Examining bias in the impulsive sensation seeking (ImpSS) Scale using Differential Item Functioning (DIF) – An item response analysis

Joseph A. De Leo *, Nicholas T. Van Dam, Andréa L. Hobkirk, Mitch Earleywine

University at Albany, SUNY, Department of Psychology, Social Sciences 310, 1400 Washington Avenue, Albany, NY 12222, USA

ABSTRACT

Impulsive sensation seeking, an important index of the disinhibited pursuit of novelty with minimal concern for potential negative consequences, varies with important health behaviors like drug use and unsafe sex. Previous work reveals associations between impulsive sensation seeking and gender, age, ethnicity and education. Links to these sociodemographic variables should arise from actual differences in the trait and not potential biases in items on the scale. The current study employed item response theory (IRT) analyses to identify differential item functioning (DIF)—a variation in scores that arises from group membership that is independent of genuine differences on the trait. Analyses of data from a large sample of Internet responders revealed DIF on multiple items of a popular index of impulsive sensation seeking. Items showed DIF in analyses related to gender, age, ethnicity and education. These results suggest that sociodemographic differences in impulsive sensation seeking should be interpreted with caution as they may be due to idiosyncratic interpretation of items rather than true group differences on the underlying trait. Future research should explore how these biases might affect links between impulsive sensation seeking and related psychological and behavioral outcomes.

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1. Introduction

The study of personality reveals some difficulties related to differential item function (DIF), where a question inaccurately presents one group as higher than another on a given trait simply because of group membership rather than genuine differences in the trait characteristic. Biases related to gender, ethnicity, age, or drug use status have appeared on several measures, including: the Hogan Personality Inventory (Sheppard, Han, Colarelli, Dai, & King, 2006), the Multidimensional Self Concept Scale (Young & Sudweeks, 2005), the NEO-PI (Huang, Church, & Katigbak, 1997), the MMPI (Stacy, Newcomb, & Bentler, 1993; Waller, Thompson, & Wenk, 2000) and the Schizotypal Personality Questionnaire (Earleywine, 2006). The purpose of the present study is to examine potential bias within the Impulsive Sensation Seeking Scale (ImpSS), a component of the Zuckerman Kuhlman Personality Questionnaire (ZKPQ; Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993). The current analysis focused on demographic variables previously linked to the scale, including gender, age, ethnicity, and education, and employed an underutilized but effective approach for identifying DIF based on item response theory (IRT) (Kulas, Merriam, & Onama, 2008).

1.1. Impulsive sensation seeking

Impulsive sensation seeking (a personality trait typified by risky activities, a quest for novel, complex, and intense sensations, and a tendency to engage in behaviors without consideration of potential negative consequences (Zuckerman & Kuhlman, 2000)), covaries with biological markers like less monoamine oxidase (MAO) and more testosterone (e.g., Eensoo, Paaver, Pulver, Harro, & Harro, 2004; Hur & Bouchard, 1997). Individuals who score higher on measures of this trait tend to use more drugs (Stacy et al., 1993; Zuckerman, Ball, & Black, 1990; Zuckerman et al., 1993) and have more risky sex (Donohew et al., 2000), perhaps because of heightened sensitivity to the reinforcing effects of risky behaviors (Perkins, Gerlach, Broge, Grobe, & Wilson, 2000; White, Lott, & de Wit, 2005). These links to important health behaviors make eliminating potential bias in the assessment of impulsive sensation seeking critical.

Research reveals consistent differences in impulsive sensations seeking, with men scoring higher than women, youth scoring higher than older participants, and U.S. citizens scoring higher than those from Germany (Aluja et al., 2006; McDaniel & Zuckerman, 2003; McDaniel & Mahan III, 2008). Scores also inversely relate with academic achievement among college students (Spinella & Miley, 2003). These studies highlight the importance of considering how gender, age, ethnicity, and education influence the relation between impulsive sensation seeking and associated behaviors.

* Corresponding author. Tel.: +1 518 937 4827; fax: +1 518 442 4867.
E-mail address: jd798667@albany.edu (J.A. De Leo).

