RICE UNIVERSITY

Meta-Analysis of Age and Job Performance Relation:
Is Job Complexity a Moderator?

by

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A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

Master of Arts

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May 2006
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ABSTRACT

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I conducted a meta-analysis of 121 samples (N = 18,694) that examined the relation between age and job performance with job complexity as a moderator. Job complexity was operationalized as the ratings on job tasks tapping fluid task abilities, or GFTA, and crystallized task abilities, or GCTA. I found that the correlation between age and job performance decreased as jobs were rated higher on GFTA; however, there was no evidence that the correlation between age and job performance increased as jobs were rated higher on GCTA. The correlation between age and job performance increased as jobs were rated lower on both GFTA and GCTA and increased as jobs were rated lower on GFTA and higher on GCTA. The correlation between age and job performance decreased as jobs were rated higher on both GFTA and GCTA.
Acknowledgments

First, I would like to thank the members of my thesis committee. I am grateful to Dr. Margaret Beier, for her extraordinary commitment to this project throughout the entire process. Her guidance and belief in me helped me to keep my head up and to persevere towards this challenging goal. I am grateful to Dr. Daniel Beal, for his generous and tireless contributions and to Dr. Jim Dannemiller, for investing his time and insight.

I am also indebted to all the talented and hard-working Research Assistants who were involved in my project: Angy Tamborello, Mark Deal, Scarlett Boulos, Melissa Waitsman, Vincent Tran, Alan Sung, and Jordy Alger.

I would also like to thank my associates at Personnel Decisions International (PDI); in particular, Dr. Edward Kahn, for his patience and support as I pursued my academic goals.

I would like to extend a special appreciation to my dear friend, Kathrin Peek, for her steady thoughtfulness and consideration. And finally, but of singular importance, I want to thank Brian Davis, for showing me with his love, understanding, encouragement, and support that behind an aspiring great woman is a great man.
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Introduction

The world is aging. Life expectancy worldwide was only 47 years of age in the year 1950. Presently, life expectancy across the globe is 66 years of age, while in the United States life expectancy at birth is 77 years of age. This dramatic increase in longevity is the result of advances in science, technology, medicine, and standards of living. Additionally, the current demographic transformations are forecast to continue well into the upcoming centuries. The present number of persons aged 60 years or older in the world is estimated to be 605 million. This number is estimated to be over 1 billion by year 2030, and almost 2 billion by year 2050 (AARP, 2004).

As a result of these demographic changes, labor force projections predict there will be a growing scarcity of younger employees in many countries, while the number of older workers will continue to increase (Warr, 1994). Many countries also face the additional demographic disequilibria created by the large generation of post-war baby-boomers that will turn 65 years of age beginning as soon as year 2011. The number of Americans aged 65 and older is predicted to more than double to 77 million between 2000 and 2040, while the number of prime working-age adults between the ages of 25 and 54 will increase by only 12 percent (Johnson, 2004). Accordingly, business leaders, government planners,
and policymakers alike are proposing that continued employment for older workers will be necessary in order to address both imminent labor shortages, as well as to ease the burden on public pension systems. Thus, a trend toward older workers in the United States is expected to gather momentum (Johnson, 2004).

In the interim, job patterns are also changing with the aging population of employees increasingly likely to experience new task demands. Most developed countries have experienced a move away from agriculture and manufacturing industries to the services and information technology sector. Hard manual labor is less common in developed countries than it formerly was, and the work demands of younger as well as older employees are more likely to call for greater cognitive abilities, rather than physical skills (Warr, 1994).

In summary, demographic transformations, an aging labor force, and changes in job patterns bring to light the growing significance regarding the relation between age and job performance. As these trends increase, employers and researchers would benefit from a clearer understanding of the relation between age and job performance. The literature on the age and job performance relation is mixed (McEvoy & Casio, 1989; Rhodes, 1983; Walman & Avolio, 1986). Additional insight into the topic of age and job performance may provide the needed clarity
that has thus far been absent from the literature. The current study aimed
to progress beyond existing research on the relation between age and job
performance by examining the differing cognitive demands of job tasks
across job types. Previous research has examined the relation between
job age and job performance as moderated by professional or non-
The current study examined the relation between job performance and
age framed within a theory of cognitive ability – the theory of fluid ability
(Gf) and crystallized ability (Gc; Horn & Cattell, 1966). Specifically, I
explored the extent to which jobs required fluid ability (Gf) and crystallized
ability (Gc; Horn & Cattell, 1966) as moderators of the age and job
performance relation. The theory and research relevant to the link
between age and job performance are described below. The research on
the association of age and Gf and Gc is reviewed first, followed by the
relation of age and job performance. A brief distinction between variably
and consistently mapped tasks is then discussed, followed by a
description of job task demands and Gf and Gc which provides the
theoretical basis for the current study. This review is followed by the
methods, results, and discussion of the current study.
Literature Review

**Age and Gf/Gc**

Hierarchical models are generally the most accepted models of human intelligence (Carroll, 1993). Through his factor analysis of hundreds of studies on human intelligence, Carroll (1993) developed a hierarchical model with g (general ability or intelligence) at the apex of the hierarchy with content specific abilities residing on the second level. For purposes of this discussion, the two most important content specific abilities on the second level of the hierarchy were first specified by Horn and Cattell (1966) and later confirmed in Carroll’s re-analysis as fluid ability (Gf) and crystallized ability (Gc). Gf includes memory, novel problem solving, attentional processes, inductive reasoning, and abstract, spatial orientation; whereas, Gc is primarily based on knowledge accumulated through education and experience (Horn & Cattell, 1966).

The distinction between the two categories of cognitive abilities, Gf and Gc (Horn & Cattell, 1966), within hierarchical theories of intelligence is of unique importance with respect to the topic of age. The Gf and Gc theory posits that the investment of Gf leads to the attainment of Gc (Horn & Cattell, 1966). Although a significant and large correlation exists between Gf and Gc both for children and adults (e.g., r > .50; Carroll, 1993), Gf and Gc show disparate relations with age. Specifically,
research has shown that Gf declines with age (Cattell, 1943; Horn &
Cattell, 1966; Salthouse, 1996). This is perhaps not surprising because
Gf is believed to be physiologically based and mainly reflects the
neurological (or central nervous system) changes that people experience
as they age that are connected to heredity and biology (Horn & Cattell,
1966; Stankov, 1988). Performance decays have been reported for older
adults with abilities represented by the Gf factor such as working memory
and processing speed (Salthouse, 1996). Deterioration in information
processing has been observed with older participants in studies that have
examined performance on abstract problem solving tasks (e.g., such as
concept formation, logical reasoning, and anagram solutions; Denny &
Palmer, 1981). For example, a cross-sectional study by Stankov (1988)
found that Gf was correlated, r = -.31, with age on measures of attentional
processes. Another cross-sectional study reported a similar correlation
between age and Gf (r = -.39, p < .01) on a composite measure of
traditional assessments of Gf abilities (e.g., math word problems, inductive
reasoning, logical reasoning, and analogical reasoning with spatial content
reasoning, memory, and problem solving ability tests; Ackerman, 2000).
Additional cross-sectional studies have indicated that Gf begins its
descent around the age of 20 and continues to decline throughout the
adult lifespan (Jones & Conrad, 1933; Miles & Miles, 1932). A cohort-
sequential study (e.g., a study in which partly overlapping samples were drawn at several different time points) provided both cross-sectional and longitudinal findings on tests of inductive reasoning (identification of abstract logical principles from letter sequences) and spatial orientation (mental rotation of abstract figures), which showed that declines happened later in the lifespan than shown in cross-sectional studies, but that these abilities do decline through the adult lifespan (Schaie, 1996).

