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Gendered Occupational Interests: Prenatal Androgen Effects on Psychological Orientation to Things Versus People

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Abstract

There is considerable interest in understanding women's underrepresentation in science, technology, engineering, and mathematics careers. Career choices have been shown to be driven in part by interests, and gender differences in those interests have generally been considered to result from socialization. We explored the contribution of sex hormones to career-related interests, in particular studying whether prenatal androgens affect interests through psychological orientation to Things versus People. We examined this question in individuals with congenital adrenal hyperplasia (CAH), who have atypical exposure to androgens early in development, and their unaffected siblings (total $N = 125$ aged 9 to 26 years). Females with CAH had more interest in Things versus People than did unaffected females, and variations among females with CAH reflected variations in their degree of androgen exposure. Results provide strong support for hormonal influences on interest in occupations characterized by working with Things versus People.

Keywords

androgens; interests; occupations; sex differences; congenital adrenal hyperplasia; STEM careers

Sex differences in occupations are a subject of intense scientific and public interest, with particular concern about women's underrepresentation in science, technology, engineering, and mathematics (STEM) careers. Many explanations of this disparity have been offered, including cultural stereotypes about what is acceptable for the sexes, situational cues that induce identity threat, social barriers that hinder women's success, and personal characteristics, such as cognitive abilities and interests (reviewed in Ceci and Williams, 2007; Halpern et al., 2007).

Particular attention has focused on interests that are stable and predict career choices, even across many years. A meta-analysis showed vocational interests to be strongly consistent

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from early adolescence to middle adulthood (Low et al., 2005). In fact, vocational interests in high school and college have been shown to predict occupations up to 30 years later (Hansen, 2005; Rottinghaus et al., 2007).

Gender differences in occupational interests have generally been considered to result from socialization (Eccles, 1994). For example, children's occupational interests and career choices are linked to their parents' expectations: Parents' gender-typed occupational expectations for their 15-year-old children predicted children's gender-typed occupational expectations two years later; moreover, parents' expectations about gender-typed occupations for their children at age 17 predicted the children's actual career choices at age 28 (Jacobs et al., 2006). Further, situational cues may affect interest in STEM careers through social identity threat (Murphy et al., 2007).

Gendered occupational interests are also influenced by sex-related biological factors, particularly sex hormones such as androgens. These hormones are present early in development and organize the brain, as studies in nonhuman animals show (Wallen, 2009). In people, prenatal androgen levels and gender socialization are typically confounded, but their effects can be disentangled in females with congenital adrenal hyperplasia (CAH), who are exposed to higher than normal (sex-atypical) prenatal androgen levels but who are reared and identify as female.

Consistent with hormone effects on interests, females with CAH are considerably more interested than are females without CAH in male-typed toys, leisure activities, and occupations, from childhood through adulthood (reviewed in Blakemore et al., 2009; Cohen-Bendahan et al., 2005); adult females with CAH also engage more in male-typed occupations than do females without CAH (Frisén et al., 2009). Male-typed interests of females with CAH are associated with degree of androgen exposure, which can be inferred from genotype or disease characteristics (Berenbaum et al., 2000; Meyer-Bahlburg et al., 2006; Nordenström et al., 2002). Interests of males with CAH are similar to those of males without CAH because both are exposed to high (sex-typical) prenatal androgens and are reared as boys.

Females with CAH do not provide a perfect test of androgen effects on gendered characteristics because they differ from females without CAH in other ways; most notably they have masculinized genitalia that might affect their socialization. But, there is no evidence that parents treat girls with CAH in a more masculine or less feminine way than they treat girls without CAH (Nordenström et al., 2002; Pasterski et al., 2005). Further, some findings from females with CAH have been confirmed in typical individuals whose postnatal behavior has been associated with prenatal hormone levels measured in amniotic fluid. Amniotic testosterone levels were found to correlate positively with parent-reported male-typed play in girls and boys at ages 6 to 10 years (Auyeung et al., 2009).