1.2. Current study

This study examined potential sources of bias in the ImpSS scale, a popular index of impulsive sensation seeking. The presence of bias in the ImpSS scale was assessed using differential item functioning (DIF), a procedure rooted within the framework of IRT. This procedure assesses whether an individual's response on a particular scale item depends on their trait level (i.e., impulsive sensation seeking) or their group membership (i.e., gender, age, ethnicity, and education). Given research showing differences in gender, age, ethnicity, and education in impulsive sensation seeking, it is important to ascertain whether these observed differences reflect the personality construct or are artifacts of measurement problems. An analysis of potential bias could inform researchers of possible limitations in the measurement of this construct as well as the application of personality constructs similar to the ImpSS scale used as assessment instruments.

2. Method

2.1. Subjects and design

Participants responded to an email request to complete an Internet survey on drug use and attitudes. In an effort to target potential drug users, an initial email was sent to members via available list-servs linked to three prominent drug policy reform groups. The email requested that willing participants complete the Internet administered questionnaire and upon completion forward the request to others for a chance to win a cash prize. Collected responses were not associated with participants' identifying information. These methods are supported by research examining the equivalence of paper and pencil versus Internet administration of personality measures, such as the ZKPQ (Zuckerman et al., 1993), which found no difference in factor structure or mean score between formats (Aluja, Rossier, & Zuckerman, 2007; Chuah, Drasgow, & Roberts, 2006; Gosling, Vazire, Srivastava, & John, 2004). The local institutional review board approved all study procedures.

2.2. Measures

2.2.1. Impulsive sensation seeking

The 19-item ImpSS scale is part of the larger ZKPQ (Zuckerman et al., 1993). The ImpSS scale correlates significantly ($r = 0.76$) with the 40-item Sensation Seeking Scale (SSS) Form V (McDaniel & Mahan III, 2008; Haynes, Miles, & Clements, 2000; Zuckerman, 1994). It shows acceptable internal consistency (alphas above 0.80) in heterogeneous samples (McDaniel & Mahan III, 2008; Zuckerman, 1994) and is 0.78 in the current sample. Participants provided responses to each of the 19 ImpSS scale items by endorsing either "true" or "false". The items were then summed to calculate a composite 'impulsive sensation seeking' score (Zuckerman, 1994). The ImpSS scale presents a number of advantages, such as being a parsimonious measure of sensation seeking with fewer potential confounds than 40-item SSS Form V. For instance, items on the ImpSS scale are not specific in content to potentially objectionable behaviors (e.g., drug use or sex) or culture-bound sporting

activities (e.g., parachuting; Zuckerman, 2007), making it a particularly useful measurement in the current sample population.

2.2.2. Sociodemograhic variables

Psychological research has been limited by the use of student samples with restricted age, ethnicity, and education levels. In fact, 67% of the studies published in the *Journal of Personality and Social Psychology* in 2007 sampled undergraduate college students (Arnett, 2008), potentially limiting the generalizability of findings. Thus, we sought a more diverse sample. For DIF analyses, men were compared to women based on reported gender, college-aged youth (ages 18–24) were compared to middle-aged participants (ages 45–64), Caucasians were compared to participants of all other ethnicities (non-Caucasian), and finally, participants reporting 'some college' were compared to those reporting 'some high school' education.

2.3. Statistical methods

2.3.1. Population characteristics

The sample included a total of 8187 respondents, 80.5% males ($n = 6665$) and 19.5% females ($n = 1522$). Mean age was 29.9 years old (SD = 12.9). The majority of respondents were Caucasian (88%), followed by Latino/Hispanic (6%), Native American (3%), African American, (2%), and Asian (1%). Approximately 41% of participants reported some college experience, 14% a bachelor's degree, 14% completed high school, 9% an associates degree, 8.5% some high school, 5% an advanced degree, and 3.5% some graduate training. The aggregate mean ImpSS scale score was 8.34 (SD = 4.38) from a range from 0 to 19, with a mode of 7. Mean scores for all sociodemographic groups are displayed in Table 1. The current sample scored lower on this scale than cocaine abusers ($M = 9.4$) and undergraduate college students ($M = 9.5$) in other studies (Ball, 1995). Similar age and gender effects were observed in the current study in a manner consistent with previous research.

