

Measurement Invariance of the Schizotypal Personality Questionnaire in Asian, Pacific Islander, White, and Multiethnic Populations

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The Schizotypal Personality Questionnaire (SPQ; Raine, 1991) is one of the most commonly used self-report measures of schizotypal personality traits. Previous work has found that the SPQ has a 3- or 4-factor structure, but most of this work was with White participants. Little is known about the psychometric properties of the scale in Pacific Islander populations, and some evidence suggests scores may differ between White and Asian participants. The current study included 398 Asian, 293 White, 159 Pacific Islander, and 308 multiethnic nonclinical participants. A 4-factor model fit the data well, and this factor structure displayed configural and metric invariance, suggesting that the factor structure is the same across these diverse groups. However, results provided mixed evidence for scalar invariance, suggesting the scale may lack scalar invariance in these populations. Follow-up analyses revealed that the questionable scalar invariance was related to the intercepts of the Ideas of Reference and Suspiciousness subscales in the White sample. This suggests that mean comparisons among ethnic groups involving the Ideas of Reference and Suspiciousness subscales are not appropriate.

Keywords: schizotypal personality disorder, measurement invariance, Asian, Pacific Islander, multiethnic, Schizotypal Personality Questionnaire

Schizotypal personality disorder (STPD) is a schizophrenia-spectrum personality disorder characterized by unusual perceptual experiences, odd thinking and behavior, unconventional beliefs, and difficulty with social situations (American Psychiatric Association, 2013). In the *DSM-5*, STPD is included with both the psychotic disorders and personality disorders, reflecting its role as both a clinically significant disorder and a predictor for the later development of a more serious psychotic disorder such as schizophrenia (e.g., Walker, Kestler, Bollini, & Hochman, 2004; Yung et al., 2003). Although conceptually distinct, STPD symptoms are similar to attenuated positive, negative, and disorganized symptoms, and interest in measuring these symptoms has grown in recent years (van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). Early intervention and treatment programs for people with attenuated psychotic symptoms have been established in North America (Addington et al., 2007), Europe (Ruhmann et al., 2010), Australia (Yung et al., 2005), and throughout Asia (Asian Network of Early Psychosis Writing Group, 2012), including China (Chen, Wang et al., 2014), Japan (Nemoto et al., 2012), and Korea (Jung et al., 2010). As this research, assessment, and treatment spreads to new and diverse cultures, it is essential to examine the psychometric properties of assessment instruments in each population, prior to conducting cross-culture research (Chen, 2008; Schmitt & Kuljanin, 2008). Thus, the primary goal of the current research is to examine the psychometric properties of a commonly used measure of STPD,

the Schizotypal Personality Questionnaire (SPQ), in three new populations: Asian, Pacific Islander, and multiethnic individuals.

The SPQ was developed over 20 years ago to measure STPD (Raine, 1991), and is one of the most commonly used measures, not just of STPD, but of psychotic-like phenomena more broadly (Stefanis et al., 2004). It contains subscales for each of the nine symptoms of STPD. Although there are many self-report scales available to measure psychotic-like experiences, the SPQ is unique in that it was developed to be a comprehensive measure of STPD, which is a heterogeneous mixture of many symptoms.

Since the SPQ was designed to measure nine symptoms rather than symptom domains or factors, its factor structure was not immediately clear. Early work suggested that the SPQ had a three-factor structure, mirroring the symptoms of schizophrenia including positive, negative, and disorganized factors (e.g., Raine et al., 1994). Although early work found borderline adequate fit for this three-factor model, a major limitation of these early studies is that four-factor models were not examined. A later study compared the fit of this three-factor model to the fit of 12 other hypothesized models and found that a four-factor model in which the positive factor splits into a cognitive-perceptual and paranoid factor fit the data best (Stefanis et al., 2004). Since then, at least three studies have found that this four-factor model fits better than the original three-factor model (Compton, Goulding, Bakeman, & McClure-Tone, 2009; Gross, Mellin, Silvia, Barrantes-Vidal, & Kwapil, 2014; Wuthrich & Bates, 2006). Thus, the first goal of the current research was to replicate this four-factor structure (cognitive-perceptual, paranoid, disorganized, and interpersonal; Stefanis et al., 2004) in a diverse sample and compare its fit with the original three-factor structure.

The SPQ has been used most frequently with White samples, but has also been used extensively with African American and Hispanic samples (e.g., Compton et al., 2009). Additionally, it has

This article was published Online First June 29, 2015.

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been translated into several other languages including Chinese (Chen, Hsiao, & Lin, 1997), French (Badoud, Chanal, Van der Linden, Eliez, & Debbané, 2011), Spanish (Fonseca-Pedrero, Paño-Piñero, Lemos-Giráldez, Villazón-García, & Muñiz, 2009), and Greek (Stefanis et al., 2006), among others. Despite this widespread use, few studies have examined the measurement invariance across diverse populations, and all of these studies have included samples drawn from different countries. To the author's knowledge, no research has examined the measurement invariance of the SPQ in majority and minority participants in the United States. For example, the factor loadings have been found to be invariant between sexes, across age (Fonseca-Pedrero, Paino, Lemos-Giráldez, Sierra-Baigrie, & Muñiz, 2011; Fossati, Raine, Carretta, Leonardi, & Maffei, 2003), between people of Indian and African heritage in Mauritius (Reynolds, Raine, Melling, Venables, & Mednick, 2000), and between Swiss and Spanish adolescents (Ortuño-Sierra et al., 2013). Although a similar three-factor structure has been found in a Chinese sample (Chen et al., 1997), the invariance of the factor loadings was not tested as compared to other ethnic groups. The measurement invariance of the SPQ has not been examined in people of Asian, Pacific Islander, or multiethnic backgrounds. Thus, the second goal of the current study is to examine the measurement invariance of the SPQ in these populations.

