Intraindividual Variability Across Cognitive Domains: Investigation of Dispersion Levels and Performance Profiles in Older Adults.

by

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B.Sc., York University, 2004

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ABSTRACT

A growing body of research suggests that substantial variability exists among cognitive abilities within individuals. This within-person variability, across cognitive domains is termed dispersion. The present study examined 304 non-demented, older adults to investigate the relationship between aging and the dispersion of cognitive functions in both a quantitative (overall levels of dispersion) and qualitative manner (patterns of dispersion). Quantitatively, higher levels of dispersion were observed in older-old adults and those identified as having suffered cognitive decline, suggesting that dispersion level may serve as a marker of cognitive integrity. Qualitatively, three distinct dispersion profiles were identified through clustering methods and found to be related to demographic, health and performance characteristics of the individuals displaying the particular profile patterns, suggesting that the patterns of dispersion may be a meaningful indicator of individual differences.

Table of Contents

List of Tables

List of Figures

Introduction

Neuropsychologists often assess the functioning of patients by examining the profile of an individual's abilities across various cognitive domains. Significant discrepancies in performance observed between cognitive domains are thought to indicate neurological dysfunction. However, a growing body of research suggests that substantial variability exists among cognitive abilities within individuals, and in fact, significant intraindividual variability may be "the rule rather than the exception" in neurologically healthy adults (Schretlen, Munro, Anthony & Pearlson, 2003, p. 869). In recent years, the term intraindividual variability has been used to represent several different facets of within-person variability. For the purpose of this paper, intraindividual variability is considered a general term describing two types of within-person variability: inconsistency and dispersion. Inconsistency refers to variability observed in a person's performance on a single task over short periods of time (i.e., minutes, hours, days). Although the concept of inconsistency is defined by fluctuations in performance across short periods of time, an increasing amount of research supports the view that it is a systematic and meaningful indicator of individual differences (i.e. age, cognitive functioning, neurological status) (Hultsch & MacDonald, 2004; Martin & Hofer, 2004). The second type of intraindividual variability, termed dispersion, refers to the variability observed in a single person's performance across different tasks. Dispersion has received relatively less research attention and will be the focus of this paper.

It is not surprising that individuals exhibit some degree of dispersion among various cognitive abilities. However, the finding that cognitively healthy individuals

may display substantial cognitive dispersion has important clinical implications making it necessary to identify what is considered to be normal dispersion both quantitatively (i.e. how much?) and qualitatively (i.e. between which abilities?). Further, investigation into what constitutes normal cognitive dispersion in various populations is required. For example, elucidating characteristics of dispersion in the elderly may be particularly important considering the clinical implications of highly variable cognitive functions coupled with the likelihood of individuals in this population encountering some sort of neuropsychological evaluation.

In addition to the clinical utility associated with distinguishing normal variability from abnormal variability, research suggests that dispersion may serve as a valuable potential marker of cognitive dysfunction because elevated levels of cognitive dispersion have been linked to central nervous system dysfunction in older adults (Christensen, Mackinnon, Korten, Jorm, Henderson, Jacomb & Rodgers 1999; Rapp, Schnaider-Beeri, Sano, Silverman & Haroutunian 2005). In fact, a recent study by Kliegel & Sliwinski (2004) reported that level of cognitive dispersion may predict later cognitive change better than overall level of performance, suggesting that dispersion may serve as a sensitive marker of future cognitive decline.

Level of Dispersion and Advancing Age

Research examining the relationship between the dispersion of cognitive abilities and aging is limited and, to some degree, conflicting. Although several studies have reported that dispersion increases with advancing age in older adults (Christensen et al, 1999; Rabbitt, 1993; Schretlen, Munro, Anthony & Pearlson, 2003;

Hultsch, MacDonald & Dixon, 2002), opposing results have also been reported (Lindenberger & Baltes, 1997, Rapp et al., 2005).

Rabbitt (1993) examined dispersion in adults based on the discrepancy between performance on crystallized tasks (i.e. vocabulary tests) and other measures (syntactic reasoning and visual search tasks) based on the theory that crystallized abilities remain relatively stable with advancing age compared to other cognitive abilities. Rabbitt reported that the discrepancy between measures of crystallized abilities and other performance measures increased with advancing age in individuals aged 50-86.

Schretlan et al. (2002) reported similar findings using a slightly different measure of dispersion in their investigation of individuals aged 20-92 years (M=55 years). Participants completed a battery of fifteen tests assessing various cognitive domains (crystallized abilities, memory, fluid abilities), and dispersion was evaluated based on the discrepancy between each individual's best and worst cognitive task. The investigators reported that increasing age was associated with increasing discrepancy between one's best and worst cognitive skill, and the findings were unchanged when age corrected scores were used.

Christensen et al. (1999) examined dispersion in a community sample of 760 individuals aged 70 and above (M=74 years) on a series of cognitive tasks evaluating four cognitive domains: crystallized intelligence, speed, memory and spatial functioning. Dispersion scores were calculated for each of the individuals in two different ways. First, a measure of dispersion was calculated based on the discrepancy method, by examining the deviation of each individual's domain score

(memory, speed, spatial functioning) from their crystallized intelligence score. Second, intraindividual standard deviations (ISDs) were calculated for each individual, representing a measure of dispersion in terms of all the cognitive tasks taken together. Christensen et al. reported that both methods of calculating dispersion scores yielded similar outcomes: dispersion scores were larger in older-old individuals compared to young-old adults. Longitudinally, it was observed that dispersion scores increased over a 3.5 year period in both age groups. No interaction effect between age and wave was observed indicating that dispersion did not increase at a faster rate in the older individuals compared to the younger. Education, which served as a proxy variable for intelligence, did not appear to be related to the dispersion scores. A sub-sample of individuals diagnosed with dementia or probable dementia (n=47) was independently examined by the researchers. This group showed a positive relationship between dispersion and aging, although the relationship was not significant.

Recently, a study by Hultsch, et al. (2002) investigated the relationship between intraindividual variability and aging based on a series of reaction time (RT) tasks. Four RT tasks which varied in cognitive demand were administered to a group of younger (aged 17-36, M=23. years) and older (aged 54-94, M=73 years) typically aging adults. In terms of dispersion, results indicated that older adults were more variable in their performance across the four RT tasks compared to the younger adults. In addition to examining dispersion, investigators also studied the second facet of intraindividual variability, inconsistency. Results on inconsistency showed that across all four RT tasks older adults were significantly more variable in their RT

performance across trials compared to younger adults. Taken together these results suggest that advancing age is associated with an increase in the variability of an individual's performance both across tasks (increase in dispersion) and time (increase in inconsistency).

Hultsch and colleagues (2002) also examined the relationship between the two measures of intraindividual variability by examining the intercorrelation between inconsistency and dispersion. The correlations were found to be modest, ranging from .12 to .47, but statistically significant suggesting that the more variable individual's profiles were across the tasks (greater dispersion), the more variable their performance was across time (greater inconsistency).

Although the hypothesis that dispersion increases with age is supported by several studies that have quantified dispersion in different ways (discrepancy scores, ISDs), contradictory findings have also been reported. Lindenberger & Baltes (1997) investigated dispersion cross-sectionally in a sample of 516 older adults aged 70-103 (M=85 years). A single intraindividual standard deviation score (ISD) was calculated for each person indicating how variable each performed across a set of 14 cognitive tasks assessing five domains of cognition (reasoning, memory, perceptual speed, knowledge and fluency). The results indicated that the variability in performance across tasks decreased as age increased for individuals whose intellectual performance was below average for their age. In contrast, dispersion did not differ as a function of age in individuals whose intellectual performance was considered above average for their age.

Possible causes of the discrepancy between Lindenberger & Baltes' results and the findings of the other studies include the age and level of cognitive functioning of the samples. The sample in Lindenberger & Baltes' study was substantially older (e.g. Christensen et al. M=74 years, Hultsch et al. M=73 years; Lindenberger & Baltes: M= 85 years) and more functionally impaired compared to the samples examined in the other studies. Lindenberger suggested that 'young-old' and/or functionally healthy adults may show an increase in dispersion with advancing age because some abilities are naturally beginning to decline while others remain intact; thus, with increasing age these individuals would exhibit a more dispersed cognitive pattern of strengths and weaknesses consistent with the results of studies with younger samples. Alternatively, 'older-old' and/or unhealthy individuals may demonstrate declining dispersion scores with advancing age because several abilities may be declining together yielding a more uniformly poor profile across cognitive domains and thus a lower dispersion score as was observed in Lindenberger & Baltes' study (Christensen et al., 1997). Sampling methodology and different outcome measures are alternative possible causes of the discrepancy between the outcome of Lindenberger & Baltes' study and others.