Gc, alternatively, has been shown to remain stable and even improve with age in both longitudinal and cross-sectional studies of ability (Horn, 1982; Schaie & Willis, 1993). Studies employing intellectual ability tests that measure Gc (e.g., verbal comprehension) have confirmed that individuals performed better on these tests when they were older, suggesting that these verbal abilities may even be enhanced across the life span (Sands, Terry, & Meredith, 1989; Schaie, 1996). Cross-sectional research has shown that older individuals perform better than younger individuals on tests of Gc; this demonstrates that Gc also remains fairly stable, at least until the age of 70 or so (Jones & Conrad, 1933; Miles & Miles, 1932). A cross-sectional study by Ackerman (2000) also found Gc was correlated .14 (p < .01) with age on a composite measure of traditional Gc ability assessments (e.g., vocabulary, reading speed and comprehension, general knowledge, verbal fluency and knowledge, and
common cultural knowledge ability tests) for a sample of participants aged 21 to 62 years. Another cross-sectional study in which adults were administered measures of Gc and a broad array of knowledge scales also showed that Gc shared substantial common variance with most of the knowledge scales, and that older adults (ages 30 to 59) were more knowledgeable on almost the entire range of knowledge domains compared to younger adults (ages 18-27; Ackerman & Rolphus, 1999).

Furthermore, cross-sectional research by Stankov (1988) found that Gc was correlated .27 with age and that when the Gc factor was partialled out of the correlation between age and Gf, the decline in Gf was more pronounced. A proposed explanation was that Gc provided a “holding-up mechanism” (Stankov, 1988, p. 70) and kept Gf from declining at a faster rate. Stankov concludes that Gc remediates for the effects of declines in Gf. The reciprocal relation between Gf and Gc may not only indicate that the investment of Gf leads to the attainment of Gc (Horn & Cattell, 1966), but that Gc provides a protective influence upon the decay of Gf.

Further support for the compensating mechanism of Gc was described by Salthouse and Maurer (1996). The stability or enhancement of Gc with age is analogous to the proposition that older workers uphold high levels of effective job performance due to acquired job relevant
experience, knowledge, and skills. For example, academic professors and faculty members maintain very high levels of effective job performance in conducting informative research and writing up findings and conclusions as a result of their long acquired expertise and extensive body of knowledge. This is one of potentially many examples of the “holding-up mechanism” that Gc can provide to older workers with certain jobs and job tasks.

In the work domain, the findings regarding the decay and stability of cognitive abilities throughout the lifespan carry important implications given the finding that cognitive ability is the best predictor of job performance across all jobs that have been examined (Schmidt & Hunter, 1998). Cognitive ability (or g) has most often been described as information processing power (Jensen, 1988) or the ability to learn (Hunter, 1986). As measured in most industrial settings, cognitive ability is a mixture of both Gf and Gc type abilities and is mainly concerned with gaining a sense of an individual’s ability to learn in a job. In a meta-analytic study examining various predictors of job performance, cognitive ability was the most consistent predictor (Schmidt & Hunter, 1998). However, the correlation between cognitive ability and job performance was found to depend on the job type. For example, the validity coefficient (i.e., correlation between predictor and criterion; in this case cognitive
ability and job performance) for professional–managerial jobs was reported to be .58 and for unskilled jobs it was .23 (Schmidt & Hunter, 1998). These findings suggest that performance on jobs that are more complex is more highly predicated on cognitive ability than jobs that are less complex; however, cognitive ability was still important for all job types. Additionally, Schmidt and Hunter found that job knowledge accounted for more variance in job performance than measures of cognitive ability. Because one can consider job knowledge to be a type of Gc – that is, knowledge acquired through education and experience, these findings suggest knowledge (Gc) plays an important role in job performance.

Because some cognitive abilities decline with advancing age, and because cognitive ability is an important predictor of job performance, it is interesting to consider the relation between age and job performance. Research on this topic will be discussed next.

**Age and Job performance**

Literature reviews have provided mixed results on the relation between age and job performance with approximately equal numbers of studies reporting that job performance increases with age (positive), decreases (negative) with age, or remains the same (no relation; Rhodes, 1983). Several possible reasons why contradictory relations between age and job performance have been found include: (1) the type of measures
used to assess the criterion (job performance) such as objective (indices of productivity) versus subjective (supervisor ratings); (2) the task demands associated with the job type; and (3) the variability in job experience among workers being assessed (Rhodes, 1983). Subsequent meta-analyses examining the relation between age and job performance have attempted to examine these potential moderators.

Waldman and Avolio (1986) and McEvoy and Cascio (1989) conducted meta-analyses to examine the relation between age and job performance and found mixed results when job performance type was measured as a moderator of the age and job performance relation. Differences in methodology between the two studies, which I will discuss in more detail below, likely affected the results. Waldman and Avolio's meta-analysis examining the relation between age and job performance reported a .27 mean correlation between age and objective (productivity indices such as number of units produced, patents, publications, etc.) measures of job performance (range of \( r = -.30 \) to .48), but a -.14 mean correlation between age and subjective (supervisor ratings) measures of job performance (range of \( r = -.36 \) to .23; no 95% confidence intervals were reported). In contrast, McEvoy and Casio found a .07 mean correlation between age and objective measures of job performance (range of \( r = -.39 \) to .66; 95% confidence interval = -.12 to .26; non-
significant), and a .03 mean correlation between age and subjective measures of job performance (range of \( r = -0.44 \) to \( 0.31 \); 95% confidence interval = \(-0.23\) to \(0.28\); non-significant). Even though the results between these two studies are discrepant, both found higher correlations between age and job performance for objective measures of job performance and lower correlations between age and subjective measures of job performance. One potential reason for these results is that subjective job performance measures are susceptible to rating biases, especially in the case of older workers. For example, past research has found that younger raters rate older workers less favorably than younger workers (Finkelstein, Burke, & Raju, 1995).

Waldman and Avolio (1986) and McEvoy and Cascio (1989) also found mixed results when job type was measured as a moderator of the age and job performance relation. Waldman and Avolio and McEvoy and Cascio classified job type as either professional (e.g., scientists, academicians, managerial personnel, engineers, and nurses) or nonprofessional (e.g., skilled to semiskilled workers and technicians, clerical jobs, sales jobs, air traffic controllers, and bank tellers). For professional job types, Waldman and Avolio found a .27 mean correlation with age and objective job performance measures and a -0.05 mean correlation with age and subjective measures of job performance (no
range of r's or 95% confidence intervals were provided). McEvoy and Cascio found a -.08 mean correlation between age and job performance for professional jobs (range of r = -.44 to .26; 95% confidence interval = -.34 to .18; non-significant).

