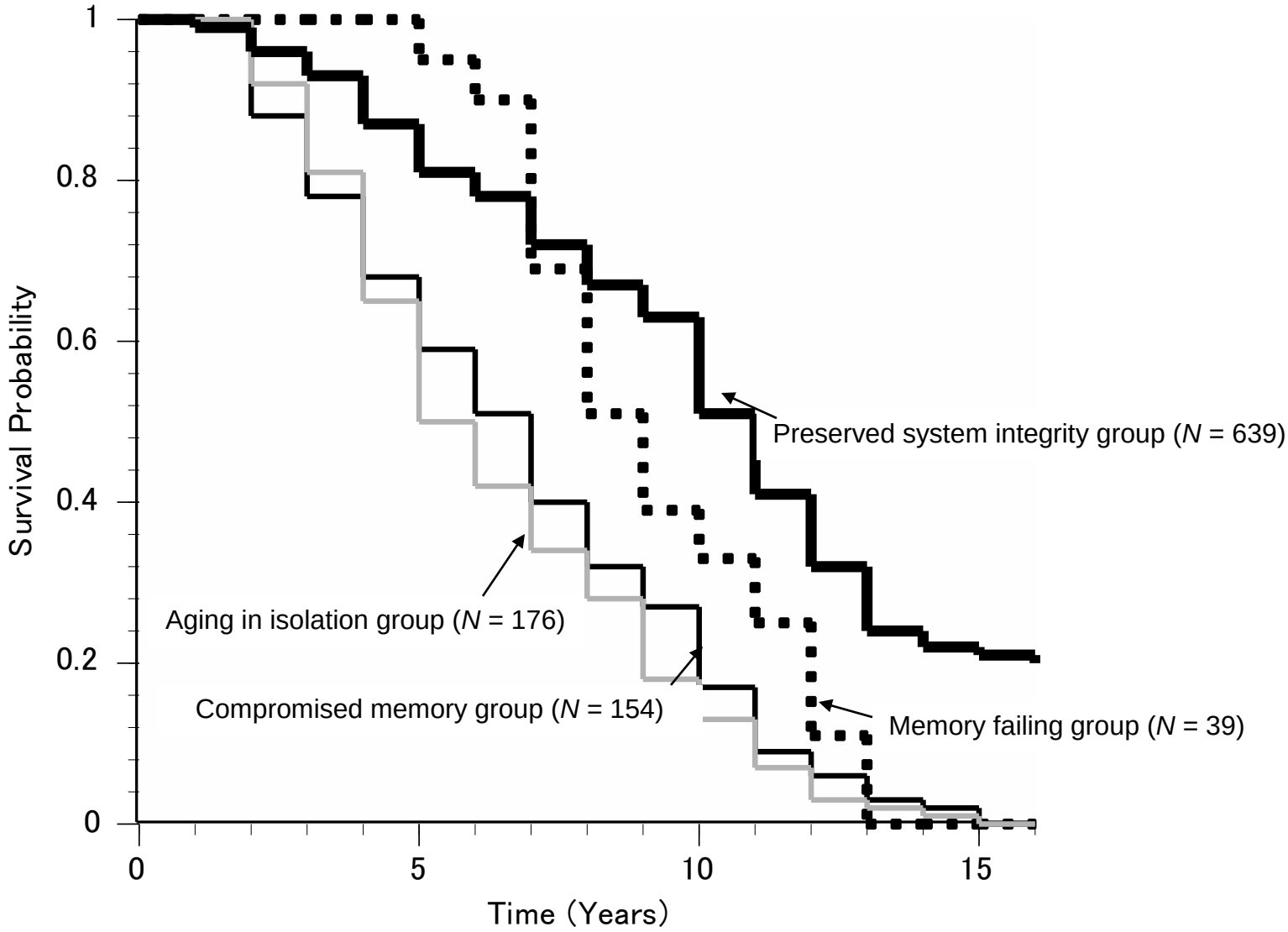


*Figure 5.* Differences between subgroups in survival probabilities over 17 years. The preserved system integrity group lived longer on average than the other profiles.

Appendix B

Examples of Studies Applying a Person- or Subgroup-Oriented Approach to the Study of Differential Aging