A recent study by Rapp et al. (2005) evaluated the relationship between aging and dispersion cross-sectionally in samples of very-old institutionalized (M=82 years) and community dwelling individuals (M=87 years). Dispersion was assessed by ISD scores which were calculated for each individual based on six neuropsychological tests (tests assessing memory and fluid abilities). The authors reported that dispersion overall was greater in the institutionalized elderly, supporting the notion that

dispersion may serve as a marker for neurological dysfunction. The relationship between dispersion and age varied as a function of presumed cognitive/functional ability in that dispersion was positively related to age in the institutionalized elderly sample but was negatively related to age in the sample of community dwellers. These results suggest that in very-old adults dispersion levels vary with cognitive ability which Lindenberger & Baltes (1997) also reported. However, Rapp et al.'s results suggest that diminished cognitive ability is related to increasing dispersion with age whereas Lindenberger & Baltes reported the opposite effect- that lower levels of cognitive functioning were associated with decreasing dispersion levels with increasing age. In light of the conflicting results reported on dispersion and aging in samples of very-old adults to date, it is clear that additional research is necessary in order clarify the impact that physical aging and cognitive ability have on cognitive dispersion in very-old adults.

Despite these contradictions, studies investigating changes in dispersion that accompany aging in younger samples of elderly adults appear to be more consistent, generally reporting that the variability of cognitive functioning increases with age (Christensen et al., 1999; Rabbitt, 1993; Hultsch 2002).

Moving a step beyond simply classifying levels of dispersion in relation to age, Christensen et al. (1999) investigated dispersion levels in relation to level of performance on the cognitive tasks and changes in the level of performance over time. Results showed that a more dispersed profile of cognitive abilities was associated with significantly lower performance on the cognitive measures and significantly greater cognitive deterioration at follow-up. Taken together, this

suggests that a relatively more uniform cognitive profile may signify greater cognitive health, a proposition supported by the finding that community dwelling older-adults exhibit less cognitive dispersion than institutionalized adults (Rapp et al., 2005).

Patterns of Dispersion

Examining overall levels of cognitive dispersion in relation to advancing age may provide important information about the aging process; however, simply investigating dispersion in this way is limited as it is entirely possible that two people could display identical levels of dispersion among their abilities yet exhibit two distinct profiles of cognitive skills. Thus, to more fully understand how dispersion of cognitive abilities relates to aging it should be characterized both quantitatively in terms of overall level of cognitive dispersion, and qualitatively in terms of the pattern or shape of an individual's profile of abilities.

One way to examine possible patterns in cognitive dispersion is to identify groups of individuals who perform similarly across cognitive tasks. Classifying individuals based on the shape of their cognitive profiles allows for investigation into whether membership in a certain subgroup is associated with certain distinguishing characteristics (i.e., age, current cognitive ability, later cognitive decline). This subgroup approach to examining performance profiles is often used in aging research as it suits the heterogeneity of the population, allowing for differences within the population to be considered. In particular, this method has been used to predict which individuals in a sample of healthy elderly will go on to experience cognitive decline. To date, research aimed at identifying subgroups at risk for future cognitive

deterioration based on patterns of cognitive functioning has produced mixed findings with some studies reporting that membership in subgroups identified as "at risk" based on neuropsychological test performance predicts later cognitive decline and others reporting that membership in "at risk" subgroups is not predictive of later cognitive status (Ritchie, Leibovici, Ledesert & Touchon, 1996; Malec, Smith, Ivnik, Petersen & Tangalos, 1996). The discrepancy between studies may be related to different methods used by researchers to evaluate those considered to be at risk. Although some researchers have classified individuals into subgroups based on relative strengths and weaknesses noted within the performance profile (Malec, Smith, Ivnik, Petersen & Tangalos, 1996) others have classified individuals based on overall level of performance (Ritchie, Leibovici, Ledesert & Touchon, 1996). Creating subgroups considered to be "at risk" based on overall level of performance may be useful in predicting decline on a short term basis (i.e. 6 months) however, it may lack longer-term predictive value (2-10 years) as individuals displaying an overall low performance profile may be on the cusp of the diagnostic criteria for cognitive impairment (Peters, Graf, Hayden & Feldman, 2005).

A recent study by Peters et al. (2005) used the subgroup approach with older adults diagnosed with mild cognitive impairment (Cognitive-Impairment-No-Dementia, CIND) in order to determine whether subgroups based on distinct patterns of neuropsychological performance exist within a CIND sample, and whether membership in particular subgroups at baseline is related to diagnosis during a follow up period of 2-5 years. The researchers were interested in examining the neuropsychological profile shape alone in creating the subgroups, without influence

of overall level of performance. This was achieved by ipsatizing the scores of each individual, thereby removing any confounds of profile elevation. In other words, the data collected for each individual was ipsatized in order to make each person's cognitive profile relative to his or her own performance on the tasks. In this way, each person's profile displayed a pattern of individual strengths and weaknesses while controlling for overall level of performance. The profiles created for each individual evaluated performance in three domains: Memory, Verbal and Visuospatial functioning. Upon running the data through various clustering methods, the researchers concluded that subgroups of CIND can be identified based on distinct neuropsychological profiles. Further, they concluded that membership in certain subgroups was associated with later diagnosis. Specifically, individuals who displayed a distinct weakness in the Memory domain or in the Memory and Verbal domains together were more likely to be diagnosed with dementia at a follow up evaluation. Individuals displaying a weakness in Verbal ability relative to their other abilities were more likely to be assessed as having no cognitive impairment at follow up. The researchers concluded that because the subgroups were based solely on profile shape in that membership in a subgroup was based on "a distinct pattern of impaired and intact test scores rather than by an overall low performance profile" (p. 184), then differences in groups could not be accounted for by overall cognitive functioning.

Research Questions

The goal of the current study is to clarify the relationship between dispersion of cognitive abilities and advancing age. To do this, cognitive dispersion will first be investigated quantitatively by focusing on three central questions:

(1) Are there age differences in the dispersion of cognitive functions?

Based on research suggesting that dispersion increases with age in samples of young-old to mid-old individuals (Christensen et al., 1997; Hultsch et al., 2002; Rabbitt, 1993), it is expected that dispersion will increase with advancing age in the present sample which contains relatively few very-old adults.

(2) Is level of dispersion influenced by intellectual decline in aging?

Based on the research suggesting that dispersion is associated with impaired functioning (Christensen et al., 1997; Rapp et al., 2005) it is expected that dispersion levels will be greater in individuals who are experiencing intellectual decline compared with those maintaining their intellectual abilities.

(3) What is the relationship between levels of dispersion and inconsistency?

It is expected that the two measures of intraindividual variability, dispersion and inconsistency, will be correlated positively as was reported by Hultsch et al. (2002).

Next, the qualitative aspects of dispersion will be examined in an attempt to characterize distinct patterns of dispersion that may exist. To do this, individuals will be classified based on their cognitive performance profiles so that individuals exhibiting similar patterns of strengths and weaknesses across the tasks will be grouped together. The investigation will then focus on whether membership in the

subgroups is related to demographic and health characteristics of the individuals making up the subgroup. Examining the subgroups in this way is expected to clarify whether these sub-groups have any functional relevance; that is, do they reflect various characteristics of the individual? Further, do patterns of dispersion exist that might be considered pathological? Analyses associated with identifying and examining potential patterns in dispersion are purely exploratory and thus carry no hypotheses. Overall it is expected that examining dispersion by focusing on both dispersion levels and qualitative patterns in dispersion will shed further light on within-person variability and the heterogeneous process of cognitive aging.

Method

Data used for the current investigation was collected as part of Project MIND at the University of Victoria, a longitudinal study investigating intraindividual variability and aging.

Participants

A total of 304 community-dwelling adults (208 women and 96 men) ranging in age from 64 to 92 years ($\underline{M}$ = 74.02, $\underline{SD}$ = 5.95) participated in the study. They were recruited through advertisements in the local media (newspaper and radio) requesting healthy community-dwelling volunteers who were concerned about their cognitive functioning. All participants were Caucasian. Exclusionary criteria included a diagnosis of dementia by a physician or a Mini Mental Status Examination (MMSE; Folstein, Folstein, & McHugh, 1975) less than 24, a history of significant head injury (defined as loss of consciousness for more than 5 minutes), other neurological or major medical illnesses (e.g., Parkinson's disease, heart disease,

cancer), severe sensory impairment (e.g., difficulty reading newspaper-size print, difficulty hearing a normal conversation), drug or alcohol abuse, a current psychiatric diagnosis, psychotropic drug use, and lack of fluency in English.