For non-professional job types, Waldman and Avolio (1986) found a .26 mean correlation between age and objective measures of job performance and a -.18 mean correlation between age and subjective measures of job performance (no range of r's or 95% confidence intervals were provided). McEvoy and Cascio (1989) found a .06 mean correlation between age and job performance for non-professional jobs (range of r = -.39 to .66; 95% confidence interval = -.16 to .27; non-significant). The inconsistent findings from these meta-analyses for job types were potentially due to the large differences in sample size. The total individual sample size was 38,983 and 10,027 for McEvoy and Cascio (1989) and Waldman and Avolio (1986), respectively. Furthermore, Waldman and Avolio (1986) located only 13 published studies; whereas, McEvoy and Cascio (1989) located 96 independent studies. Another potential reason why the pattern of results that emerged from these past meta-analyses did not provide clear differences between professional and non-professional job types and their relations with age and job performance may have been due to their classification of job type as simply professional and non-
professional. By classifying jobs into just two categories, the degree of
cognitive complexity present in jobs, and their subsequent differing
relations with age and job performance, may not have been sufficiently
captured.

The most recent meta-analytic examination of the relation between
age and job performance attempted to take job complexity into account
complexity scale defined job complexity based on the degree to which
jobs involved data, people, or things. Sturman (2002) measured job
complexity based only on the degree to which jobs involved working with
data (an example of a complex job task dealing with data would be
synthesizing; an example of a low complex job task dealing with data
would be comparing; Muchinsky, 2006). The results from Sturman's
(2003) meta-analysis provided a .05 (non-significant) mean correlation
between age and job performance involving low complex jobs (range of \( r =
-.36 \) to .39), and a -.02 (non-significant) mean correlation between age and
job performance involving high complex jobs (range of \( r = -.36 \) to .38).
Although age was not related to job performance, when Sturman (2003)
plotted the results of age, job performance, and job complexity, a
significant interaction was found. The correlation between age and job
performance increased for high complex jobs; whereas, the correlation
between age and job performance declined for low complex jobs (Sturman, 2003). These results suggest that a promising area of future research would be to examine the effect of job complexity on the relation between age and job performance. However, criticisms exist for the system for rating job complexity used by Sturman. Researchers have concluded Hunter’s scale is “crude and imprecise” (Murphy, 1989, p.193). Furthermore, Hunter’s scale does not provide as much information on the extent of complexity present in a job as much as it provides a systematic approach to classifying jobs based on broad task dimensions of data (mental), people (interpersonal), or things (physical).

An alternative approach to defining the complexity of job tasks can be found in the framework of consistently mapped tasks versus variably mapped tasks (Schnieder, Dumais, & Shrieffrin, 1984). Consistently mapped tasks can easily be automatized because components of these tasks are the same (or consistent) each time the task is executed. With practice on these tasks, performance becomes automated and performance on these tasks is subsequently less reliant on cognitive demands (e.g., automated tasks require less focused attention). Consistently mapped tasks are those that can benefit from practice and experience since performance can become progressively automatized as a result of both. Because performance on these tasks becomes
crystallized with performance, one could consider them Gc-type tasks. Conversely, components of variably mapped tasks change each time the task is executed, and thus, performance cannot be automated. Performance on inconsistent, or variably mapped tasks continues to require high cognitive demands each time the task is executed. Variably mapped tasks are those that cannot benefit from practice and expertise since performance is resistant to automatization as a result of the continuous degree of requisite cognitive processing. These types of tasks could thus be considered Gf-type tasks. It is interesting to consider the cognitive abilities involved in executing job tasks in the context of the age and job performance relation. A framework for examining the abilities involved in different types of jobs will be considered next.

**Job task demands and Gf/Gc**

One conceptualization of differing ability demands for different jobs is a four-category framework developed by Warr (1994). The framework is based upon the body of age and performance literature to date. This categorical scheme attempts to adequately reflect the nature of cognitive complexity present in laboratory tasks and more generally in job task demands. Furthermore, it is described in terms of expected declines and gains in performance. The first category, Type A, includes activities that do not exceed basic cognitive capacities, as well as activities that are
improved by knowledge and experience (e.g., Gc). Warr subsequently predicted a positive relation to exist between age and performance for Type A activities because automatization can occur due to the consistently mapped nature of the tasks. The second category, Type B, includes activities that neither exceed basic capacities nor are enhanced through knowledge and experience. Therefore, Warr predicted no relation to exist between age and performance for Type B activities. The third category, Type C, includes activities that are subject to a performance decrement, but are expected to be met with opportunities of behavioral compensation and accommodation. Again, no relation is predicted to exist between age and performance for Type C activities because the benefits of consistently mapped tasks would be offset by the decrements of variably mapped tasks. And finally, in the fourth category, Type D, activities include those that are physiologically based such as information processing, inductive reasoning, speed of psychomotor reaction, learning (e.g., Gf), as well as strenuous manual work demands. Thus, a negative relation is predicted to exist between age and performance for Type D activities because automatization cannot occur due to the variably mapped nature of the tasks. A description of Warr's (1994) four-category framework is shown in Table 1.
Table 1.

Four-category framework, illustrative laboratory tasks, and predicted relations of performance with age (Warr, 1994)

<table>
<thead>
<tr>
<th>Task category</th>
<th>Illustrative tasks</th>
<th>Predicted relations with age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>Tasks that do not exceed basic cognitive capacities as well as tasks that are improved by knowledge and experience (e.g., Gc)</td>
<td>Positive relation</td>
</tr>
<tr>
<td>Type B</td>
<td>Tasks that neither exceed basic capacities nor are enhanced through knowledge and experience</td>
<td>Zero/no relation</td>
</tr>
<tr>
<td>Type C</td>
<td>Tasks that are subject to a performance decrement, but are expected to be met with opportunities of behavioral compensation, accommodation, and cognitive compilation</td>
<td>Zero/No relation</td>
</tr>
<tr>
<td>Type D</td>
<td>Tasks that are physiologically based such as information processing, inductive reasoning, speed of psychomotor reaction, learning (e.g., Gf), and strenuous manual work demands.</td>
<td>Negative relation</td>
</tr>
</tbody>
</table>
Warr's categorization of job type is a promising framework for understanding the age and job performance relation. However, no current scheme for rating job complexity based on the cognitive demands of the job (and the relation between these cognitive skills and age) is available. The theory of Gf and Gc (Horn & Cattell, 1966) fits nicely into Warr's framework. For example, one might consider that performance on Type A job tasks would benefit from Gc type abilities; while performance on Type D job tasks would benefit from Gf type abilities. This type of approach can potentially be used to understand job complexity in terms of the cognitive demands of the job, and the relation between age and job performance for different levels of job complexity.