| Study | Waves | *N* | Group Defining Domains | External variables | Grouping Method | Group Findings |
|---|---|---|---|---|---|---|
| Kansas City Study of Adult Life (Neugarten et al., 1968) | 1 | 59 | Activity, Personality, Well-Being | - | Predefined top-down procedure | 8 groups characterized primarily by personality and also activity and well-being |
| MacArthur Studies on Successful Aging (Berkman et al., 1993) | 1 | 1,354 | Cognition, Functional Health | Psychosocial, Physiological, Sociodemographic | Predefined by successful aging criteria | 3 groups – high, middle, and low functioning |
| OCTO study (Zarit et al., 1993) | 1 | 320 | Cognition, Functional Health, Sensory Functioning | - | Examination of disability base rates and degree of co-disability | 3 groups – no significant impairments, impairments in IADLS only, and co-disability |
| Americans' Changing Lives Survey (Garefin & Herzog, 1995) | 1 | 1,644 | Cognition, Functional Health, Productivity, Well-Being | Health, Personality, Psychosocial, Sociodemographic | Predefined robust aging criteria for each domain | Groups identified for each domain (4 groups for each domain except functional health with 5 groups) |
| Seattle Longitudinal Study (Bosworth & Schaie, 1997) | 1 | 387 | Social Integration | Health, Sociodemographic | Cluster analysis | 4 groups characterized by levels of social integration |
| Berlin Aging Study (Smith & Baltes, 1997) | 1 | 510 | Cognition, Self & Personality, Social Integration | Health, Mortality, Sociodemographic, Well-Being | Cluster analysis | 9 groups characterized by differing levels across all group defining |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | domains |
| Epidemiological Survey in Canberra (Jorm et al., 1998) | 1 | 997 | Cognition, Health | Health Habits, Personality, Sociodemographic, Verbal Intelligence | Predefined by successful aging criteria | 3 groups – successful aging, usual aging, and diseased aging |
| Berlin Aging Study (Smith & Baltes, 1998) | 1 | 508 | Cognition, Health, Self & Personality, SES, Social Integration, Well-Being | Age, Sex | Cluster analysis | 11 groups characterized by differing levels across all group defining domains; categorized by desirability level |
| Australian Longitudinal Study of Aging (Andrews, Clark, & Luszcz, 2002) | 1 | 1,043 | Cognition, Functional Health | Health, Lifestyle, Psychological Status, Sociodemographic | Predefined by successful aging criteria | 3 groups – higher, intermediate, and lower functioning |
| New England Centenarian Study (Evert, Lawler, Bogan, & Perls, 2003) | 1 | 424 | Health | Sex | Predefined top-down procedure | 3 groups characterized by age of onset of age-related illness |
| Health and Aging Study (Ko et al., 2007) | 1 | 287 couples | Cognition, Health, Personality, Social Support | Age, Well-Being | Latent profile analysis | 2 and 4 group solutions characterized by differing degrees of successful aging |
| Duke Longitudinal Study of Aging (Manton, Siegler, Woodbury, 1986) | 11 | 267 | Cognition | Mental health, Physical Health, Sociodemographic | Grade of membership model (GoM) | 5 groups characterized by differing cognitive abilities over time |
| Health-70 Study (Maxson et al., 1996) | 3 | 335 | Cognition, Health, Social Contacts, Well-Being | Mortality, SES, Sex | Cluster analysis | 5 groups characterized by differing levels across all group defining |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | domains |
| Wisconsin Longitudinal Study (Singer et al., 1998) | 3 | 1,172 | Depression, Well-Being | Multiple Life History Variables | Predefined by history of depression and current well-being | 4 groups – depressed/unwell, healthy, vulnerable, and resilient |
| National Long-Term Health Survey (Manton & Land, 2000) | 4 | 20.000 | Functional health | Medical Conditions, Mortality, Sex | Grade of membership model (GoM) | 7 groups characterized by disability state |
| Normative Aging Study (Aldwin et al., 2001) | 4 | 1,515 | Mental and Physical Health | Health Behaviors, Mortality, Personality, Sociodemographic | Cluster analysis | 4 mental health groups and 6 physical health groups characterized by health trajectories |
| Betula Study (Lövdén et al., 2005) | 3 | 500 | Cognition | Age, Education, Sex | Cluster analysis | 6 baseline groups characterized by differing cognitive levels; stable membership |
| Berlin Aging Study (Gerstorf, Smtih, & Baltes, 2006) | 3 | 132 | Cognition, Self & Personality, Social Integration | Health, Mortality, Sociodemographic, Well-Being | Cluster analysis | 3 baseline groups characterized by differing levels across all group defining domains; fairly stable membership over time |
| National Longitudinal Survey of Mature Women (Wong & Hardy, 2009) | 4 | 1,064 | Retirement Expectations | Employment, Health, Sociodemographic | Latent class analysis | 4 groups characterized by retirement expectation patterns |

# Appendix C

## Items and Scales of the Profile Defining Measures

Well-Being: CES-D
*Below is a list of some of the ways you may have felt or behaved. Please indicate how often you've felt this way during the past week.*
1. I felt I was as good as other people.
2. I felt depressed.
3. I felt hopeful about the future.
4. I thought my life had been a failure.
5. I felt fearful.
6. I was happy.
7. I felt lonely.
8. I enjoyed life.
9. I had crying spells.
10. I felt sad.
Response scale: Rarely or never, Some of the time, Occasionally, Most of the time

Social Integration: Adapted from UCLA Loneliness Scale
*The following statements describe how people sometimes feel. For each statement, please indicate how often you feel that way.*
1. Do you have someone you can talk with?
2. Do you feel you are part of a circle of friends?
3. Do you lack companionship?
4. Do you feel you have been abandoned?
5. Are you troubled by feelings of loneliness?
Response scale: Not at all, Seldom, Often, Nearly always

Cognition: Memory recall subtest of the Memory in Reality Test
*Participants were told the following list of common objects and asked to recall them 30 minutes later.*
Keys
Medicine
Wrist watch
Comb
Pencil
Matchbox
Ring
Eyeglasses
Scissors
Glass