2.3.2. Item response theory

Item Response Theory (IRT) is an advantageous alternative to classical test theory (see e.g., de Ayala, 2009; Embretson & Reise, 2000). One notable advantage of IRT is that estimations are based on responses to individual items and are theoretically sample invariant. Theoretical sample invariance means that the item should apply similarly across all samples, assuming no DIF is present. A primary objective of IRT is to predict the relationship between an individual's trait level and the probability of choosing a particular response (e.g., Van Dam, Earleywine, & Borders, 2010). This relation is depicted by an item characteristic curve (ICC) for each item. As the standardized estimate of trait level (θ) increases, the probability of endorsing a given response typically increases.

2.3.3. IRT likelihood-ratio tests for differential item functioning

In the current study, IRT likelihood-ratio tests were used to test for invariance of item response parameters across several sociodemographic variables on the ImpSS scale. Data were analysed using IRTLRDIF v2.0b (Thissen, 2001). IRTLRDIF computes the likelihood-ratio statistic to test the null hypothesis that item parameters do not differ between groups. A significant result indicates the

Table 1
ImpSS scale sociodemographic group descriptives.

	Mean	SD		Mean	SD	*P* value	Cohen's *d*
Males	8.56	4.33	Females	7.34	4.42	<.001	0.28
College-age	9.62	4.22	Middle-age	6.18	3.95	<.001	0.84
Caucasians	8.32	4.36	Non-Caucasians	8.53	4.44	>.10	0.05
Some college	8.67	4.49	Some high school	9.48	4.46	<.001	0.18

probable presence of DIF. One common approach to IRT-based DIF analyses is to use an anchor item or items (Thissen, 2001). No such items were available in the current study. Accordingly, for each target item, all non-target items were used as a reference or "anchor"; for each analysis. There was one target item and 18 "anchor" items for the 19-item scale. Because 3PL IRT models would require four dimensional graphical representations (in theory), the common approach is to generate a complex series of interacting static multiple surfaces. However, such an approach can yield estimates with very large error margins for complex data sets with no "correct" answer (see de Ayala, 2009). Accordingly, only the slope and threshold parameters were estimated (2PL model) in the present analyses.

The IRTLRDIF software computes the likelihood ratio statistic (G^2) by fitting the data such that the parameters of the item response curves of the two groups are constrained to be equal for all items. Subsequently, the data are fit with the parameters of the item response curves equal for all items except the item in question. If G^2 exceeded 13.9 (the $\alpha = 0.001$ critical value of χ^2 distribution for two degrees of freedom) this was taken as evidence of DIF.

Unlike other statistical approaches of DIF analysis, IRTLRDIF allows for an easy examination of whether DIF is uniform or non-uniform across trait level. DIF is uniform if bias is in the same direction across the entire span of trait level. In other words, there is continuous bias against one group no matter the trait level. Non-uniform DIF items favor one group at certain trait levels, and other groups at other levels. With visual inspection of the item response curves for the two groups, one can recognize non-uniform DIF if the curves cross one another.

3. Results

3.1. Estimated item parameters

3.1.1. DIF by gender

Table 2 provides a summary of all ImpSS scale items and indicates items identified with DIF. Item parameter estimates appear in Table 3 for each of the examined group categories (i.e., gender, age, ethnicity, and education). An analysis of DIF by gender revealed that items 5, 9, 15, and 19, showed DIF. Item discrimination parameters (a_i) for this category suggest that items on the ImpSS scale moderately discriminate among individuals at different trait

levels (e.g., Van Dam et al., 2010) for both men ($M = 1.38$) and women ($M = 1.41$). Also, similar threshold parameters (b_i) were found for men and women across levels of the latent trait. Item response curves of all items identified with DIF by gender appear in Fig. 1. The graphical representations reveal uniform DIF for items 5, 9 and 19. For men and women matched on latent trait level (i.e., impulsive sensation seeking), women are more likely to endorse items 5 and 9 while men are more likely to endorse item 19. Item 15 showed non-uniform DIF, suggesting that when the genders are matched on impulsive sensation seeking, men are more likely to endorse the item at low levels of the latent trait, but women are more likely to endorse it at high levels.