In summary, the overall state of the existing literature still highlights the need for a more extensive analysis of the age and job performance relation. The current study attempted to disentangle the relation between age and job performance through the use of meta-analysis by taking into consideration the cognitive skills that are tapped by job task demands with a framework that is based on, but expands upon, Warr's (1994) notions of job ability demands.
The Current Study

The current meta-analytic study aimed to move beyond past research on the relation between age and job performance by examining a potential moderator, job complexity, using a job classification scheme of two categories somewhat analogous to Warr's (1994) four-category framework. Moreover, the current study considered the relative levels of fluid and crystallized abilities, as well as consistently mapped tasks and variably mapped tasks required by a job. Thus, the moderator of job complexity was based on a classification scheme that categorized jobs continuously on the degree to which performance on the job independently required fluid task abilities (GFTA), crystallized task abilities (GCTA), and opportunities for automatization. Gf- and Gc-type tasks are somewhat analogous to variably and consistently mapped tasks in the respect that variably mapped tasks mainly comprise Gf type tasks, while consistently mapped tasks mainly comprise Gc type tasks. However, neither variably mapped tasks or consistently mapped tasks are exclusive to either Gf- and Gc-type tasks because performance of a job could be predicated on GFTA or GCTA while being comprised of both variably- and consistently-mapped tasks. Therefore, a greater emphasis was placed on the degree to which job performance was predicated on tasks that required GFTA and GCTA rather than on the extent to which a job was
variably or consistently mapped. For example, if a job was highly consistently mapped, yet job performance was not predicated on a body of knowledge (or GCTA), then the job was rated lower on GCTA. Alternatively, if a job was minimally consistently mapped, yet job performance was predicated on a large body of knowledge (or GCTA), then the job was rated higher on GCTA. Thus, the depth of knowledge for GCTA jobs, rather than just the extent to which tasks could be automated was weighted with more consideration during the rating of a job. A description of the two-category framework is shown in Table 2.
Table 2.

Two-category job complexity framework and illustrative job type tasks

<table>
<thead>
<tr>
<th>Job complexity category</th>
<th>Illustrative job tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFTA</td>
<td>Job performance is influenced by job tasks that are predicated on Gf type abilities (e.g., complex reasoning in novel situations, high demands on working memory with heavy time pressures, comprehension on instructions, learn and analyze problems, and make judgments), numerical ability (e.g., ability to perform complex arithmetic operations rapidly and precisely), spatial aptitude (e.g., ability to think visually and understand geometric forms and two-dimensional representations of three-dimensional objects) and minimal to no opportunities for automatization.</td>
</tr>
<tr>
<td>GCTA</td>
<td>Job performance is influenced by job tasks that are predicated on Gc type abilities (e.g., tasks that require applied knowledge and verbal aptitude such as ability for verbal and language comprehension) and opportunities for automatization.</td>
</tr>
</tbody>
</table>
In summary, the expected relations between age and job performance as a function of GFTA and GCTA are theoretically based. Gf has been found to decay with age, whereas, Gc has been found to remain stable and even improves with age (Cattell, 1943; Horn, 1982; Horn & Cattell, 1966; Salthouse, 1996; Schaie & Willis, 1993). Furthermore, there is evidence that Gc provides a mechanism that remediates the effects of declines in Gf (Stankov, 1988; Salthouse & Maurer, 1986). In other words, experience and knowledge can provide a potential compensating mechanism that buffers older individuals from the detrimental effects of novel problem solving and working memory demands. Thus, job relevant experience, knowledge, and skills can conceivably aid older workers in maintaining higher levels of effective job performance, even in jobs that include novel problem solving and high working memory demands. Furthermore, in cases where job performance cannot benefit from Gc, but neither is a performance decrement evident due to an absence of Gf, no relation between age and job performance would be expected.

**Hypotheses**

On the basis of the notion that job tasks require differing cognitive abilities and opportunities for automatization, I hypothesized the following relations between age and job performance.

Main effects:
The correlation between age and job performance would exhibit an overall negative trend as jobs were rated higher on GFTA due to the Gf-type tasks that would be necessary for performance on these jobs such as novel problem solving and working memory.

H1: The correlation between age and job performance will decrease as jobs are rated higher on GFTA.

The correlation between age and job performance would exhibit an overall positive trend as jobs were rated higher on GCTA due to the Gc-type tasks that would be necessary for performance on these jobs due to job relevant experience, knowledge, and skills.

H2: The correlation between age and job performance will increase as jobs are rated higher on GCTA.

Interaction:

The correlation between age and job performance would remain stable as the job rating decreased on both GFTA and GCTA. Due to the lower cognitive demands necessary for performance on these job tasks, there would be no expected decrements from Gf-type tasks such as novel problem solving or working memory demands, nor any expected benefits from Gc-type tasks such as job relevant experience, knowledge, and skills.
H3: The correlation between age and job performance will not increase or decrease as jobs are rated lower on GFTA and GCTA.

The correlation between age and job performance would increase as the job rating decreased on GFTA and increased on GCTA. Since there would be lower levels of GFTA, decrements from Gf-type tasks such as novel problem solving or working memory demands would not be expected; however, beneficial performance effects such as job relevant experience, knowledge, and skills would be expected from the Gc-type tasks that would be necessary for performance on these jobs.

H4: The correlation between age and job performance will increase as jobs are rated lower on GFTA and higher on GCTA.

The correlation between age and job performance would decrease as the job rating increased on both GFTA and GCTA, but the correlation would be higher than if the job rating increased on GFTA, but decreased on GCTA, due to the potential buffering effect of Gc-type tasks. Since there would be higher levels of GFTA, decrements from Gf-type tasks such as novel problem solving or working memory demands would be expected; however, beneficial performance effects such as job relevant experience, knowledge, and skills would also be expected from the Gc-type tasks that would also be necessary for performance on these jobs.
H5: The correlation between age and job performance will decrease as jobs are rated higher on both GFTA and GCTA, but the decline will not be as large as it will be when jobs are rated higher on GFTA and lower on GCTA.

Method

In order to identify potential studies on the relation between age and job performance, I utilized reference lists from previous meta-analytic studies by McEvoy and Cascio (1989), Waldman and Avolio (1986), and Sturman (2003). I also performed computer-assisted searches through the Psyc Info database. Dates that were included in the searches for both sets of terms were from the earliest abstracts available to an end date of October 22, 2004. A total of 629 and 939 abstracts resulted from the search terms “age and job performance” and “age and work performance,” respectively. Studies that were selected from the references and searches needed to report either relational statistics, specifically, Pearson product moment correlations (r), or data, that could be converted to an r (e.g., means, standard deviations, t values, chi-squares, F values) for each job type. In order to judge how many studies on job performance reported correlations with age and whether I should broaden my search for potential studies, I ran an additional search through the Psyc Info
database with just the search terms “work” and “job performance” and randomly sampled articles to see if they included age. A total of 10,212 articles were yielded from the additional search, and of the 20 articles randomly selected and reviewed, none were found to include age. Thus, I did not extend my search to include the broader terms (“work” and “job performance”). A total of 104 studies and 139 samples met my criteria. Of these, 9 samples from 8 studies were eliminated because the data they included did not allow for an accurate estimation of a correlation coefficient, and another 9 samples from 5 studies were deleted from further analyses because they were outliers (discussion to follow). Thus, the final sample included 91 studies, 121 independent samples, and a total N of 18,694, which were included in subsequent analyses.

Like previous meta-analyses that have examined the age and job performance relation (e.g., McEvoy & Cascio, 1989; Sturman, 2003; Waldman & Avolio, 1986), the current meta-analysis did not include proxies for job performance such as laboratory test and/or experiment performance, but only actual job performance. Actual job performance included objective job performance (e.g., individual productivity or output) and subjective job performance (e.g., supervisory and peer ratings). Individual productivity or output consisted of measures of unit output over a period of time, such as numbers of units produced, sales, patents, and
publications. The current meta-analysis also did not include an examination of studies that reported additional proxies for job performance such as self-ratings of job performance, performance on assessment center exercises, absenteeism, and salary level. In order for the moderator, job complexity, to be tested, studies that pooled job types together were not included in the current study. In other words, only studies that differentiated among jobs and provided relational statistics or data for each job type were included.

