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Person-environment and gender comparisons in the integration of interests, abilities, and skills

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Person-environment and gender comparisons in the integration of interests, abilities, and skills

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ABSTRACT

This study evaluated Holland’s (1997) theory of the equivalence of person and work environment structures by comparing the relationships among interest, ability, and skills based on individual and occupational ratings of constructs selected from the U. S. Department of Labor’s O*NET database. Individual ratings by 816 college students were analyzed separately by gender. A bootstrapped property vector fitting technique was used to embed ability and skill constructs into a two-dimensional RIASEC interest circumplex. No significant gender differences were found in the integration of these constructs. There were differences between the person and environment models for 14 of the 32 (44%) abilities and skills. Discussion of the results focuses on implications for Holland’s theory, occupational data, and measurement issues.

CHAPTER 1. INTRODUCTION

Identifying educational and occupational options that capitalize on an individual's interests and abilities is a hallmark of career counseling and exploration. Person-environment (P-E) fit theories, including those proposed by Holland (1959, 1985, 1997) and Dawis and Lofquist (1984), assume that "people and work environments can be categorized in parallel ways and that a match between the person and the environment bodes well for job performance, stability, and satisfaction" (Rounds & Day, 1999, p. 104). Models that provide parallel structures for both individuals and work environments, such as Holland's (1997) typology, facilitate the career counseling process of matching people to suitable environments (Rayman & Atanasoff, 1999). The present study will evaluate Holland's (1997) theory of the equivalence of individual and environment structures by comparing individual and occupational ratings of the interest, ability and skill constructs in the U. S. Department of Labor's (USDOL) Occupational Information System (O*NET; USDOL, 2006).

Interests, abilities, and skills are conventional individual differences variables in vocational psychology (Hansen, 2005; Dawis, 2005), due to the predictive and incremental validity for educational and career outcomes (Lubinski, 2000). While historically research on interests and abilities has occurred apart from the other, there have been recent calls for investigations regarding the relationships among these constructs (Lubinski, 2000; Ackerman & Heggestad, 1997). Likewise, many interest inventories now include ability self-ratings alongside interest profiles (Hansen, 2005). Additionally, these preferences and traits are unlikely to be separate in the mind of an individual making career-related choices, but instead are aspects of one's vocational personality and identity (Holland, 1959, 1997). The development of these traits is interrelated and interactive, with abilities affecting interest and skill development, and interests affecting the development of abilities and skills (Ackerman & Heggestad, 1997; Lubinski, 2000; L. S. Gottfredson, 2003). In order to better understand these traits and how they impact adult development, it is necessary to examine the interrelations among these constructs.

Several approaches to integrating interests and abilities have been investigated, some ability-based (Ackerman & Heggestad, 1997; L. S. Gottfredson, 2003) and others interest-based (Ackerman & Heggestad, 1997; Armstrong, Smith, Donnay, & Rounds, 2004; Armstrong, Day, McVay & Rounds, 2008). As noted by Armstrong et al. (2008), interest-based structures offer many advantages as a template for integrative models of individual differences. Interests have been conceptualized as the expression of individual characteristics applied to the context of work (Holland, 1997). Holland's (1959, 1997) RIASEC structure of interests is the dominant model in career counseling, and integrating other traits into this framework would facilitate their applied use. In addition to the widespread use of Holland's theory and the predictive validity of interests, the high stability of vocational interests over time makes interests an appealing candidate to consider as a framework for integrating psychological constructs (Swanson, 1999; Hansen, 2005; Low, Yoon, Roberts, and Rounds, 2005). There is theoretical, empirical, and practical support that the RIASEC structure should be further investigated as an integrative framework for characteristics of individuals and work environments.

To describe the environment side of the P-E equation, occupational classification systems have been developed to organize career information (Gore & Hitch, 2005). The most recent innovation for cataloging and accessing occupational information is the U.S.

Department of Labor's O*NET Online (http://online.onetcenter.org; USDOL, 2006), designed to replace their former product (Dye & Silver, 1999), the *Dictionary of Occupational Titles* (DOT; USDOL, 1991). The O*NET content model captures the breadth of variables needed to describe the world of work (Mumford & Peterson, 1999). Over 275 variables describe worker characteristics including abilities, interests, values, and work styles; worker requirements of skills, knowledge and education; occupational requirements such as work activities, tasks, and context; experience requirements; and occupational outlook data for 974 occupations (O*NET Online, n.d.b; Mumford & Peterson, 1999).

Models representing both individuals and occupations that are used in career counseling to facilitate person-environment fit, such as the RIASEC hexagon (Holland, 1997) and the World-of-Work Map (Prediger, 1976), rely on evidence of the structural equivalence between the person and environment characteristics to support the validity of these tools. Similarly, in order to use the O*NET appropriately in person-environment fit applications according to Holland's (1997) theory, the assumption that the relationships between these variables are structurally equivalent for occupations and individuals needs to be investigated.

In the present study, the O*NET database was accessed for occupational information in the United States regarding interests, cognitive abilities, and skills. Self-ratings of the interest, ability and skill constructs adapted from the O*NET content model were used to measure individual differences in these career-related attributes. Property vector fitting, a multidimensional scaling (MDS) and linear multiple regression-based technique, was used to embed ability and skill constructs into the RIASEC interest structure, according to previously established methods (Kruskal & Wish, 1978; Jones & Koehly, 1993; Armstrong et al., 2004).

The individual and occupational structures of interests, abilities and skills were compared for their equivalence, and gender differences of the individual ratings were examined.

CHAPTER 2. LITERATURE REVIEW

Holland's Theory

Holland's (1997) theory of vocational personalities and work environments proposes that individuals and work environments can be described by one of six types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional, known as RIASEC. Each type is described by Holland as having a unique set of interests, abilities, personality traits, values, goals, and self-beliefs. According to the theory, when individuals choose a college major or vocation, they will tend to seek environments that allow for the expression of their individual characteristics. Individuals will tend to be most satisfied in an environment that is similar in type to their own personality because the environment will support and reinforce the individual's traits and preferences. Thus, specific educational and work environments consist of individuals with similar constellations of interests, abilities, and personalities, who have selected environments that fit their vocational personality. Holland (1997) also demonstrated that environments are ultimately defined by the individuals who work in them, making his model a parsimonious way to describe both individuals and work environments.

Holland's RIASEC Typology

The six types are arranged circularly in the RIASEC order (see Figure 1), with adjacent types more similar than those opposite on the hexagon (Holland, 1997). Characteristics of an opposite type on the hexagon describe what an individual does not like and wishes to avoid, making dislikes as important as preferences in describing a type. The Realistic (R) type prefers mechanical and technical work that is practical and concrete, and develops abilities and skills in these areas. Conversely, the Realistic type dislikes helping and teaching activities characteristic of the Social type. A Realistic person has high ability self-perception for Realistic tasks and low ability self-perception for social and academic tasks. A Realistic environment consists of Realistic activities, supports Realistic interests, and requires Realistic abilities and skills.

Similarly, Holland (1997) outlines preferences, aversions, and required abilities for each type. The Investigative (I) type prefers theoretical and scientific work that is novel and creative, and dislikes activities that are repetitive or require socializing with or influencing others. In turn, the Investigative person cultivates scientific and research abilities and has a positive perception of these abilities. An environment made up of Investigative people reinforces and encourages behavior that is consistent with the Investigative type.

The Artistic (A) individual prefers unstructured, creative activities, which the Artistic environment provides (Holland, 1997). Abilities relevant to this type involve the arts, language, and writing. Business and organizational skills are disliked and may be lacking in Artistic individuals. It is characteristic for Artistic types to be open to feelings, experiences, and others' beliefs. Individuals of the Social (S) type prefer working with people in a helping role, and dislike practical, Realistic activities (Holland, 1997). These individuals have high ability self-perceptions regarding interacting with and helping others, and considering their technical and science abilities to be less strong. The Social environment provides teaching, counseling, and helping interactions, and rewards abilities in these areas.

Enterprising (E) individuals also like working with people, but prefer persuasive, influencing, and leadership activities more than helping (Holland, 1997). This type tends to dislike theoretical and scientific tasks typical of the Investigative area. Enterprising people see themselves as interpersonally skilled, confident, and out-going, and lacking in scientific skills. The Enterprising environment requires influencing and persuasive abilities and encourages self-perceptions related to confidence, extraversion, and power.

The final RIASEC type is Conventional (C). Conventional people prefer organized, predictable work with data, as opposed to unstructured, creative activities (Holland, 1997). Conventional abilities include organization, computation, and others required for business tasks. These individuals prefer following instructions and keeping data in order. The Conventional environment consists of orderly organizational and numerical activities. Holland (1959, 1997) proposed a model of vocational choice that relates work-relevant knowledge about the self and occupations at a conceptual level. While Holland's (1997) RIASEC typology is most often used to represent vocational interests, the theory also describes the interrelationships of abilities and skills with interests in six model types and environments.

Individuals and Work Environments

Interest Structure

Holland's (1997) theory describes both individuals and work environments with the same RIASEC structure. His calculus hypothesis states that the six personality types and environments are arranged in a circumplex, in R-I-A-S-E-C order, with the degree of similarity among types inversely proportional to the distance between them (Holland, 1997). For example, Realistic is most similar to Investigative and Conventional, less similar to Artistic and Enterprising, and the least similar to Social. Although it is commonly called a hexagon, the equilateral arrangement of RIASEC types by degree of similarity meets the definition of a circumplex (Guttman, 1954).

Vocational interests have been represented in three distinct ways: dimensional models, classification systems, and spatial models (Rounds & Day, 1999; Tracey & Rounds, 1997). While the dimensional factor analytic approach has been the most popular in psychology literature, spatial structures can communicate more information about interrelationships and overlaps than the factor approach (Tracey & Rounds, 1997). The circumplex, a constrained circular model with points equally spaced around the circumference, is a type of spatial structure that has been supported in interest research (Tracey & Rounds, 1997). Meta-analyses of the structure of interest inventories based on RIASEC provide support that interests have a circumplex structure (Rounds & Tracey, 1993; Tracey & Rounds, 1993).

Reviews of gender and racial-ethnic minority group differences of interest structure have found “remarkable invariance” (Swanson & Gore, 2000, p. 252). While singular studies have found gender differences in underlying interest structure (Fouad, Harmon, & Borgen, 1997; Hansen, Collins, Swanson, & Fouad, 1993), meta-analyses support the conclusion that there are minimal differences by gender (Anderson, Tracey, & Rounds, 1997; Ryan, Tracey, & Rounds, 1996). Some of the inconsistency in these findings has been attributed to sampling issues, differences in the interest inventories examined, and the method of analysis (Holland, 1997; Swanson & Gore, 2000). Regarding racial-ethnic groups, Armstrong, Hubert and Rounds (2003) concluded that interest structure is similar and consistent with a circumplex structure among Caucasian American and Asian American groups, yet questions remain about the fit of the circumplex model for African American and Hispanic American groups. There is growing consensus that Holland’s model is an accurate representation of interests in general, and across gender (Tracey & Rounds, 1997; Rounds & Day, 1999; Swanson & Gore, 2000).

Prediger (1982) and Hogan (1983) named two-dimensional structures underlying the Holland circumplex, attempting to further simplify Holland's model (see Figure 1). Prediger's (1982) work identified the Data/Ideas dimension bisecting C-E and I-A, and the Things/People dimension lining up with R and S, respectively. In what can be described as a 30° rotation of Prediger's (1982) dimensions (Rounds and Tracey, 1993), Hogan (1983) labeled a conformity dimension running from C to A, and a sociability dimension between E-S and R-I. The conformity dimension is similar to the personality trait of openness to experience, and the sociability is similar to extraversion in Costa and McCrae's (1992) big five model of personality. Rounds and Tracey's (1993) meta-analysis of these two-dimensional interest structures and others revealed that although the structures differ semantically, they are structurally equivalent.

Occupational Structure

In addition to describing individual interests, Holland's RIASEC theory also describes work environments (Holland, 1997). Work environments consist of people from specific occupations (i.e., physicians, nurses, and other health care providers work in the hospital environment; teachers and students make up a school environment), and occupations are defined by the abilities and skills required to complete work tasks (Prediger, 1999b).

If interest structure were similar to the structure of occupations, the career exploration process would be enhanced by having one model to match individuals to corresponding work environments (Prediger, 1999b). Occupational structure has been tested using interest profiles of workers in occupations (incumbent method), expert ratings, and through job analyses of work tasks and requirements. The structures emerging from these methods are described by Holland (1997) as being consistent with RIASEC theory. Occupations have been empirically described by Prediger's (1982) Data-Ideas and Things-People dimensions that underlie Holland's hexagon (Prediger, 1982; 1996; Prediger & Swaney, 2004), and by Holland's (1997) six environmental models (McCormick, Jeanneret, & Mecham, 1972; G. D. Gottfredson, Holland, & Ogawa, 1982; G. D. Gottfredson & Holland, 1996).

Gender Differences in Interests

Possible differences that exist between groups regarding the assessment of psychological constructs include mean differences at the item and scale level, and differences in the underlying structure (Swanson & Gore, 2000). Gender comparisons of both the structure and the strength of interests need to be made to understand the implications of possible gender differences in vocational theories when applied to career counseling and assessment. As previously described, meta-analyses of the interest structures for females and males have found minimal differences (Ryan, Tracey, & Rounds, 1996; Anderson, Tracey, & Rounds, 1997).

Gender differences in the strength of interests, however, have been studied from the beginning of interest assessment, and indisputable evidence of gender differences has accumulated (Hansen, 1984; 2005; Lippa, 1998). While it has been found that males and females have similar interest levels along Prediger's (1982) Data/Ideas dimension, on the Things/People dimension, females tend to prefer working with people more than males do, and males tend to prefer working with things more than females do (Lippa, 1998). In terms of Holland (1997) types, women endorse more Artistic and Social interests, and men prefer Realistic and Investigative interests more (Hansen, 2005). Lubinski (2000) described this as "reflecting perhaps the largest of all sex differences on major psychological dimensions" (p. 421). However, despite gender differences in the strength of interests, the underlying structure does appear to be similar for males and females.

Abilities and Skills

The assessment of cognitive abilities has deep roots in vocational psychology (Lubinski & Dawis, 1992), yet the discussion of abilities has fallen out of favor in career counseling and the career literature (L. S. Gottfredson, 2003). However, the importance of abilities is difficult to ignore. The predictive validity of abilities is one of the greatest of vocational constructs, predicting about 50 percent of performance (Lubinksi & Dawis, 1992; Lubinksi, 2000).

L. S. Gottfredson (2003) suggested that one reason abilities tend to be ignored in career counseling, in addition to social movements and the ideal that all career options should be available to all people, is that counselors do not have an adequate model for communicating ability information. She has found similar structures between individual cognitive abilities and job aptitude requirements in her job performance and analyses research (L. S. Gottfredson, 2003). The common structure of person and environment provides the opportunity for one comprehensive model describing both. Furthermore, to facilitate career counseling, abilities should be structurally integrated with vocational interests (Ackerman & Heggestad, 1997; Prediger, 1999b; Lubinski, 2000).

In a hierarchical arrangement of cognitive abilities, content specific abilities, such as mathematical, spatial/mechanical, and verbal reasoning, are components of the general intelligence factor *g* (Carroll, 1993). These broad ability factors are the best predictors of job performance (L. S. Gottfredson, 2003). Abilities can be assessed either by standardized tests or normative self-ratings. The correlation between these approaches varies greatly depending on the ability in question and the procedure for obtaining self-estimates (Mabe & West, 1982; Lowman & Williams, 1987; Prediger, 1999a). Despite the debate on the relationship of ability self-estimates to standardized tests, it has been found that each method provides related, yet distinct, appraisals that are both useful in the career exploration process.

Work-relevant abilities can be defined as an individual's capacity for conducting a certain range of tasks required by the work environment (Prediger, 1999a; Fleishman, Costanza, & Marshall-Mies, 1999). Cognitive abilities tend to be the focus of ability testing, yet occupations require additional tasks, such as social abilities, that tests may not capture (Prediger, 1999a). Skills, a dimension related to abilities, require specific learning and training for adequate performance, and develop over time with practice (Fleishman et al., 1999). The acquisition and performance of a skill is also dependent on one's level of ability (Fleishman et al., 1999; L. S. Gottfredson, 2003).

Prediger (1999a, 1999b) summarized five studies comparing standardized tests to ability self-estimates for predicting occupational choice group. Abilities based on informed self-estimates yielded higher prediction rates in each study compared to standardized tests (Prediger, 1999a). Informed self-estimates are based on descriptive task statements that call on experience (Prediger, 1999b). While both methods are valid, self-ratings of abilities should be included in career counseling as a client's self-assessment impacts choice (Darcy & Tracey, 2003), and occupational selection is ultimately a means of exercising one's self-concept (Super, 1957).