The psychological mechanism through which androgen affects interests has not been well-investigated, but there is some consensus that sex differences in interests reflect an orientation toward people versus things (Diekmann et al., 2010) or similar constructs, such as organic versus inorganic objects (Benbow et al., 2000). The Things-People distinction is, in fact, the major conceptual dimension underlying the measurement of the most widely-used model of occupational interests (Holland, 1973; Prediger, 1982); it has also been used to represent leisure interests (Kerby and Ragan, 2002) and personality (Lippa, 1998). For example, occupational interests measured by the Strong Interest Inventory (Harmon et al., 1994) are classified into six dimensions (Realistic, Investigative, Artistic, Social, Enterprising, Conventional, RIASEC), that form two higher-order, orthogonal, bipolar factors, Things-People and Data-Ideas. The Things-People factor displays a large sex

difference, $d = .93$, whereas the Data-Ideas factor does not, $d = -.10$ (Su et al., 2009). Boys and men prefer occupations related to objects (e.g., auto mechanic, chemist), whereas girls and women prefer occupations involving work with people (e.g., day care worker, art teacher).

In this study we tested whether prenatal androgen effects on occupational interests reflect the underlying psychological dimension of things versus people. Specifically, we hypothesized that females with CAH would have masculinized occupational interests, and thus, compared to unaffected females, would have more interest in Things-People. Moreover, scores of females with CAH on interest in Things-People were hypothesized to be correlated with their degree of prenatal androgen exposure.

Method

Participants

Females and males with congenital adrenal hyperplasia (CAH) due to 21-hydroxylase deficiency were studied as part of an ongoing project on androgen effects on psychological development. They were recruited through university-affiliated pediatric endocrinology clinics in the Midwestern United States, and compared to their unaffected siblings. Occupational interests were assessed in 125 individuals: 46 females with CAH, 21 unaffected sisters, 27 males with CAH, and 31 unaffected brothers. Participants aged from 9 to 26 years ($M = 16.0$, $SD = 4.5$); groups did not differ in age, $F(3, 121) = .65$, $p > .05$. Because not all participants with CAH had a same-sex sibling, siblings of males and females with CAH were combined to form control groups. Participants represented a variety of socioeconomic backgrounds and most were Caucasian. Other findings from the larger study are summarized elsewhere (e.g., Blakemore et al., 2009). The main hypotheses concerned females, but males were also tested to examine specificity of findings.

Degree of prenatal androgen exposure was indexed by two features of the disease (Speiser, 2001), rated from medical records (see Berenbaum et al., 2000 for details). (1) Type of CAH was classified from least to most severe (Speiser, 2001): nonclassical (NC), simple virilizing (SV), mild salt-wasting (SW), and severe SW. SW-CAH required elevated plasma renin activity for age and responsiveness to mineralocorticoid therapy. Classification as mild SW-CAH required that all measurements of serum sodium be at least 129 mmol/L, and that there be no episodes of hypotension or shock; classification as severe SW-CAH required that serum sodium in the neonatal period be less than 129 mmol/L, or that there be at least one episode of hypotension or shock. Information on disease type was available for 43 of 46 females with CAH (6 NC, 5 SV, 10 mild SW, 22 severe SW) and all 27 males with CAH (5 NC, 1 SV, 5 mild SW, 16 severe SW). (2) Genital virilization at birth was rated on the Prader scale (Prader, 1954), which ranges from 0 (typical female genitalia) through 6 (typical male genitalia). This information was available for 37 of 46 females with CAH; scores ranged from 0 to 4 ($M = 2.4$, $SD = 1.5$). The two indices of prenatal androgen exposure (CAH type and Prader rating) were significantly related for females with CAH, $r(37) = .73$, $p < .01$.

Measures and Procedure

The Occupational Interests Inventory (OII) was developed for this study because standard instruments are intended only for older adolescents and adults. The OII parallels the Strong Interest Inventory (Harmon et al., 1994) and measures the same dimensions (Realistic, Investigative, Artistic, Social, Enterprising, Conventional, RIASEC) in participants of a wide age range. Participants rated their interest in each of 64 jobs by indicating whether they would *dislike* (0), be *indifferent* to (1), or *like* (2) doing that type of work.