The compilation of the data entailed recording the following information into a spreadsheet: (a) article reference information; (b) sample characteristics such as size and composition by age; (c) range restriction (e.g., sample standard deviation of age divided by the best approximation of the American population standard deviation of 14 years of age based on national statistics from the U.S Department of Commerce between 1940 and 1980; Waldman and Avolio, 1986); (d) type of job performance measurement used along with the means, standard deviation, and reliability of the criterion measures (job performance); (e) type of job, (f) job experience, (g) organizational tenure, (h) statistics concerning the relation between age and job performance; and (i) classification of job complexity. Refer to Appendix A for a list of the
variables and information from meta-analytic references that were recorded.

The moderator, job complexity, was rated continuously (e.g., 1-5 scale; 1 = Very low, 2 = Moderately low, 3 = Moderate, 4 = Moderately high, to 5 = Very high) on two different categories based upon the cognitive and task demands of a job. That is, each job was rated on the extent to which performance on the job tasks was predicated on fluid abilities (GFTA), as well as crystallized abilities and opportunities for automatization (GCTA). Because it is difficult to imagine any job with tasks that demand no degree of fluid and crystallized abilities, the scale did not include zero. A rating on the GFTA category reflected the extent to which job performance was predicated on tasks that required novel processing and focused attentional resources. A rating on the GCTA category reflected the extent to which job performance was predicated on tasks that benefited from experience and accumulated job knowledge or crystallized ability and opportunities for automatization. More than the degree to which job tasks could be automated, however, a rating on the GCTA category reflected to a greater extent the depth of knowledge required by the job tasks. For example, a semi-skill job such as a sewing machine operator, while easily automated does not require as in depth of a knowledge structure as the job of an air traffic controller; which would
benefit both from automatization and an in depth knowledge structure. In this scenario, the job of an air traffic controller would be rated higher on the GCTA scale than that of sewing machine operator. Table 3 and 4 shows examples of the job complexity category classifications and illustrative job tasks.
Table 3.

Job complexity GFTA category classifications and illustrative job tasks

<table>
<thead>
<tr>
<th>Category</th>
<th>Illustrative job type tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 on GFTA</td>
<td>Semi-skilled jobs such as sewing machine operators because they rarely encounter novel situations or endure high cognitive demands on their working memory with heavy time pressures.</td>
</tr>
<tr>
<td>2 on GFTA</td>
<td>Bank tellers and salespersons because they deal with similar problems every day, yet there are small demands on their working memory with some time pressure. Faculty members/researchers and engineers because they sometimes encounter novel situations and endure high demands on their working memory during presentations and meetings.</td>
</tr>
<tr>
<td>3 on GFTA</td>
<td>Nurses because they regularly deal with novel patient situations. Managers because they regularly solve novel business challenges.</td>
</tr>
<tr>
<td>4 on GFTA</td>
<td>Police officers because they often encounter novel situations such as high speed chases or arrests.</td>
</tr>
<tr>
<td>5 on GFTA</td>
<td>Air traffic controllers because the factors involved in each landing are highly variable and require a high degree of novel problem solving.</td>
</tr>
</tbody>
</table>
Table 4.

Job complexity GCTA category classifications and illustrative job tasks

<table>
<thead>
<tr>
<th>1 on GCTA</th>
<th>Semi-skilled jobs such as sorters and sewing machine operators because they perform tasks that require minimal knowledge.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 on GCTA</td>
<td>Bank tellers and clerks because they handle tasks that require some knowledge.</td>
</tr>
<tr>
<td>3 on GCTA</td>
<td>Police officers because they must know how to properly arrest and book individuals, as well as criminal laws and citizen rights. Nurses because they must know how to properly administer medical procedures and conduct patient rounds.</td>
</tr>
<tr>
<td>4 on GCTA</td>
<td>Air traffic controllers because they benefit from knowledge of their sector and rules for landing a plane. Salespersons because they benefit from product knowledge.</td>
</tr>
<tr>
<td>5 on GCTA</td>
<td>Faculty members/researchers because they rely on a large body of knowledge and experience on a constant basis while writing and conducting research. Engineers and managers because they rely on a considerable body of knowledge and experience in performing tasks.</td>
</tr>
</tbody>
</table>
The assignment of a rating of job complexity was based on the description of the job type included in the article. In the case that job complexity could not be coded because there was little description of the job tasks involved in the article, the assignment was based on information (e.g., a job description) available from O*Net online. In order to achieve inter-rater reliability in coding job complexity for each job type, a professor of Industrial/Organizational Psychology and I classified and recorded the extent to which each job fit into each of the two job complexity categories based on the job characteristics (cognitive and task demands) without knowledge of what each other recorded and without consulting the correlations in each article. To estimate interrater agreement, I used the average deviation (AD) index recommended by Burke, Finkelstein, and Dusig (1999) for the rating of a single target on a single occasion. Since the AD index measures dispersion of ratings about the average rating, a smaller score denotes better agreement. In the current study, the average deviation between the two coders was AD = .06. Thus, the interrater agreement was more than acceptable because on average the two coders were only .06 scale units apart. All instances in which perfect agreement did not occur were discussed and the job reclassified.
Results

A random effects model is normally employed in cases when a researcher believes that the effects of the studies in a meta-analysis do not estimate a common population effect and are therefore heterogeneous. A fixed effects model is normally employed in cases when a researcher believes that the effects of the studies in a meta-analysis do estimate a common population effect and are therefore homogenous. Since the effects of the studies in the current meta-analysis are believed to be random, or heterogeneous, for all the variables (e.g., age, job performance, job type, and job complexity), a random effects model was utilized. Furthermore, since in a fixed effects model the main source of variability is understood to be due to sampling error, if the collection of effect sizes is in fact heterogeneous, the fixed effects model would then underestimate the true degree of heterogeneity and produce mistakenly narrow confidence values. Conversely, a random effects model, would correctly estimate confidence intervals when heterogeneity is present because it treats the effect size from each study as obtained from a distribution of study effects. One final important distinction between fixed effects and random effects models is that fixed effects models usually produce a Type I bias (i.e., inflated type I error rates) in significance tests for mean-effect sizes and moderator analyses; whereas,
a random effects model is more immune to this bias (Rothstein, McDaniel & Borenstein, 2002).

After all the studies had been selected and their characteristics recorded, I tested the hypotheses by applying the Raju, Burke, Normand, and Langlois' (RBNL; 1991; Finkelstein, Burke, & Raju, 1995) meta-analytic procedures, with a random effects model (cf. Burke & Landis, 2003). The RBNL procedures provide specific formulas for incorporating studies with complete and incomplete sample-based artifact data (e.g., predictor and criterion reliabilities) together into a procedure for meta-analysis. By employing sample statistics and information available on sample-based artifacts, individually corrected effects along with the standard errors for these effects are estimated. Thus, this meta-analytic approach calculates sample-size weighted estimates of the mean and variance of corrected effects. Furthermore, the RBNL meta-analytic approach allows for the creation of confidence intervals around the estimated mean corrected effects (cf. Finkelstein et al., 1995). Refer to Appendix B for these specific formulas recommended by the RBNL approach.