Age Groups

For purposes of cross-sectional comparison, participants were classified by age into two groups: a young-old group aged 64-74 years (n = 170, M = 69.67, SD = 2.74), and an old-old group aged 75-92 years (n = 134, M = 79.54, SD = 4.02). These age ranges map onto earlier work (e.g., Hultsch et al., 2002), and are designed to capture the quantitative differences in performance often observed within the older adult age range.

Cognitive Status Groups

Participants completed several cognitive benchmarks including the Wechsler Adult Intelligence Scale-III (WAIS-III) Block Design and Vocabulary subtests (Psychological Corporation, 1997), and the North American Adult Reading Test (NAART, Blair & Spreen, 1989). Estimates of current intelligence (full-scale IQ or FSIQ) were computed based on the age-adjusted Block Design and Vocabulary subtest scaled-scores (Sattler & Ryan, 1999), and estimates of premorbid intelligence were computed based on the NAART (Blair & Spreen, 1989). A discrepancy score was created based on these estimates, classifying each individual as having experienced intellectual decline (premorbid intelligence estimate>current intelligence estimate) or as having remained intellectual stable (premorbid intelligence estimate<current intelligence estimate).

Sample Description

During an initial intake interview, demographic information (age, years of education) and self-reported health information (self-rated health, self-rated memory efficacy and memory change, self-reported chronic conditions) were obtained for the purpose of describing the sample. Participants were also asked to rate their level of difficulty with nine activities of daily living: walking across a room, bathing self, dressing self, getting up from a bed or chair, climbing stairs, walking several blocks, managing finances, performing household activities, and driving a car. The scale ranged from 0 to 2 (0 = no difficulty, 1 = some difficulty, 2 = a lot of difficulty), and a total score was obtained by summing participants' responses across the nine activities. Finally, participants completed the depressive affect subscale (7 items) of the Center for Epidemiological Studies Depression Scale (Hertzog, Van Alstine, Usala, Hultsch, & Dixon, 1990; Radloff, 1977).

An age by cognitive status MANOVA was performed to examine group differences in the demographic, health and cognitive variables. Table 1 shows the mean scores of these variables by age and cognitive status group. Overall, effects of age ($F(10, 291) = 7.586$, $p<.01$) and cognitive status ($F(10,291) = 2.351$, $p=.01$) were significant. There was no significant age by cognitive status interaction.

In terms of the univariate analyses, there were significant age differences for years of education ($F(1,300) = 11.44$, $p<.01$), total MMSE score ($F(1,300) = 31.52$ $p<.01$), activities of daily living self-report ($F(1,300) = 34.28$, $p<.01$), perceived memory self-efficacy ($F(1,300) = 4.44$, $p<.05$), perceived memory change ($F(1,300) = 4.156$, $p<.05$) and number of chronic illnesses ($F(1,300) = 17.76$, $p<.01$) . The OO adults had fewer years of education, had lower scores on the MMSE and reported

more difficulties with activities of daily living compared to YO adults. In addition the OO adults reported poorer memory ability compared to peers, perceived a higher degree of memory change and reported more chronic illnesses. There were no significant differences between age groups in terms of self-rated health, reported depressive affect and total number of medications.

There were significant group differences in terms of cognitive status for MMSE scores ($F(1,300) = 15.97$, $p<.01$) and activities of daily living self-report ($F1,300) = 3.98$, $p<.01$). Individuals classified as having experienced cognitive decline scored lower on the MMSE and reported more difficulties with activities of daily living. The cognitive status groups did not differ on years of education, self-rated health perceptions, reported depressive affect, perceived memory self-efficacy and memory change, number of chronic conditions and total number of medications.

Table 1

Demographic Variables by Age and Cognitive Status

	Young-Old		Old-Old	
Variable	Stable	Decliner	Stable	Decliner
Years of Education				
M	15.89	15.46	14.48	14.39
SD	2.86	3.18	3.01	3.52
MMSE Total				
M	29.11	28.94	28.72	27.80
SD	0.920	1.13	1.19	1.47
Self-Rated Health Compared to a Perfect State				
M	4.29	4.21	4.24	4.04
SD	0.640	0.587	0.742	0.720
Self-Rated Health Compared to Peers				
M	4.53	4.44	4.47	4.37
SD	0.559	0.581	0.612	0.720
Memory Efficacy Self-Report				
M	4.24	4.17	3.94	3.96
SD	0.972	0.963	1.12	1.08

Table 1 continued

	Young-Old		Old-Old	
Variable	Stable	Decliner	Stable	Decliner
Perception of Memory Change				
M	3.15	3.17	3.12	2.76
SD	0.833	0.994	0.892	1.00
Activities of Daily Living Inventory				
M	1.078	1.12	1.24	1.31
SD	0.184	0.198	0.282	0.329
Depression Self-Report				
M	1.11	1.17	1.15	1.23
SD	0.273	0.294	0.262	0.447
Number of Chronic Illnesses				
M	2.38	2.71	3.34	3.61
SD	1.79	1.69	2.00	1.97
Total Number of Medications Used				
M	5.25	5.83	3.54	4.06
SD	3.38	3.37	3.54	4.06

Procedure

Potential participants were initially screened for inclusion and exclusion criteria by a telephone interview. Testing occurred during seven sessions (one group and six individual) scheduled over approximately 3 months. The group testing session was held at the university, and the individual testing sessions were conducted in the participant's home. Participants attended two testing sessions (one group and one individual) during which they provided demographic and health information, and completed a series of benchmark (e.g., NAART) and the cognitive measures designed to assess multiple abilities (e.g., perceptual speed, reasoning, episodic memory, verbal fluency, and vocabulary). Participants then completed five individual testing sessions scheduled approximately two weeks apart. During each of these sessions, they performed a battery of tasks designed to assess short-term fluctuations in reaction time. Because we were interested in variability, an effort was made to distribute these five sessions across days of the week and times of the day rather than scheduling them at the same time.

Cognitive Performance Measures

A set of nine paper and pencil tasks formed the basis of the dispersion scores. These tasks may be arrayed along a continuum ranging from indicators of basic information processing resources to more complex acquired products of cognition. Ordered along this continuum, there were three measures of perceptual speed (Trails A, Trails B, WAIS-R Digit Symbol Substitution), one measure of fluid reasoning (Letter Series), three measures of episodic memory (word recall, incidental symbol

recall, story recognition), and two measures of semantic memory (verbal fluency, vocabulary).

Trails A and B. In the Trails A portion of the task, the participant is presented with 25 encircled numbers randomly arranged on a page. They are asked to connect the encircled numbers as quickly as possible by drawing pencil lines from one to another in numeric order. In the Trails B portion of the task, the page contains randomly arranged encircled numbers and letters. The participant is asked to draw pencil lines as quickly as possible to the encircled numbers and letters in alternating numeric and alphabetical order. Both of these tasks are seen as indicators of perceptual speed, but the Trails B portion of the task presumably places greater demands on working memory as well.

Code copy. Perceptual processing speed was also assessed using the WAIS-R Digit Symbol Substitution task (Wechsler, 1981). Participants were presented with a coding key pairing nine numbers (1 through 9) with nine different symbols. Printed under the coding key were rows of randomly-ordered numbers with empty boxes below. Participants were given 90 seconds to transcribe as many symbols as possible into the empty boxes based on the digit-symbol associations specified in the coding key. The number of correctly completed items represented the outcome measure

Letter series. Inductive reasoning was assessed using the Letter Series test (Thurstone, 1962). Participants were presented with a string of letters forming a distinct pattern. The task required inductively deciphering the pattern in the target string and providing the next letter in the string congruent with the pattern presented. The outcome measure used was the total number correct out of 20 patterns.

Word recall. The word recall task consisted of immediate free recall of 30 English words (Hultsch, Hertzog, & Dixon, 1990). The word list consisted of 6 words from each of 5 taxonomic categories (e.g., birds, flowers) typed on a single page in unblocked order. Participants were given 2 min to study each list and 5 min to write their recall. The number of correctly recalled words was used as the measure.