A composite score was created for each RIASEC dimension by averaging items representing that dimension (see Table 1), excluding 17 items endorsed by less than 10% of the sample; high scores indicate high interest. The Conventional dimension was excluded because it had few items and low reliability, consistent with other findings (Lippa, 1998). The remaining five RIASEC scores were internally consistent (see Table 1).

Results

Descriptive data and group comparisons (from independent samples *t*-tests) for the five RIASEC composite scores are presented in Table 2. There were large sex differences in four of the five RIASEC dimensions examined: Unaffected females reported more interest in Artistic, Social, and Enterprising occupations than did unaffected males, whereas unaffected males reported more interest in Realistic occupations than did unaffected females. Females with CAH also reported more interest in Realistic and Investigative occupations than did unaffected females; differences were moderate in size. Males with CAH and unaffected males did not differ significantly on any of the five RIASEC dimensions.

The validity of the OII for assessing the Things-People distinction was determined by correcting the five RIASEC composite scores for overall response set (tendency to endorse items) and then conducting a principal components analysis with varimax rotation to extract two components (Lippa, 1998). Response set correction involved subtracting a participant's average response (mean of five RIASEC composite scores) from each composite score. Groups did not differ in response set, $F(3, 121) = 1.29, p > .05$. The five RIASEC dimensions defined the two expected components that could be labeled *Things-People* and *Data-Ideas*; Figure 1 shows the location of the dimensions in two-component space. The only anomaly was the Artistic dimension: it loaded on Data more than Ideas, perhaps reflecting the meaning of "art" for children versus adults. The Artistic dimension was appropriately represented on Things-People.

The Things-People component score was used for subsequent analyses; higher scores represent a predominance of interest in Things, and lower scores a greater interest in People. The Data-Ideas component was not considered further because it shows no sex difference.

Androgen effects on interests were examined by comparing groups on Things-People using a two-way analysis of variance (ANOVA), with factors of sex (male, female) and condition (CAH, unaffected). The primary hypothesis was tested in the interaction between sex and condition, which was expected to result from a specific pattern of group means reflecting interest in Things relative to People: unaffected females < females with CAH < males with CAH = unaffected males.

Results supported our hypotheses, as shown in Table 3. There was a significant sex difference (females had lower scores than males), $F(1, 121) = 47.16, p < .001$, partial $\eta^2 = .28$, no significant effect of condition, $F(1, 121) = 2.49, p > .05$, partial $\eta^2 = .02$, and a significant interaction between sex and condition, $F(1, 121) = 5.51, p < .05$, partial $\eta^2 = .04$. The interaction was probed with *t*-tests using Type I error of .01 to correct for multiple comparisons. Statistical test results and *d*'s are shown in Table 3. Interest in Things relative to People was higher in females with CAH than in unaffected females, and lower than in males (CAH and unaffected). Unaffected females showed less interest in Things relative to People than males. Males with and without CAH were not significantly different. There were no between-group differences in variability ($p > .05$ for all Levene's equality of variance tests).

There was considerable within-group variability, as shown in Figure 2. We examined whether variability among individuals with CAH was related to degree of prenatal androgen

exposure. Among females with CAH, scores on Things-People were positively correlated with degree of androgen exposure, reflected in both degree of genital virilization, $r(37) = .39, p < .01$, and CAH type, $r(43) = .34, p < .05$. Females with severe SW-CAH had higher scores on Things-People ($M = .16, SD = .83$) than females with other forms of CAH: mild SW ($M = -.81, SD = .85$), SV ($M = -.85, SD = 1.17$), and NC ($M = -.46, SD = .43$). Among males with CAH, scores on Things-People were not significantly correlated with CAH type, $r(27) = -.07, p > .05$.

Discussion

The results support the hypothesis that sex differences in occupational interests are due, in part, to prenatal androgen influences on differential orientation to objects versus people. Compared to unaffected females, females with CAH reported more interest in occupations related to Things versus People, and relative positioning on this interest dimension was substantially related to amount of prenatal androgen exposure. Females with CAH scored in between males and typical females on the Things-People dimension; their intermediate score might reflect a dose effect of prenatal androgen or the feminizing effects of socialization or other biological factors related to XX karyotype.