After implementing the RBNL procedure, all correlations were corrected for sampling error and unreliability in the job performance criterion measure. By correcting correlations for sampling error (e.g.,
range restriction due to imperfect samplings of the population) and unrelia-

cibility in the job performance criterion measure, undesirable variance which was not true variation across studies was eliminated. In cases where a study did not report reliability information, an average sample-weighted reliability from available studies was replaced for the missing reliability values. A total of 69 out of 121 samples (57%) did not report reliability information. The RBNL procedures replaced the missing reliability values with an average reliability from available studies.

In order to test the moderating effects of job complexity (based on GFTA and GCTA), I used Weighted Least Squares (WLS) multiple regression as recommended by Steel and Kammeyer-Mueller (2002) for testing continuous moderators. The WLS multiple regression approach was found in their Monte Carlo analysis of generated meta-analytic data to yield the most accurate results since it was principally unaffected by multicollinearity and heteroscedasticity; whereas the results were affected when other techniques were used.

Before running the WLS multiple regression analysis, I identified potential outliers. Outliers were tested by using the sample adjusted meta-analytic deviancy (SAMD) statistic procedure for identifying outliers in correlational meta-analyses results (Huffcut & Arthur, 1995). The SAMD technique examines the impact of each study on the average effect
size and computes an associated deviancy value for each data point (this value can be conceptualized as a t-score). The data points with the largest deviancy value are subsequently identified as potential outliers. In order to eliminate the asymmetric identification of outliers as a result of the skew present in the sampling distribution of correlations, I used a modified SAMD statistic using Fisher's z transformation on the uncorrected correlations as recommended by Beal, Corey, and Dunlap (2002). SAMD assumes a single distribution of effects. However, in the current meta-analysis there were two potential moderators (GTFA and GCTA), which when combined, resulted in potentially four distributions of effects. Thus, I tested for potential outliers in each of the following separate job complexity distributions: 1) low GTFA, low GCTA, 2) high GTFA, low GCTA, 3) low GTFA, high GCTA, and 4) high GTFA, high GCTA. Once SAMD values were obtained for each of the four distributions of effects, I plotted these values in decreasing order with smaller values to the right. I then identified potential outliers by treating these plotted values as one does a scree plot in factor analysis. A total of 13 potential outliers were identified as extreme values from the SAMD procedure. After reviewing the characteristics of the studies with a professor of Industrial Organizational Psychology, I removed 9 outliers due to reasons explicated in Table 5.
Table 5.

Study information and removal reason for each outlier

<table>
<thead>
<tr>
<th>Study</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ali, H., &amp; Davies, D.R. (2003).</td>
<td>Imprecise r due to data converted to an r and an unusual sample (rubber tappers)</td>
</tr>
<tr>
<td>Cobb, B.B. (1968).</td>
<td>Low reliability (rxy = .54)</td>
</tr>
<tr>
<td>Kutscher, R.E., &amp; Walker, J.F. (1960).</td>
<td>Imprecise r due to data converted to an r</td>
</tr>
<tr>
<td>Kutscher, R.E., &amp; Walker, J.F. (1960).</td>
<td>Imprecise r due to data converted to an r</td>
</tr>
<tr>
<td>Kutscher, R.E., &amp; Walker, J.F. (1960).</td>
<td>Imprecise r due to data converted to an r</td>
</tr>
<tr>
<td>Kutscher, R.E., &amp; Walker, J.F. (1960).</td>
<td>Imprecise r due to data converted to an r</td>
</tr>
<tr>
<td>Oberg, W. (1960).</td>
<td>Imprecise r due to data converted to an r</td>
</tr>
<tr>
<td>Walker, J.F. (1964).</td>
<td>Imprecise r due to data converted to an r</td>
</tr>
</tbody>
</table>
After removing these outliers, the RBNL procedures yielded an overall mean corrected correlation between age and job performance of .09 (95% confidence interval = .01 - .17; significantly different from zero).

Subgroup analyses for job performance type (objective/subjective) and job type (professional/non-professional) were also conducted using the RBNL procedures. The overall mean corrected correlation between age and job performance for objective measures of job performance was .14 (95% confidence interval = .05 to .23; significantly different from zero). The overall mean corrected correlation between age and job performance for subjective measures of job performance was .09 (95% confidence interval = .00 to .17; non-significant). My results are consistent with past research in that they display a pattern of higher correlations between age and job performance for objective measures of job performance and lower correlations for subjective measures of job performance (McEvoy & Cascio, 1989; Waldman & Avolio, 1986). The overall mean corrected correlation between age and job performance for professional jobs was -.19 (95% confidence interval = -.37 to -.01; significantly different from zero). The overall mean corrected correlation between age and job performance for non-professional job types was .12 (95% confidence interval = .04 to .20; significantly different from zero). Again, my results also found a pattern for higher correlations between age and job.
performance for non-professional job types and lower correlations for professional job types as found in past studies. Refer to Table 6 for summary information.
Table 6.

Summary statistics (mean corrected r between age and job performance, 95% confidence intervals, total number of studies, total number of samples, and total sample size)

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>95% CI</th>
<th>Studies</th>
<th>K</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>.09*</td>
<td>.01 -.17</td>
<td>91</td>
<td>121</td>
<td>18,694</td>
</tr>
<tr>
<td>Objective</td>
<td>.14*</td>
<td>.05 -.23</td>
<td>31</td>
<td>40</td>
<td>4,610</td>
</tr>
<tr>
<td>Subjective</td>
<td>.09</td>
<td>.00 -.17</td>
<td>70</td>
<td>91</td>
<td>18,322</td>
</tr>
<tr>
<td>Professional</td>
<td>-.19*</td>
<td>-.37 -.01</td>
<td>37</td>
<td>42</td>
<td>1,821</td>
</tr>
<tr>
<td>Non-professional</td>
<td>.12*</td>
<td>.04 -.20</td>
<td>54</td>
<td>79</td>
<td>16,873</td>
</tr>
</tbody>
</table>

Note. *p < .05
For the moderator of job complexity (GFTA and GCTA), I found a standardized beta-weight of -.49, p < .05, when jobs were rated higher in GFTA and a standardized beta-weight of .02, (non-significant), when jobs were rated higher in GCTA. Thus, as the amount of GFTA required for the job increased, the correlation between age and job performance decreased. However, as the amount of GCTA required for the job increased, the correlation between age and job performance remained about the same. Both GFTA and GCTA accounted for a significant amount of variance with $R^2 = .23$, and $F(2, 118) = 17.41$, $p < .05$. The interaction accounted for a small but significant amount of incremental variance over the main effects, $R^2 = .09$, and $F(1, 117) = 16.07$, $p < .05$. Results of the regression analysis are shown in Table 7.
Table 7.