Previous studies of work-related abilities have extended beyond the broad cognitive areas. Randahl (1991) used the standardized general aptitude test battery (GATB) to assess nine aptitudes including general learning ability, and verbal, numerical, spatial, form perception, clerical perception, motor coordination, finger dexterity, and manual dexterity aptitudes. She found related typologies between measured vocational interests and abilities among 846 adult vocational assessment clients (Randahl, 1991). Swanson (1993) extended this work using self-ratings of 14 general abilities and 30 specific skills. Her results supported that interests, abilities, and skills are distinct constructs that relate according to Holland's (1985) theory. The ability and skill measure in this study designed by Swanson and Lease (1990) included helping, social, leadership, organizational, scientific, artistic expression, and literary abilities in addition to the traditional cognitive abilities found in the GATB.

Prediger (1999a) determined that the basic structure of work-relevant abilities corresponds to Holland's model (1997). This examination used the Inventory of Work-Relevant Abilities (American College Testing; ACT, 1999), which includes 15 abilities, adding sales to the Swanson and Lease (1990) list. Principal components analysis identified dimensions interpreted as Things-People and Data-Ideas, consistent with Prediger's (1982) interest structure. This structure accounted for about 50% of the variance, suggesting there are additional dimensions of work-related abilities not identified (Prediger, 1999a).

Gender Differences in Abilities and Skills

Several aspects of gender differences in abilities and skills need to be considered to formulate an accurate picture of differences. Ability level as well as variability by gender needs to be examined in standardized test results (Lubinski, 2000). Such a meta-analysis found higher scores for females on some verbal abilities, and higher scores and larger variance for males on certain quantitative and spatial/mechanical abilities (Hedges & Nowell, 1995).

Looking at self-rated abilities and skills provides an additional view of gender differences. There is some evidence of systematic gender bias in ability self-ratings, with women rating their abilities lower than their standardized test scores compared to men (Bailey & Lazar, 1976; Lunneborg, 1982), and of self-ratings interacting with gender and skill type (Swanson & Lease, 1990). Swanson (1993) found gender differences in the level of self-rated abilities and skills consistent with those in standardized tests. Men rated their Realistic abilities and their Realistic and Investigative skills higher than the women did, and the women's self-ratings of Social skills were higher than the men's self-ratings (Swanson, 1993). Structural gender differences in abilities and skills have not been reported.

O*NET Occupational Database

Studies of occupational structure often rely on public databases of work-related information (Prediger, 1982; Prediger & Swaney, 2004). The U.S. Department of Labor's Occupational Information Network (O*NET; Peterson, Mumford, Borman, Jeanneret, & Fleishman, 1999) was developed to improve on previous occupational classification systems by providing a system for describing occupations with a common set of variables (Dunnette, 1999). The O*NET content model summarizes the variables selected to describe work requirements and characteristics (Mumford & Peterson, 1999).

The O*NET database contains incumbent (those employed and satisfied in an occupation) ratings and job analyst ratings of the content model variables for 974 occupations. The first O*NET version, O*NET 98, relied entirely on job analyst ratings, and subsequent updates have added incumbent data (O*NET Online, n.d.b). Reflecting the rapidly changing marketplace, new data is added for approximately 200 occupations each year, with the goal that the entire database will be updated every five years. While the O*NET covers 25 content areas, this study will focus only on interests, cognitive abilities, and skills.

*O*NET Interests*

Due to extensive empirical support for Holland's (1997) theory, and it's ubiquitous use in career counseling, Holland's six RIASEC types were used to describe occupational interests in the O*NET (Sager, 1999). Occupational interest profiles (OIP) based on the RIASEC typology were created for each occupation in the database (Rounds, Smith, Hubert, Lewis, & Rivkin, 1999). An interest profile consists of six scores describing the occupation according to each of Holland's (1997) model work environments. Empirical and judgment methods were used to generate the interest profiles, and the judgment method using expert ratings proved to be the most reliability, valid, and practical (Rounds et al., 1999).

*O*NET Cognitive Abilities*

The taxonomy developed for occupational cognitive ability requirements for O*NET is based on existing programmatic, replicated literature of cognitive abilities, specifically Carroll's (1993) factor analytic review (Fleishman et al., 1999). In the O*NET, abilities are defined as "relatively enduring attributes of an individual's capability for performing a particular range of different tasks" (Fleishman et al., 1999, p. 175), and cognitive abilities are defined as abilities that influence the acquisition and application of knowledge in problem solving (O*NET Online, n.d.a). The O*NET abilities are arranged in a three-level hierarchical system (Fleishman et al., 1999). Within cognitive abilities, the second level content specific constructs included in this study are verbal, idea generation and reasoning, quantitative, memory, perceptual, spatial, and attentiveness. Each second level construct contains specific abilities important for work performance (see Table 1).

*O*NET Skills*

Compared to abilities, the area of skills has not received as much attention in occupational research (Mumford, Peterson, & Childs, 1999). In addition to performance capability, the workplace requires continual skill acquisition to meet the demands of technological and marketplace changes (Mumford et al., 1999). In light of the need for continuous learning, skills are defined in the O*NET as "procedures for acquiring and working with information" (Mumford et al., 1999, p. 50). By examining theories of work behavior, a three-level hierarchical skills taxonomy was developed for the O*NET (Mumford et al., 1999). Basic skills were defined as "developed capacities that facilitate learning or the more rapid acquisition of knowledge" (O*NET Online, n.d.a). The second level basic skills are content and process skills (see Table 2), including basic skills required for learning. Cross-functional skills were defined as "developed capacities that facilitate performance of activities that occur across jobs" (O*NET Online, n.d.a). The second level cross-functional skill constructs are social, problem solving, technical, systems, and resource management skills (see Table 2), which summarize several specific skills identified as being required across jobs (Mumford et al., 1999).

Integrating Abilities and Skills into Interest Structure

Despite the status of interest and ability as the "twin pillars in person-job match" (L. S. Gottfredson, 2003, p. 115), there have been relatively few studies of their relationship (Swanson & Gore, 2000). The majority of such studies have focused on abilities measured by standardized tests. Ackerman and Heggestad's (1997) review and meta-analysis supported

Holland’s (1997) theory that interests in one Holland type correlate with abilities associated with that type. Proposing their own integrative model, Ackerman and Heggestad (1997) identified science/math, intellectual/cultural, social, and clerical/conventional trait complexes of interests, personality, and ability that line up with Holland’s (1997) RIASEC order.

Looking at the other side of person-environment fit, Armstrong et al. (2008) investigated the fit of occupational ability requirements into an interest-based circumplex. Thirteen cognitive abilities from the O*NET database were examined. Using property vector fitting analysis, four of the cognitive abilities investigated fit the RIASEC circumplex at R^2 (variance accounted for) greater than .50. Some of the ability variables that did not fit the two-dimensional RIASEC circumplex did fit a three-dimensional RIASEC model with an additional dimension of cognitive complexity. Thus, it appears there are limitations of the two-dimensional RIASEC model that do not account for complexity in work requirements and activities (Armstrong et al., 2008).

Armstrong et al. (2004) examined the fit of 62 O*NET variables to a three-dimensional basic interest structure, rather than a RIASEC structure. Using a R^2 (variance accounted for) cutoff greater than .50, 15 of 21 skills fit the basic interest model. The dimensions interpreted in the three-dimensional structure of basic interests were persuasive versus problem solving, structured versus dynamic work environments, and social service versus solitary work (Armstrong et al., 2004).

Previous studies support further exploration of Holland’s (1997) RIASEC structure for integrating interests, abilities and skills for both individuals (Ackerman & Heggestad, 1997; Prediger, 1999) and the world of work (G. D. Gottfredson & Holland, 1996; Armstrong et al., 2004; Prediger & Swaney, 2004; Armstrong et al., 2008). With the exception of Prediger's (1999a) use of ability self-estimates, most of the prior investigations of individual abilities have been based on standardized test scores, leaving the need for further study of ability self-ratings. In addition, as addressed by Armstrong et al. (2004, 2008), most studies have focused on linear bivariate relationships of interests and abilities. The linear multiple regression-based technique of property vector fitting (Jones & Koehly, 1993; Kruskal & Wish, 1978) used by Armstrong et al. (2004, 2008) allows the placement of a variable into a multidimensional space, describing the inter-relations between interests, abilities and skills within the RIASEC circumplex. This area of research also lacks gender comparisons of multidimensional integrated models of interests with abilities and skills. The spatial representations resulting from these multivariate studies yield integrative maps of people's work characteristics and occupations. As Holland proposed (1997), distinct individual and environmental types exist in the maps that can be described by the RIASEC typology.

Overview of Present Study

This study examined Holland's (1997) hypothesis of equivalent structures for individual's work characteristics and those of work environments. The structure of individual self-ratings of interests, abilities, and skills was compared to the structure of interest, ability, and skill requirements of occupations. In addition to a comparison of individuals and occupations, gender differences in the individual model were examined. The linear multiple regression-based technique of property vector fitting (Jones & Koehly, 1993; Kruskal & Wish, 1978) was used to create person and occupation maps integrating the properties of abilities and skills into the RIASEC structure. Interest profiles and ability and skill requirements of occupations from the U.S. Department of Labor's O*NET database

(USDOL, 2006) were used to create the occupations map. College students' self-ratings of interests, abilities, and skills based on O*NET constructs were used to form the individual map. The magnitude of effect (R^2) and direction (angle θ) of each property vector on the spatial maps were compared to investigate the equivalence of the environment and individual structures.

Holland's (1997) theory assumes structural equivalence for work-related characteristics among males and females, as well as between individuals and the work environment. Evidence for equivalent structures provides support for this aspect of Holland's theory, whereas evidence of structural differences between individuals and the environment, or between genders, suggests limitations to Holland's theory. This study examined the following three hypotheses. First, it was predicted that gender differences in self-ratings of interests, abilities, and skills would emerge that are consistent with previous studies. Second, despite mean differences in self-ratings, the overall fit of abilities and skills into Holland's RIASEC model were expected to be equivalent for females and males. Third, the fit of individual self-ratings and O*NET occupational ratings of interests, abilities and skills into Holland's RIASEC model was predicted to be equivalent, and consistent with Holland's (1997) type definitions.

Table 1

*Cognitive Ability Variables Formed From O*NET Constructs*

Variable	O*NET Constructs
Verbal comprehension	Oral comprehension, Written comprehension
Verbal expression	Oral expression, Written expression
Idea generation	Fluency of ideas, Originality
Problem sensitivity	Problem sensitivity
Deductive reasoning	Deductive reasoning
Inductive reasoning	Inductive reasoning
Information ordering	Information ordering
Category flexibility	Category flexibility
Quantitative	Mathematical reasoning, Number facility
Memorization	Memorization
Perceptual	Speed of closure, Flexibility of closure, Perceptual speed
Spatial orientation	Spatial orientation
Visualization	Visualization
Selective attention	Selective attention
Time sharing	Time sharing

Table 2

*Skill Variables Formed From O*NET Constructs*

Variable	O*NET Constructs
Written communication	Reading comprehension, Writing
Oral communication	Active listening, Speaking
Mathematics	Mathematics
Science	Science
Critical thinking	Critical thinking, Active learning
Teaching	Learning strategies, Coordination, Instructing
Leading	Monitoring, Social perceptiveness, Persuasion, Negotiation
Service orientation	Service orientation
Technical	Operations analysis, Technology design, Equipment selection, Installation, Programming, Operation monitoring, Operation and control, Equipment maintenance, Troubleshooting, Repairing, Quality control analysis
Judgment and decision making	Judgment and decision making
Systems analysis	Systems analysis
Systems evaluation	Systems evaluation
Time management	Time management
Management of financial resources	Management of financial resources
Management of material resources	Management of material resources
Management of personnel resources	Management of personnel resources
Complex problem solving	Complex problem solving

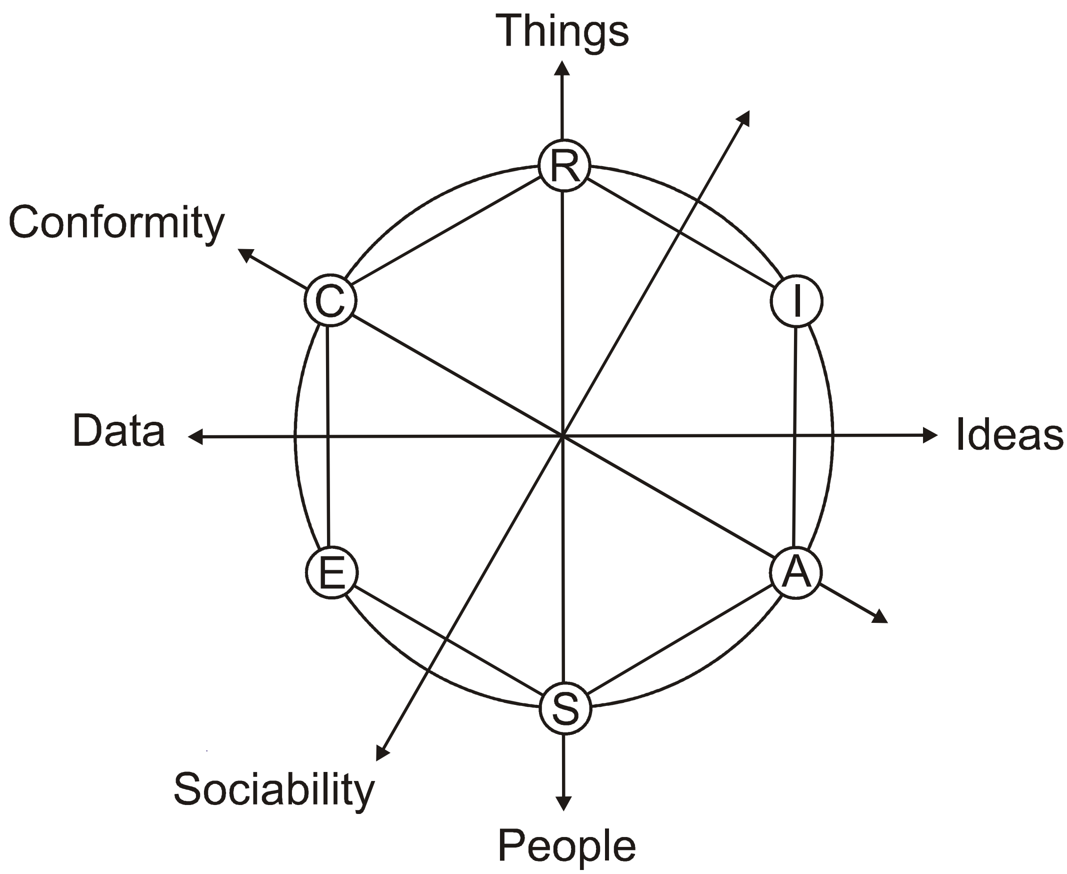

Figure 1. Holland’s (1959, 1997) hexagon, a circumplex model of interest structure with dimensions proposed by Prediger (1982) and Hogan (1983).

CHAPTER 3. METHOD

Participants

Participants were undergraduate college students recruited from psychology classes at a mid-size, Midwestern university. The sample included 816 participants with 494 (60%) being female and 322 (40%) being male. Participants ranged in age from 17 to 50 years, and 80.6% of the participants were between the ages of 18 and 20 (M = 19.7, SD = 2.9). The majority of the sample consisted of students identifying as White/Caucasian (87.3%). Participants identifying as Asian American (3.9%), African American (3.4%), Hispanic American (2.3%), and Native American (0.4%) composed most of the rest of the sample. Nineteen participants (2.3%) indicated their race/ethnicity as "other", including multiracial American, Latina/o, and Asian international students, and three participants did not report their ethnicity. The required sample size for sufficient power was determined using the guideline proposed by Cohen and Swerdlik (2005) for factor analysis and scale development suggesting five to ten participants for each new item in development.

*O*NET Occupational Data*

Version 12.0 of the O*NET database (USDOL, 2007) was be used to develop the environment model. The database contains mean scores of content model variables rated by expert judges for 974 occupations, and an update based on incumbent ratings for 580 of the occupations. Occupations in the O*NET database are stratified by Job Zone, based on the amount of preparation needed (Oswald, Campbell, McCloy, Rivkin & Lewis, 1999). Job Zones 1 and 2 include occupations requiring little to some preparation, such as a high school diploma, GED, vocational training or job-related course work. Occupations in Job Zones 3 to 5 require medium to extensive preparation, including associate's, bachelor's, or graduate degrees. Since the individuals in this study were college students pursuing bachelor's degrees, the 450 occupations in Job Zones 3, 4, and 5 were used to create an environment model representing occupations requiring formal education beyond a high school diploma.