Code recall. A measure of incidental episodic recall was derived from the Digit Symbol Substitution task. Following the 90 second coding portion of the task (during which participants marked the appropriate symbol below the associated number), participants were presented with a sheet containing the nine symbols and asked to recall the number that had been paired with the symbol.

Story recognition. Story recognition was based on five narrative stories selected from a set of 25 structurally equivalent texts (Dixon, Hultsch, & Hertzog, 1989). Each story was approximately 300 words long, and described events in the life (lives) of older adults (e.g., purchasing a car, going camping). Participants listened to the story (presented by audiotape on a cassette recorder), and then immediately completed a recognition task. Twenty-four test statements were shown one at a time on the computer screen, and participants were asked to press one of two keys to indicate whether the statement was contained in the story or not. Participants heard a total of five stories across separate sessions, and the measure used was the total number of correctly recognized statements.

Similarities. Participants' verbal fluency was assessed using the Controlled Associations test from the Educational Testing Service (ETS) Kit of Factor-

Referenced Cognitive Tests (Ekstrom, French, Harman, & Dermen, 1976). The test required the generation of as many synonyms as possible in response to a set of target words. Participants were given 6 minutes to complete the test with the total number of correct synonyms representing the fluency score.

Vocabulary survey. Crystallized ability was measured using a recognition vocabulary test. The 36-item multiple-choice test was composed by concatenating two 18-item tests (Ekstrom et al., 1976). Participants were given 8 minutes. The measure used was the total number of correct items.

RT Tasks

Two indicators of RT were used to form inconsistency scores. The RT tasks were presented on a laptop computer with a 14" color screen and equipped with a card for timing responses to the nearest millisecond. Participants responded to stimuli by pressing keys on an external keyboard attached to the computer that was configured specifically for the task.

Choice reaction time (CRT). For CRT, participants received a warning stimulus consisting of a horizontal row of four plus signs on the screen. The response keyboard had four keys in an horizontal array corresponding to the display on the screen. After a delay of 1000 ms, one of the plus signs changed into a box. The location of the box was randomly equalized across trials. Participants were instructed to press the key corresponding to the location of the box as quickly as possible. Although the instructions emphasized speed, participants were also instructed to minimize errors. A total of 10 practice trials followed by 52 test trials were

administered. The measures used were the latencies and percent correct for the 52 test trials.

Choice reaction time 1-back (1-Back). This task used the same stimulus display and response keyboard as the basic CRT task. However, in this version of the task, participants were instructed to press the key corresponding to the location of the box on the previous trial as quickly as possible. Although the instructions emphasized speed, participants were also instructed to minimize errors. A total of 10 practice trials and 61 test trials were administered. Because participants made no response on Trial 1, the latencies and percent correct of the remaining 60 test trials were actually used for analysis.

Measures of Within-Person Variability

Within-person variability over time (inconsistency) and across tasks (dispersion) was assessed through intraindividual standard deviations (ISDs). ISD scores were calculated for each individual across the cognitive tasks forming a measure of dispersion, and across trials in each of the two RT tasks to evaluate inconsistency. Effects associated with group differences in average level of performance were removed from the cognitive and RT data and systematic time-related effects (practice effects) were partialed from the RT data as both these sources of variability act as potential confounds to examining within-person variability. Removing group and systematic time-related effects from the data does not remove effects associated with examining the standard deviation of scores, so that group differences in ISD scores can still be examined. Removing group and time-related

effects from the data yielded purified residual scores that were then converted to T-scores allowing the different tasks to be compared in the same metric.

Results

The results are presented in two main sections. The first section (Dispersion Levels) describes analyses carried out to explore overall levels of within-person variability across tasks (dispersion) in relation to age, cognitive decline and inconsistency. The second section (Patterns of Cognitive Dispersion) explores qualitative aspects of dispersion through the identification and classification of distinct patterns of dispersion. To do this clusters of individuals who performed similarly across the tasks were grouped together. These subgroups were then described based on the demographic and health characteristics of the individuals making up the subgroups.

Levels of Intraindividual Variability

Dispersion Levels

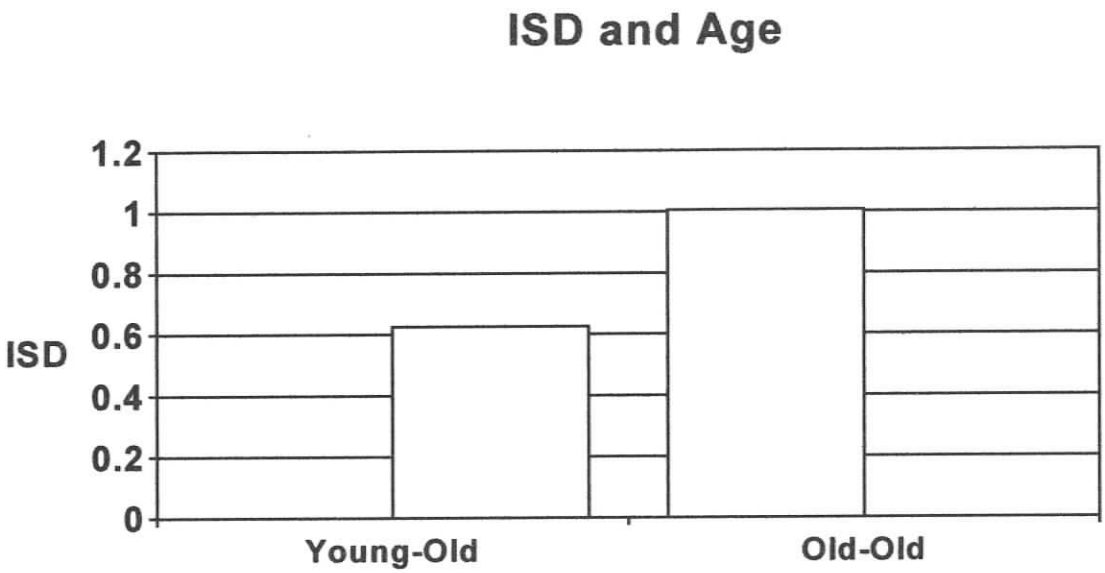
Dispersion was first examined in terms of overall level of intraindividual variability across the cognitive tasks. This was achieved by creating a standard deviation for each individual across the nine cognitive measures using the purified residual T-scores. Larger scores indicate a relatively uneven performance profile across the tasks whereas smaller ISD scores reflect a flatter more consistent profile of abilities.

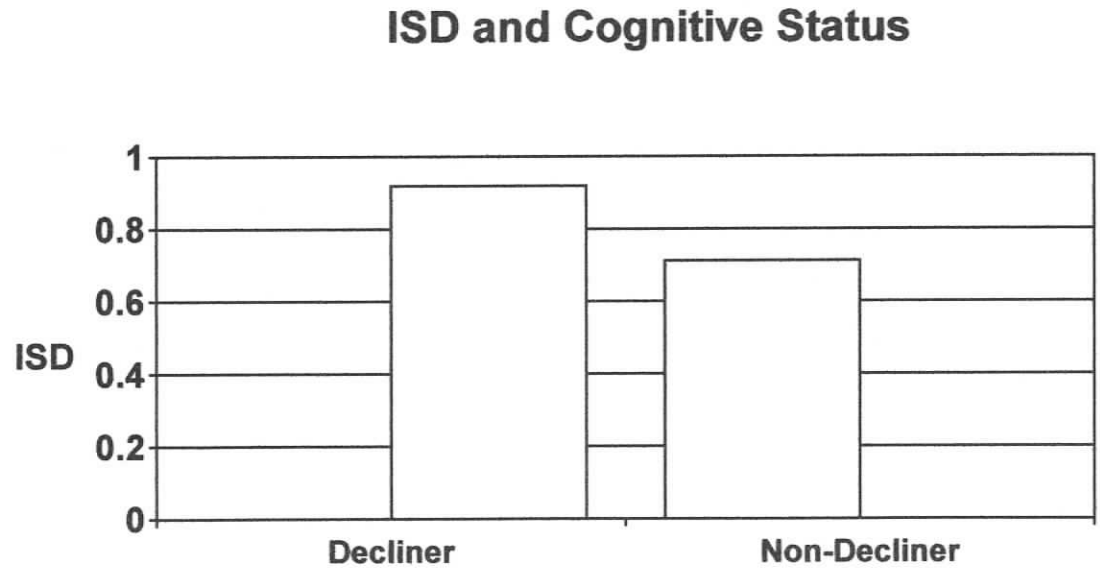
To examine group effects in intraindividual variability related to age and cognitive status classification a 2 (age) X 2 (cognitive status) analysis of variance (ANOVA) was performed for both the dispersion scores and the inconsistency scores.