Summary of WLS Multiple Regression Analysis for Variables Moderating Age and Job Performance (K = 121; N = 18,694)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GFTA</td>
<td>-.09</td>
<td>.02</td>
<td>-.41*</td>
</tr>
<tr>
<td>GCTA</td>
<td>-.01</td>
<td>.02</td>
<td>-.04</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GFTA and GCTA Interaction</td>
<td>-.08</td>
<td>.02</td>
<td>-.31*</td>
</tr>
</tbody>
</table>

Note. $R^2 = .23$ for Step 1; $\Delta R^2 = .09$ for Step 2 (ps < .05). *p < .05
After plotting the interaction, I found a strong, overall negative trend for GFTA. As jobs were rated higher on GFTA, the relation between age and job performance became more negative. This negative trend between age and job performance became greater as jobs were also rated higher on GCTA and flattened out as jobs were rated lower on GCTA. Refer to Figure 1 for the interaction plot.

In order to determine the relative changes in the correlation between age and job performance as a function of GFTA and GCTA, I first calculated the predicted values for jobs rated higher and lower in GCTA while ignoring GFTA. Across all studies, the predicted corrected correlation of age and job performance when jobs were rated lower in GCTA (-1 standard deviation) was .12 and .11 for jobs rated higher in GCTA (+1 standard deviation). Next, I calculated the predicted values for jobs rated higher and lower in GFTA while ignoring GCTA. Across all studies, the predicted correlation of age and job performance when jobs were rated lower in GFTA (-1 standard deviation) was .20 and .03 for jobs rated higher in GFTA (+1 standard deviation). Refer to the note in Figure 1 for the regression equation used to predict the average effects for jobs.
Figure 1. Interaction plot of corrected correlations between age and job performance by job complexity. Note: Regression equation for interaction was: $\hat{r} = .114 + -.008 \text{ (GCTA)} + -.085 \text{ (GFTA)} + -.075 \text{ (GCTA X GFTA)}$.

**Discussion**

The current meta-analytic study examined the age and job performance relation using a moderator of job complexity based on the cognitive and task demands of the job. More specifically, I considered the cognitive ability demands of job tasks (i.e., the relative level of Gf and Gc, as well as opportunities for automatization) in my consideration of job
complexity. I expected the relation between age and job performance would exhibit an overall negative trend as jobs were rated higher on GFTA due to the assumed decrement experienced by older workers on tasks that require novel problem solving and cognitive demands on working memory (Gf), while the relation between age and job performance would exhibit an overall positive trend as jobs were rated higher on GCTA due to the benefits of accumulated experience and knowledge (Gc) for older workers. As jobs were rated lower on both GFTA and GCTA due to low cognitive demands of minimal Gf- and Gc-type tasks, I expected no relation between age and job performance. Additionally, I expected the interaction between GFTA and GCTA would result in the relation between age and job performance being moderated by GCTA such that as jobs were rated higher on GCTA and lower on GFTA, the trend would be positive and as jobs were rated higher on both GFTA and GCTA, the trend would not be as negative due to the benefit and buffering function served by experience and knowledge (Gc; Horn & Cattell, 1966).

My results reveal several notable findings. First, in line with predictions, as jobs were rated high in GFTA the correlation between age and job performance decreased. That is, as jobs required more GFTA, the relation between age and job performance weakened, approaching zero at high levels of GFTA. These results suggest that jobs low in GFTA
were performed better with age, but as jobs required more GFTA, age became less and less of an advantage with no clear benefit for jobs high in GFTA. Second, as jobs increased in their level of GCTA, the relation between age and job performance did not increase as expected. The results show that there is no change in the relation between age and job performance as the level of GCTA involved in a job increased or decreased. Even though the results of the regression analysis show that the relation between age and job performance did not change as a function of the level of GCTA involved in a task, using the regression equation to predict the correlation between age and job performance for high and low levels of GCTA (holding GFTA constant), showed that the average correlation between age and job performance was positive for high and low GCTA type jobs. These findings highlight the stability of Gc type abilities throughout the lifespan by demonstrating that regardless of the level of Gc-type tasks (e.g., low) age showed no disadvantage, but in fact a small advantage in performance. Additionally, as jobs were rated lower on both GFTA and GCTA, there was a small but significant increase in the relation between age and job performance. This suggests that jobs with overall low cognitive demands (e.g., minimal Gf- and Gc-type tasks) provided an advantage for age. One explanation for this job performance advantage for age may be due to the lower cognitive load associated with
tasks on these jobs. Cognitive Resource Theory states that the allocation of cognitive, or attentional resources to successful task accomplishment is determined by the amount of cognitive load present in the associated cognitive demands (Kanfer & Ackerman, 1989). When there is a heavier cognitive load as a result of multiple, demanding tasks, there is a high demand on cognitive resources (Kanfer & Ackerman, 1989). When there is a lighter cognitive load, there is not a high demand on cognitive resources. Furthermore, when individuals perform novel problem solving or Gf-type tasks, cognitive resources are fully utilized (Kanfer & Ackerman, 1989). In these jobs, since greater attentional focus and cognitive resources were able to be devoted to task accomplishment, a small gain in job performance was found for age as jobs were rated lower on levels of GFTA and GCTA.

Additionally, a positive change in the correlation was observed between age and job performance as jobs were rated higher on GCTA, but lower on GFTA. This suggests that age experiences beneficial job performance effects from experience and knowledge, but only when cognitive demands from fluid task abilities are low. Contrary to my expectations, as jobs were rated higher on GFTA and GCTA, the correlation between age and job performance decreased. This negative trend has important implications because it suggests that when job
performance was predicated on tasks that tapped both fluid and crystallized task abilities to a greater extent, there was no evidence that the GCTA involved in a job buffered the decline in job performance experienced with jobs higher in GFTA as people aged. This was perhaps due to the high cognitive load associated with performance on these types of jobs (e.g., Kanfer & Ackerman, 1989). The jobs that were rated higher on both GFTA and GCTA may have been more complex jobs because performance was predicated on tasks that involved not just Gf-type tasks or Gc-type tasks, but both types of tasks. Jobs that were rated higher on both GFTA and GCTA included nurses, police officers, managers, and executives. The tasks involved in these jobs not only depended on a body of job relevant experience, knowledge, and skills, but also involved a considerable amount of novel problem solving and working memory demands. The combination of performance predicated on higher levels of Gf-type tasks, as well as the additional task demands of higher Gc-type tasks may have led to situations in which the use of cognitive resources were taxed and overburdened. Thus, as jobs were rated higher on levels of GFTA and GCTA and subsequently, greater cognitive resources were used, a decrement in job performance was observed for age.

High cognitive load may not have been the only contributor to lower job performance with age among these jobs. Two factors that may have
influenced the age and job performance relation that were not examined in the moderator analyses of the current meta-analytic study include physical abilities and motivation. Nurses and especially police officers are two job types that are conceivably predicated on physical abilities. Nurses must be able to maintain long working hours while maintaining the care of patients which often involve moving, lifting, and carrying patients. Police officers must also maintain long shifts while being able to chase down and apprehend suspects. Athleticism and physical abilities are potentially of benefit to the effectiveness of police officers.

Managers and executive are two job types that conceivably involve a good deal of motivation for success on performance outcomes. As workers age, the strength of achievement motives (e.g., need for mastery) lessen and goals are reorganized (Kanfer & Ackerman, 2004). Extrinsic rewards such as promotion and pay are lessened, while intrinsic rewards such as positive affective events and a strengthened sense of identity are increased (Kanfer & Ackerman, 2004). In other words, older workers may not value the same outcomes as much as younger workers do. For older workers such as managers and executives, who have likely attained the upper levels of their organizations or occupational strata, higher levels of performance are not likely to be related with promotion or substantial pay increases (Kanfer & Ackerman, 2004). Therefore, older workers in these
roles may not be motivated to perform at higher levels since they do not value promotion or pay raise outcomes as much as younger workers.