*O*NET interest ratings.* Occupational interest profiles were developed using a judgment method by expert raters for 1,172 occupational units (Rounds et al., 1999). Occupations were assigned a score for each Holland (1997) RIASEC type. Evidence for external validity of these profiles is supported by fairly strong agreement with Strong Interest Inventory profiles (Harmon, Hansen, Borgen, & Hammer, 1994).

*O*NET cognitive ability ratings.* Cognitive abilities are defined in O*NET as abilities that influence the acquisition and application of knowledge in problem solving (O*NET Online, n.d.a). Expert job analysts and incumbents provided ratings of ability level required for the occupations in the O*NET database (Fleishman et al., 1999). Based on the O*NET content model, 21 cognitive ability measures are grouped into seven ability areas (see Table 1). The O*NET ability survey was based on the Fleishman-Job Analysis Scales (F-JAS; Fleishman, 1992) which has strong psychometric properties and has been found to accurately represent abilities required in a variety of jobs. Fleishman et al. (1999) reported intraclass correlations generally above .80.

Verbal abilities are defined as abilities that influence the acquisition and application of verbal information in problem solving. This subscale measures the level of oral comprehension, written comprehension, oral expression, and verbal expression. *Idea generation and reasoning abilities* are defined as abilities that influence the application and manipulation of information in problem solving. This subscale measures the level of fluency of ideas, originality, problem sensitivity, deductive reasoning, inductive reasoning, information ordering, and category flexibility. *Quantitative abilities* are defined as abilities that influence the solution of problems involving mathematical relationships. This subscale measures the level of mathematical reasoning and number facility. *Memory* is defined as abilities related to the recall of available information. This subscale measures the ability to remember information. *Perceptual abilities* are defined as abilities related to the acquisition and organization of visual information. This subscale measures the level of speed of closure, flexibility of closure, and perceptual speed. *Spatial abilities* are defined as abilities related to the manipulation and organization of spatial information. This subscale measures the level of spatial orientation and visualization. *Attentiveness* is defined as abilities related to application of attention. This subscale measures the level of selective attention and time-sharing abilities.

*O*NET skill ratings.* The O*NET database contains ratings for the level of skill required by each occupation. Skill ratings were developed with an incumbent sample and analyst ratings (Mumford et al., 1999). In the O*NET content model, 35 skill measures are grouped into seven skill areas (see Table 2). Mumford et al. (1999) reported a median interrater agreement coefficient of .84 when used with an incumbent sample, and interrater agreement in the low .90s for analyst ratings. Incumbents' and analysts' ratings had a median correlation of .75, and .87 after correcting for attenuation due to unreliability, supporting convergent validity of these items.

Content skills are defined as background structures needed to work with and acquire more specific skills in a variety of different domains. This area includes reading comprehension, active listening, writing, speaking, mathematics, and science. *Process skills* are defined as procedures that contribute to the more rapid acquisition of knowledge and skill across a variety of domains. This area includes critical thinking, active learning, learning strategies, and monitoring. *Social skills* are defined as developed capacities used to work with people to achieve goals. This domain measures the level of social perceptiveness, coordination, persuasion, negotiation, instructing, and service orientation. *Complex problem solving skills* are defined as developed capacities used to solve novel, ill-defined problems in complex, real-world settings. This measures the level of identifying problems and reviewing related information to develop and evaluate options and implement solutions. *Technical skills* are defined as developed capacities used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems. This subscale includes the level of operations analysis, technology design, equipment selection, installation, programming, operation monitoring, operation and control, equipment maintenance, troubleshooting, repairing, and quality control analysis. *Systems skills* are defined as developed capacities used to understand, monitor, and improve socio-technical systems. This subscale measures the level of judgment and decision making, systems analysis, and systems evaluation. *Resource management skills* are defined as developed capacities used to allocate resources efficiently. This subscale includes time management, management of financial, material, and personnel resources.

Self-Report and Standardized Measures

Measures of student characteristics in this study include self-ratings of occupational interests, cognitive abilities, and skills based on the established constructs in the O*NET content model (Mumford & Peterson, 1999; Fleishman et al., 1999; Mumford et al., 1999).

Vocational interests. Interests were measured using the O*NET Interest Profiler (Lewis & Rivkin, 1999). This measure consists of 180 items, originally designed as a career exploration interest self-assessment to measure the six RIASEC Holland types. Lewis and

Rivkin (1999) reported coefficient alphas ranging from .95 to .97 for each of the six scales. Evidence for convergent and discriminant validity was supported by comparing the Interest Profiler with the Interest-Finder, another O*NET interest assessment, with a median correlation of .82 for similar scales, and a median correlation of .46 for dissimilar scales (Lewis & Rivkin, 1999). The assessment tool has been adapted for research proposes. A subset of 60 of the 180 items was used, based on structural analysis identifying the items that best fit the RIASEC structure. There are 10 items endorsing each of the six Holland personality types. The items represent work activities across a wide range of training requirements. Respondents were asked to rate on a Likert-type scale from 1 (*strongly dislike*) to 5 (*strongly like*) how much they like a particular interest. Scores were computed based on the mean for each of the six Holland types.

Self-rated abilities. The ability scale has 21 items consisting of O*NET operational definitions of cognitive ability constructs (Fleishman et al., 1999). The ability definitions were converted into items for ability self-ratings. Some of the O*NET definitions were shortened or slightly rephrased for use in the questionnaire. For example, the O*NET operational definition for perceptual speed was shorted from "the ability to quickly and accurately compare similarities and differences among sets of letters, numbers, objects, pictures, or patterns" (O*NET Online, n.d.a) to the "ability to quickly and accurately compare similarities and differences." Respondents rated the amount of ability they have for each item on a scale from 1 (*not at all*) to 5 (*very much*).

Self-rated skills. The skills scale has 35 items consisting of the operational definitions of the O*NET skills (Mumford et al., 1999) adapted to use as items that participants rated on a 5-point Likert type scale. Some of the O*NET definitions were shortened or slightly rephrased for use in the questionnaire. For example, the O*NET operational definition for systems analysis “determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes” (O*NET Online, n.d.a) was modified for self-rating to the “skill to determine how a system should work and how changes will affect outcomes”. Participants in this study were asked to rate the amount of skill they have on a scale from 1 (*not at all*) to 5 (*very much*) for each item.

Preliminary analyses on the ability and skill variables grouped according to the O*NET content model hierarchy revealed limitations of using these categories with the property vector fitting technique. For example, the idea generation and reasoning abilities include seven specific abilities that could link with more than one area of the interest circumplex. To determine appropriate variable groupings, angle point estimates for the property vectors were obtained, and subscales were created from the original content model based on items that grouped together in proximity, retaining the original hierarchy as much as possible. The final subscales used in the analysis are listed in Tables 1 and 2.

Standardized ability measure. Students’ ACT scores (ACT, 1999) were used as standardized measures of cognitive ability. These scores were obtained from official university records with students’ permission. ACT scores were available for 61% of the participants (N = 496), including 303 women (61%) and 193 men (39%) who were predominately White/Caucasian (90%).

Procedure

Undergraduate college students in psychology classes were recruited to participate in this study as part of the psychology research requirement. Participants selected a time to come to the lab through the online sign-up system or experiment posting bulletin board. At the lab, participants read an informed consent document, which requested permission to access university records to obtain ACT information. Once participants consented, they were asked to complete a demographic survey and the interest, ability, and skill measures described above. Participants completed the surveys through one of two methods, either pencil-and-paper survey packets, or an online version of the survey. Forty-four percent of participants (n = 362) completed the paper version, and 56% (n = 454) completed the online survey. Those who completed the paper survey packets did so over a two-week period. Each week, participants were given a survey packet containing survey booklets and bubble answer sheets to take and complete at their own convenience at a time and place free from distractions. Participants were asked to return the completed surveys to the lab within one week. The complete set of questionnaires used in this study took about one hour to complete, for which participants received research credit in their psychology class.

Data Analysis

Mean level analysis. Gender differences in the mean level of self-ratings and ACT scores were tested using multivariate analysis of variance (MANOVA).

Property vector fitting. The property vector fitting (Jones & Koehly, 1993; Kruskal & Wish, 1978) statistical technique was used to integrate individual and environment characteristics into a RIASEC interest-based circumplex spatial map. The first step in this procedure was to select a set of coordinates that describes the interest structure. Coordinates for the theoretical structure of Holland's model have been determined from previous research (Rounds & Tracey, 1993): R (.00, .58), I (.50, .29), A (.50, -.29), S (.00, -.58), E (-.50, -.29), C (-.50, .29). The next step was to calculate scores for each ability and skill construct, described as properties in this technique, which relate the abilities and skills to each of the RIASEC interest types.

These scores were obtained by regressing each property over the coordinates in the RIASEC circumplex using a linear multiple regression procedure. Salience of how well each property fits the RIASEC circumplex structure was assessed by the variance accounted for (R^2) in the multiple regression procedure, with higher values indicating a stronger relationship with the RIASEC structure. The location of the property's vector in the circumplex was determined by calculating directional cosines (regression coefficients standardized so that the sum of squared values equal 1.00) from the regression analyses. Angles were calculated from the cosines, with the zero degree location set at the mid-point between Investigative and Artistic in the circumplex, with angles increasing in a counter-clockwise direction, consistent with the unit circle polar coordinates (see Figure 3).

A bootstrap procedure (Efron & Tibshirani, 1993) was used to empirically generate distributions for the R^2 and angle parameters. By creating 1,000 bootstrap samples (n = 450 for O*NET, 494 for women, and 322 for men) from the original data by random sampling with replacement for each property, 95% confidence intervals for R^2 and θ were computed using the percentile method (Mooney & Duval, 1993) for each variable separately for male self-ratings, female self-ratings, and the occupational ratings.

A property vector was considered to fit into the model when the 95% confidence interval for R^2 contained values greater than .50, and the range of the 95% confidence interval for the angle is less than or equal to 90 degrees. Vectors were considered consistent with Holland's theory (1997) when these criteria were met, and the location in the interest circumplex was in a direction consistent with Holland's predictions. In short, vectors meeting these requirements have locations consistent with Holland's theory, and 50% of the variance in the property can be explained in terms of Holland's structure. In comparison, variables with 95% confidence interval R^2 values less than or equal to .50, or with an angle range greater than 90 degrees, but less than 180 degrees, were considered to have a questionable fit into the RIASEC circumplex. Properties were considered to have a poor fit with the interest structure when the range of the 95% confidence interval for the angle is greater than 180 degrees, thus indicating possible range of locations that contradict the order predictions in Holland's RIASEC model. Additionally, if a vector met the R^2 cutoff of .50, but pointed in a direction contrary to Holland's theory, the variable in question was viewed as a good fit to the interest circumplex, but inconsistent with Holland's type definitions and structural model.

The ability and skill constructs are shown as vectors that radiate from the center of the RIASEC circumplex with a corresponding strength (R^2) and direction (θ). The self-ratings of O*NET constructs were fit to the RIASEC model separately by gender. To test the equivalence of individual and environmental structures, confidence intervals for the strength and direction of each property vector in the environment model were compared to property vectors for males and females. To test if there is structural equivalence between males and females, confidence intervals for the strength and direction of each property vector was compared by gender.

Hypotheses of Alignment into RIASEC Model

General predictions of how the O*NET ability and skill constructs may embed into the RIASEC structure were made to illustrate how the property vector fitting technique would work. Based on Holland's (1997) description of the RIASEC types and Prediger's (1982) definitions of the People/Things and Data/Ideas dimensions underlying Holland's model, it was expected that the abilities and skills constructs will line up in the following ways within the RIASEC structure. The cognitive ability constructs (see Figure 2) were expected to be distributed around the RIASEC circumplex. While some abilities have straightforward associations with a RIASEC type, others were predicted to relate with multiple types. Verbal abilities were expected to align with the Artistic type. It was expected that Idea Generation and Reasoning abilities would bisect Investigative and Artistic, consistent with Prediger's (1982) Ideas dimension. Both Memory and Attentiveness abilities were expected to align with Conventional. Perceptual abilities were predicted to line up with Realistic, as these abilities are strongly related to working with things.

It was hypothesized that Quantitative abilities may not fit well into the RIASEC circumplex due to the relationship of mathematical reasoning and number facility with both Investigative and Conventional. These types are not adjacent in the RIASEC order, and the relation of quantitative abilities with both types is inconsistent with the order predictions of expected strength of relationship in a circumplex. Based on the association between working with data and the Conventional type, as well as math ability also being characteristic of the Investigative type, it was hypothesized that Quantitative abilities will line up at some point between C and I, likely pointing between Conventional and Realistic. Like quantitative abilities, spatial abilities are associated with many RIASEC types. Spatial abilities were expected to embed at some point between Realistic and Artistic in the circumplex due of the use of spatial ability in working with things, ideas, and the visual arts. Due to the strong connection with science and the arts, it is hypothesized that spatial abilities will line up between Investigative and Artistic.

Hypotheses were also generated for how the cross-functional skills are expected to fit the RIASEC circumplex (see Figure 2). Social skills were expected to line up with the Social type and slightly oriented toward Enterprising, due to the teaching, helping, and persuasive aspects of social skills. At the other end of the Things/People dimension (Prediger, 1982), technical skills were expected to align with Realistic. Additionally, it was hypothesized that resource management skills would point between Enterprising and Conventional.

Since skills require specific training and practice for performance, and there are gender differences in the cultural, educational and work experiences of young people (L. S. Gottfredson, 2005), it was proposed that gender differences could emerge when integrating skills into RIASEC. While generally this was not expected, the following examples are provided. Complex problem solving skills were expected to embed in the Investigative direction, however gender differences in the preference for working with things or working with people may result in this property lining up between Realistic and Investigative for men, and between Artistic and Social for women. Similarly for systems skills, these properties were expected to align between Realistic and Investigative, although a relationship could also exist with Social, Enterprising, or Conventional.

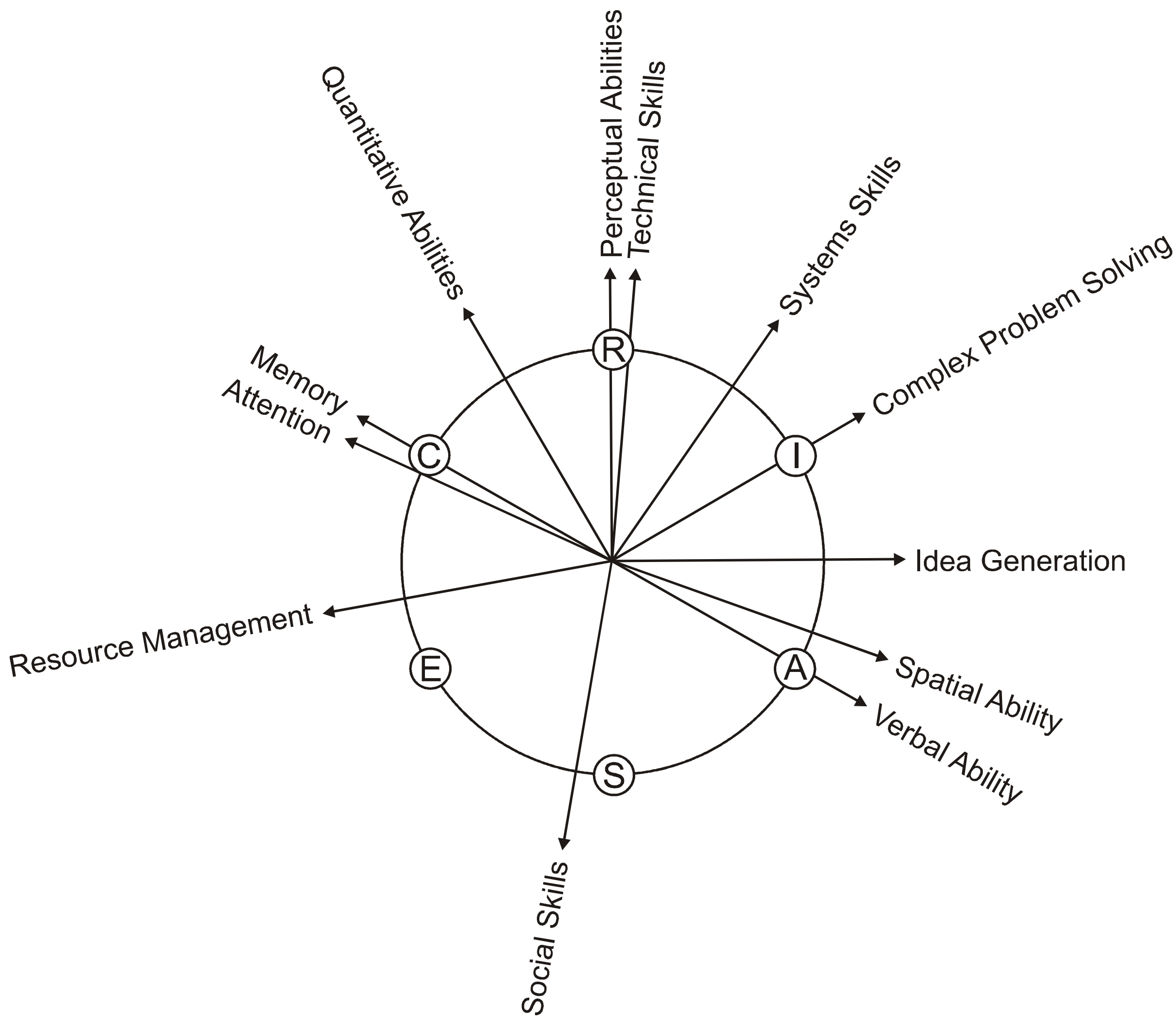

Figure 2. Demonstration of possible locations of O*NET cognitive ability and cross-functional skill construct property vectors in the RIASEC interest structure using property vector fitting.