In terms of dispersion, the groups differed significantly by age $F(3, 300) = 32.623$, $p<.01$ with the OO adults ($M = .996$) exhibiting greater dispersion scores than YO ($M = .626$) (see Figure 1). Groups also differed significantly by cognitive status $F(3,300) = 9.685$, $p<.01$, indicating that individuals classified as having experienced cognitive decline performed less consistently across the tasks ($M = .905$) than individuals who had not experienced cognitive decline ($M = .713$). The interaction between age and cognitive status was not significant.

Figure 1

Dispersion Levels by Age and Cognitive Status





Inconsistency Levels

Inconsistency was evaluated by computing ISDs for each individual on the residual trial scores for both the Choice RT task and the 1-Back RT task. The groups differed significantly by age on both the CRT $F(3,300) = 96.47$, $p<.01$ and 1-Back task $F(3,300) = 147.45$, $p<.01$ indicating that OO adults were less consistent across trials of each task compared to YO adults. The groups also differed significantly by cognitive status for both the CRT $F(3,300) = 17.75$, $p<.01$ and the 1-Back task $F(3,300) = 28.56$, $p<.01$, with individuals classified as having experienced cognitive decline exhibiting greater inconsistency scores than YO adults. The interaction between age and cognitive status for the 1-Back task was not significant. The interaction between age and cognitive status for the CRT task was significant $F(3,300) = 6.77$, $p<.05$. When this interaction was probed results suggested that no differences in inconsistency existed between cognitive status groups for the younger adults however, for the older adults level of inconsistency was greater for those who had experienced decline than those who had not ($p<.01$).

Relationship of Dispersion and Inconsistency

The relationship between the two measures of intraindividual variability was examined by calculating the correlation between dispersion (variability across tasks) and inconsistency (variability across trials). Measures of dispersion and inconsistency were correlated significantly for both the CRT task ($r = .384$, $p<.01$) and the 1-Back task ($r = .314$, $p<.01$). The positive correlation between the two types of within-person variability indicated that individuals who were more variable across tasks were also more variable across time.

Next, the relationship between dispersion and inconsistency was examined in terms of age and cognitive status. To do this, dispersion was regressed on each of the RT tasks separately, along with cognitive status group, age group and all of the interactions. For the CRT task the interaction between inconsistency, cognitive status and age group was significant ($t(7,296) = 2.313$, $p<.05$), indicating that the relationship between dispersion and inconsistency varied by age and cognitive status. Next, that significant interaction was examined in terms of age by regressing dispersion on the interaction of inconsistency and cognitive status separately by age group. The results were significant for the Older-old individuals ($t(3,130) = 2.833$, $p<.01$) but not the Young-Old adults, suggesting that the relationship between dispersion and inconsistency varied by cognitive status in the older adults but not in younger adults. For older adults the regression of dispersion on inconsistency for decliners was $ß = 0.130$, $p < .05$, whereas for non-decliners the regression was $ß = 0.02$, $p > .05$.

In terms of the 1-back task, the regression of dispersion on cognitive status, age group, inconsistency and all interactions revealed that the interaction between these variables was not significant. Next, the analysis was re-run with the three-way interaction between age, cognitive status group and inconsistency removed, in order to examine the two-way interactions between the variables. The two-way interaction between cognitive status and inconsistency was significant ($t(6,297) = 2.373$, $p<.05$) due to the relationship between dispersion and inconsistency being larger for those classified as having experienced decline ($ß =0.075$, $t(1,119) = 4.322$, $p<.01$) than for

cognitively stable individuals ($\beta = 0.036$, $t(1,181) = 2.850$, $p<.01$,) although the relationship was significant for both groups.

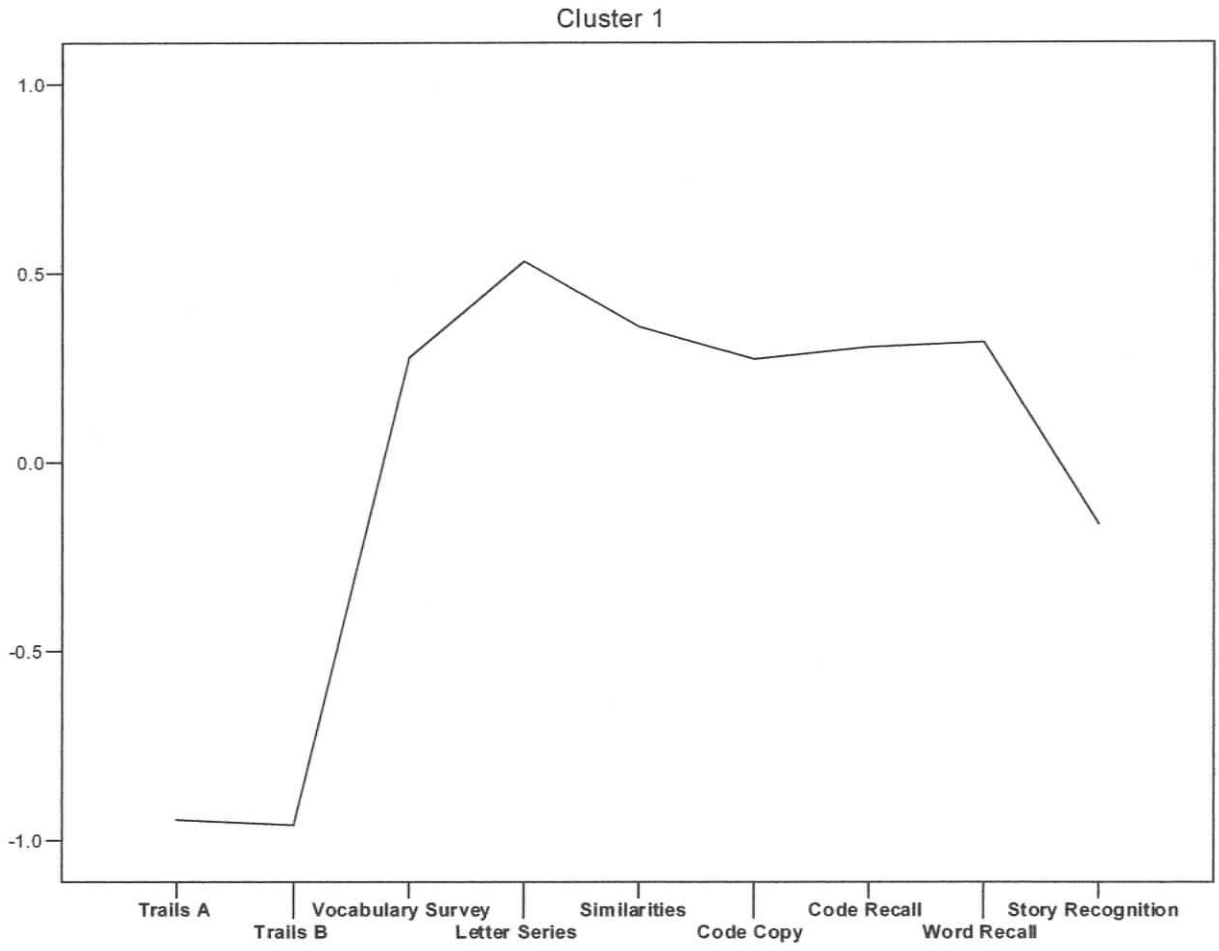
Patterns of Cognitive Dispersion

To examine qualitative aspects of dispersion a series of cluster analyses were carried out to determine whether subgroups of individuals who performed similarly across the tasks could be identified, and further, whether the profiles of dispersion identified represent clinically meaningful groups. In order to examine profile shape alone, it was necessary to remove effects of overall profile elevation. This was achieved by ipsatizing the purified data, so that each individual's profile of abilities represented a pattern of strengths and weaknesses relative to his or her own performance across the tasks. To examine the number of possible clusters present, the ipsatized scores were entered into a k-means clustering procedure. Several clustering analyses were run in order to examine the formulation of the subgroups when various levels of clusters were specified (between two and five). The optimal number of clusters selected was a decision guided by two requirements: (1) maintaining a reasonable sample size in each cluster to ensure reliability (2) ensuring that the samples appeared to have meaning (for example a two cluster solution may have provided a suitable sample size, but may not have been very meaningful). In the end, a three cluster solution appeared to maximize both the reliability and the clinical meaning of the clusters suggesting that three distinct profile patterns were distinguishable in the data. Figure 2 shows the cognitive profiles of the three clusters. Note that performance on the Trails tasks was based on time taken to complete the task so that a lower performance is considered better.