3.1.2. DIF by age

An analysis of DIF by age revealed DIF in nine items: 1, 2, 4, 9, 10, 11, 15, 17, and 19. Item discrimination parameters (a_i) for the 'college-age' ($M = 1.24$) and the 'middle-age' group ($M = 1.21$) suggest that items moderately discriminate at different levels on the latent trait for these age groups. Threshold parameters (b_i) similarly ranged across levels of the latent trait for both 'college-age' and 'middle-age' participants. Fig. 2 shows the presence of uniform DIF across all levels of the latent trait for items 2, 4, 9, 10, and 15. For college and middle-age individuals matched on impulsive sensation seeking, middle-age individuals are more likely to endorse items 2 and 15, while college-age individuals are more likely to endorse items 4, 9, and 10. Non-uniform DIF appeared for items 1, 11, 17, and 19, providing evidence of DIF at different levels of the latent trait on the basis of age. Notably, item 1 poorly discriminated at levels of the latent trait for these age groups (college-age, $a_i = 0.51$; middle-age, $a_i = 0.65$), hence the flattened ICC (see Fig. 2).

3.1.3. DIF by ethnicity

DIF across ethnicity appeared for items 2 and 6. Item discrimination parameters (a_i) for the Caucasian group ($M = 2.84$) and the non-Caucasian group ($M = 2.88$) suggest that items strongly discriminate at different levels of the latent trait for these ethnic groups. Threshold parameters (b_i) similarly ranged for both Caucasians and for non-Caucasians. Fig. 3 shows non-uniform DIF for items 2 and 6.

3.1.4. DIF by education

DIF was found for items 2, 3 and 17, with item discrimination parameters (a_i) for 'some college' ($M = 1.29$) and 'some high-school'

Table 2
Impulsive Sensation Seeking (ImpSS) items identified with DIF.

Item		DIF
1.	I tend to start a new task or project, without much advance planning on how I will do it	College-aged, middle-aged
2.	I usually think about what I am going to do before I do it	Middle-aged, non-Caucasians, Caucasians, high school
3.	I tend to do things on impulse	High school, college
4.	I very seldom spend much time on the details of planning ahead	College-aged
5.	I like to have new and exciting experiences and sensations even if they might be a little scary to me	Women
6.	Before I begin a complicated job or project, I tend to make careful plans	Non-Caucasians, Caucasians
7.	I would like to take off on a trip with no preplanned or definite routes or timetable	
8.	I enjoy getting into new situations where I can't predict how things will turn out	
9.	I like to do certain things just for the thrill of it	Women, college-aged
10.	I tend to change interests frequently	College-aged
11.	I sometimes like to do things that are a little frightening	College-aged, middle-aged
12.	I will try anything once	
13.	I would like the kind of life where I am on the move and traveling a lot, with lots of change and excitement	
14.	I sometimes do crazy things just for fun.	
15.	I like to explore a strange city or section of town by myself, even if it means getting lost	Women, men, middle-aged
16.	I prefer friends who are excitingly unpredictable	
17.	I often get so carried away by new and exciting things and ideas that I never stop to consider possible complications	College-aged, middle-aged, high school, college
18.	I am generally an impulsive person	
19.	I tend to enjoy "wild" uninhibited parties	Men, college-aged, middle-aged

Table 3
Item Response Theory differential item functioning parameter estimates of the Impulsive Sensation Seeking (ImpSS) scale.