Examination of the measurement invariance of the SPQ in Asian, Pacific Islander, and multiethnic participants is important for at least three reasons. First, research has shown higher rates of schizotypal personality in ethnic minorities in general (Sharpley & Peters, 1999), and Pacific Islanders in particular (Linscott, Marie, Arnott, & Clarke, 2006). These increased rates may be related to increased social disadvantage, social defeat, or social adversity associated with minority status (Morgan & Hutchinson, 2010; Morgan et al., 2008; Selten & Cantor-Graae, 2005). In addition to schizotypal personality broadly, at least two studies have found differences in levels of schizotypal personality between White participants and Asian, Pacific Islander, or multiethnic samples with the SPQ. Chen et al. (1997) found that a community Taiwanese sample had lower means on the SPQ than previously reported in White samples. Other work suggests that multiethnic and Asian undergraduates have higher interpersonal subscale scores than White undergraduates (Schiffman, 2004). Without examining measurement invariance, it is not possible to determine whether these group differences represent true differences among groups in schizotypal personality traits or are artifacts related to the psychometric properties of the SPQ.

Second, there may be differences among these four groups in specific symptoms. As mentioned, the SPQ is thought to be composed of at least three factors: positive, negative, and disorganized. In some models, the positive factor is split into a cognitive-perceptual factor and a paranoia factor. There are reasons for thinking these groups may differ on all four factors. Cognitive-perceptual schizotypal traits (i.e., the Magical Ideation and Unusual Perceptual Experiences subscales; Stefanis et al., 2004) may be higher in Pacific Islander populations than the other groups due to cultural differences in supernatural beliefs in experiences. For example, belief in the presence of spirits is common in Hawaiian culture, as are visions and hearing of supernatural voices (Schiffman, 2004; Young, 1980). For example, the question: "Have you ever had the sense that some person or force is around you, even

though you cannot see anyone?" may be more likely to be endorsed by Pacific Islanders than the other ethnic groups.

The interpersonal schizotypal factor scores (i.e., the Constricted Affect, Excessive Social Anxiety, No Close Friends, and Suspiciousness subscales) may be lower in White participants than other groups. Previous research suggests that people in White cultures express emotions more strongly than people in Asian cultures, especially in social situations (Ekman, 1972; Fridlund, 1997; Matsumoto, 1998). Due to cultural differences in emotion expression, White participants may have lower scores on the Constricted Affect subscale. Moreover, the extent and purpose of eye contact varies across cultures. In European or White cultures, eye contact is considered respectful; whereas in East-Asian cultures, too much eye contact could be disrespectful (Kleinke, 1986; McCarthy, Lee, Itakura, & Muir, 2006). Thus, an affirmative answer to "I tend to avoid eye contact when conversing with others," may constitute a violation of social norms for a White participant but be consistent with cultural norms for an Asian participant (McCarthy et al., 2006). Moreover, a recent meta-analysis found that individuals of Asian heritage have higher levels of social anxiety than do individuals of European heritage (Krieg & Xu, 2015), which could lead to higher scores on the Excessive Social Anxiety subscale. These differences may be due to cultural differences in independent versus interdependent self-concepts, with Western cultures emphasizing independent self-construal and Eastern cultures emphasizing interdependent self-construal (Ho & Lau, 2011).

Ethnic minorities might also have higher Paranoia factor scores (i.e., Suspiciousness, Ideas of Reference, and Excessive Social Anxiety subscales) than White participants as a result of acculturative stress or perceived discrimination, two factors that have been found to be associated with worse mental health in Asian and Pacific Islander undergraduates (Chen, Szalacha, & Menon, 2014). Finally, there may be differences in the disorganization factor (i.e., Odd Speech and Odd or Eccentric Behavior subscales) related to ethnicity. Although the current research was conducted in English with fluent English speakers, the Asian and Pacific Islander groups were more likely to have been born outside of the United States and may have learned English as a second language. For example, a person with English as a second language may be more likely to answer "true" to "I find it hard to communicate clearly what I want to say to people" than a native speaker. In this instance, the question would be measuring English fluency rather than disorganized speech related to disorganized symptoms of schizotypal personality.

Finally, a third reason to examine measurement invariance is that many research studies using the SPQ in the United States have included participants from these backgrounds, even in studies where the majority of participants is White. Without establishing the measurement invariance of the SPQ, it is possible that the subscale scores are not valid indicators of schizotypal personality in those groups, which could invalidate the results of the studies.

The first goal of the current research was to confirm the commonly found four-factor structure of the SPQ in an ethnically diverse sample. The second goal of the current research was to examine the measurement invariance (i.e., configural, metric, and scalar invariance) of the SPQ across Asian, Pacific Islander, White, and multiethnic participants in a diverse English-speaking sample living in the United States of America.