Cluster 1 (n=125; 41.1%) exhibited a pattern of relative strengths across all of the cognitive measures. Cluster 2 (n=106; 34.9%) exhibited a pattern of relative weaknesses across most cognitive measures, with the exception of semantic memory tasks (Vocabulary, Similarities) and an episodic recognition task (Story Recognition). Cluster 3 (n=73; 24.0%) displayed a pattern of relative strengths in terms of speeded tasks (Trails A, Trails B, Code Copy) and episodic memory tasks (Code Recall, Word Recall, Story Recognition) and weaknesses in semantic memory tasks (Vocabulary, Similarities) and fluid reasoning (Letter Series).

Figure 2

Z-Score Performance Profiles of Clusters 1, 2 and 3



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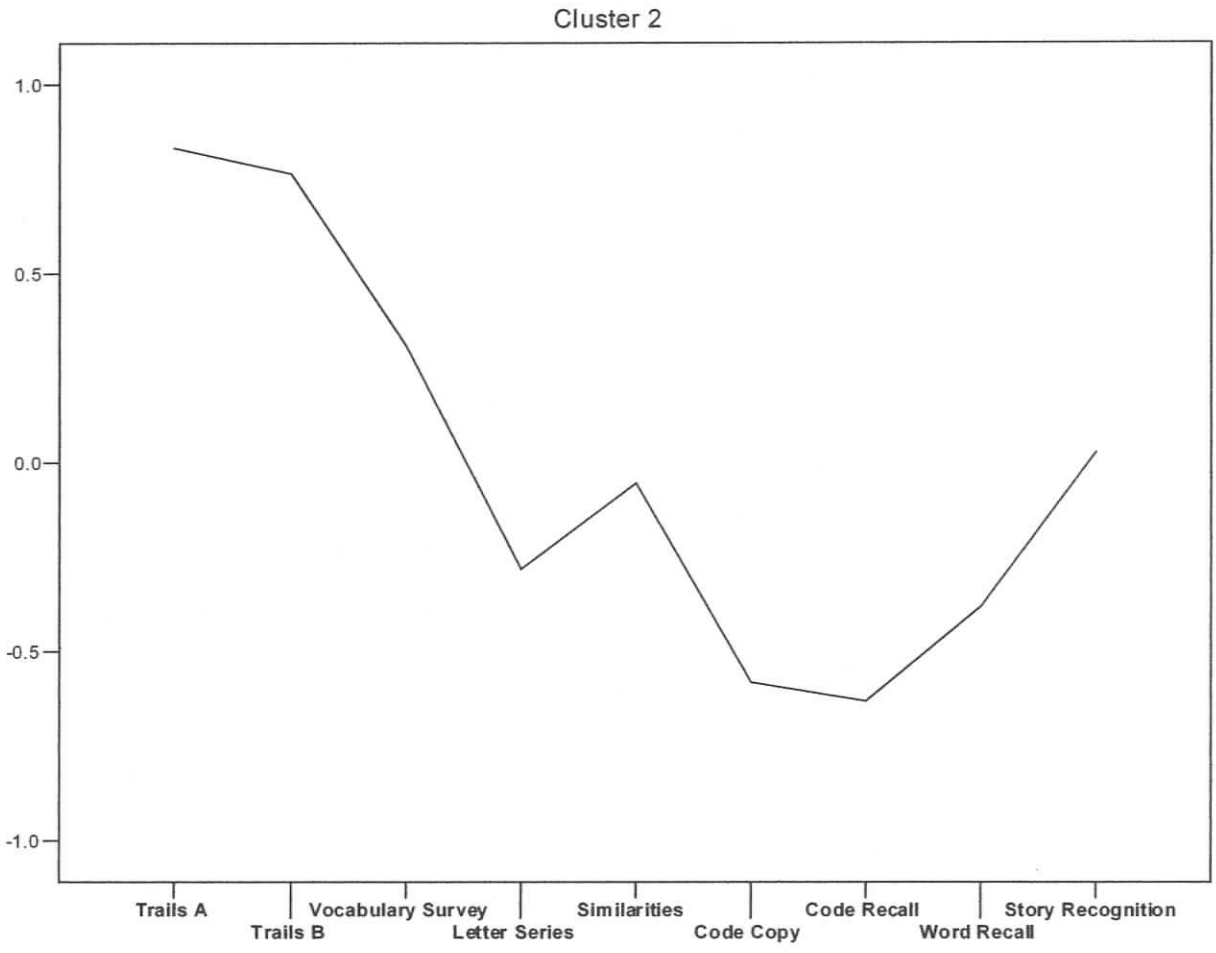

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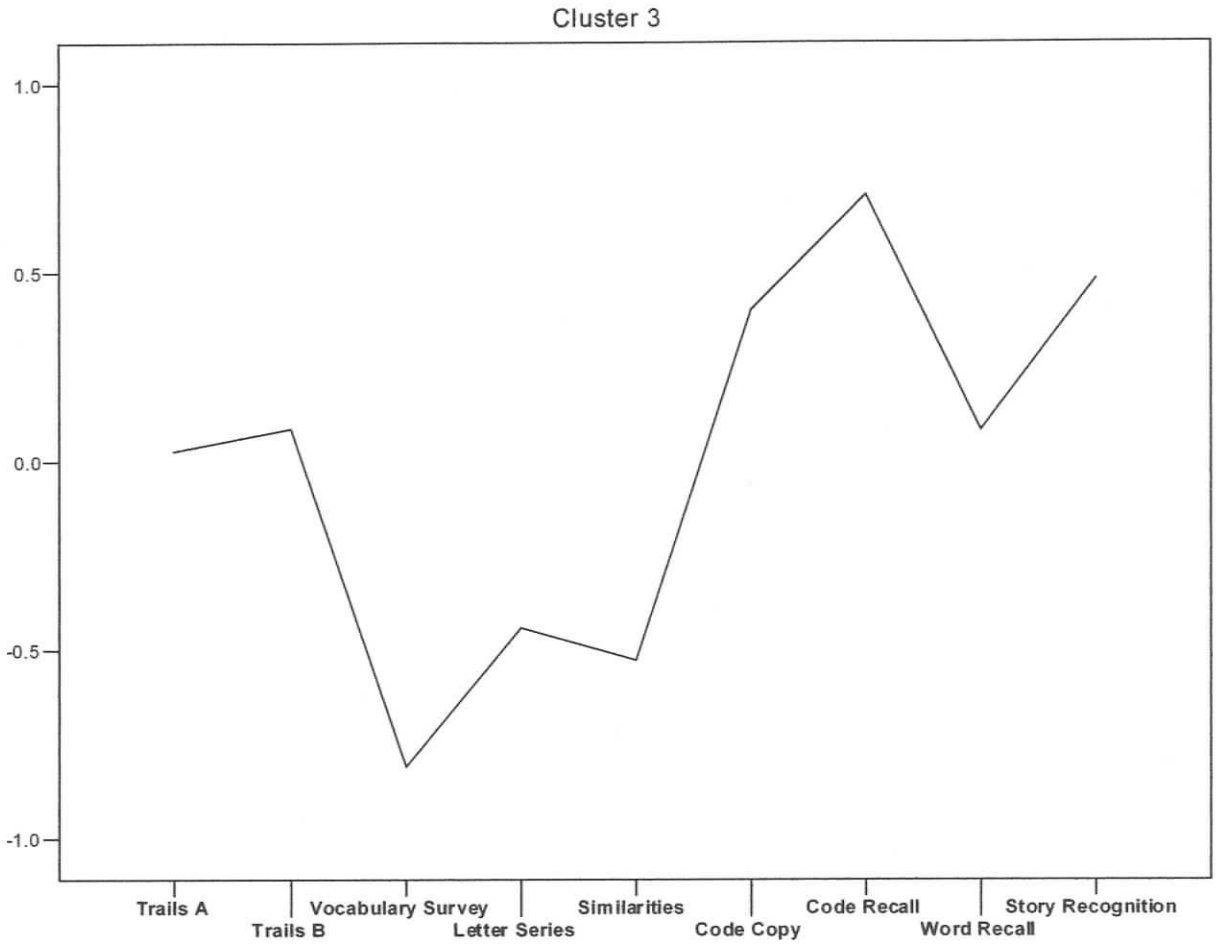

Cluster Description- Demographic and Health Variables

After distinguishing the three clusters, a series of ANOVA's were performed on the demographic and health variables in order to characterize the clusters in terms of differences between the individuals making up the clusters. A chi square analysis was performed to determine whether differences existed in the proportion of males and females in the subgroups. Tables 2 and 3 show the means and standard deviations for the demographic and health variables as a function of the three identified clusters.