In sum, the current meta-analytic study provided some valuable insight into the age and job performance relation by using a moderator of job complexity based on the cognitive and task demands of the job. This study adds to the literature in the following ways: By considering the relative levels of GFTA and GCTA, as well as opportunities for automatization required by the tasks of a job, the current definition of job complexity was broader than past considerations which have only looked at one dimension of job complexity (e.g., the data dimension; Sturman, 2002). In addition to including more than one dimension of job complexity, I also rated each job on the level of GFTA and GCTA on a continuous scale which allowed for a more fine grained analysis of job complexity than that provided by a dichotomous scale. Furthermore, unlike past meta-analyses, the current definition of job complexity was based on the theory of Gf and Gc (Horn & Cattell, 1966) and also took into consideration the direct relevance of cognitive ability. This allowed me to make predictions based on theories regarding the relation between age and job performance, in contrast to prior methods that were only descriptive in nature and not theoretically, driven.
Limitations

Despite these advantages, there were a few limitations of the current meta-analytic study that should be mentioned. First, the ratings of jobs on complexity were based on the brief descriptions of the jobs in the articles (or on O*Net), and thus were at a grosser level of analysis than would result from a detailed job analysis. That is, a job analysis would provide a more precise and detailed examination of every type of task involved in a job and the corresponding abilities each specific task taps. However, the meta-analytic methodology employed here did not allow for this type of fine-grained analysis, nor was it my purpose. My results do suggest that a more fine tuned approach may be valuable in the future for understanding the relation between the cognitive abilities tapped by the job, job performance, and age.

As with all meta-analyses, I was limited by the studies that were included in the analysis. That is, the analysis was limited by the jobs that have been examined to date by researchers examining the age and job performance relation. A wider sample of different types of jobs may have yielded different results. At minimum, it is unclear how the inclusion of such studies might have affected my results.

There is also a possible limitation related to the samples of older adults working in organizations. The samples included in the meta-
analysis may have only included older workers that had been successful and remained with the job; whereas, it is likely that older workers that performed poorly quit, or were fired were not a part of the studies. If only successful workers remained in jobs, then the correlations between age and job performance reported in studies were stronger than had only random samples of workers been used. Thus, the effects found in the current study may have overestimated the true relation between age and job performance. However, since worker attrition (e.g., turnover) as a result of poor performance is an event that commonly occurs within organizations, then the results from the meta-analysis are generalizable.

Conclusions

The current study made a contribution to the understanding of the age and job performance relation by signifying the important role of fluid and crystallized based abilities in job tasks. The results of this study convey good news, as well as potentially troubling news for older workers. Older workers in jobs in which performance is predicated on tasks that require greater crystallized type abilities with little demands on fluid type abilities may experience increased job performance. The positive implications of this finding are that older workers in such jobs are likely to be valued to a greater extent than younger workers and will be selected
into or retained in such jobs. Alternatively, older workers in highly complex jobs in which performance is predicated on tasks that require both greater fluid and crystallized type abilities may experience small performance decrements. However, readers should keep in mind that although the correlation between age and job performance decreased, the correlation was barely less than zero.

With an aging labor population on the horizon, businesses, governments, and societies are likely to face even greater labor shortages if proactive responses on to how to manage potential performance challenges for older workers are not addressed. Providing training opportunities for older workers to learn compensatory strategies may be one solution organizations may assume. Job redesign to accommodate older workers is another potential solution organizations may choose to undertake. Modifying jobs and developing older workers so that their job performance contributions are maximized and job performance decrements are reduced may become organizational necessities.

Future research with fine-grained analyses of jobs and the identification of tasks that require greater GCTA and GFTA may yield the type of information needed to redesign jobs and/or to develop training programs. The current study may have been a vital first step in identifying the cognitive task demands and opportunities for automatization that
influence the performance of older workers in specific jobs. When these aspects are further understood, specific job redesign and/or training interventions may be developed to aid older workers to effectively manage the cognitive demands they face in their job tasks. Furthermore, by adding to our knowledge of the relation between age and job performance, such solutions on how to address the growing concerns surrounding the demographic changes of an aging labor population may be more effectively explored.
References

References marked with a single asterisk indicate studies included in the
meta-analysis. References marked with a double asterisk indicate studies
identified as outliers and excluded from the meta-analysis.

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Appendix A

List of variables and information from meta-analytic references that were recorded.

Article reference number

Article reference information

Sample number

Sample size (or n)

Mean age

Standard deviation of age

Range of age

Range restriction of sample

Performance measure type

Reliability of performance measure

Mean of performance measure

Standard deviation of performance measure

Type of job

Job experience

Organizational tenure

Unadjusted correlation

Test statistics (Data that was converted to an r such as m, sd, t, x^2, F, etc.)

Job complexity (based on GFTA and GCTA)
Appendix B

Meta-analytic formulas by Raju, Burke, Normand, and Langlois (RBNL; 1991).

(1) In order to obtain an estimate of the corrected $r$, or an estimate of the unrestricted and unattenuated population correlation ($\hat{\rho}_i$), use

$$\hat{\rho}_i = \frac{k_i r_i}{\sqrt{r_{xx} r_{yy} - r_i^2 + k_i^2 r_i^2}},$$

Where $r_i$ represents the correlation between the predictor ($x$) and the criterion ($y$) in a sample from population $i$, and $r_{xixi}$ and $r_{yiyi}$ represents the sample based, restricted reliabilities for the predictor and criterion, respectively. Furthermore, let $k_i = 1/ u_i$ and $u_i$ be the ratio of restricted standard deviation to unrestricted standard deviation on the predictor.

(2a) In order to obtain an estimate of the sampling variance when the predictor reliability ($r_{xixi}$) is unavailable, use

$$\hat{\sigma}^2_v = \frac{k_i^2 r_{xixi}^2 r_{yiyi} (r_{xixi} - r_i^2)(1 - r_i^2)}{N_i \hat{\rho}_i^2},$$

Where $V_{ei}$ represents the sampling variance of $\rho_i$, $W_i = r_{xixi} r_{yiyi} - r_i^2 + k_i^2 r_i^2$, and $N_i$ is the number of subjects in sample $i$.

(2b) In order to obtain an estimate of the sampling variance when the criterion reliability ($r_{yiyi}$) is unavailable, use
\[ \hat{\nu}_e = \frac{k_i^2 r_{x,i}^2 r_{y,i}^2 (1 - r_i^2)(r_{x,j}^2 - r_i^2)}{N_i \hat{W}_i^3} , \]

and (2c) In order to obtain the sampling variance when the predictor reliability \((r_{\text{xxd}})\) and criterion reliability \((r_{\text{xxi}})\) are unavailable, use

\[ \hat{\nu}_e = \frac{k_i^2 r_{x,i}^2 r_{y,i}^2 (1 - r_{y,i}^2)^2}{N_i \hat{W}_i^3} . \]