Method

Participants

Participants were 1,239 undergraduates at a large Pacific, public university who participated in exchange for partial completion of a course requirement. Undergraduates are an appropriate group to examine the measurement invariance of the SPQ because previous research suggests that psychopathology is prevalent in undergraduates, including personality disorders (Blanco et al., 2008) and psychotic-like experiences (Cicero, Martin, Becker, Docherty, & Kerns, 2014). Participants in the analyses included 398 Asian (32.1%; Age [$M = 19.62$, $SD = 3.46$]; 66.6% female), 159 Pacific Islander (12.8%; Age [$M = 20.03$, $SD = 3.61$]; 71.1% female), 293 White (23.6%; Age [$M = 20.36$, $SD = 4.43$]; 73.7% female), 308 multiethnic (24.9%; Age [$M = 20.09$, $SD = 3.91$]; 66.6% female), and 81 other (6.5% Age [$M = 21.69$, $SD = 5.15$]; 62.4% female; See Table 1). The mean age of the total sample was 20.08 ($SD = 4.00$). Participants were 69.4% female. Only Asian, Pacific Islander, White, and multiethnic participants were included in the multigroup CFA analyses. Participants in the White group reported being White or Portuguese. The ethnicity “Portuguese,” but no other European groups, was included due to the unique history of people emigrating from Portugal to the state in which these data were collected in the late nineteenth and early twentieth centuries (Andrade & Nishimura, 2011). Participants in the Asian group reported being Japanese, Okinawan, Chinese, Korean, or Vietnamese. Participants in the Pacific Islander group reported being Samoan, Native Hawaiian, Tongan, or Filipino. Participants who selected only one of “Black,” “Hispanic,” “Native American or Alaska Native,” or “Mexican” categories were excluded from the analyses due to small sample size. Participants who selected one of these four groups and an ethnicity from the Asian, White, or Pacific Islander categories were coded as multiethnic. Participants

selecting an ethnicity from two or three of the Asian, Pacific Islander, and White categories were coded as multiethnic. Participants who were born outside of the United States were categorized as first-generation, while participants with at least one parent born outside of the United States were categorized as second generation, and participants with both parents born in the United States were categorized as third generation or more. The majority of participants in all groups were the second, third, or more generation in their families to live in the United States and only a small minority of participants were first generation (see Table 1).

Schizotypal Personality Questionnaire

The Schizotypal Personality Questionnaire (SPQ; Raine, 1991) is a 74-item, yes-no questionnaire designed to measure *DSM-III-R* schizotypal personality disorder. In the current research, the SPQ was administered to all participants in English, and all participants were English-speaking. The SPQ has been the most frequently used scale in studies examining the factor structure of schizotypal traits (e.g., Stefanis et al., 2004). Rather than being designed to measure any specific factor structure, the SPQ was designed to have one subscale for each of the nine symptoms of STPD including ideas of reference, odd beliefs or magical thinking, unusual perceptual experiences, odd thinking and speech, suspiciousness or paranoid ideation, inappropriate or constricted affect, odd behavior, lack of close friends, and excessive social anxiety. Each subscale contains between seven and nine items, and affirmative answers are summed for subscale scores. Scores on the SPQ are typically reported as subscale scores, and factor scores are used in studies conducted from a structural equation modeling framework. Total scores are sometimes used in research to create a high schizotypy or schizotypal group for comparisons. In the current research, the subscale scores were used as the observed variables in the measurement invariance analyses because the sample size

Table 1
Demographic Characteristics of All Participants

Participant characteristics	Total <i>N</i> (Column %)	1st-Generation <i>N</i> (Row %)	2nd-Generation <i>N</i> (Row %)	3rd-Generation or Longer <i>N</i> (Row %)
White	293 (25.3%)	28 (9.6%)	28 (9.6%)	237 (80.8%)
Portuguese	9 (0.8%)	0	2 (22.2%)	7 (77.8%)
White/Caucasian	265 (22.9%)	28 (10.6%)	24 (9.1%)	213 (80.4%)
More than one White	19 (1.6%)	0	2 (10.5%)	17 (89.5%)
Asian	398 (34.4%)	78 (19.6%)	108 (27.1%)	212 (53.3%)
Japanese/Okinawan	154 (13.3%)	16 (10.4%)	14 (9.1%)	124 (80.5%)
Chinese	98 (8.5%)	39 (39.8%)	42 (42.9%)	17 (17.3%)
Korean	61 (5.3%)	18 (29.5%)	35 (57.4%)	8 (13.1%)
Vietnamese	12 (1.0%)	3 (25.0%)	6 (50.0%)	3 (25.0%)
More than one Asian	73 (6.3%)	2 (2.8%)	11 (15.5%)	60 (82.2%)
Pacific Islander	159 (13.7%)	30 (19.6%)	85 (53.5%)	44 (27.7%)
Native Hawaiian	11 (0.9%)	0	1 (9.1%)	10 (90.9%)
Samoan	9 (0.8%)	7 (77.8%)	0	2 (22.2%)
Tongan	4 (0.3%)	0	4 (100%)	0
Filipino	124 (10.7%)	21 (16.9%)	75 (60.4%)	28 (22.5%)
More than one Pacific Islander	11 (0.9%)	2 (18.2%)	5 (45.5%)	4 (36.4%)
Multiethnic	308 (26.6%)	22 (7.1%)	51 (16.6%)	235 (76.3%)

Note. All analyses include 293 White, 298 Asian, 159 Pacific Islander, and 308 multiethnic participants. “More than one White” is people who reported being both White and Portuguese. “More than one Asian” is people who reported being more than one of Japanese/Okinawan, Chinese, Korean, and Vietnamese. “More than one Pacific Islander” is people who reported being more than one of Native Hawaiian, Samoan, Tongan, and Filipino. “Multiethnic” is people who reported an ethnicity from more than one broader category of White, Asian, and Pacific Islander.

was not large enough for item-level analyses with four subgroups. Although designed for the *DSM-III*, the SPQ is still applicable to the *DSM-5* because the nine symptoms have not changed.