Results of these analyses showed that the clusters differed significantly in terms of demographic variables including, age ($F(2,301) = 4.78$, $p<.01$), education ($F(2,301) = 8.96$, $p<.01$), NAART score ($F(2,301) = 40.81$, $p<.01$), NAART discrepancy score (premorbid-current IQ estimate) and total MMSE score ($F(2,301) = 16.75$, $p<.01$). The clusters did not differ by gender. Post hoc analyses were run using Tukey's pairwise procedures. These analyses showed that in terms of age, Clusters 1 and 3 did not differ significantly from each other, however both were significantly younger than Cluster 2. In terms of education, Cluster 1 had significantly more years of education than Clusters 2 and 3, which did not differ from each other. All three clusters differed significantly on NAART score, with Cluster 1 performing better than Clusters 2 and 3, and Cluster 2 performing better than Cluster 3. In terms of the NAART discrepancy score Cluster 1 exhibited less decline than Clusters 2 and 3, which did not differ significantly from each other.

The clusters also differed significantly in terms of several health variables, including, self-rated health relative to perfect health ($F(2,301) = 8.32$, $p<.01$), self-rated health relative to same aged peers ($F(2,301) = 4.45$, $p<.05$), activities of daily

living inventory ($F(2, 301) = 8.06$, $p<.01$), depressive affect ($F(2,301) = 3.99$, $p<.01$), memory efficacy ($F(2,301) = 5.27$, $p<.01$) and perceived change in memory ability ($F(2,301) = 5.24$). The clusters did not differ overall in terms of reported number of chronic conditions experienced or total number of medications taken. Tukey Post Hoc analyses revealed that in terms of self-rated health relative to a perfect state, Cluster 2 reported worse health than both Clusters 1 and 3, which did not differ significantly. Cluster 1 reported better health relative to same age peers than both Cluster 2 and 3, which did not differ significantly from each other. Clusters 2 and 3 reported both more difficulties performing activities of daily living and reported more depressive symptoms than Cluster 1. Clusters 2 and 3 did not differ significantly from each other in terms of difficulty with daily activities or depressive affect. Cluster 1 reported greater memory efficacy than Cluster 2. Clusters 1 and 3 and Clusters 2 and 3 did not differ significantly on memory efficacy. Clusters 1 and 3 reported fewer perceived memory changes than Cluster 2. Clusters 1 and 3 did not differ significantly in terms of perceived memory change.

Table 2

Demographic Variables by Cluster

Variable		Cluster 1 (n=125)	Cluster 2 (n=106)	Cluster 3 (n=73)
Age				
	M	73.24	75.44	73.29
	SD	5.31	6.77	5.37
Sex				
	M	31.2%	37.7%	23.3%
	F	68.8%	62.3%	76.7%
Education				
	M	15.98	14.87	14.15
	SD	2.54	3.58	3.08
MMSE				
	M	29.11	28.43	28.58
	SD	0.952	1.441	1.166
NAART (Errors)				
	M	11.02	14.07	21.22
	SD	5.708	8.288	9.551
NAART Discrepancy Score				
	M	7.121	0.228	0.655
	SD	10.61	9.944	8.794

Table 3

Health Variables by Cluster

Variable	Cluster 1 (n=125)	Cluster 2 (n=106)	Cluster 3 (n=73)
Self-rated health compared to perfect state			
M	4.35	4.01	4.29
SD	0.625	0.683	0.677
Self-rated health compared to peers			
M	4.58	4.34	4.47
SD	0.543	0.631	0.647
Activities of Daily Living Inventory			
M	1.103	1.235	1.189
SD	0.182	0.287	0.300
Depression Inventory			
M	1.097	1.200	1.196
SD	0.230	0.337	0.377
Memory Efficacy			
M	4.308	3.876	4.039
SD	0.980	1.107	0.960
Perception of Memory Change			
M	3.211	2.852	3.201
SD	0.794	0.867	1.137

Table 3 continued

Health Variables by Cluster

Variable	Cluster 1 (n=125)	Cluster 2 (n=106)	Cluster 3 (n=73)
Number of Chronic Illnesses			
M	2.620	3.180	3.070
SD	1.767	1.956	2.030
Total Number of Medications			
M	5.630	5.870	6.180
SD	3.472	3.596	3.664

Cluster Description- Neuropsychological Measures

A series of ANOVA's were run on the neuropsychological variables to examine differences between the clusters in overall level of performance. Table 4 contains the descriptive data for each of the three subgroups on the 9 cognitive tasks. Cluster 1 performed better than Clusters 2 and 3 on all tasks, except Story Recognition where Cluster 1 did not differ from each and on Code Recall where Cluster 1 and 3 did not differ. Cluster 3 performed better than Cluster 2 on all tasks except for Letter Series (the clusters did not differ) and the verbal fluency task where Cluster 2 actually performed more strongly than Cluster 3.

Table 4

Neuropsychological Variables by Cluster

Variable	Cluster 1 (n=125)	Cluster 2 (n=106)	Cluster 3 (n=73)
Trails A			
M	32.98	51.97	38.46
SD	7.958	16.90	8.537
Trails B			
M	72.84	115.94	90.68
SD	19.59	45.30	30.13
Vocabulary Survey			
M	31.94	30.50	25.77
SD	2.353	3.696	5.335
Letter Series			
M	12.13	6.972	6.420
SD	3.263	4.539	4.663
Similarities			
M	16.33	12.29	9.99
SD	4.711	4.824	4.293

Table 4 continued

Neuropsychological Variables by Cluster

Variable	Cluster 1 (n=125)	Cluster 2 (n=106)	Cluster 3 (n=73)
Code Symbol Copy			
M	46.62	34.71	43.66
SD	9.992	8.272	8.826
Code Symbol Recall			
M	7.08	4.00	6.93
SD	1.753	2.178	1.851
Word Recall			
M	18.59	14.12	15.73
SD	3.511	4.157	3.772
Story Recognition			
M	20.26	19.83	20.52
SD	1.981	2.166	1.901

Discussion

Major Findings

The present investigation examined intraindividual variability across cognitive domains in elderly individuals in both a quantitative and qualitative fashion. The quantitative analysis of dispersion entailed examination of age and cognitive status group differences in overall levels of dispersion. The qualitative investigation centered upon the delineation and characterization of potential patterns of cognitive dispersion. This was achieved by first identifying neuropsychological profile patterns through cluster analyses. Next, the subgroups were characterized based on differences between the individuals making up the distinct subgroups on demographic, health and neuropsychological variables in order to evaluate the potential clinical meaning of the cognitive profile patterns.

The quantitative examination of overall dispersion levels yielded three main findings. First, in a cross-sectional analysis of older adults aged 65-92, level of dispersion was found to increase with advancing age. Second, individuals classified as having experienced cognitive decline exhibited a more uneven profile of cognitive abilities compared with individuals classified as not having experienced cognitive decline. Third, a correlational analysis examining the association between the two types of within-person variability, showed that there was a significant positive relationship between measures of dispersion and inconsistency.

With respect to the qualitative analyses, the present study generated two main findings. First, three subgroups of older adults exhibiting distinct profiles of cognitive skills were distinguished in the sample using non-hierarchical clustering

methods. The first subgroup exhibited a pattern of relative cognitive strengths across the cognitive tasks (Cluster 1). The second cluster displayed a pattern of relative cognitive weaknesses across the tasks with the exception of the semantic memory tasks and the episodic recognition task (Cluster 2). The final cluster displayed particular weaknesses in fluid reasoning and semantic memory tasks (Cluster 3) and relative strengths across the other cognitive tasks. The second central finding in the qualitative investigation was that the separate dispersion subgroups identified differed significantly by demographic, health and neuropsychological variables. Clusters 1 and 2, in many ways, differed expectedly from each other; members of Cluster 1, a group that displayed a distinctly strong profile of abilities, were generally younger, more highly educated, experienced less cognitive decline, performed better on brief measures of mental status, and displayed a more favourable health and neuropsychological profile than Cluster 2 a group characterized by a distinctly weaker pattern of cognitive abilities. Cluster 2 displayed a profile of relative strengths in tasks of crystallized abilities; this type of profile is an expected performance pattern in aging and is suggestive of some sort of cognitive deterioration, as crystallized abilities are less susceptible to decline than other abilities. Cluster 3 displayed a less explainable pattern of performance across the tasks and related differences in demographic and health variables.