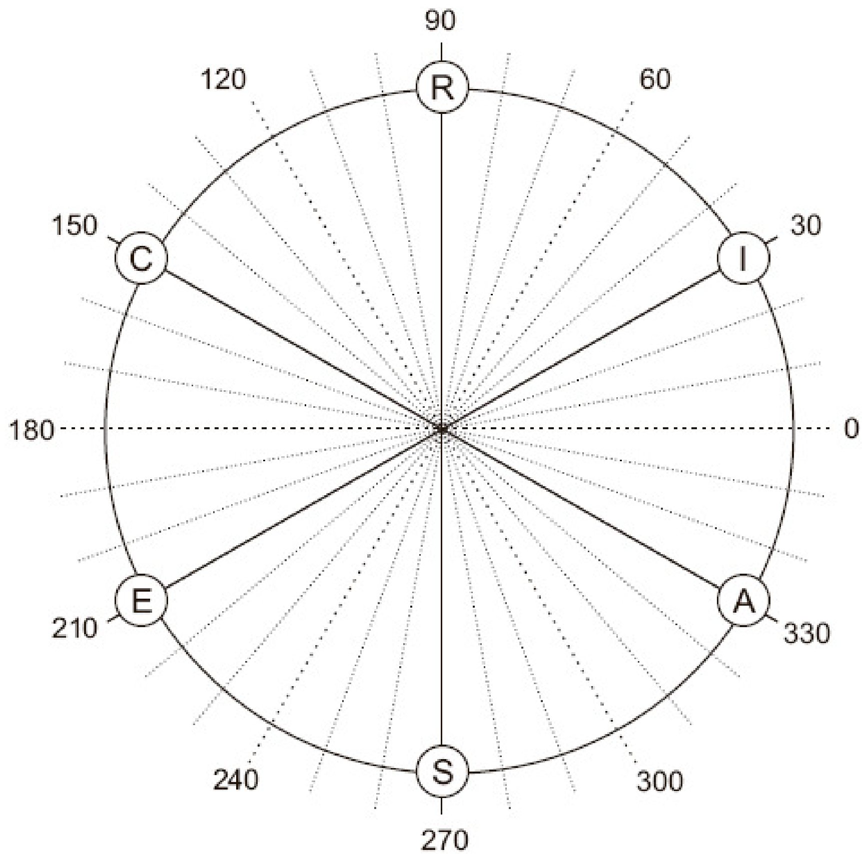

Figure 3. RIASEC interest circumplex with polar coordinates.

CHAPTER 4. RESULTS

Multivariate analysis of variance were conducted to evaluate the presence of mean level gender differences in interests, standardized ability tests, and expressed abilities and skills. Expected gender differences consistent with previous research were found, providing support for the suitability of using this dataset in exploring integrated structural models of interests, abilities, and skills. A bootstrapped property vector fitting technique was used to create person and environment models in order to investigate the integrated structures for consistency with Holland's RIASEC type definitions, gender comparisons, and person-environment differences.

Mean Level Analysis

As predicted, there were mean level gender differences in interests, on standardized ability tests, and expressed abilities and skills. Gender differences found are consistent with previous research (Hansen, 2005; Lubinski, 2000; Swanson, 1993), with the largest effects found along the people-things dimension (Prediger, 1982; Lippa, 1998).

Gender Differences in Interests

There was a significant multivariate effect of gender on interests for the six Holland-based measures, $\lambda = .59$, $F(6, 809) = 92.10$, $p < .001$, $\eta^2 = .41$. The means, standard deviations, and univariate analysis of variance for vocational interests are presented in Table 3. Analysis of each individual dependent variable, using a Bonferroni adjusted alpha level of .002, showed that a gender difference existed at a .99 confidence level for each of the interests except Conventional. In general, the strength of interests by gender differed along Prediger's (1982) people-things dimension. Men expressed higher levels of Realistic and Investigative interests than women, and women expressed higher levels of Social and Artistic interests than men. These findings are consistent with previous research (Lippa, 1998; Hansen, 2005). Additionally, men's Enterprising interests were also greater than women's in this sample. There was a large effect of gender on Realistic interest, with gender accounting for 23% of the variance in Realistic interest, and a medium to large effect on Social interest, account for 11% of the variance. Effect sizes for the gender differences in the other interests were small ($\eta^2 \leq .04$).

Gender Differences in ACT Scores

Means, standard deviations, and univariate analysis of variance for ACT achievement test scores are presented in Table 4. ACT scores were available for a subset of participants (n = 496). There was a significant multivariate effect of gender on the five ACT test scores, λ = .83, $F(5, 490) = 20.20$, $p < .001$, $\eta^2 = .17$. Analysis of each individual dependent variable, using a Bonferroni adjusted alpha level of .002, showed that gender differences existed at a .99 confidence level for the Math and Science tests. Men scored significantly higher than women on ACT math and science tests with small to medium univariate effect sizes of η^2 = .04 and .06, respectively. There were no gender differences on ACT English, reading, or composite test scores. Finding that men had higher math and science test scores is consistent with previous meta-analysis on quantitative and spatial abilities, however higher scores were not found for women on the verbal tests, as reported in previous research (Hedges & Nowell, 1995). The pattern of ACT scores in this sample is consistent with national averages (ACT, 2007), with higher than average mean scores expected in a college student sample.

Gender Differences in Expressed Cognitive Abilities

There was a significant multivariate effect of gender on 15 self-ratings of cognitive abilities, $\lambda = .81$, $F(15, 800) = 12.69$, $p < .001$, $\eta^2 = .19$. Means, standard deviations, and univariate analysis of variance for self-rated cognitive abilities are presented in Table 5. Analysis of each individual dependent variable, using a Bonferroni adjusted alpha levels of .003 and .0007, showed that gender differences existed for six of the 15 ability self-ratings, however all of the effect sizes were small ($\eta^2 \leq .05$). Women endorsed higher ability self-ratings on verbal comprehension and expression, information ordering and memorization. Men's mean ability self-ratings were greater than women's for quantitative abilities and spatial orientation, which is consistent with previous research finding gender differences in self-rated Realistic abilities (Swanson, 1993).

Gender Differences in Expressed Skills

There was a significant multivariate effect of gender on the 17 self-rated measures of skills, $\lambda = .69$, $F(17, 798) = 20.96$, $p < .001$, $\eta^2 = .31$. Means, standard deviations, and univariate analysis of variance for self-rated skills are presented in Table 6. Analysis of each individual dependent variable, using a Bonferroni adjusted alpha levels of .003 and .0006, showed that gender differences existed for 12 of the 17 skill self-ratings. Women endorsed higher skill self-ratings than men for written and oral communication, and service orientation, with small to medium effect sizes (η^2 ranged from .01 to .05). Men's mean skill self-ratings were greater than women's for mathematics, science, critical thinking, technical skills, judgment and decision making, management of financial and material resources, and complex problem solving. While most of the effect sizes were small to medium (η^2 ranged from .01 to .06), there was a large effect of gender on self-rated technical skills, accounting for 20% of the variance. Overall, these gender differences in mean self-ratings of skills tend to fall along the people-things dimension and are generally consistent with previous research (i.e., Swanson, 1993).

Property Fitting Analysis

Across the environmental ratings and individual self-ratings, the skill vectors fit into the RIASEC model better than the cognitive ability vectors. The standardized ACT measures of academic ability fit well into the interest model, and most had locations in the RIASEC circumplex that were consistent with similar self-report measures of abilities and skills.

Cognitive Abilities

Occupational demands. The results obtained from the bootstrapped property vector fitting analysis of cognitive ability variables based on occupational ratings are presented in Table 7. Overall, 10 of the 15 ability vectors met the fit criteria for the RIASEC circumplex with R^2 point estimate values ranging from .31 to .84, R^2 confidence intervals including values greater than .50, and angle confidence intervals with a range of less than 90 degrees (see Figure 4). Four ability variables had a questionable fit with R^2 point estimate values ranging from .13 to .35, and one ability fit poorly into the model with an R^2 value of .19. The ability variables were distributed around the circumplex from the Conventional to the Social regions. None of the occupational ratings of cognitive abilities obtained from the O*NET database were located in the Enterprising area. There appears to be a lack of abilities specific to Enterprising work environments based on the current occupational ratings.

Of the 10 cognitive abilities that fit well into the interest circumplex, eight were located in a direction consistent with Holland’s (1997) definitions of the RIASEC types. Spatial Orientation and Perceptual abilities were associated with the R type, and Visualization and Selective Attention were oriented between the R and I types. Information Ordering also fit between the R and I types, somewhat inconsistent with Holland’s definitions, which would predict an ability requiring order and rules to be associated with the

C and R types. The ability of Category Flexibility was associated with an area between I and A. Verbal Expression and Idea Generation were located in the A region. Quantitative abilities were oriented in the region between the C and R types. As numerical and mathematical abilities are mentioned in Holland's definitions of both the Conventional and Investigative types, this location is consistent with Holland's theory. Memorization fit with the S type, which is difficult to interpret due to the lack of a clear association between this ability and Holland's RIASEC type definitions.

The results for Verbal Comprehension, Problem Sensitivity, Deductive Reasoning, and Inductive Reasoning suggest a questionable fit to the interest circumplex with R^2 values that fell below the interpretive cutoff identified in previous research. It is interesting to note, however each of these ability vectors are oriented in a direction consistent with Holland's theory. Time Sharing, which cannot be inferred from Holland's definitions to be associated specifically with any one type, had a poor fit with the RIASEC model.

Expressed Abilities – Women. The results obtained from the bootstrapped property vector fitting analysis of cognitive ability variables based on college women's self-ratings are presented in Table 9. Overall, four of the 15 ability variables met the fit criteria for the RIASEC circumplex with R^2 point estimate values ranging from .40 to .96, R^2 confidence intervals including values greater than .50, and angle confidence intervals with a range of less than 90 degrees (see Figure 5). Four variables had a questionable fit with R^2 point estimate values ranging from .41 to .98, and angle confidence intervals ranging from 101 to 116 degrees in width. Seven abilities fit poorly into the interest circumplex, with R^2 point estimate values ranging from .08 to .49, and angle confidence interval widths greater than 180 degrees. While the ability variables were distributed throughout the circumplex, there appears to be a concentration of these measures in an orientation consistent with Prediger's (1982) people-things dimension.

Of the four cognitive abilities that fit well into the interest circumplex, two were located in a direction that is clearly consistent with Holland's (1997) definitions of the RIASEC types. Holland proposed that mathematical ability is linked to Investigative and numerical ability is related to Conventional. Quantitative abilities were oriented between the R and C types in this sample, demonstrating the link with both Conventional and Investigative, with the vector located between these two types. Idea Generation was located in the A region, consistent with Holland's description of the Artistic type as original and imaginative.

In comparison, the orientations of Verbal Comprehension and Verbal Expression were somewhat less consistent with the predictions made in Holland's model. These verbal measures were expected to point towards A as Holland described this type as expressive and having verbal abilities, but were oriented more towards the S type in this sample. However, it is worth noting that the angle 95% confidence intervals for these vectors span the A-S region. It appears that self-reported verbal abilities may be tied more to Social interest for women than what is predicted in the Holland model. The connection of speaking abilities with Enterprising interests in Holland's theory may also be pulling these results toward the S type.

The results obtained for self-ratings of Problem Sensitivity, Information Ordering, Perceptual abilities, and Spatial Orientation suggest a questionable fit to the interest circumplex. While Problem Sensitivity could be interpreted in terms of scientific problem solving, it appears that the college women in this sample viewed this ability more broadly, as Problem Sensitivity was located in a region that spans the A, S, and E types, and aligned with the people dimension (Prediger, 1982). The Information Ordering, Perceptual abilities, and Spatial Orientation vectors each point in a direction consistent with Holland's theory. Deductive Reasoning, Inductive Reasoning, Category Flexibility, Memorization, Visualization, Selective Attention, and Time Sharing all fit poorly into the RIASEC model for college women.

Expressed Abilities – Men. The results obtained from the bootstrapped property vector fitting analysis of cognitive ability variables based on college men's self-ratings are presented in Table 11. Overall, five of the ability variables met the fit criteria for the RIASEC circumplex with R^2 point estimate values ranging from .50 to .99, and angle confidence intervals ranging less than 90 degrees (see Figure 6). Three ability variables had a questionable fit to the model with R^2 point estimate values ranging from .47 to .57, and angle confidence intervals ranging from 98 to 125 degrees in width. Seven abilities fit poorly into the interest circumplex with R^2 values ranging from .23 to .82, and angle confidence interval widths greater than 180 degrees. The ability variables were distributed around the circumplex from the Conventional to the Social regions. It is interesting to note that none of the men's cognitive ability vectors were located in the Enterprising area, which is consistent with the pattern of results obtained from the environmental ratings from the O*NET database of occupational information.

The five cognitive abilities that fit well into the interest circumplex were located in the A and S regions. Verbal Comprehension, Verbal Expression, and Idea Generation were grouped together in the area between A and S, in a direction consistent with Holland's (1997) definitions of the RIASEC types. Problem Sensitivity was also located in the area between the A and S types, suggesting that this ability was linked more with artistic and social interests than with investigative. Perceptual abilities were oriented between A and I, which appears consistent with Holland's theory in which perceptual abilities are related to R, I and the A types.

The results for Quantitative abilities, Spatial Orientation, and Visualization suggest a questionable fit to the interest circumplex, however each of these ability vectors point in a direction consistent with Holland's theory. Deductive Reasoning, Inductive Reasoning, Information Ordering, Category Flexibility, Memorization, Selective Attention, and Time Sharing did not fit into the RIASEC model.

Comparison of Individual and Occupational Ability Ratings. Overall, there was better fit of the environmental ratings of cognitive ability to the interest-based circumplex than for the college student ratings. Ten out of 15 environmental ratings fit into the RIASEC model, while four of the abilities met these criteria for women, and five for men. There were also three measures, Deductive Reasoning, Inductive Reasoning, and Time Sharing, that consistently did not fit well across the occupational-level ratings and individual self-ratings of abilities.

There were person-environment differences for the fit of the verbal abilities in terms of both the salience and location. There was a significantly higher degree of fit to the interest circumplex for Verbal Comprehension for women (R^2 = 0.84; 95% CI: .48, .96), and for Verbal Expression for men (R^2 = 0.99; 95% CI: .81, 1.0) and women (R^2 = 0.96; 95% CI: .68, .99) compared to the environmental ratings for Verbal Comprehension (R^2 = 0.29; 95% CI: .18, .42) and Expression (R^2 = 0.39; 95% CI: .27, .51). The finding that higher percentages of the variance in these properties can be explained in terms of Holland's structure by the college student ratings suggests that verbal abilities are linked more to individual interests, than occupational demands for verbal abilities are connected with the interest types. Additionally, there was a significant difference between the environment and the women in the location of the Verbal Comprehension vector, with this ability pointing toward the A type for occupations (θ = 337, 95% CI: 319, 359), and between A and S for women (θ = 279, 95% CI: 247, 318). Similarly, for Problem Sensitivity there was a higher degree of fit for men (R^2 = 0.85; 95% CI: .50, .96) than for occupations (R^2 = 0.27; 95% CI: .12, .46), and the location differed significantly between person and environment ratings, with an orientation toward the People dimension for men (θ = 294, 95% CI: 264, 321) and women (θ = 256, 95% CI: 200, 316), and toward the Dynamic or Ideas dimension for the environment (θ = 0, 95% CI: 333, 25). Information Ordering was oriented between R and C for women ((θ = 146, 95% CI: 91, 192), and between R and I for occupations (θ = 55, 95% CI: 39, 68). Perceptual ability environmental ratings aligned with the R type (θ = 84, 95% CI: 67, 99), while for men this vector was located between the I and A types (θ = 350, 95% CI: 308, 38). Finally, Visualization had a higher degree of fit based on occupational ratings (R^2 = 0.64; 95% CI: .53, .74) than for women (R^2 = 0.08; 95% CI: .01, .52), and the vector pointed between R and I for occupations (θ = 70, 95% CI: 59, 82), and between A and S for men (θ = 309, 95% CI: 253, 359).