These findings extend previous work by identifying an underlying psychological dimension – interest in engaging with objects versus people – for prenatal androgen effects on leisure and occupational interests (Berenbaum, 1999; Meyer-Bahlburg et al., 2006). This work is relevant to the broad question of women's underrepresentation in STEM careers because it points to a hormonally-influenced psychological characteristic – interest in working with objects versus people – that underlies vocational interests. Those interests are important because they predict career choices (Hansen, 2005; Rottinghaus et al., 2007). Our results suggest that typical women, who are exposed to low levels of prenatal androgen, participate less than do men in STEM careers partly because they are interested in working with people. This is consistent with evidence that women value communal goals, which are perceived to be at odds with STEM careers (Diekman et al., 2010) and that women who enter STEM careers often do so in people-oriented professions, such as medicine (Benbow et al., 2000).

There are several methodological issues to consider in interpreting the results. First, CAH is not a perfect experiment; females with CAH differ from unaffected siblings in ways other than prenatal androgen. Nevertheless, prenatal androgen is the most likely explanation for the results because there was a high correlation between degree of prenatal androgen exposure and occupational interest, and males with CAH did not differ from unaffected males; further, androgen effects on interests have been confirmed in typical samples (Auyeung et al., 2009). Second, our sample was not racially or ethnically diverse. However, the structure of interests is invariant across ethnic groups (Gupta et al., 2008). Third, the measure we used was developed specifically for this study. But it is based upon the RIASEC theoretical framework, generally conformed to the expected higher-order structure, and Things-People showed the expected sex difference (Su et al., 2009).

An important issue concerns the bipolarity of Things-People. Although analyses generally produce a bipolar factor, it is important to consider the possibility that there are two separate dimensions – Things *and* People. This parallels discussions of the dimensionality of gender-typing, with the original conceptualization of a bipolar dimension of masculinity-femininity refined to acknowledge the separability of masculinity and femininity (Bem, 1975). The bipolar structure of Things-People is maintained by standard analyses that include correction for response set and varimax rotation in factor analyses. Our sample was not large enough to determine whether occupational interests were better described by two separate factors than by a single bipolar factor.

Nevertheless, some insight into the nature of Things-People is provided by an examination of group means for the Realistic and Social dimensions which anchor theoretically (Prediger, 1982) and empirically (Figure 1) the poles of Things and People, respectively. As shown in Table 2, the pattern of findings on Realistic and Social composite scores for unaffected males and females is consistent with an interpretation of Things-People as a bipolar dimension: Males were interested in Realistic but not Social occupations whereas females were interested in Social but not Realistic occupations. The pattern of findings for females with CAH, however, might be easier to interpret with two separate dimensions (Things and People) rather than a bipolar one. Females with CAH reported similar interest in Realistic and Social occupations, resulting in a score on the Things-People component that is close to 0, which should not be interpreted as a lack of occupational interests. Moreover, compared to unaffected females, females with CAH were as interested in Social occupations but more interested in Realistic occupations (although not as interested as unaffected males). This suggests that the scores of females with CAH on Things-People reflect an increased interest in Things-related occupations and not a decreased interest in People-related occupations.

Our findings indicate that career choices are influenced by prenatal androgens through a psychological orientation to objects versus people that manifests in gender-typed occupational interests. We emphasize, however, the complexity of career choices: Occupational interests are not determined exclusively by sex or prenatal androgen exposure, as seen in the overlapping scores of our groups, and in other data showing parent socialization of occupational interests (Eccles, 1994); moreover, interests are only one contributor to career choice (Ceci and Williams, 2007; Halpern et al., 2007). In combination with other findings on gendered interests, our results are relevant to efforts to increase participation of girls and women in STEM careers. It is important to recognize that career choices have roots in early-developing and biologically-influenced interests. Girls and women might be encouraged to pursue STEM careers by focusing on the ways in which an orientation to people is compatible with those careers.