Data Analytic Strategy

All analyses were conducted with Mplus version 7.2 (Muthén & Muthén, 1998–2012). First, the fit of Raine et al.'s (1994) original three-factor model was compared to the fit of Stefanis et al.'s (2004) four-factor model. In the three factor model (see Figure 1a), the Magical Ideation, Unusual Perceptual Experiences, Suspiciousness, and Ideas of Reference subscales were specified to load on the positive factor, the Excessive Social Anxiety, No Close Friends, and Constricted Affect subscales load on the Negative factor, and the Odd Speech and Odd or Eccentric Behaviors subscales load on the Disorganized factor. In the four-factor model (see Figure 1b), the Magical Ideation and Perceptual Aberration subscales load on the Cognitive-Perceptual factor, the No Close Friends, Constricted Affect, Suspiciousness, and Excessive Social Anxiety subscales load on the Interpersonal factor, the Suspiciousness, Excessive Social Anxiety, and Ideas of Reference subscales load on the Paranoid Ideation factor, and the Odd Speech and Odd or Eccentric Behavior subscales load on the Disorganization factor.

The Invariance analyses were conducted with the Mplus “convenience” code to specify configural, metric, and scalar invariance. In all models, the nine subscale scores from the SPQ were the manifest variables. In the configural invariance model, all of the factor loadings and intercepts are allowed to load freely and differ among groups. In the metric invariance model, the factor loadings

are constrained to be equal across groups, but the intercepts are allowed to differ. In the scalar invariance model, the factor loadings and intercepts are constrained to be equal across groups. Finally, the fit of the metric and scalar invariance models are compared to the fit of the configural model. If the metric model does not fit significantly worse than the configural model, then the SPQ has metric invariance. If the factor loadings are not invariant across groups (i.e., metric invariance), then it is possible the scales are not measuring the same constructs in the different groups. If the scalar invariance model does not fit significantly worse than the configural model, then the SPQ has scalar invariance. If the intercepts of the scales are not invariant across groups (i.e., scalar invariant), then the same score may have different meanings in different groups. As a result, mean comparisons between groups would not be appropriate because one group may display higher means as a result of the nonequivalent intercepts of the scale, rather than actual level of schizotypal traits (Chen, 2008).

Following the recommendations of statisticians, if the scale failed to display metric or scalar invariance, the plan was to examine the modification indices for clues as to which subscales in which groups may be responsible for the lack of invariance (e.g., Byrne, Shavelson, & Muthén, 1989; Marsh & Hocevar, 1985; Sörbom, 1989; van de Schoot et al., 2013). This approach is commonly done in measurement invariance work and is referred to as *partial measurement invariance* (e.g., Skriner & Chu, 2014; Spaapen, Waters, Brummer, Stopa, & Bucks, 2014; Torres, Miller, & Moore, 2013). Follow-up analyses focused on parameters with modification indices greater than 10.00 (Heene, Hilbert, Freudenthaler, & Buhner, 2012).

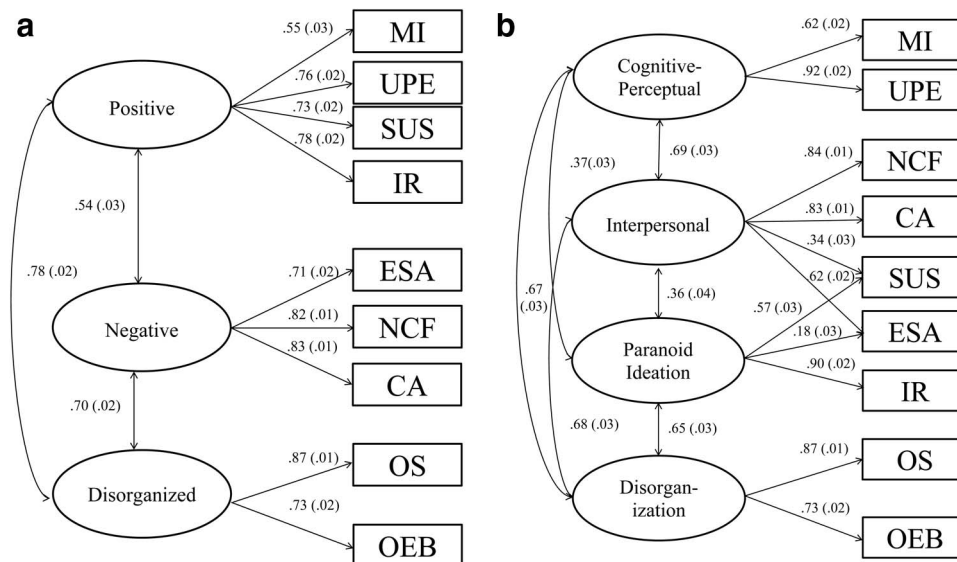


Figure 1. (a) Three-factor model of the Schizotypal Personality Questionnaire in the total sample. Ellipses represent latent variables; rectangles represent observed variables. MI = Magical Ideation, UPE = Unusual Perceptual Experiences, SUS = Suspiciousness, IR = Ideas of Reference, ESA = Excessive Social Anxiety, NCF = No Close Friends, CA = Constricted Affect, OS = Odd Speech, OEB = Odd or Eccentric Behavior. (b) Four-factor model of the Schizotypal Personality Questionnaire in the total sample. Ellipses represent latent variables; rectangles represent observed variables. MI = Magical Ideation, UPE = Unusual Perceptual Experiences, ESA = Excessive Social Anxiety, NCF = No Close Friends, CA = Constricted Affect, SUS = Suspiciousness, IR = Ideas of Reference OS = Odd Speech, OEB = Odd or Eccentric Behavior.

To determine whether the scale was invariant, the Satorra-Bentler chi-square (SB χ^2) difference test was used (Satorra & Bentler, 2001). Given the well-documented limitations in chi-square-based likelihood ratio tests (e.g., Cheung & Rensvold, 2002), the SB χ^2 was supplemented with change in McDonald's noncentrality index (Mc; McDonald, 1989) and change in comparative fit index (Δ CFI) as suggested by Meade, Johnson, and Braddy (2008). Following the recommendations of Cheung and Rensvold (2002), the cutoffs of .02 for Mc and .010 for Δ CFI were used.