	Item parameter estimates															
	Gender				Age				Ethnicity				Education			
Item	Men (N = 6665)		Women (N = 1522)		College-aged (N = 3519)		Middle-aged (N = 1564)		Caucasian (N = 5128)		Non-Caucasian (N = 3066)		Some College (N = 3600		Some High School (N = 718)	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1	0.63	1.77	0.69	1.59	0.51	1.39	0.65	1.46	1.70	1.01	1.40	1.06	0.77	1.04	0.66	1.13
2	0.78	−0.27	0.89	−0.45	0.81	−0.81	0.95	−1.30	2.40	0.14	1.81	0.07	0.67	−0.19	0.87	−0.89
3	0.84	1.62	0.95	1.37	0.84	1.00	0.69	1.35	2.31	0.89	1.84	0.97	0.78	0.64	0.97	0.94
4	1.45	0.26	1.45	0.41	1.21	−0.33	1.22	−0.04	2.96	0.46	2.95	0.45	1.14	−0.26	1.36	−0.12
5	1.56	−0.14	1.56	−0.48	1.37	−1.07	1.57	−0.94	3.45	0.05	3.31	0.08	1.49	−0.87	1.50	−0.93
6	1.51	1.25	1.43	1.24	1.17	0.86	1.24	0.91	2.23	1.11	3.03	0.86	1.38	0.57	1.28	0.86
7	1.06	0.82	1.11	1.03	0.88	0.66	1.23	0.43	2.08	0.79	2.25	0.75	1.08	0.87	1.04	0.55
8	1.26	1.07	1.21	1.12	1.09	0.67	0.97	0.81	2.54	0.83	2.45	0.81	1.12	0.35	1.18	0.64
9	1.13	1.23	1.19	0.79	0.98	0.31	0.98	0.76	2.59	0.68	2.40	0.69	1.26	0.19	1.12	0.50
10	1.20	0.04	1.18	0.06	1.00	−0.72	0.96	−0.31	2.42	0.32	2.50	0.29	0.86	−0.40	1.09	−0.52
11	1.94	0.55	1.87	0.70	1.67	0.22	1.35	0.09	3.09	0.65	3.82	0.59	1.58	0.32	1.85	0.16
12	1.80	−0.63	1.97	−0.60	1.62	−1.33	1.93	−1.14	4.28	−0.02	4.01	−0.03	1.90	−0.92	1.82	−1.14
13	1.99	−0.22	1.99	−0.15	1.78	−0.82	1.63	−0.73	3.75	0.18	4.10	0.19	2.00	−0.73	1.86	−0.67
14	1.36	1.29	1.22	1.24	1.07	0.88	1.11	0.74	2.77	0.85	2.53	0.88	1.08	0.55	1.30	0.72
15	0.95	−0.86	1.21	−0.52	1.09	−1.05	1.03	−1.53	2.77	0.03	2.36	−0.02	1.09	−0.94	1.12	−1.20
16	1.39	0.50	1.51	0.40	1.32	−0.12	1.29	−0.12	2.83	0.43	3.11	0.47	1.34	0.01	1.48	−0.02
17	1.58	1.75	1.39	2.06	1.45	1.66	1.19	1.48	2.29	1.43	2.95	1.25	1.07	1.58	1.42	1.62
18	1.64	−0.57	1.75	−0.66	1.58	−1.25	1.55	−1.32	3.95	−0.04	3.55	−0.04	1.99	−1.04	1.60	−1.16
19	2.22	0.49	2.20	0.64	2.15	0.15	1.51	−0.03	3.54	0.63	4.44	0.57	1.91	0.18	2.15	0.10

Note. Each of the *b* parameters corresponds to a 0.5 probability of choosing the response that endorses impulsive sensation seeking. The *a* parameter is the slope at the location of the *b* parameter and corresponds to the item's ability to discriminate between individuals of different trait levels.
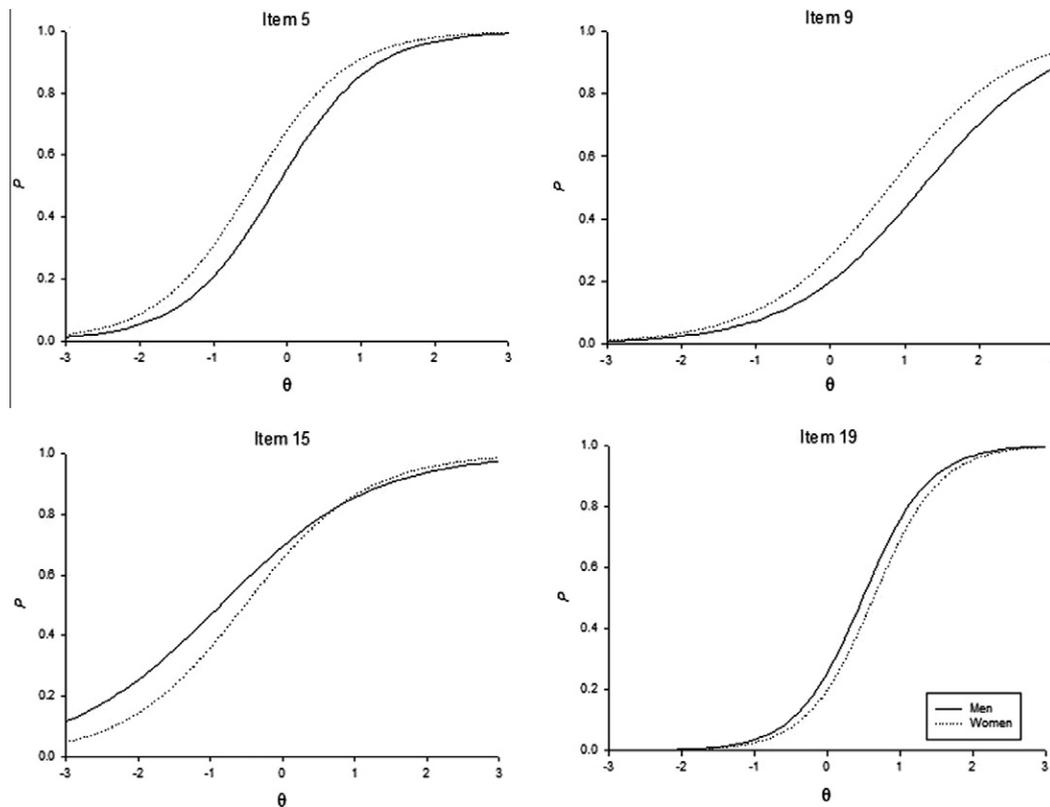