Research Highlights

- Sex-typed interests partly underlie women's underrepresentation in STEM careers
- Sex-typed career interests are influenced by prenatal androgens
- Sex-typed career interests reflect orientation to objects (vs. people)
- Females with CAH are more likely than controls to prefer careers related to objects
- Prenatal androgens affect interests through orientation to Things vs. People

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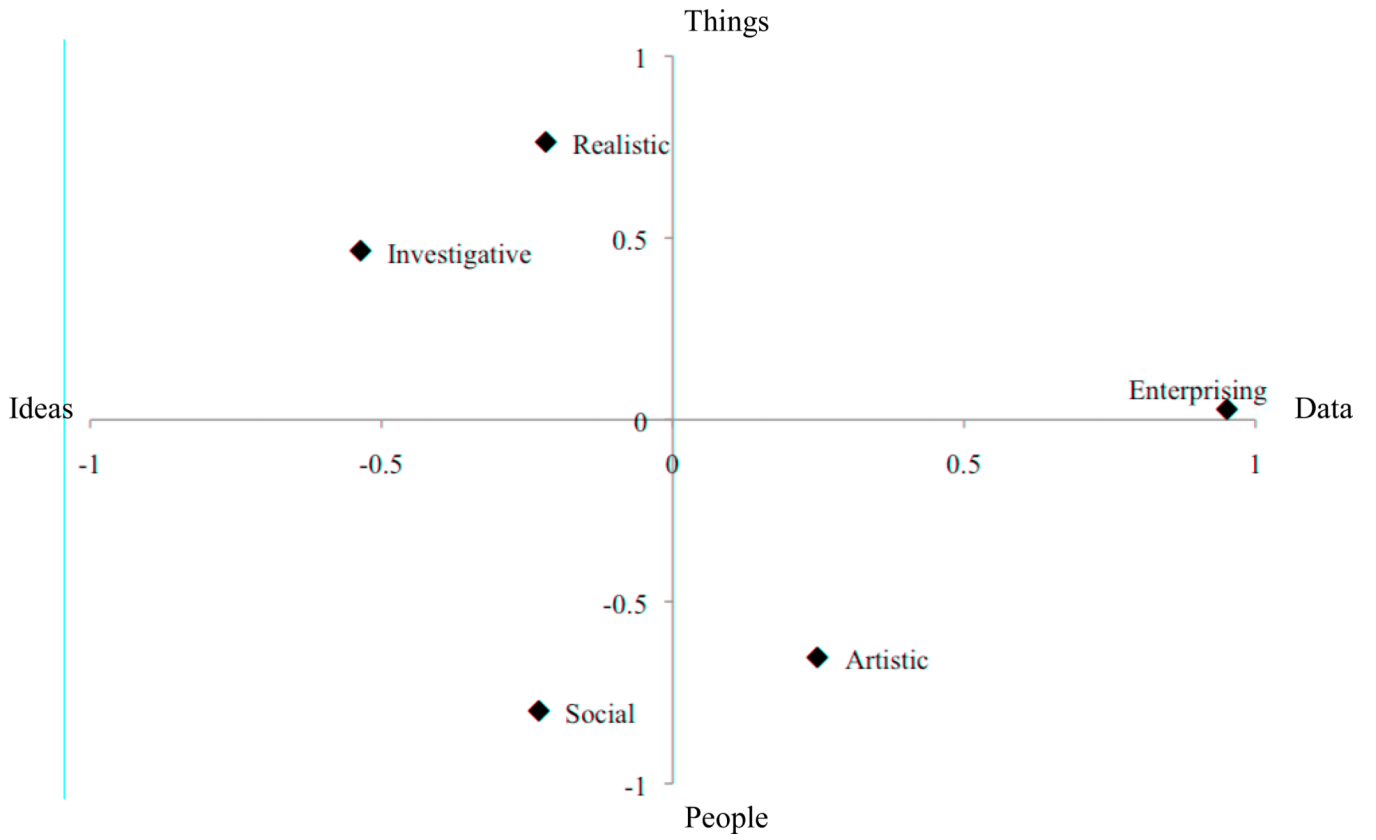


Figure 1. Five RIASEC dimensions plotted according to their loadings on two extracted and rotated orthogonal components, Things-People and Data-Ideas.