Results

Comparison of Structural Models

The four-factor model fit the data well in the full sample and in all four subsamples (see Table 2). The three-factor model had reasonable to borderline adequate fit in the full sample and in the four subsamples. The four-factor model fit the data significantly better than did the three-factor model in the total sample and in the four subsamples. All of the subscales loaded highly on their respective latent factors in the three-factor model, and the factors were strongly correlated with each other (see Figure 1). As in previous work, the weakest correlation was between the positive and negative factors, while the correlations among the other factors were stronger in the total sample and in each of the subgroups (e.g., Raine et al., 1994). Most of the subscales loaded highly on their respective latent factor in the four-factor model and the factors were moderately to strongly correlated with each other. Similar to other research (e.g., Stefanis et al., 2004), the Suspiciousness subscale did not load highly on the Interpersonal factor, and the Excessive Social Anxiety subscale did not load highly on the Paranoid factor in any of the four groups. Also consistent with previous work, the weakest correlations were between the Interpersonal and Cognitive-Perceptual factors and between the Interpersonal and Paranoid Ideation factors in the total sample and subgroups (see Table 3). The correlations among the other factors were stronger, consistent with previous results (Compton et al.,

2009; Stefanis et al., 2004; Wuthrich & Bates, 2006). Since the four-factor model clearly fit the data better than the three-factor model in the total sample and in each group, the measurement invariance of the SPQ was tested with the four-factor model (see Figure 1b).

Measurement Invariance

The configural model, in which the loadings and intercepts were not constrained to be equal, fit the data well (see Table 4). The loadings were similar in all four groups (See Table 5). Most of the subscales loaded highly on the latent factors in all ethnic groups, mirroring the total sample as shown in Figure 1b. The metric invariance model also fit the data well and did not fit significantly worse than the configural model when using the SB χ^2 , Δ CFI, or Mc (See Table 4). This suggests that the factors of the SPQ are the same in all four groups, and the SPQ is measuring the same constructs in these groups. The scalar invariance model fit the data well, but the model comparisons provided mixed support. The Mc Noncentrality Index was below the cutoff of .02, which provides some evidence for scalar invariance. However, the SB χ^2 was significant, which suggests worse fit, and the Δ CFI was inconclusive, given that it was equal to the cutpoint of .010. Taken together, this provides equivocal evidence for the scalar invariance of the SPQ across these four groups. This potential lack of scalar invariance suggests that mean comparisons between groups on subscale or factor scores are not appropriate because the scores may represent different levels of schizotypal traits in different groups.

Since the scale did not unequivocally display scalar invariance, the modification indices were examined to see which intercepts were problematic. The modification indices for the intercepts of two subscales (Ideas of Reference and Suspiciousness) were above 10.00 for the White group. Follow-up analyses revealed that freeing the intercept for the White group improved the fit of the scalar model for the Ideas of Reference (SB $\chi^2(1) = 19.89, p < .001$) and the Suspiciousness (SB $\chi^2(1) = 13.09, p < .001$) subscales. When both subscales were freed in the same model, the model fit just as well as the configural model according to the Mc and Δ CFI, but

Table 2
Fit Statistics for the Three- and Four-Factor Models in the Total Sample and Four Subgroups

Model	χ^2	df	RMSEA	90% CI	TLI	CFI	BIC	AIC	$\chi^2_{diff}(4)$	p value
Total sample										
Three-factor	294.473	23	0.100	[0.090, 0.110]	0.910	0.943	42,576.418	42,419.146		
Four-factor	104.359	19	0.062	[0.050, 0.074]	0.966	0.982	42,397.080	42,219.515	195.102	<.001
White										
Three-factor	84.520	23	0.097	[0.076, 0.120]	0.912	0.944	10,120.732	10,007.723		
Four-factor	46.800	19	0.072	[0.046, 0.098]	0.952	0.975	10,100.020	9,972.430	36.930	<.001
Asian										
Three-factor	124.864	23	0.108	[0.090, 0.127]	0.879	0.923	13,891.463	13,769.399		
Four-factor	46.638	19	0.062	[0.040, 0.085]	0.960	0.979	13,832.856	13,695.043	78.226	<.001
Pacific Islander										
Three-factor	63.022	23	0.107	[0.076, 0.139]	0.917	0.947	5,523.209	5,523.209		
Four-factor	23.512	19	0.040	[0.000, 0.086]	0.989	0.994	5,504.400	5,398.795	35.993	<.001
Multiethnic										
Three-factor	85.449	23	0.096	[0.075, 0.119]	0.913	0.944	10,594.345	10,480.366		
Four-factor	50.660	19	0.076	[0.051, 0.101]	0.972	0.947	10,580.160	10,451.473	35.698	<.001

Note. df = degrees of freedom; RMSEA = root mean square error of approximation; CI = confidence interval; TLI = Tucker-Lewis index; CFI = comparative fit index; BIC = Bayesian information criterion; AIC = Akaike information criterion.