In the current analyses there were no significant gender differences in the variance accounted for or the location in the RIASEC interest structure for the cognitive ability vectors. However, applying the criteria for assessing overall fit suggest some qualitative differences that may be appropriate for further investigation. For example, Problem Sensitivity was oriented in the People direction for both women and men, but there was better overall fit to the interest circumplex for men compared to women. At the other end of the people-things dimension (Prediger, 1982), Quantitative abilities were located in the Things direction for both men and women, but there was a better fit to the model for the women's self-ratings. Overall, four of the abilities fit well into the RIASEC circumplex for women, and five fit well for men.

Skills

Occupational demands. The results obtained from the bootstrapped property vector fitting analysis of skills based on occupational ratings are presented in Table 8. Of the 17 skills, 15 skill variables met the fit criteria for the RIASEC circumplex with R^2 point estimate values ranging from .35 to .86, R^2 confidence intervals including values greater than .50, and angle confidence intervals with a range of less than 90 degrees (see Figure 4). One skill had a questionable fit with a R^2 point estimate of .28, and angle confidence interval width of 104 degrees. One skill fit poorly into the interest circumplex (R^2 = .16). The property vectors for environmental ratings of skill importance were distributed across half of the circumplex from the Realistic to the Social region. None of the occupational ratings of skills were located in the Enterprising or Conventional areas.

Of the 15 skills that fit well into the interest circumplex, nine were located in directions that can be interpreted as being consistent with Holland's (1997) definitions of the RIASEC types. Mathematics pointed in the R direction, a location consistent with the RIASEC ordering for a skill that Holland linked to both the Conventional and Investigative types. Technical skills and Systems Analysis were associated with the R type, and Systems Evaluation pointed in the area between R and I. Technical and systems analysis skills are consistent with Holland's definition of the Realistic environment that fosters technical competencies, and work with machines and tools. Systems Evaluation describes more creative work with systems, linked with R and I environments. Science skill and Complex Problem Solving fit with the I type, in line with the theoretical, scientific, and abstract analytical elements of the Investigative environment. Written Communication was associated with the A type, and Oral Communication was oriented in the region between the A and S types. Although Holland associates both writing and speaking explicitly with the Artistic environment, Oral Communication skill was linked with Artistic expressive, speaking occupations, and Social occupations, such as teaching. Consistent with Holland's Social environment, Service Orientation fit with the S type.

Six skills fit well into the RIASEC model, but were located in areas that would not be predicted using Holland's type descriptions. Critical Thinking and Teaching were associated with the A type. In Holland's model, the logical reasoning skills associated with critical thinking are tied to Investigative, and teaching is linked with Social. Leading skills, Management of Personnel Resources, and Management of Financial Resources were expected to point toward Enterprising due to the connection with organizational responsibility, but were oriented toward the S type based on occupational ratings. Finally, Time Management, expected to link with Enterprising, was located in the region between A and S, which is somewhat inconsistent with the free and unsystematic nature of the Artistic environment. The results for Management of Material Resources suggest a questionable fit to the interest circumplex, however this vector pointed in the Things (Prediger, 1982) direction, and is consistent with Holland's theory. Judgment and Decision Making had a poor fit with the RIASEC model.

Expressed skills – Women. The results obtained from the bootstrapped property vector fitting analysis of skills based on women's ratings are presented in Table 10. Of the 17 skills, 13 variables met the fit criteria for the RIASEC circumplex with R^2 point estimate values ranging from .54 to .85, R^2 confidence intervals including values greater than .50, and angle confidence intervals with a range of less than 90 degrees (see Figure 5). Three skills had a questionable fit with R^2 point estimate values ranging from .45 to .71, and angle confidence intervals ranging from 99 to 127 degrees in width, and one fit poorly into the interest circumplex (R^2 = .20). The skill property vectors were distributed throughout the RIASEC model, with most of the properties located along the people-things (Prediger, 1982) dimension.

Of the 13 skills that fit well into the interest circumplex, 12 were located in a direction consistent with Holland's (1997) definitions of the RIASEC types. Technical skills were associated with the R type, Critical Thinking pointed in the area between R and I, and Science skill fit with the I type. For women, expressed technical skills were linked as expected to applied interests, science skills were linked with theoretical interests, and critical thinking skills were related to both types. The angle confidence intervals for the technical (θ = 83, 95% CI: 68, 100) and science skill (θ = 44, 95% CI: 32, 59) vectors do not overlap, delineating the unique aspects associated with each type. Written Communication, Oral Communication, Service Orientation, and Teaching were oriented in the region between the A and S types, suggesting a relationship among expressive and helping skills. Leading was located in the area between the S and E types. Management of Financial Resources pointed between the E and C types demonstrating both the organizational and numerical aspects of this skill. Systems Analysis, Mathematics, and Management of Material Resources were oriented between R and C, consistent with the portion of the circumplex representing structured work with things.

Systems Evaluation fit well into the RIASEC model, but was located in an area not predicted by Holland's type descriptions. While Systems Evaluation was conceptualized as evaluating the performance of a technical system based on occupational ratings, it appears that the college women in this sample rated this skill regarding the performance evaluation of people, as this property was located in the region between the S and E types. Complicating this result was an error found after data collection in the wording of this skill, in which the critical term 'system' was omitted. This result highlights the contextual nature of some of the cross-functional skill terms, and provides an example of a type of skill currently missing in the O*NET skills hierarchy, particularly skills associated with management in the Enterprising environment.

The results for three skills suggested a questionable fit to the interest circumplex due to the lower R^2 values and wide angle confidence intervals obtained in the property vector fitting analyses. Judgment and Decision Making pointed in the Things direction of the people-things dimension, and Management of Personnel Resources lined up in the People direction, consistent with Holland's theory. Complex Problem Solving, however, was oriented in a direction contrary to Prediger's (1982) underlying dimensions of the RIASEC model. While it was expected that this skill would be associated with the Dynamic or Ideas end of the structured-dynamic (Armstrong et al., 2004) or data-ideas (Prediger, 1982) dimension, this vector pointed in the opposite direction to the region spanning the E, C, and R types. However, the results for Complex Problem Solving suggest a questionable fit to the interest circumplex, and should be interpreted with caution. Finally, Time Management had a poor fit with the RIASEC model.

Expressed Skills – Men. The results obtained from the bootstrapped property vector fitting analysis of skills based on men's ratings are presented in Table 12. Of the 17 skills, 11 variables met the fit criteria for the RIASEC circumplex with R^2 point estimate values ranging from .64 to .93, R^2 confidence intervals including values greater than .50, and angle confidence intervals with a range of less than 90 degrees (see Figure 6). Three skills had a questionable fit with R^2 point estimate values ranging from .45 to .82, and angle confidence intervals ranging from 90 to 201 degrees in width, and three fit poorly into the interest circumplex with R^2 values ranging from .13 to .66, and angle confidence interval widths greater than 180 degrees. The skill property vectors were distributed throughout the RIASEC model, with most of the properties located in the areas spanning from Artistic to Realistic. While the skill vectors for women were concentrated in either the People or Things direction, the men's skill vectors were distributed throughout the circumplex except in the Dynamic dimension.

Of the 11 skills that fit well into the interest circumplex, eight were located in a direction consistent with Holland's (1997) definitions of the RIASEC types. Science skill fit in the area between the R and I types. Written Communication, Oral Communication, and Service Orientation were oriented in the region between the A and S types, similar to the location women, and linking the expressive and helping types. Teaching was associated with the S type, linked more with the People dimension of helping, rather than towards Artistic as with occupations and women. Spanning the Enterprising and Conventional areas, Management of Personnel Resources was located in the area between the S and E types ($\theta =$

236, 95% CI: 201, 273), and Management of Financial Resources pointed between the E and C types (θ = 190, 95% CI: 168, 219). The location of these two vectors highlight the distinct nature of working with either people or data, yet the overlap in the vector locations demonstrate the shared skill of management. Finally, Technical skills were oriented between R and C, associated with interest in systematic, explicit, and ordered activities.

Leading skills fit well into the RIASEC model, but was oriented toward S, rather than with the E type as predicted from Holland's type definitions. It appears that these skills were linked more with general interpersonal competencies related to the Social type, rather than specific leadership skills associated with Enterprising. Similar to the college women's ratings, Systems Evaluation was located in the region between the S and E types, suggesting that this skill was interpreted as evaluating performance of people, rather than technical systems. The location for the Judgment and Decision Making vector aligning between the E and C types was surprising, given the Holland type definitions would suggest some association with the I type. However, when viewing this placement in terms of the structured-dynamic (Armstrong et al., 2004) or data-ideas (Prediger, 1982) dimension, the role of data and structure in judgment and decision making tasks provides some context for this location.

Although the results for three skills suggested a questionable fit to the interest circumplex, the locations were consistent with Holland's theory. The angle confidence interval for Mathematics ranged across the C, R, and I regions, suggesting that the association of math with both the C and I types contributed to the questionable fit. Math skill appears to be related to a wide range of interests for men. Management of Material Resources was also oriented in the Things direction in the area spanning C, R, and I. Time Management pointed to the area between the E and C types. Finally, the results for Critical Thinking, Systems Analysis, and Complex Problem Solving showed that these skills fit poorly into the RIASEC model for male college students.

Comparisons of Occupational and Individual Skill Ratings. Overall, most of the skills fit the interest-based circumplex for occupations, women, and men, suggesting a strong link between interests and skills. Fifteen out of 17 environmental ratings fit into the RIASEC model, while 13 of the skills met these criteria for women, and 11 for men. There were no differences between the groups in the variance accounted for in a skill by the RIASEC structure. There were person-environment differences in vector location for eight of the 17 skills. Notably, no skills were oriented toward the E or C types for occupations, while the vectors were distributed throughout the circumplex for women and men. While the Structured region is underrepresented for all groups compared to other regions of the circumplex, there were skill vectors consistent with Holland's Enterprising and Conventional type descriptions for individuals, yet not for occupations.

There were significant differences in the location of Critical Thinking, Judgment and Decision Making, Systems Evaluation, Management of Financial Resources, and Complex Problem Solving skill vectors when comparing occupations and the self-ratings from female college students. Critical Thinking was oriented between R and I for women ($\theta = 64$, 95% CI: 36, 96), and aligned with the A type for occupations ($\theta = 344$, 95% CI: 332, 356). The vector for Judgment and Decision Making pointed in the Things direction for women ($\theta = 95$, 95% CI: 47, 146), and toward the A type for occupations ($\theta = 315$, 95% CI: 282, 353), however there was a questionable fit for both groups due to the lower R^2 values and wide angle confidence intervals. Systems Evaluation aligned with the R type for occupations ($\theta =$

72, 95% CI: 56, 88), while for women this vector was located between the S and E types (θ = 243, 95% CI: 203, 287). Management of Financial Resources was oriented with the S type for occupations (θ = 269, 95% CI: 243, 297), and was located between the E and C types for women (θ = 168, 95% CI: 142, 191). Finally, Complex Problem Solving was oriented with the I type for occupations (θ = 15, 95% CI: 1, 29), and between R and C for women (θ = 141, 95% CI: 79, 206), however the fit was questionable for women (R^2 = .45, 95% CI: .08, .79).

There were significant differences in the location of vectors when comparing occupational ratings and the self-ratings provided by male college students, including Teaching, Technical skills, Judgment and Decision Making, Systems Evaluation, Time Management, and Management of Financial Resources. Teaching was oriented with the S type for men (θ = 260, 95% CI: 235, 286), and aligned with the A type for occupations (θ = 318, 95% CI: 308, 328). The vector for Technical skills pointed between R and C for men (θ = 115, 95% CI: 90, 134), and was linked with R for occupations (θ = 79, 95% CI: 72, 86). Systems Evaluation was located between the S and E types (θ = 253, 95% CI: 218, 287) for men, while this vector aligned with the R type for occupations (θ = 72, 95% CI: 56, 88). Time Management was located between E and C for men (θ = 192, 95% CI: 151, 241), and between A and S for occupations (θ = 296, 95% CI: 286, 307). Management of Financial Resources was located between the E and C types for men (θ = 190, 95% CI: 168, 219), and was oriented with the S type for occupations (θ = 269, 95% CI: 243, 297).

There were no significant gender differences in the variance accounted for or the location in the RIASEC interest structure for the skill vectors. However, applying the criteria for assessing overall fit suggest some qualitative differences that may be worth continued exploration in future research. The confidence intervals for these parameters overlap when comparing the skill vectors for women and men, precluding statistically significant results, however, these vectors are linked into the model in distinct ways by gender. Critical Thinking (angle CI width: 336), Systems Analysis (angle CI width: 262), and Complex Problem Solving (angle CI width: 188), fit poorly into the interest-based circumplex for men, and reached a good or questionable fit for women. Conversely, Time Management had a poor fit for women (angle CI width: 335), and a questionable fit for men (angle CI width: 90). Mathematics skill was located in the Things direction for both men and women, but there was a better fit to the model for women. There was a questionable fit for Judgment and Decision Making for women and it was oriented in the Things direction, while for men this skill fit well and pointed between the E and C types.

Standardized Test Scores

ACT achievement tests. The results obtained from the bootstrapped property vector fitting analysis of ACT scores by gender are presented in Table 13 and Figure 7. Results for each of the four tests and composite scores for both men and women met the fit criteria for the RIASEC circumplex. Vectors for the ACT subtests were located in the area from the R type to the A type, with most of the objectively rated abilities concentrated in the region between I and A. The locations were in a direction consistent with Holland's (1997) definitions of the RIASEC types. The point estimates for R^2 ranged from .73 to .77, demonstrating that 73-77% of the variance in the men's test scores can be explained in terms of Holland's structure. For women, the R^2 point estimate for Mathematics was .58, while the other test R^2 ranged from .71 to .81.

No significant gender differences were found in the fit of standardized tests scores to the interest circumplex. Mathematics scores fit in the area between the R and I types. The angle point estimates for Science scores were oriented with the I type, which confidence intervals ranging from I to A for women, and a wider confidence interval from R to A for men. English, Reading, and Composite scores were located in the region between the I and A types. Previous research (Ackerman & Heggestad, 1997) has found that measures of general mental ability (*g*) line up with the area between Investigative and Artistic.

Comparison of Standardized Tests to Expressed Abilities and Skills. The R^2 and angle confidence intervals for each ACT test were compared to corresponding results for self-rated abilities and skills. No significant differences were found for the degree of fit between objective and expressed scores. In most cases, there were no location differences between the objective and self-rated tests when linked to the interest circumplex. However, differences were found in the location for the English test compared to corresponding expressed abilities and skills. For women, there were significant differences in the location of the ACT English test ($\theta = 9$, 95% CI: 340, 32) and Verbal Comprehension ($\theta = 279$, 95% CI: 247, 318) and Verbal Expression ($\theta = 278$, 95% CI: 254, 305) abilities. The location also differed between the English test ($\theta = 350$, 95% CI: 325, 22) and Verbal Expression ($\theta = 297$, 95% CI: 274, 319) ability for men. The English test was oriented between the I and A types, while Verbal Comprehension and Verbal Expression were located between the A and S types.

Table 3

Means, Standard Deviations, and Univariate Analysis of Variance for Interests by Gender

	Women (N = 494)		*Men (N = 322)*			
Scale	M	SD	M	SD	*F(1, 814)*	η^2
Realistic	1.88	.03	2.65	.04	245.95**	.23
Investigative	2.61	.04	2.93	.04	32.83**	.04
Artistic	3.04	.04	2.81	.05	13.88**	.02
Social	3.40	.03	2.88	.04	98.32**	.11
Enterprising	2.52	.03	2.74	.04	21.98**	.03
Conventional	2.40	.04	2.43	.05	0.29	.00

**p < .01.

Table 4

Means, Standard Deviations, and Univariate Analysis of Variance for ACT Achievement Test Scores by Gender

	Women (N=303)		*Men (N=193)*			
Test	M	SD	M	SD	*F(1, 494)*	η^2
English	23.99	.27	23.15	.33	2.99	.01
Math	23.05	.25	24.75	.31	18.04**	.04
Reading	24.68	.29	24.13	.36	1.43	.00
Science	22.89	.22	24.83	.28	29.34**	.06
Composite	23.74	.22	24.37	.27	3.23	.01

$^{**}p < .01$.