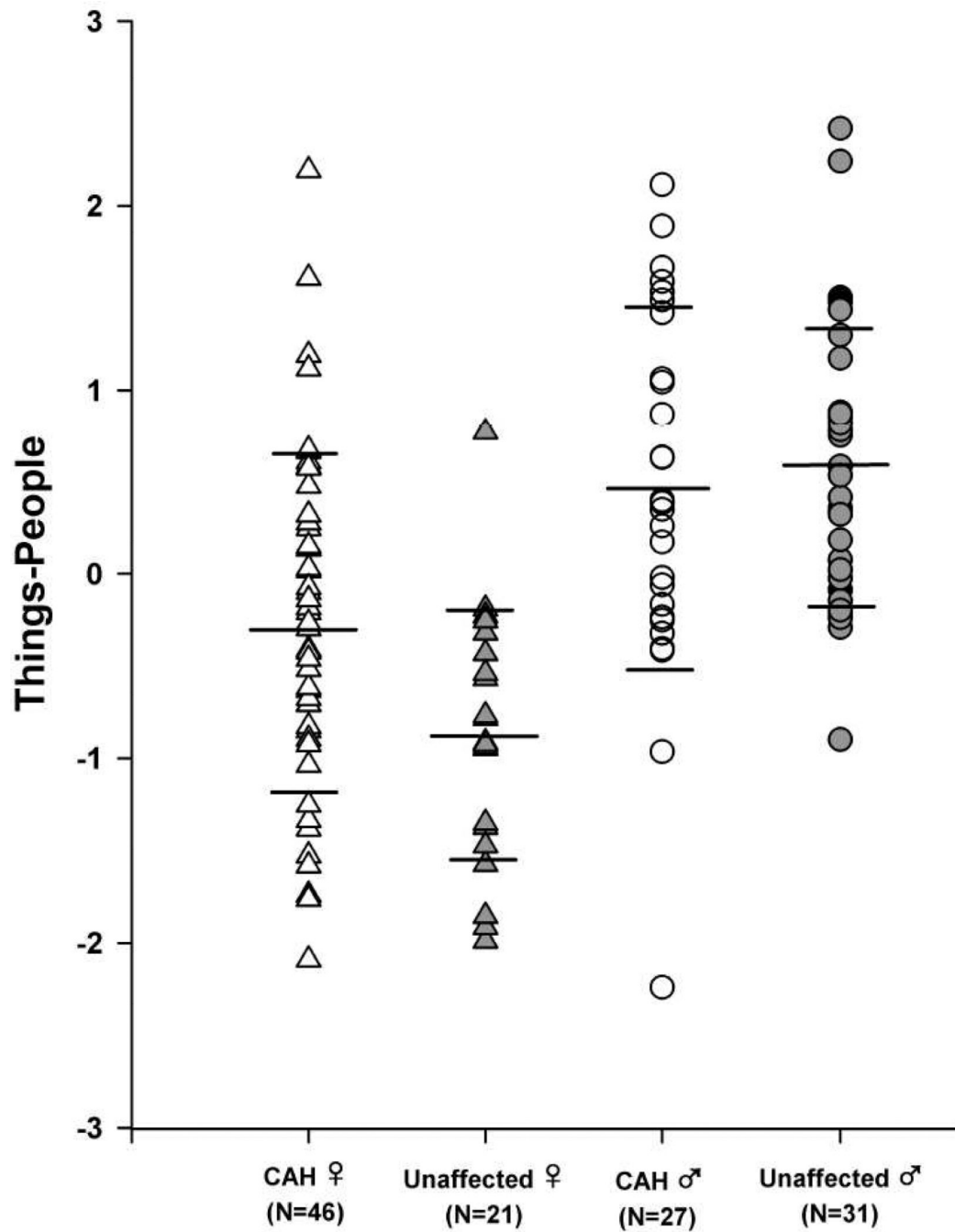


Figure 2. Scores of individual participants on the Things versus People component plotted by group. Males are represented by circles and females by triangles; open shapes indicate individuals with CAH, gray shapes indicate unaffected individuals. Horizontal lines represent group means and standard deviations.