Fig. 1. Item response curves of items identified with DIF by gender.

(M = 1.35) moderately discriminating at different trait levels for these educational groups. Threshold parameters (b_i) similarly ranged for groups 'some college' and 'some high school'. Fig. 4 shows uniform DIF for item 2, with the 'some high school' group endors-ing the item more than the 'some college' group. Non-uniform DIF was found for items 3 and 17.
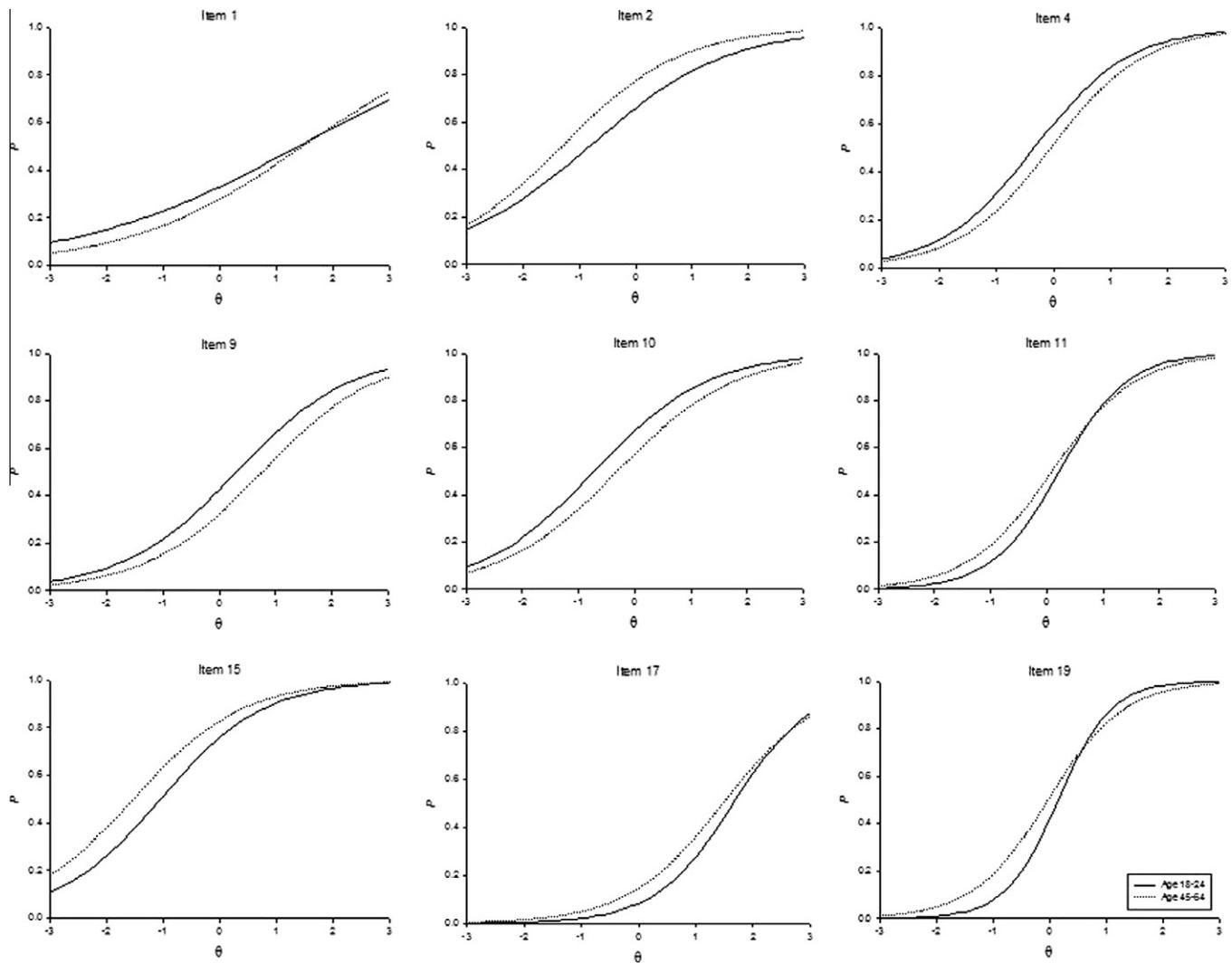
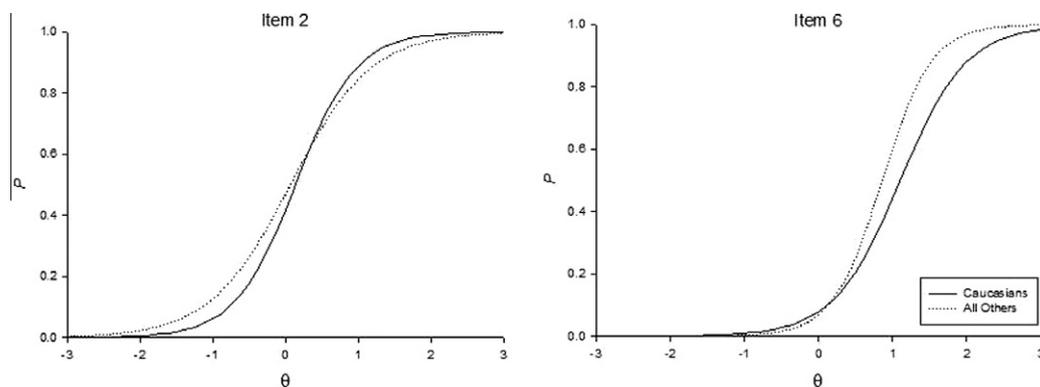**Fig. 2.** Item response curves of all items identified with DIF by age.