Table 5

Means, Standard Deviations, and Univariate Analysis of Variance for Self-Rated Cognitive Abilities by Gender

	Women (N=494)		*Men (N=322)*			
Scale	M	SD	M	SD	*F(1, 814)*	η^2
Verbal comprehension	4.06	.03	3.80	.04	28.93**	.03
Verbal expression	3.85	.04	3.50	.04	39.51**	.05
Idea generation	3.63	.03	3.73	.04	3.05	.00
Problem sensitivity	3.98	.04	3.81	.05	8.78	.01
Deductive reasoning	3.62	.04	3.59	.05	.21	.00
Inductive reasoning	3.47	.04	3.59	.05	3.28	.00
Information ordering	3.89	.04	3.65	.05	14.01**	.02
Category flexibility	3.41	.04	3.37	.05	.35	.00
Quantitative	3.33	.04	3.59	.05	16.31**	.02
Memorization	3.75	.04	3.51	.05	13.67**	.02
Perceptual	3.50	.03	3.53	.04	.43	.00
Spatial orientation	3.09	.05	3.51	.06	30.59**	.04
Visualization	3.63	.04	3.67	.05	.39	.00
Selective attention	3.59	.04	3.42	.05	6.21	.01
Time sharing	3.84	.04	3.71	.05	4.09	.01

$^*p < .05$. $^{**}p < .01$.

Table 6

Means, Standard Deviations, and Univariate Analysis of Variance for Self-rated Skills by Gender

	Women (N=494)		Men (N=322)			
Scale	M	SD	M	SD	*F(1, 814)*	η^2
Written communication	3.90	.04	3.61	.05	23.29**	.03
Oral communication	4.00	.03	3.69	.04	38.67**	.05
Mathematics	3.05	.05	3.42	.06	20.88**	.03
Science	2.84	.05	3.28	.06	30.99**	.04
Critical thinking	3.26	.04	3.58	.05	30.49**	.04
Teaching	3.39	.03	3.35	.04	.50	.00
Leading	3.52	.03	3.44	.04	2.83	.00
Service orientation	3.80	.04	3.36	.05	43.14**	.05
Technical	2.42	.03	3.11	.04	205.25**	.20
Judgment & decision making	2.64	.05	3.27	.07	52.80**	.06
Systems analysis	2.97	.05	3.36	.06	27.20**	.03
Systems evaluation	3.35	.05	3.37	.06	.14	.00
Time management	3.10	.05	3.18	.07	.85	.00
Mgmt. of financial resources	3.20	.05	3.43	.06	9.68*	.01
Mgmt. of material resources	2.93	.05	3.35	.06	33.33**	.04
Mgmt. of personnel resources	3.43	.04	3.51	.05	1.59	.00
Complex problem solving	3.11	.05	3.35	.06	10.42*	.01

*$p < .05$. **$p < .01$.

Table 7

Property Vector Fitting Results for Cognitive Abilities – Occupational Ratings

*O*NET property*	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
Verbal comprehension	.29	(.18, .42)	337	(319, 359)
Verbal expression	.39	(.27, .51)	312	(300, 327)
Idea generation	.73	(.62, .82)	317	(304, 330)
Problem sensitivity	.27	(.12, .46)	0	(333, 25)
Deductive reasoning	.13	(.04, .29)	357	(322, 31)
Inductive reasoning	.35	(.20, .50)	359	(341, 16)
Information ordering	.68	(.42, .84)	55	(39, 68)
Category flexibility	.31	(.14, .53)	12	(341, 34)
Quantitative	.41	(.22, .58)	118	(100, 139)
Memorization	.65	(.29, .86)	279	(252, 308)
Perceptual	.84	(.68, .92)	84	(67, 99)
Spatial orientation	.56	(.44, .67)	107	(96, 118)
Visualization	.64	(.53, .74)	70	(59, 82)
Selective attention	.83	(.63, .93)	60	(41, 79)
Time sharing	.19	(.01, .72)	223	(117, 301)

Table 8

Property Vector Fitting Results for Skills – Occupational Ratings

*O*NET property*	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
Written communication	.51	(.38, .63)	326	(316, 336)
Oral communication	.63	(.53, .72)	299	(290, 306)
Mathematics	.81	(.70, .88)	81	(71, 91)
Science	.81	(.74, .86)	42	(34, 50)
Critical thinking	.57	(.42, .69)	344	(332, 356)
Teaching	.76	(.61, .86)	318	(308, 328)
Leading	.76	(.68, .83)	286	(278, 294)
Service orientation	.77	(.62, .87)	269	(258, 279)
Technical	.83	(.76, .88)	79	(72, 86)
Judgment & decision making	.16	(.04, .34)	315	(282, 353)
Systems analysis	.86	(.77, .91)	78	(69, 88)
Systems evaluation	.72	(.52, .85)	72	(56, 88)
Time management	.71	(.58, .82)	296	(286, 307)
Mgmt. of financial resources	.35	(.15, .54)	269	(243, 297)
Mgmt. of material resources	.28	(.04, .60)	68	(23, 127)
Mgmt. of personnel resources	.55	(.34, .73)	265	(245, 284)
Complex problem solving	.55	(.39, .69)	15	(1, 29)

Table 9

Property Vector Fitting Results for Cognitive Abilities – Female Ratings

*O*NET property*	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
Verbal comprehension	.84	(.48, .96)	279	(247, 318)
Verbal expression	.96	(.68, .99)	278	(254, 305)
Idea generation	.40	(.10, .75)	315	(274, 358)
Problem sensitivity	.65	(.12, .91)	256	(200, 316)
Deductive reasoning	.27	(.02, .83)	64	(256, 156)
Inductive reasoning	.10	(.01, .59)	96	(198, 174)
Information ordering	.41	(.09, .73)	146	(91, 192)
Category flexibility	.20	(.03, .90)	189	(24, 340)
Quantitative	.70	(.40, .87)	113	(85, 141)
Memorization	.42	(.03, .91)	344	(234, 90)
Perceptual	.55	(.10, .89)	56	(10, 112)
Spatial orientation	.98	(.38, .99)	77	(31, 132)
Visualization	.08	(.01, .52)	29	(215, 147)
Selective attention	.40	(.06, .73)	178	(182, 179)
Time sharing	.49	(.03, .88)	232	(187, 169)

Table 10

Property Vector Fitting Results for Skills – Female Ratings

*O*NET property*	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
Written communication	.73	(.18, .95)	311	(269, 353)
Oral communication	.84	(.63, .95)	288	(270, 307)
Mathematics	.81	(.59, .92)	102	(82, 123)
Science	.85	(.69, .94)	44	(32, 59)
Critical thinking	.74	(.38, .92)	64	(36, 96)
Teaching	.85	(.45, .97)	278	(241, 316)
Leading	.76	(.49, .92)	266	(240, 290)
Service orientation	.70	(.54, .84)	284	(268, 301)
Technical	.76	(.56, .88)	83	(68, 100)
Judgment & decision making	.60	(.16, .92)	95	(47, 146)
Systems analysis	.65	(.35, .87)	109	(76, 141)
Systems evaluation	.67	(.18, .91)	243	(203, 287)
Time management	.20	(.02, .85)	217	(14, 349)
Mgmt. of financial resources	.59	(.33, .77)	168	(142, 191)
Mgmt. of material resources	.54	(.21, .82)	99	(63, 143)
Mgmt. of personnel resources	.71	(.21, .93)	279	(228, 330)
Complex problem solving	.45	(.08, .79)	141	(79, 206)

Table 11

Property Vector Fitting Results for Cognitive Abilities – Male Ratings

*O*NET property*	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
Verbal comprehension	.83	(.37, .97)	304	(262, 338)
Verbal expression	.99	(.81, 1)	297	(274, 319)
Idea generation	.97	(.79, .99)	310	(290, 330)
Problem sensitivity	.85	(.50, .96)	294	(264, 321)
Deductive reasoning	.23	(.02, .81)	106	(198, 168)
Inductive reasoning	.39	(.04, .90)	298	(199, 138)
Information ordering	.80	(.06, .97)	21	(295, 128)
Category flexibility	.10	(.01, .74)	173	(21, 341)
Quantitative	.47	(.10, .81)	114	(62, 160)
Memorization	.20	(.02, .78)	262	(189, 169)
Perceptual	.50	(.08, .82)	350	(308, 38)
Spatial orientation	.49	(.07, .87)	21	(333, 98)
Visualization	.57	(.11, .87)	309	(253, 359)
Selective attention	.62	(.04, .97)	208	(100, 322)
Time sharing	.82	(.09, .96)	273	(93, 334)

Table 12

Property Vector Fitting Results for Skills – Male Ratings

*O*NET property*	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
Written communication	.93	(.60, .99)	310	(283, 333)
Oral communication	.90	(.66, .98)	284	(259, 305)
Mathematics	.45	(.09, .83)	108	(54, 155)
Science	.69	(.40, .89)	49	(20, 77)
Critical thinking	.13	(.02, .87)	300	(190, 166)
Teaching	.80	(.50, .94)	260	(235, 286)
Leading	.92	(.75, .98)	274	(256, 290)
Service orientation	.72	(.49, .87)	291	(272, 311)
Technical	.91	(.59, .98)	115	(90, 134)
Judgment & decision making	.74	(.18, .94)	168	(132, 215)
Systems analysis	.66	(.03, .95)	142	(21, 283)
Systems evaluation	.64	(.25, .87)	253	(218, 287)
Time management	.75	(.20, .94)	192	(151, 241)
Mgmt. of financial resources	.75	(.39, .89)	190	(168, 219)
Mgmt. of material resources	.82	(.21, .97)	111	(46, 155)
Mgmt. of personnel resources	.77	(.31, .94)	236	(201, 273)
Complex problem solving	.41	(.04, .84)	222	(119, 307)

Table 13

Property Vector Fitting Results for ACT Achievement Tests – Female Scores

Test	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
English	.81	(.47, .94)	9	(340, 32)
Math	.58	(.15, .82)	59	(25, 98)
Reading	.71	(.12, .95)	8	(308, 55)
Science	.74	(.28, .94)	24	(340, 59)
Composite	.72	(.27, .92)	23	(341, 55)

Table 14

Property Vector Fitting Results for ACT Achievement Tests – Male Scores

Test	R^2	95% CI for R^2	Angle (θ)	95% CI for θ
English	.77	(.30, .96)	350	(325, 22)
Math	.73	(.29, .94)	55	(7, 100)
Reading	.77	(.23, .96)	359	(311, 48)
Science	.73	(.21, .96)	27	(351, 80)
Composite	.75	(.29, .96)	16	(341, 52)

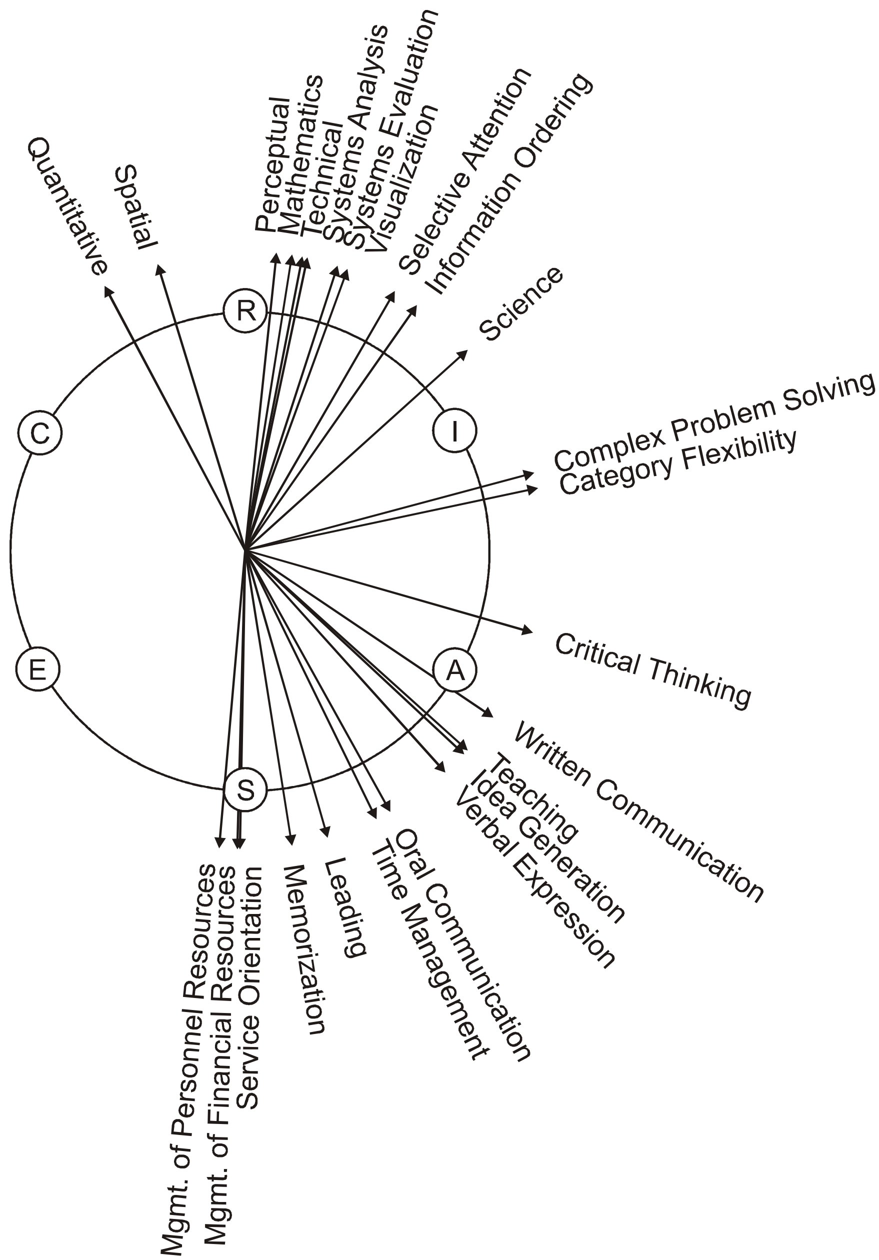

Figure 4. Occupational ability and skill demands integrated into a RIASEC interest circumplex.

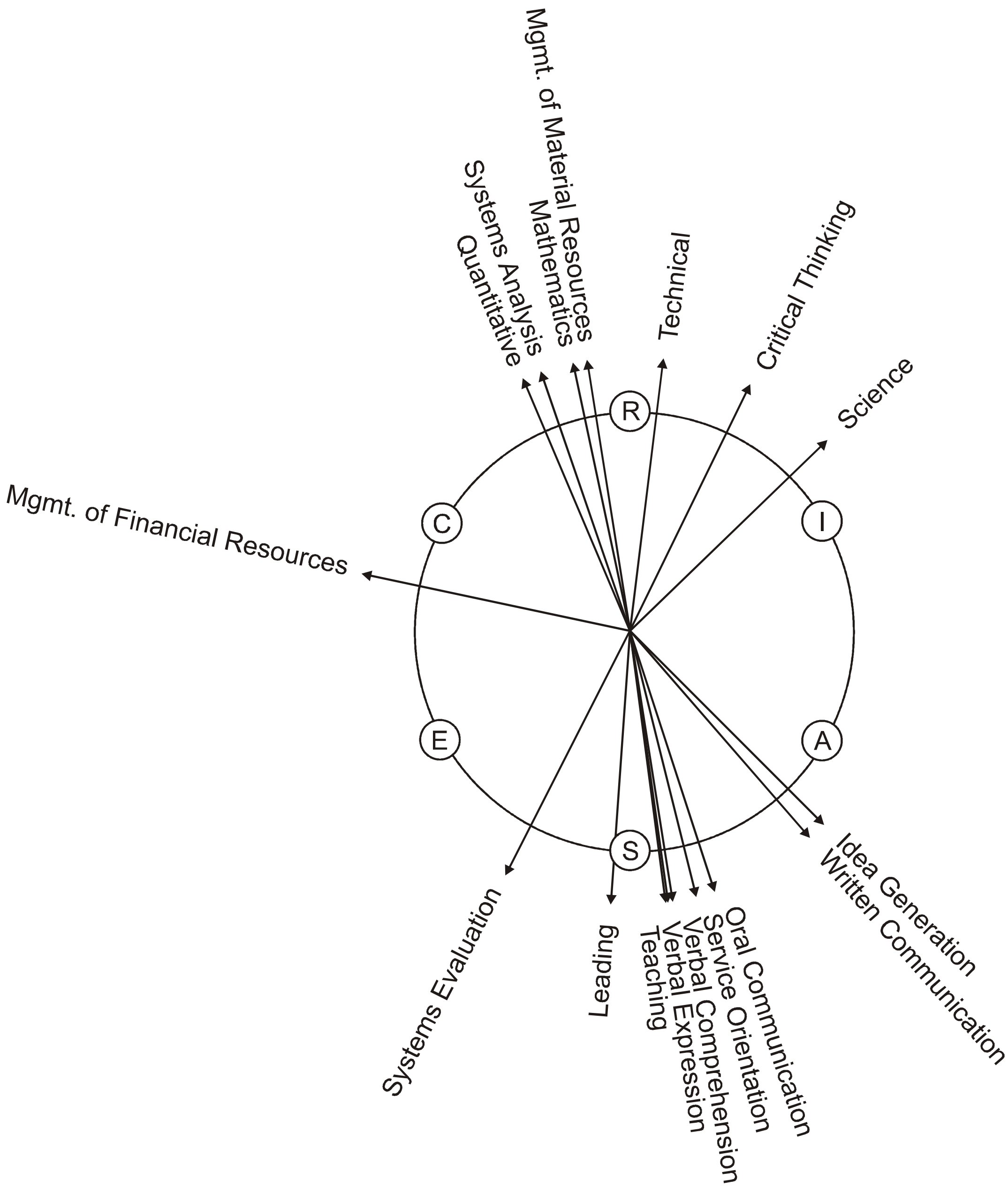

Figure 5. Women's expressed abilities and skills integrated into a RIASEC interest circumplex.