Table 1

Occupational Interest Inventory Items and Dimensions

Dimension	OII Item	α	Dimension	OII Item	α
Realistic	10. Auto mechanic	.84	Social	26. Day care worker	.89
	11. Auto racer			28. Elementary school teacher	
	16. Building contractor			31. High school teacher	
	18. Carpenter			37. Manager, child care center	
	27. Electronics technician			46. Playground director	
	29. Farmer			53. Religious leader ^a	
	30. Forest ranger			55. School principal	
	36. Jet pilot			58. Social worker	
	39. Mechanical engineer			59. Special education teacher	
	51. Rancher			63. Vocational counselor ^a	
Investigative	7. Astronomer	.79	Enterprising	3. Advertising	.81
	9. Author of technical books ^a			12. Autosalperson ^a	
	14. Biologist			17. Buyer of merchandise	
	21. Chemist			24. Customer service representative ^a	
	45. Physician			33. Hotel manager	
	56. Scientific illustrator ^a			38. Manager, clothing store	
	57. Scientific research worker			50. Public relations director ^a	
	61. Surgeon			52. Realtor ^a	
	2. Actor/Actress			54. Sales manager	
	4. Art museum director			60. Stockbroker	
Artistic	5. Art teacher	.88	Conventional ^b	62. Travel agency manager	.55
	6. Artist			1. Accountant	
	8. Author of novels			13. Bank teller ^a	
	19. Cartoonist			15. Bookkeeper ^a	
	22. Clothes designer			20. Cashier in bank	
	25. Dance teacher			23. Computer operator	
	35. Interior decorator			32. Hospital records clerk ^a	

Dimension	OII Item	Dimension	OII Item	α
	40. Musician		34. Income tax accountant ^a	
	43. Orchestra conductor ^a		41. Office clerk ^a	
	44. Photographer		42. Office manager	
	47. Poet		48. Private secretary ^a	
	49. Professional dancer		64. Word processor ^a	

^a indicates an item removed due to less than 10% endorsement

^b indicates all items in a dimension removed due to poor reliability

Table 2
Descriptive Statistics⁺ and Group Comparisons for Five RIASEC Composite Scores

RIASEC Dimension	Females		Males		Sex Difference (Unaffected)	<i>d</i>
	CAH n = 46	Unaffected n = 21	CAH n = 27	Unaffected n = 31		
Realistic	.68 (.49)	.39 (.38)	.94 (.51)	1.04 (.47)	-.20	-1.5***
Investigative	.93 (.55)	.63 (.56)	.66 (.55)	.80 (.63)	-.24	-.29
Artistic	.90 (.51)	.98 (.54)	.58 (.46)	.55 (.44)	.05	.89**
Social	.76 (.59)	.93 (.60)	.44 (.51)	.41 (.51)	.05	.97**
Enterprising	.63 (.56)	.78 (.55)	.58 (.49)	.41 (.39)	.39	.81

⁺ Means with standard deviations in parentheses; range of possible scores: 0 to 2

* Group differences significant by *t*-test: $p < .05$;

** $p < .01$;

*** $p < .001$

Table 3
 Descriptive Statistics⁺ and Group Comparisons for the Things-People Component Score

	Females		Males		Sex Difference (Unaffected)	<i>d</i>
	CAH n = 46	Unaffected n = 21	CAH n = 27	Unaffected n = 31		
Things-People	-.26 (.91)	-.88 (.68)	.46 (.98)	.58 (.75)	-.14	-2.02***

⁺ Means with standard deviations in parentheses; range of possible scores: -1 to 1

** Group differences significant by one-tailed *t*-test: $p < .01$;

*** $p < .001$