Table 3
Factor Correlations for the Three- and Four-Factor Models in the Total Sample and Each Subgroup

Factor	Three-factor model			Factor	Four-factor model			
	1	2	3		1	2	3	4
Total sample				Total Sample				
1. Positive	—			1. Cognitive-Perceptual	—			
2. Negative	.54	—		2. Interpersonal	.37	—		
3. Disorganized	.78	.70	—	3. Disorganization	.67	.68	—	
				4. Paranoia	.69	.36	.65	—
White				White				
1. Positive	—			1. Cognitive-Perceptual	—			
2. Negative	.51	—		2. Interpersonal	.30	—		
3. Disorganized	.80	.64	—	3. Disorganization	.65	.61	—	
				4. Paranoia	.71	.36	.71	
Asian				Asian				
1. Positive	—			1. Cognitive-Perceptual	—			
2. Negative	.51	—		2. Interpersonal	.30	—		
3. Disorganized	.72	.70	—	3. Disorganization	.63	.68	—	
				4. Paranoia	.63	.35	.56	—
Pacific Islander				Pacific Islander				
1. Positive	—			1. Cognitive-Perceptual	—			
2. Negative	.54	—		2. Interpersonal	.51	—		
3. Disorganized	.81	.67	—	3. Disorganization	.71	.64	—	
				4. Paranoia	.77	.29	.72	—
Multiethnic				Multiethnic				
1. Positive	—			1. Cognitive-Perceptual	—			
2. Negative	.50	—		2. Interpersonal	.35	—		
3. Disorganized	.77	.72	—	3. Disorganization	.65	.70	—	
				4. Paranoia	.70	.30	.62	—

not the SB χ^2 (See Table 4, Model 4). This suggests that the reason the model was not unequivocally scalar invariant was that the intercepts for these two scales are different in the White group compared to the other three groups. Coupled with the clear metric invariance, this finding suggests that the scales are measuring the same construct in the different groups, but the same scores on these two subscales may represent a different level of true ideas of reference and suspiciousness in White participants than in the other three groups.

Mean Comparisons

Next, mean comparisons were examined for the scores that did not include the two subscales responsible for the lack of scalar invariance. To account for multiple comparisons, the Bonferroni

correction was applied to all post hoc comparisons. Table 6 shows the means, standard deviations, and Cronbach's alpha for each subscale in the four groups, and Table 7 shows the means for the total and factor scores. As mentioned, two subscale scores failed to meet the basic assumption of being scalar invariant. These were the Suspiciousness and Ideas of Reference subscales. These subscales are also a part of the total scores, Paranoid Ideation factor, and Interpersonal factor. Thus, these scores were not compared across groups.

On the scores available for comparison, there was a pattern of differences such that White participants tended to have lower scores than the other three groups (see Table 7). The White group had lower cognitive-perceptual scores than the Pacific Islander group, and lower disorganization scores than the Asian group. The

Table 4
Fit Statistics for Configural, Metric, Scalar, and Scalar Modified Invariance Models for the Four-Factor Model

Model	χ^2	df	RMSEA	90% CI	TLI	CFI	BIC	AIC	χ^2_{diff} (df)	p value	Mc	ΔCFI
1. Configural	168.814	76	0.066	[0.053, 0.080]	0.959	0.979	40,218.805	39,517.741				
2. Metric	199.015	97	0.062	[0.049, 0.074]	0.965	0.976	40,097.354	39,501.450	27.972 (21)	.1410	-.004	.003
3. Scalar	244.172	112	0.065	[0.054, 0.078]	0.961	0.969	40,038.196	39,517.406	74.959 (36)	.0001	-.017	.010
4. Scalar-Mod	221.402	110	0.061	[0.049, 0.072]	0.966	0.974	40,028.648	39,497.842	50.499 (34)	.0340	-.014	.005

Note. Model 1 = Configural model in which the factor loadings and intercepts are free to differ in all groups; Model 2 = Metric invariance model in which the intercepts are free but the factor loadings are constrained to be equal across groups; Model 3 = Scalar invariance model in which the factor loadings and intercepts are constrained to be equal across groups; Model 4 = Scalar Invariance model with the Referential Thinking and Suspiciousness subscale intercepts free in the White group, Total N = 1,159. df = degrees of freedom; RMSEA = root mean square error of approximation; CI = confidence interval; TLI = Tucker-Lewis index; CFI = comparative fit index; BIC = Bayesian information criterion; AIC = Akaike information criterion; Mc = McDonald's noncentrality index.

Table 5
Standardized Factor Loadings in the Configural Model by Ethnicity

	White (<i>n</i> = 293) Parameter (SE)	Asian (<i>n</i> = 398) Parameter (SE)	Pacific Islander (<i>n</i> = 159) Parameter (SE)	Multiethnic (<i>n</i> = 308) Parameter (SE)
Cognitive-Perceptual				
Magical Ideation	.64 (.05)	.57 (.05)	.69 (.05)	.63 (.05)
Unusual Perceptual Experiences	.92 (.04)	.92 (.04)	.93 (.04)	.88 (.04)
Interpersonal				
Suspiciousness	.44 (.05)	.30 (.06)	.26 (.06)	.30 (.06)
Excessive Social Anxiety	.65 (.04)	.58 (.04)	.49 (.07)	.67 (.04)
No Close Friends	.88 (.02)	.82 (.03)	.83 (.04)	.83 (.03)
Constricted Affect	.85 (.02)	.79 (.03)	.83 (.05)	.83 (.03)
Disorganization				
Odd Speech	.84 (.04)	.87 (.03)	.91 (.03)	.85 (.03)
Eccentric/Odd Behavior	.72 (.04)	.68 (.03)	.74 (.04)	.79 (.03)
Paranoid Ideation				
Ideas of Reference	.92 (.04)	.90 (.04)	.92 (.03)	.88 (.05)
Suspiciousness	.48 (.05)	.60 (.05)	.74 (.05)	.54 (.06)
Excessive Social Anxiety	.16 (.05)	.17 (.05)	.25 (.07)	.20 (.05)

Note. SE = standard error.

Asian and Pacific Islander scores were similar for cognitive-perceptual and disorganized scores.