Dispersion Levels

As expected, the present study supports a solid base of past research evaluating samples of young-old adults and reporting increasing levels of cognitive dispersion with advancing age. The findings from the present study, were not

consistent with two previous studies that used samples of very-old adult and reported either decreasing dispersion scores or no age differences in dispersion scores with increasing age (Lindenberger & Baltes, 1997; Rapp et al., 2005). Additional research examining samples of very-old adults (i.e. 85 years and older) will likely further clarify changes that may exist in the relationship between dispersion and age at various stages of aging.

The age differences in dispersion found in the current investigation have important implications for practitioners involved in the clinical assessment of older adults. Clinical neuropsychologists typically examine dispersion when evaluating a patient's neurological functioning by examining discrepancies between different ability domains. The finding that it may be typical for older-old adults to display a more inconsistent profile of abilities than younger-old adults highlights the care required in making a valid clinical diagnosis with elderly individuals. Practitioners relying too heavily on the discrepancy approach to assessment risk labeling older adults as neurologically unhealthy when this might more accurately reflect typical developmental changes associated with normal aging. Further investigation focused on what constitutes typical and atypical, as well as healthy and unhealthy amounts of cognitive dispersion at different ages and the implications dispersion has for clinical assessment is required.

A link between elevated levels of cognitive dispersion and central nervous system dysfunction in older adults has been reported suggesting that dispersion levels may be considered an indicator of pathology (Christensen et al., 1999; Rapp, et al., 2005). Results of the current study support this research as a more uneven pattern of

cognitive abilities was related to cognitive decline based on estimates of current and premorbid intelligence. This finding adds to the body of evidence supporting the potential clinical utility of using dispersion level as a marker of cognitive integrity.

In addition to the clinical relevance of the current results, these findings also contribute to the growing research on intraindividual variability. The present findings support an increasing body of research that has shown that variability across short time periods is a lawful and meaningful indicator of individual differences. In addition, the results of the present investigation support the view that level of dispersion may also serve as meaningful and systematic indicator of individual differences, including age and cognitive status.

A positive relationship between the two facets of intraindividual variability was observed in the present investigation, suggesting that individuals that exhibited more variability across time also displayed greater variability across tasks. These results support previous research by Hultsch et al. (2002) who found similar results across four reaction time tasks. These results suggest an overlap between the two facets of intraindividual variability and further support the hypothesis that within-person variability, both across tasks and across time, represent a meaningful indicator of individual differences. Future investigation could focus on characterizing the overlap between dispersion and inconsistency by examining the clinical utility of dispersion versus inconsistency in terms of predicting cognitive change.

Patterns of Cognitive Dispersion

To examine cognitive dispersion more fully, potential patterns in dispersion were examined. Three distinct subgroups exhibiting separate profiles of cognitive

strengths and weaknesses were distinguished in the sample of older adults. Of the three distinct patterns identified, two were not surprising. Cluster 1 displayed a particularly strong pattern of performance across the measures and likely reflects a cognitively healthy group. Cluster 2 demonstrated a relatively weak pattern of performance across most measures with the exception of a semantic memory task and an episodic memory recognition task, an expected pattern in aging that likely represents a group experiencing some sort of cognitive decline. Cluster 3 displayed a less expected pattern of abilities with relative weaknesses across measures of semantic memory and fluid reasoning tasks.

In terms of individual differences on the demographic and health variables, Cluster 1 and Cluster 2 differed somewhat expectedly from each other based on their performance profiles. Individuals making up Cluster 1, the strongest group, were significantly younger, more educated, experienced less decline, performed better on the MMSE and performed better on almost all of the cognitive tasks compared to Cluster 2, the weaker group. In addition, Cluster 1 exhibited a stronger health profile relative to Cluster 2, reporting better health, less difficulties with tasks of daily living, less depressive affect, better memory efficacy, less memory change and reported fewer chronic illnesses. These differences further suggest that Cluster 1 represents a group of cognitively healthy individuals who are likely to remain cognitively stable over some time while Cluster 2 represents a subgroup of individuals who have experienced some degree of cognitive decline and may be considered to be at increased risk for future cognitive deterioration.

Cluster 3, a group defined by a relative weakness on measures of fluid reasoning and semantic memory, fell somewhere in-between Cluster 1 and Cluster 2 in terms of the descriptor variables. Cluster 3 was similar to Cluster 1 in terms of age, self-health ratings and perceived memory change as individuals making up Cluster 3 were generally younger, reported better health and perceived less change in memory functioning compared to Cluster 2. On the other hand, Cluster 3 was similar to Cluster 2 in terms of level of decline experienced, years of education, MMSE score, activities of daily living inventory and depressive affect self-report. In other words, Cluster 3 had experienced significantly more decline, was less educated, scored lower on the MMSE, had more difficulties with activities of daily living and reported more depressive symptoms than Cluster 1.

In sum, Cluster 3 displayed a rather unexpected pattern of strengths and weaknesses across the cognitive variables that are not easily explained by previous aging research or the individual differences observed in the descriptor variables. Cluster 3 represents a group identified in the sample with a particular weakness in measures of crystallized ability, an ability thought to remain relative stable with advancing age. As such, it is possible that this pattern does not represent a distinctly "at risk" group despite the weakness observed. Instead, this cluster may represent a group of less educated individuals within a sample of very highly educated individuals so that the weakness displayed on tasks dependent on vocabulary knowledge is the result of having never learned this information to begin with as opposed to representing a decline in functioning. However, according to the demographic variables, this group did experience a greater level of decline than

Cluster 1, the strongest group, suggesting some sort of impairment. Thus, another possibility is that Cluster 3 represents a heterogeneous group of less able individuals coping with a variety of physical and emotional difficulties (they exhibited greater functional difficulties and more depressive symptoms than Cluster 1). At this point it is difficult to conclude the clinical meaning of the clusters, particularly Cluster 3. Longitudinal research evaluating the relationship between membership in a particular cluster and later cognitive status would bring to light the clinical significance and consequence of these clusters.

It should be noted that the dispersion patterns delineated in this study were based on ipsatized scores, so that the groups were created based only on pattern of performance and not based on overall level of performance. Peters et al. (2005) point out that formulating subgroups based on overall performance profiles may have only short-term predictive value as these individuals may be on the cusp of cognitive decline. Alternatively, creating subgroups of individuals considered to be at-risk based on the pattern of performance, by removing effects of overall profile levels, yields groups considered to be at risk with more long-term prognostic value. As such, the relation between current cluster membership and later cognitive status may not be observable without several years of longitudinal data.

Limitations

There are two potential limitations to the current study. First, the classification of individuals into cognitive status groups was rather unrefined. Individuals were organized based on *estimates* of premorbid and current intelligence based on only a few tasks. In addition, participants whose estimated premorbid

intelligence was larger than their estimated current intelligence were labeled as having suffered cognitive decline, even if the difference was very small. The same was true of those labeled as cognitively stable. As such, it is possible that some individuals were incorrectly assigned to the cognitive status groups.

A second potential limitation to the current investigation is the instability of clustering procedures. The number of clusters we ultimately selected was based on two criteria: that each cluster had enough subjects in it to ensure appropriate reliability and that the clusters appeared to have meaning. The second rule entails some degree of subjectivity and raises uncertainty as to whether these clusters might be observed in other populations.

Conclusions

The study of intraindividual variability is necessary to fully understanding the aging process. To date, the study of dispersion as a facet of within-person variability has generally been limited and incomplete. In terms of quantitative aspects of dispersion, findings from the current investigation indicate that dispersion does increase with age in young-older adults. In addition, the findings of the current study indicate that level of dispersion may serve as a marker for cognitive integrity. Qualitatively, distinct cognitive patterns of dispersion were distinguished in the sample of older adults and the patterns of dispersion were related to demographic, health and performance characteristics of the individuals displaying the particular profile patterns suggesting that these patterns may be meaningful. Longitudinal investigation following the development of the clusters should shed further light on the significance of these clusters.

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