Fig. 3. Item response curves of all items identified with DIF by ethnicity.

4. Discussion

An underutilized but powerful IRT analysis revealed DIF on the ImpSS scale, a popular personality measure previously linked to important health behaviors as well as gender, age, ethnicity, and education. The current study is the first to identify potential mea-surement bias across a broad range of sociodemographic variables (gender, age, ethnicity, and education) in a widely used measure of impulsive sensation seeking. These findings are consistent with previous research that has uncovered potential sources of bias on other personality scales (Huang et al., 1997; Young & Sudweeks, 2005). DIF analyses of the ImpSS scale allow researchers to assess whether links between the scale and important sociodemographic
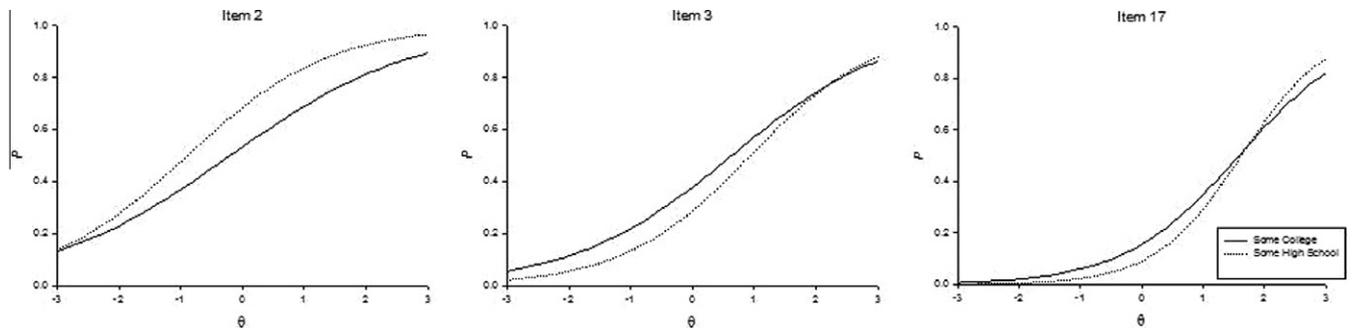
Fig. 4. Item response curves of all items identified with DIF by education.

variables stemmed from genuine differences on the trait of impulsive sensation seeking rather than potential item bias.