There were no significant differences in levels of Magical Ideation across groups. However, White participants had lower Unusual Perceptual Experiences than did the Pacific Islander group. The White group had lower Excessive Social Anxiety, No Close Friends, and Constricted Affect scores than the other three groups, while the multiethnic group had lower Excessive Social Anxiety scores than both the Asian and Pacific Islander Groups. There were no ethnic differences on Odd Behavior scores. Finally, Pacific Islanders had higher Odd Speech scores than the White and multiethnic groups, while the Asian group had higher scores than the White group.

Discussion

The primary goal of the current research was to test whether the SPQ had measurement invariance in White, Asian, Pacific Is-

lander, and multiethnic populations. The four-factor model fit the data well in the total sample and in all four of the subgroups. The model had configural and metric invariance, but questionable scalar invariance. Follow-up analyses suggested that the lack of scalar invariance was related to constraining the intercepts of the Suspiciousness and Referential Thinking subscale in White participants to be equal to the intercepts in the other three participant groups. These results suggest that SPQ is measuring the same construct in these four groups, but mean comparisons involving the total scores, Suspiciousness and Referential Thinking subscales, and Interpersonal and Paranoid Ideation factors are inappropriate.

The current results are consistent with past research that has found similar psychometric properties and factor structure of the SPQ in diverse populations. Previous work has found measurement invariance between sexes, across age (Fonseca-Pedrero et al., 2011; Fossati et al., 2003), between people of different ethnicities (Reynolds et al., 2000), and people living in different countries

Table 6
Psychometric Characteristics of the SPQ Across Ethnic Groups

	White (<i>n</i> = 293)		Asian (<i>n</i> = 398)		Pacific Islander (<i>n</i> = 159)		Multiethnic (<i>n</i> = 308)		<i>F</i>
	<i>M</i> (<i>SD</i>)	α	<i>M</i> (<i>SD</i>)	α	<i>M</i> (<i>SD</i>)	α	<i>M</i> (<i>SD</i>)	α	
Mag	1.47 (1.76) ^a	0.74	1.46 (1.57) ^a	0.64	1.74 (1.65) ^a	0.65	1.45 (1.65) ^a	0.70	1.21
UPE	2.15 (2.08) ^a	0.75	2.40 (1.95) ^{ab}	0.67	2.80 (2.26) ^b	0.77	2.32 (2.03) ^{ab}	0.74	3.20*
S	2.08 (1.93)	0.78	3.19 (2.27)	0.77	3.66 (2.30)	0.83	2.76 (2.02)	0.82	NA
IR	3.23 (2.54)	0.78	3.78 (2.53)	0.75	4.28 (2.89)	0.83	3.57 (2.59)	0.78	NA
ESA	3.27 (2.61)	0.83	4.74 (2.46) ^a	0.80	4.80 (2.37) ^a	0.81	4.11 (2.48) ^b	0.82	21.39***
NCF	2.16 (2.13)	0.74	3.07 (2.23) ^a	0.72	3.37 (2.28) ^a	0.72	2.79 (2.31) ^a	0.78	12.07***
CA	1.81 (1.75)	0.70	2.52 (2.02) ^a	0.72	2.74 (1.94) ^a	0.72	2.34 (1.97) ^a	0.74	10.10***
OEB	2.17 (2.17) ^a	0.83	2.53 (2.22) ^a	0.82	2.70 (2.25) ^a	0.83	2.49 (2.30) ^a	0.85	2.23
OS	3.25 (2.44) ^a	0.78	4.10 (2.25) ^{bc}	0.77	4.70 (2.80) ^c	0.83	3.79 (2.60) ^{ab}	0.82	11.01***

Note. Mag = Magical Ideation; UPE = Unusual Perceptual Experiences; S = Suspiciousness; IR = Ideas of Reference; ESA = Excessive Social Anxiety; NCF = No Close Friends; CA = Constricted Affect; OEB = Odd or Eccentric Behavior; OS = Odd Speech. Values that share a superscript letter do not significantly differ from each other.

* <.05. *** <.001.

Table 7
Means and Standard Deviations for SPQ Factor Scores Across Ethnic Groups

Factor	White (<i>n</i> = 293)	Asian (<i>n</i> = 398)	Pacific Islander (<i>n</i> = 159)	Multiethnic (<i>n</i> = 308)	<i>F</i>
Total score	21.62 (13.30)	28.01 (13.48)	30.39 (15.67)	25.34 (13.70)	NA
Cognitive-Perceptual	3.61 (3.39) ^a	3.38 (3.07) ^{ab}	4.53 (3.59) ^b	3.72 (3.22) ^{ab}	2.59
Interpersonal	9.36 (6.97)	13.53 (7.02)	14.55 (7.01)	12.10 (6.99)	NA
Disorganization	5.37 (4.09) ^a	6.68 (4.25) ^b	7.37 (4.64) ^{ab}	6.20 (4.47) ^{ab}	7.84 ^{***}
Paranoia	8.60 (5.57)	11.70 (5.83)	12.71 (6.23)	10.46 (5.58)	NA

Note. SPQ = Schizotypal Personality Questionnaire. Values that share a superscript letter do not significantly differ from each other.

*** <.001.

(Ortuño-Sierra et al., 2013). As the use of self-report psychotic-spectrum disorders questionnaires spreads throughout the world, one issue for future research is to examine the measurement invariance of the SPQ and other scales in non-English-speaking populations. Although the SPQ has been translated into several different languages, few of these studies examined the measurement invariance of the SPQ in those languages prior to other data collection. Since the current research was conducted in English, the results may not be generalizable to translations of the SPQ in languages with non-English-speaking participants.