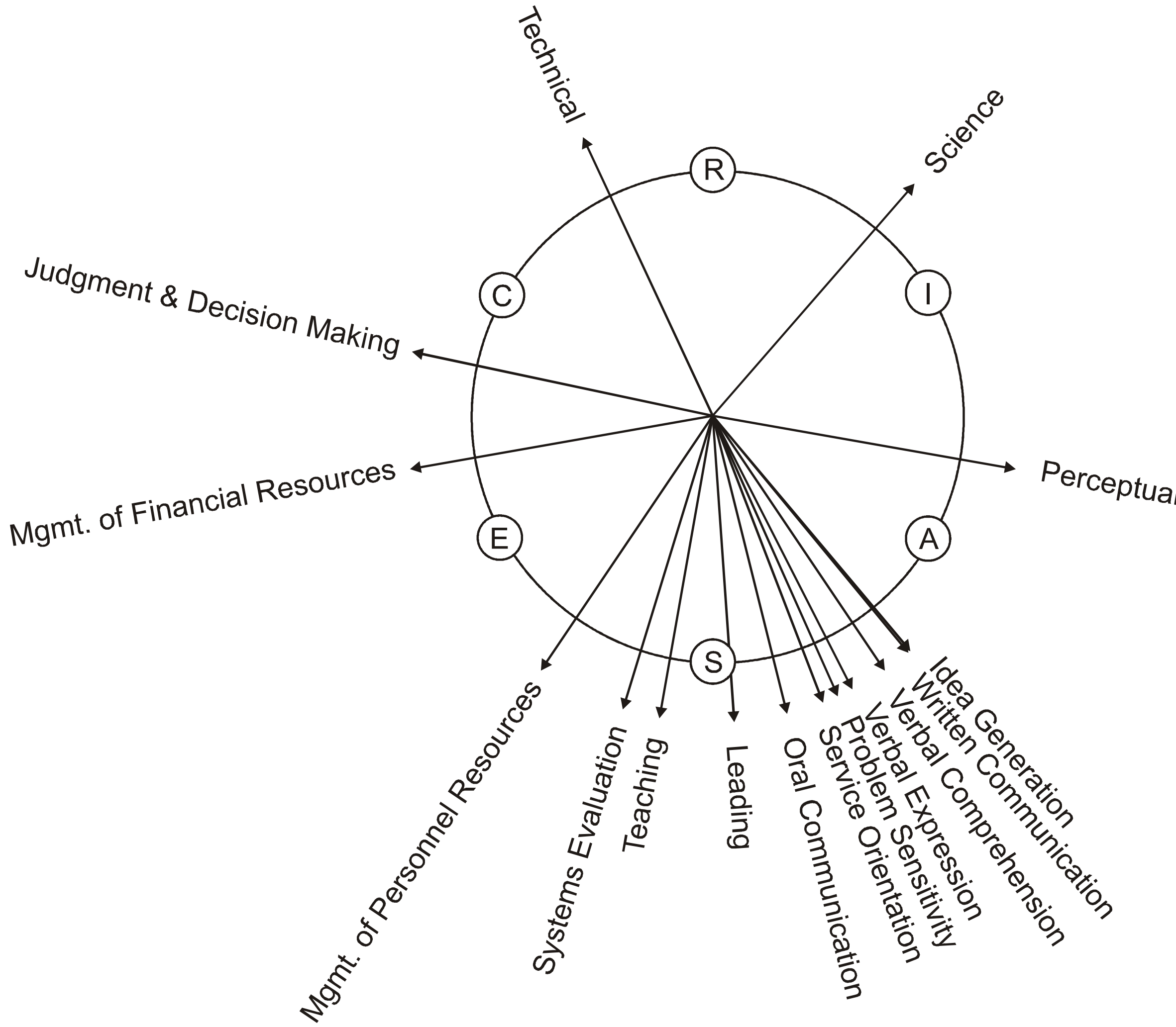

Figure 6. Men's expressed abilities and skills integrated into a RIASEC interest circumplex.

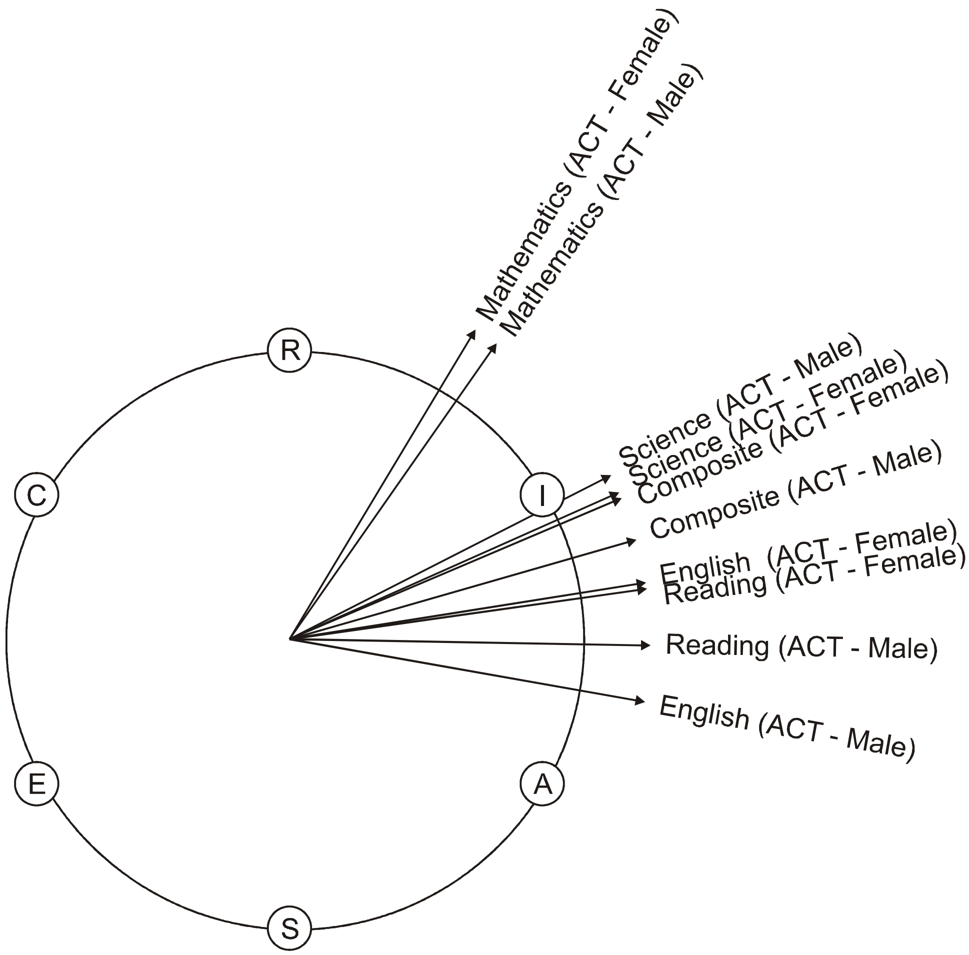

Figure 7. ACT tests integrated into a RIASEC interest circumplex.

5. DISCUSSION

The present study tested integrated models of interests, abilities and skills for person-environment structural equivalence according to Holland's theory. First, mean level analyses were conducted to investigate the appropriateness of this sample for use in structural analysis, and expected gender differences along the Things-People dimension were demonstrated. Next, bootstrapping was applied to property vector fitting, extending this technique beyond point estimates to the application of inferential statistics. There were no significant gender differences found in the integration of abilities and skills into the RIASEC circumplex based on individual ratings. Finally, while the individual and occupation models were equivalent for most of the examined variables, unexpected differences were found in 14 of the 32 (44%) abilities and skills. Discussion of these results focuses on possible implications for Holland's theory, occupational data, and measurement issues.

Gender Differences

The mean level gender differences in interests found along the People-Things dimension is consistent with what has been found repeatedly in previous studies (i.e., Lippa, 1998; Hansen, 2005), that gender is strongly related to this dimension and not to Data-Ideas. While most effect sizes for mean level differences are small, gender accounts for 23% of the variance in Realistic interests, 11% of the variance in Social interests, and 20% of the variance in expressed technical skills. An unexpected gender difference was found in this sample with men rating their Enterprising interests higher than women, however gender accounts for 3% of the variance, suggesting it is not a meaningful result. Overall, results from this sample are consistent with previous research, providing validity evidence supporting the use of this data for structural modeling with property vector fitting analysis.

While the presence of mean level gender differences along the People-Things dimension has significant implications for individual's career decisions and occupational trends in the United States (Lubinski & Benbow, 2007), the differences in preferences do not translate into significant differences in the integrated structure of interests, abilities, and skills. Despite the mean level differences found, the property vector fitting results support that men and women have a common view on how interests, abilities and skills are connected. This shared sense of how these individual characteristics are linked supports Holland's theory of one model for describing both men and women's work personalities.

Although there were no significant differences found in the location and magnitude vectors by comparing confidence intervals based on male and female ratings in the present study, some patterns emerged that warrant additional investigation of gender differences in integrated models. Despite overlapping confidence intervals, there are differences in the extent to which vectors reached the fit criteria for men and women. Future studies applying bootstrapping to property vector fitting should continue to explore the use and interpretation of confidence intervals for the angle and R^2 parameters, particularly regarding sample size requirements, variability, confidence interval width, and the relationship between the R^2 and angle confidence intervals in determining fit to the model.

The results for Quantitative ability and Mathematics skill suggest that there may be possible gender differences in how ability perception is related to career choices. For women, quantitative abilities and skills are linked to the Conventional-Realistic region, whereas for men quantitative abilities and skills are connected with Conventional, Realistic, and Investigative (C-R-I). Quantitative and Mathematics meet the fit criteria for women, but for men the fit is questionable due to wide R^2 and angle confidence intervals. The connection of a variable with multiple areas in the circumplex reduces the strength of the fit in a property vector fitting model. The results are also anchored by the interest types in the opposing direction due to the order prediction, which in this case associates lack of math ability with the People dimension.

These results suggest that for women, math ability is circumscribed to a smaller interest area, whereas for men a wider range of interests is connected with math ability. In this sample, women connect math ability with explicit, systematic computational and technical interests, but not with dynamic, research-oriented interests. Men view math ability as being linked across the area representing structured and dynamic work with things. Reviews of women's career development have implicated stereotypic gender socialization as a barrier in women's career choices, related to restricted vocational interests and underutilization of ability that many women encounter as a result (Betz, 2005). Self-beliefs about math ability in particular have been found to be related to women's career choices, performance, and persistence in science and engineering (Betz, 2005).

A similar pattern can be seen regarding the questionable fit of Perceptual abilities for women spanning the C-R-I region, while for men these abilities fit in the Investigative-Artistic region. Differences were not detected due to overlapping confidence intervals, however, it appears that the connections among these characteristics may vary in nuanced ways for men and women, and more research is needed to determine whether actual differences exist. Previous research on gender differences in abilities has found more variance in quantitative and spatial abilities for men compared to women (Lubinski, 2000; Hedges & Nowell, 1995). The effect that gender differences in variability have on bootstrapped property vector fitting results should be examined in future studies.

Expressed Abilities and Standardized Tests

Previous meta-analysis of intelligence and interests (Ackerman & Heggestad, 1997) has found general cognitive ability to be associated with the Investigative and Artistic types. When imbedded into the interest circumplex in this study, standardized ACT tests of English, Reading, and Science, and composite scores are located in the region between Investigative and Artistic, suggesting that these scores are related to general mental ability. The Mathematics Test is oriented in the region between Realistic and Investigative, suggesting that performance on this test may be more closely linked with math interest. However, all of the angle confidence intervals for ACT tests overlap in the Investigative region, and locations based on angle point estimates alone should not be over-interpreted.

In addition, the expressed abilities and skills appear to be more relativistic and linked to interests. The difference in location between the English Test and expressed verbal abilities suggests that performance on standardized English tests may be more related to general mental ability, while self-perceptions of verbal abilities may be closer linked with interests. These results support Prediger's (1999a) position that assessment of abilities by self-estimate and standardized tests offer related, yet unique information. Standardized ability tests provide information about one's aptitude in an area, while ability self-ratings reflect one's interests as well as ability perceptions.

Integrated Models of Interests, Abilities and Skills

Holland (1997) described six distinct vocational personalities and work environments encompassing interests, abilities, values, and other self-beliefs. Ackerman and Heggestad (1997) proposed four trait complexes that captured the inter-relations among interests, personality, and abilities, named science/math, intellectual/cultural, social, and clerical/conventional. The models created in this study are generally consistent with the concept of four trait complexes, however slightly different groups emerge. The four groups identified from these results can be interpreted as representing technical, science/intellectual, expressive/social, and business trait complexes. Ackerman and Heggestad (1997) did not find any standardized ability measures to be connected with their social trait complex. The results of the present study highlight several expressed abilities and skills linked to Social interest. In fact, more variables integrated into the expressive/social group consistently across individuals and occupations, than in the other groups.

The Technical group includes Realistic interests, and quantitative abilities and technical skills, which are particularly distinct for occupations and women. In the Ackerman and Heggestad (1997) study, there was overlap between the science/math and intellectual/cultural trait complexes, with Investigative interests bridging these two groups. In this study, the location of science skill is significantly different from technical skills, suggesting a second group. This Science/Intellectual group includes Investigative and Artistic interests, expressed science skill, and general intelligence, as represented by the ACT tests. The Expressive/Social group consists of verbal abilities and social skills, idea generation, and Social and Artistic interests. A Business group emerged for the individual models, made up of Enterprising and Conventional interests, and management of financial resources. Judgment and decision making is also included in the group for men. However, the Business trait complex is not represented in the O*NET model.

Regarding the general fit of abilities and skills to the RIASEC circumplex, skills are linked more with interests compared to cognitive abilities. For abilities, 19 out of 45 (42%) of the vectors fit well into the RIASEC model, while 39 out of 51 (76%) skill vectors achieved the fit criteria. The questionable and poor fit of many ability vectors based on individual ratings largely contributes to this difference. Almost half of the abilities have a poor fit with the RIASEC circumplex for individuals, while two-thirds of the abilities based on occupational ratings fit well into the model. For occupations, ability and skill requirements are in general strongly linked to the Holland types, where as for individuals, expressed skills fit well with interests, while the fit of many cognitive abilities is questionable or poor.

Cognitive abilities are viewed as enduring capacities that impact learning and performance (Fleishman et al., 1999). While it was expected that some of the abilities would be connected with interests, many of the cognitive abilities appear to be domain irrelevant and not linked with the RIASEC circumplex, especially based on college student ratings. Reasoning abilities, for example, have a poor fit with the interest model for individuals and occupations. It is likely that college students perceive themselves as capable of deductive and inductive reasoning despite interest preference, and that these abilities are required in occupations with many Holland types. Similarly, memorization, selective attention, and time sharing abilities fit poorly for individuals and are not linked to interests. Skill attainment, on the other hand, requires learning, training, and practice (Fleishman et al., 1999), and interests may be a motivating force for acquiring specific skills.

Integration Along the People-Things Dimension

Many vectors integrate along the People-Things dimension, creating arcs encompassing the Social and Realistic types. This pattern is particularly clear based on occupational and women’s ratings, with most of the vectors for these groups located in either a people or things-oriented arc. As expected, quantitative abilities, and mathematics, systems analysis, and technical skills are associated with working with things for individuals and occupations. Visualization and selective attention abilities are related to Things based only on environmental ratings. Material resource management skills fit with this region for women, while the fit is questionable for men and occupations.

Alternatively, verbal abilities, oral communicational skills, service orientation skill, personnel resource management skill, and leadership skills are linked with the People dimension. Holland links verbal abilities with Artistic, and also includes speaking abilities with Enterprising, which may orient the integration of verbal abilities and communication skills between Artistic and Social when using the property vector fitting technique. Teaching skills are associated with the S type for individuals, and were linked with the A type for occupations, suggesting dynamic work with people. Problem sensitivity is also people-oriented for individual ratings, but not based on environmental demands. On the other hand, time management skill is people-oriented for occupations, yet did not fit the model for individuals. These differences between the individual and occupational models in the integration along the People dimension suggest slight discrepancies in how working with people is viewed by college students and the O*NET occupational database.