For personality assessment instruments, an individual's tendency to endorse a particular item should only reflect their level on the trait of interest (e.g., impulsive sensation seeking) and should not differ based on variables that should be independent of the construct of interest (i.e., gender, age, ethnicity, education). If this assumption is violated, the personality item exhibits DIF and is considered as a potential source of instrument bias. Results from the current study suggest the possibility that gender bias as well as bias related to other sociodemographic factors may be operating in the assessment of personality constructs like impulsivity. IRT-based DIF analyses identified different proportions of items for each of the categories examined (i.e., gender-DIF items: 5, 9, 15, 19; age-DIF items: 1, 2, 4, 9, 10, 11, 15, 17, 19; ethnicity-DIF items: 2, 6; education-DIF items 2, 3, 17). Given that DIF was found to vary by category, with some items favoring the focal group and other items the reference group, it is possible that overall test scores on this scale could be relatively unaffected by the presence of DIF. However, such a possibility would require a delicate balance of probability such that bias in one group exactly cancelled bias in the other. Furthermore, uniform and non-uniform DIF were found on items across different levels of the trait, suggesting that interaction effects within group membership play a role in item responding on this measure of the latent trait.

Issues of measurement bias are of particular importance when examining the relation between various personality constructs and risky behaviors (i.e., substance use). Differential relations appear between impulsive sensation seeking and risky behaviors in different groups (Donohew et al., 2000; Stacy et al., 1993; Zuckerman et al., 1993), highlighting the importance of considering potential sources of bias in personality measures, such as the ImpSS scale, when examining observed effects. Given the relation between impulsive sensation seeking and observable behaviors, researchers can further minimize the impact of measurement bias by using alternative methods, such as behavioral measures of impulsivity.

In cases where DIF has been identified on a given measure, future research might benefit from assessing the psychometric properties of personality scales both with and without identified DIF items included. To illustrate, previous work revealed that current cannabis users were more likely to endorse an item on the Schizotypal Personality Questionnaire (SPQ) regardless of whether or not they were more schizotypal than former users. An elimination of this item did not decrease internal consistency for the SPQ. Removing the biased item did eliminate the statistically significant difference between current and former cannabis users (Earleywine, 2006). These findings suggest that analysing data with and without DIF items may further elucidate links between personality dispositions and associated behaviors. Additionally, future research may also benefit from examining rather than excluding items identified with DIF, as there may be common themes across DIF items that emerge and are specific to identified group categories (Smith, 2002).

There are a number of limitations of the present study worth noting. Participants were recruited via groups devoted to changing drug policy. This approach yielded a large sample that was primarily Caucasian and male, producing sample size disparities among the reference and focal groups for certain sociodemographic variables examined (i.e., gender and ethnicity). However, the sample demographics in the present study are consistent with those of a large proportion of psychological research (Arnett, 2008). The Internet also offers potential advantages and disadvantages as a recruitment tool. It is important to note that the reach of this method might require computer skills and financial resources that prevent certain individuals from participating. The use of the Internet for data collection purposes, however, might also encourage honest responding on measures relating to controversial topics by increasing perceptions of anonymity (Wang et al., 2005). In addition, this study expressly examined drug use behaviors and attitudes, which may have resulted in data collection from individuals particularly interested in participating in research related to drug policy and other sensitive topics (i.e., drug use).

The present findings suggest that sociodemographic differences in impulsive sensation seeking should be interpreted with caution, as observed differences may be a result of different interpretations of items rather than reflect true group differences. Previous research suggests that group membership may impact the way individuals comprehend and respond to questionnaires intended to represent psychological constructs and account for differential response patterns between groups (Van Dam, Earleywine, & Danoff-Burg, 2009; Van Dam et al., 2010). This study primarily emphasizes the need for further investigation into various relevant sociodemographic and group differences in personality scale measurement response patterns. Future research should continue to use robust statistical methods, such as IRT DIF analyses, as an approach to examining potential sources of measurement bias in popularly used personality assessment instruments.

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