The results of the mean comparisons are consistent with several previous studies and with a theoretical framework for differences in these constructs among ethnic groups. In six of the seven subscales and both factors that were found to be scalar invariant, White participants tended to have lower scores than the other groups. This pattern is consistent with previous work showing that ethnic minorities, including Pacific Islanders (Linscott et al., 2006), have higher levels of schizotypal personality traits than Whites (Sharpley & Peters, 1999). Moreover, there are well-known differences in rates of psychopathology in ethnic minority versus majority participants in research studies, including dozens of studies on psychotic-spectrum disorders (e.g., Fearon et al., 2006; Morgan & Hutchinson, 2010; Veling, 2013).

The three interpersonal subscales that were found to be scalar invariant were consistently lower for White participants. This finding is consistent with previous work examining ethnic differences in schizotypal traits, which found that White undergraduates have lower interpersonal schizotypal traits than Asian and multiethnic participants. (Schiffman, 2004). The finding that White participants had lower Excessive Social Anxiety scores than Asian participants is consistent with a long-line of research on ethnic differences in social anxiety. Previous work has found that this relationship is related to ethnic differences in independent versus interdependent self-construal (Ho & Lau, 2011; Krieg & Xu, 2015), and that this increase in social anxiety remains after controlling for other types of psychopathology such as depression (Okazaki, 1997). White participants also had lower No Close Friends and Constricted Affect scores than the other groups. Previous research has found that these two subscales are strongly correlated with introversion (Cicero & Kerns, 2010), and other work has shown greater introversion in people of Asian heritage than in people of European heritage (e.g., Allik & McCrae, 2004; Schmitt, Allik, McCrae, & Benet-Martínez, 2007). Moreover, these differences may be related to cultural differences in the appropriateness of the expression of emotions (Ekman, 1972;

Fridlund, 1997; Matsumoto, 1998) or eye contact (Kleinke, 1986; McCarthy et al., 2006).

In addition to interpersonal traits, the current research found that Pacific Islanders had higher Cognitive-Perceptual scores than White participants. The subscale-level analysis suggests that this may be driven by the Unusual Perceptual Experiences subscale scores. This difference may be a result of visions and hearing voices being more common in Pacific Islander culture than White or European cultures (Schiffman, 2004; Young, 1980). Finally, there were few differences among the groups with regard to the disorganized factor. The Pacific Islander group had higher scores on the Odd Speech subscale than the White and multiethnic groups. This may be related to difficulties with English as a second language, rather than the disorganization seen in schizophrenia-spectrum disorders like schizophrenia personality disorder.

In some research using the SPQ, participants are grouped into a “schizotypy” group by setting a cut-score as a sex normed *z*-score of 1.65, or the top five percent of the sample (e.g., Minor, Cohen, Weber, & Brown, 2011). The lack of clear scalar invariance across groups in the current research suggests that this grouping strategy, which is based on the mean and standard deviations of scores, may not be appropriate for Asian, Pacific Islander, and multiethnic participants in the United States. For example, the finding that the intercepts for the Suspiciousness and Ideas of Reference subscales needed to be freed in the White group to provide good fit for the scalar invariance model suggests that the means of these scores have different meanings in the different groups. Calculating sex-normed *z*-scores with these scales could result in an inaccurate classification of Asian, Pacific Islanders, and multiethnic participants into the “schizotypy” group. Researchers could consider calculating separate *z*-scores for each ethnic group based on the means and standard deviations for each group, and selecting the top five percent within each group.

In the current study, the measurement invariance of the SPQ was examined by using the subscale scores as manifest variables, as opposed to the individual items. This is consistent with nearly all studies that have examined the measurement invariance of the SPQ (e.g., Fonseca-Pedrero et al., 2011; Reynolds et al., 2000). However, one potential limitation of this approach is that it could mask differences in individual items among groups by summing them into subscale scores. The current research did not have a large enough sample to examine the differential item functioning of all 74 items in four different groups. Future research could examine differential item functioning of each individual item in these same groups with a larger sample.

Although the SPQ measures STPD and not risk for psychosis, the current research may have implications for understanding psychosis risk screening instruments. Like the SPQ, psychosis risk instruments have been used throughout the world in the United States, Finland, the Netherlands, Spain, Austria, the United Kingdom, Palau, China, Japan, Korea, Taiwan, Malaysia, and Kenya (see Kline & Schiffman, 2014 for a review). Most psychosis risk assessment instruments were developed with a high percentage of White participants in North America, Europe, or Australia. If other instruments have similar psychometric properties to the SPQ (i.e., metric invariance, but questionable scalar invariance), then different cut-scores for diverse populations may need to be developed. Future research could examine the measurement invariance of these instruments as well.

One clear strength of the current research was the diverse sample including people of Pacific Islander and multiethnic backgrounds. This was the first study to examine the factor structure of the SPQ in these populations. Moreover, it was the first to examine the metric and scalar invariance of the SPQ across Asian, Pacific Islander, White, and multiethnic samples. At the same time, one limitation of the current research is that the participants were undergraduates and there may be differences between undergraduate samples and clinical or community samples. For example, college students may have higher SES, more education, and less psychopathology than community samples. Future research could examine the invariance of the SPQ in these same ethnicities with samples drawn from community or clinical settings.

Another potential limitation of the current research is that we had a relatively small sample of Pacific Islanders. Researchers have recommended samples of at least 200 for each group in a multigroup CFA testing measurement invariance (Cheung & Rensvold, 2002), and only 159 were included in the current sample. Having too small of a group may have decreased the statistical power of these analyses, which decreases the probability of finding measurement invariance. Thus, a study with a larger sample of Pacific Islanders may find a lack of metric and scalar invariance. However, it is unlikely that this could explain the lack of clear evidence for scalar invariance in the current study. Moreover, excluding Pacific Islanders from the analysis resulted in the same pattern of results with the other three groups (i.e., metric invariance, but a lack of clear evidence for scalar invariance).

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Received July 28, 2014

Revision received May 5, 2015

Accepted May 13, 2015 ■

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