Overall, these results support previous findings of the People-Things dimension (Prediger, 1982) as an organizing framework for occupations and individuals' views of their own work personalities. Armstrong et al. (2008) noted a dearth of people-oriented ability constructs in their integration of occupational data into the interest circumplex. In the present study, several skills are associated with working with people, suggesting that skill measures more adequately capture people-oriented work as compared to ability measures. In particular, the teaching and leadership skills in the O*NET typology that are linked to the People dimension represent social skills that could be assessed in addition to cognitive abilities. Standardized tests do not capture the distinct skills related to Social interests (Prediger, 1999a), and basing a career-related decision solely on a cognitive ability measure may have the unintended consequence of limiting the range of occupations an individual considers. Social skills, such as social perceptiveness, instructing, persuasion, and negotiation, should be considered in addition to cognitive abilities in making career decisions. These appear to be unique skills linked to the helping and business professions.

Integration Along the Structured-Dynamic Dimension

Prediger's (1982) Data-Ideas dimension has also been described as representing differences in the structured versus dynamic nature of work environments (Armstrong et al., 2008). Compared to People-Things, few property vectors integrate consistently across individual and environmental ratings in this dimension. Most notably, there are no vectors in the structured direction based on environmental demands. These results suggest that current occupational measures do not represent demands unique to structured work environments.

For example, information ordering ability describes organization based on rules and patterns, consistent with a structured Conventional work environment, yet the definition also includes arranging things or actions, related to Realistic work. Information ordering is linked with the Things dimension for occupations, fits questionably toward Conventional for women, and has a poor fit for men. The name implies systematic, explicit, ordered tasks consistent with a structured work environment, yet the definition also describes working with things, likely contributing to inconsistent results in the integration of this ability. The item includes both Conventional and Realistic components, leaving the meaning of the item open for interpretation, which may be affected by an individual's interests. Additionally, judgment and decision making skill is oriented in the structured direction for men, has a questionable fit in the things-oriented direction for women, and has a poor fit for occupations. These demonstrate different views of potential structure-oriented abilities.

Additionally, the results suggest that occupational data for some structured-oriented constructs may have been rated in a way inconsistent with Holland's model. Financial resource management skill fits as expected in the structured direction between the E and C types based on individual ratings. However, this skill is associated with the Social type for environmental ratings, suggesting that the management aspect was emphasized more than working with financial data. It is difficult to determine whether it is the occupational interest profile ratings, the analyst and incumbent ratings of abilities and skills, or an interaction of the interest and ability ratings that contribute to this result. The mean inter-rater agreement based on the Gamma statistic for the occupational interest profiles suggest that there was less agreement among raters for Enterprising and Conventional work environments compared to the other four Holland types (Rounds et al., 1999). The lower level of agreement among raters for dynamic work environments may be contributing these results. The effect of the reliability of occupational data on integrated models should be investigated in future studies.

Several abilities and skills were expected to be associated with the dynamic dimension characterized by unstructured tasks and creative activities. Idea generation abilities and written communication skills are oriented in this direction for individuals and occupations. Science skill is located between the I and R types, suggesting dynamic work with things. Additionally, there are several differences in the integration of individual and environmental ratings in the dynamic direction. Category flexibility, critical thinking, and complex problem solving skills, are oriented in the dynamic dimension based on environmental demands. For individuals, these have a poor to questionable fit with the model, with the exception of critical thinking, which is related to working with things for women. Perceptual abilities are linked with the dynamic region for men, but are things-oriented for occupations, suggesting that for men perceptual abilities are viewed at a higher level of abstraction, while conceptualized more concretely in the occupational ratings.

Implications

The integrated models of interests, abilities and skills for individuals and occupations have more similarities than differences, supporting the use of Holland's theory and the interest circumplex as an organizing framework for individual differences and occupational information. The general agreement between the person and environment models represents a shared view of the inter-relationships between interests, abilities, and skills; that in general, individuals' self-perceptions are consistent with how the world of work is organized. This supports the use of the RIASEC model providing a parallel framework for both individuals and occupations, based on Holland's (1997) theory of vocational personalities and work environments, and provides validity evidence for O*NET Online as a career exploration tool with college students.

As described throughout this discussion, there are several possible explanations for differences found between the individual and environment models. In summary, these may be explained by differences in a number of areas, including the interpretation of meaning (i.e., problem sensitivity, information ordering), the level of abstraction or complexity perceived in the interpretation of an ability or skill (i.e., perceptual), the relevance an ability or skill has to interests (i.e., time management, visualization), how an ability or skill is connected with multiple interest types (i.e., critical thinking), and possible inaccuracies in occupational ratings (i.e., financial resource management, memorization). These conjectures need further research, and need to be explored in applied settings. Nevertheless, it is promising that most of the constructs were viewed similarly based on individual and occupational ratings.

The People-Things dimension emerged as a clear organizing framework for the occupational and female models, with most constructs integrating in either the People (i.e., service, leadership) or Things direction (i.e., technical, quantitative). People-Things has been viewed as a sex-typed or gendered dimension (Lippa, 1998), and appears to be pervasive in women's self-perceptions of their career interests and abilities, as well as in the organization of occupational data. It may be that women's self-perceptions are more influenced or circumscribed by sex-type, while men's self-perceptions are less circumscribed along this dimension, suggesting possible gender differences for Gottfredson's (1981) theory of circumscription and compromise.

Based on the variability of men's results and the nonsignificant property vectors in this two-dimensional model (i.e., reasoning abilities, complex problem solving skills), it appears there may be other important organizing factors not investigated in this study, such as prestige (Tracey & Rounds, 1996) or level of complexity (Armstrong et al., 2008) as a third dimension underlying interests (Tracey & Rounds, 1996). In addition, ability level and complexity may be possible moderating variables in the integration of ability perceptions into the interest circumplex. For example, related to the previous discussion of possible differences in the view of level of abstraction relative to perceptual abilities, perceptual abilities may be linked with working with things for individuals with average ability, and connected with dynamic work (Investigative-Artistic) for those with higher levels of cognitive ability. This possible interaction should be examined in future research on integrated models of interest and ability.

The methodological implications of this study are two-fold. First, the integration of ACT tests in expected locations (i.e., Science test aligned with Investigative, Math test aligned between the R and I types) provides validity evidence for the Interest Profiler as a measure of vocational interests. Second, previous studies using property vector fitting were limited by point estimate results. In this study, a bootstrapping technique was applied to property vector fitting to generate confidence intervals for the R^2 and angle property vector parameters, allowing for comparisons between groups. The use of bootstrapping in this and future studies will allow researchers to more accurately interpret and better understand the results of integrated models using the property vector fitting technique.

Limitations and Future Directions

The generalizability of this study is limited to Caucasian college students in the Midwest region of the United States. Given a nonrandom sample of college students enrolled in undergraduate psychology classes from one Midwestern university, the majority of whom identified as Caucasian American, the findings may not generalize beyond the characteristics of the present sample. However, generating integrated models of individual differences based on college student ratings is useful in understanding the vocational behavior of this segment of the young adult population who are in the process of making career-related decisions, and may use occupational databases through the career exploration process. Future research should employ participants of various life-stages, more diverse ethnic populations, and educational levels. Additional individual differences related to the career-decision making process such as values and goals should be integrated into the interest model in the future.

Studies of these integrative models should also explore a possible third-dimension underlying interests, as well as possible interactions.

Cognitive ability and skill measures designed to assess environmental demands of occupations were adapted as self-rated measures of individuals' expressed abilities and skills. It was originally planned to combine single items into subscales based on the hierarchical arrangement of abilities and skills (Fleishman et al., 1999; Mumford et al., 1999), yet preliminary analyses revealed that subscales generated in this way obscured some of the results due to heterogeneous item content. Items were instead combined using a rational method holding to the original categorization as appropriate, yet separating items with differing content. In addition, process and social skills were combined into new categories based on a rational method, which may be limited by the researcher's judgment. The subscales vary in item number from one item (i.e., memorization) to eleven (i.e., technical skills), which may affect the results. It is recommended that future studies use factor analysis to identify unique subscales in the ability and skill measures.

The interest measure in this study was adapted for research purposes, using the items best representing the RIASEC structure. Property vector fitting based on other interest measures may produce different results. However, the convergent validity of the Interest Profiler was supported in this study by the strong fit of ACT test scores into the interest circumplex. Regarding limitations of the statistical analysis, a correction was not used to account for multiple comparisons when constructing the bootstrapped confidence intervals.

Finally, fit to the integrative model was interpreted in previous research based on point estimates using the guideline of $R^2 > .50$ (Armstrong et al., 2004; 2008). The distribution information obtained from the bootstrapped confidence intervals brings to light the importance of the angle confidence interval width in fit interpretation. Criteria of fit, questionable fit, and poor fit used for interpreting the results of this study are extensions of the previous guidelines, and should be used cautiously based on this single study. Interpretations based on property vectors with questionable fit are suggestive of emerging patterns that should be further investigated. The results should be interpreted cautiously due to the exploratory nature of this study. Future studies should continue to explore the assumptions and potential limitations associated with the new statistical technique of bootstrapping property vector fitting models.

Conclusions

These results demonstrate that the interest circumplex structure is a useful model for integrating many O*NET abilities and skills. Holland’s model can be used effectively to integrate these characteristics for men and women without gender bias, and consistently for people and work environments in most cases. However, abilities and skills with a questionable or poor fit suggest that there are limitations to using a two-dimensional RIASEC model for capturing the complexity of work environments and individual characteristics. Differences found between the individual and environmental models also warrant future investigation.

Property vector fitting has been used in the past to produce point estimate results representing the degree of fit and location of a variable within a multi-dimensional space. The lack of inferential tests for this technique limited broader applications, such as looking at differences in the integration of variables, and in comparing groups. The generation of confidence intervals for property vector parameters using bootstrapping appears to be a promising technique that allows for greater understanding of integrated models, and the differences in inter-relationships between groups. Future studies should continue to explore the use and appropriate interpretation of bootstrapped property vector fitting models.

This study also adds to the literature by demonstrating the well-known gender differences in mean level of interests, as well as showing structural agreement in integrated models for men and women in the same sample. Although gender differences exist in the amount of interests by Holland type, the RIASEC circumplex can be used to represent work personalities for both men and women. This study also suggests that men and women may perceive the integration of interests, abilities and skills in nuanced ways that should be investigated in the future, particularly considering gender differences in the variance of interests and abilities.

Finally, four trait complexes emerged in the integration of interests, abilities, and skills: technical, science/intellectual, expressive/social, and business. These results challenge Ackerman and Heggestad's (1997) finding that there are no abilities related to the social type, which used standardized intelligence measures. The integrated models also highlight the underrepresentation of abilities and skills unique to structured, business work environments in the current O*NET database. This study identifies abilities and skills linked with each of the trait complexes, based on characteristics required by occupations, and expressed ability ratings in addition to standardized tests.

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APPENDIX

*O*NET Cognitive Ability and Skill Hierarchy and Definitions*

O*NET Construct	Operational Definition
Cognitive Abilities	Abilities that influence the acquisition and application of knowledge in problem solving
A. Verbal abilities	Abilities that influence the acquisition and application of verbal information in problem solving
A1. Oral comprehension	The ability to listen to and understand information and ideas presented through spoken words and sentences.
A2. Written comprehension	The ability to read and understand information and ideas presented in writing.
A3. Oral expression	The ability to communicate information and ideas in speaking so others will understand.
A4. Written expression	The ability to communicate information and ideas in writing so others will understand.
B. Idea generation and reasoning abilities	Abilities that influence the application and manipulation of information in problem solving
B1. Fluency of ideas	The ability to come up with a number of ideas about a topic (the number of ideas is important, not their quality, correctness, or creativity).
B2. Originality	The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem.
B3. Problem sensitivity	The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.
B4. Deductive reasoning	The ability to apply general rules to specific problems to produce answers that make sense.
B5. Inductive reasoning	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).
B6. Information ordering	The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, mathematical operations).
B7. Category flexibility	The ability to generate or use different sets of rules for combining or grouping things in different ways.
C. Quantitative abilities	Abilities that influence the solution of problems involving mathematical relationships
C1. Mathematical reasoning	The ability to choose the right mathematical methods or formulas to solve a problem.

C2. Number facility	The ability to add, subtract, multiply, or divide quickly and correctly.
D. Memory	Abilities related to the recall of available information
D1. Memorization	The ability to remember information such as words, numbers, pictures, and procedures.
E. Perceptual abilities	Abilities related to the acquisition and organization of visual information
E1. Speed of closure	The ability to quickly make sense of, combine, and organize information into meaningful patterns.
E2. Flexibility of closure	The ability to identify or detect a known pattern (a figure, object, word, or sound) that is hidden in other distracting material.
E3. Perceptual speed	The ability to quickly and accurately compare similarities and differences among sets of letters, numbers, objects, pictures, or patterns. The things to be compared may be presented at the same time or one after the other. This ability also includes comparing a presented object with a remembered object.
F. Spatial abilities	Abilities related to the manipulation and organization of spatial information
F1. Spatial orientation	The ability to know your location in relation to the environment or to know where other objects are in relation to you.
F2. Visualization	The ability to imagine how something will look after it is moved around or when its parts are moved or
G. Attentiveness	Abilities related to application of attention
G1. Selective attention	The ability to concentrate on a task over a period of time without being distracted.
G2. Time sharing	The ability to shift back and forth between two or more activities or sources of information (such as speech, sounds, touch, or other sources).
Basic Skills	Developed capacities that facilitate learning or the more rapid acquisition of knowledge
A. Content skills	Background structures needed to work with and acquire more specific skills in a variety of different domains
A1. Reading comprehension	Understanding written sentences and paragraphs in work related documents.
A2. Active listening	Giving full attention to what other people are saying.
A3. Writing	Communicating effectively in writing as appropriate for the needs of the audience.
A4. Speaking	Talking to others to convey information effectively.
A5. Mathematics	Using mathematics to solve problems.
A6. Science	Using scientific rules and methods to solve problems.

B. Process skills	Procedures that contribute to the more rapid acquisition of knowledge and skill across a variety of domains
B1. Critical thinking	Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.
B2. Active learning	Understanding the implications of new information for both current and future problem-solving and decision-making.
B3. Learning strategies	Selecting and using training/instructional methods and procedures appropriate for the situation when learning or teaching new things.
B4. Monitoring	Monitoring/assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action.
Cross-Functional Skills	Developed capacities that facilitate performance of activities that occur across jobs
C. Social skills	Developed capacities used to work with people to achieve goals
C1. Social perceptiveness	Being aware of others' reactions and understanding why they react as they do.
C2. Coordination	Adjusting actions in relation to others' actions.
C3. Persuasion	Persuading others to change their minds or behavior.
C4. Negotiation	Bringing others together and trying to reconcile differences.
C5. Instructing	Teaching others how to do something.
C6. Service orientation	Actively looking for ways to help people.
D. Complex problem solving skills	Developed capacities used to solve novel, ill-defined problems in complex, real-world settings
D1. Complex problem solving	Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.
E. Technical skills	Developed capacities used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems
E1. Operations analysis	Analyzing needs and product requirements to create a design.
E2. Technology design	Generating or adapting equipment and technology to serve user needs.
E3. Equipment selection	Determining the kind of tools and equipment needed to do a job.
E4. Installation	Installing equipment, machines, wiring, or programs to meet specifications.

E5. Programming	Writing computer programs for various purposes.
E6. Operation monitoring	Watching gauges, dials, or other indicators to make sure a machine is working properly.
E7. Operation and control	Controlling operations of equipment or systems.
E8. Equipment maintenance	Performing routine maintenance on equipment and determining when and what kind of maintenance is needed.
E9. Troubleshooting	Determining causes of operating errors and deciding what to do about it.
E10. Repairing	Repairing machines or systems using the needed tools.
E11. Quality control analysis	Conducting tests and inspections of products, services, or processes to evaluate quality or performance.
F. Systems skills	Developed capacities used to understand, monitor, and improve socio-technical systems
F1. Judgment and decision making	Considering the relative costs and benefits of potential actions to choose the most appropriate one.
F2. Systems analysis	Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes.
F3. Systems evaluation	Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.
G. Resource management skills	Developed capacities used to allocate resources efficiently
G1. Time management	Managing one's own time and the time of others.
G2. Management of financial resources	Determining how money will be spent to get the work done, and accounting for these expenditures.
G3. Management of material resources	Obtaining and seeing to the appropriate use of equipment, facilities, and materials needed to do certain
G4. Management of personnel resources	Motivating, developing, and directing people as they work, identifying the best people for the job.

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