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Measurement Invariance of the Yale Food Addiction Scale 2.0 Across Gender and Racial Groups

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Food addiction describes a psychological and behavioral eating pattern that is similar to the experience of those compulsively taking drugs of abuse. Recent developments related to food addiction, including the development and validation of an updated measure (Yale Food Addiction Scale 2.0; Gearhardt, Corbin, & Brownell, 2016), have increased knowledge as to the prevalence and associated correlates of food addiction. However, less is known about the phenomenological experience of food addiction in diverse samples or how the existing measure of food addiction performs in heterogeneous samples. In a cross-sectional survey design, using a diverse sample of undergraduate students ($N = 642$) tests of measurement invariance were performed. Confirmatory factor analysis supported the hypothesized factor structure, indicating a single latent construct of food addiction modeled by 11 dichotomous indicators, in samples of White and Black participants as well as samples of men and women. Measurement invariance testing across the various demographic groups broadly provided good psychometric support for use of the measure. However, a single indicator related to attempts to cut down on highly palatable food varied across men and women. Thus, when using the measure in mixed gender samples researchers may consider obtaining additional information regarding gender and its relative impact on the experience of food addiction, particularly with respect to efforts to quit or cut down intake of highly palatable foods.

Public Significance Statement
A new tool, the Yale Food Addiction Scale 2.0, tests very similar constructs for White and Black people and mostly similar constructs for men and women. Results suggest that this tool may be useful with several different groups, but some symptoms may be different for men.

Keywords: food addiction, measurement invariance, diversity, scale validation

For several decades, researchers have explored whether some forms of undercontrolled eating may represent an addictive behavior (see Meule, 2015, for a comprehensive review), although controversy certainly persists (Avena, Gearhardt, Gold, Wang, & Potenza, 2012; Ziauddeen, Farooqi, & Fletcher, 2012; Ziauddeen & Fletcher, 2013). Food addiction (FA) describes a particular form of undercontrolled eating that is thought to have both behavioral and neurobiological similarities to substance use disorders (SUDs; Meule & Gearhardt, 2014). Although there is no single agreed upon definition of FA, and it is not a formally recognized eating or addictive disorder, the criteria outlined in the Yale Food Addiction Scale (YFAS; Gearhardt, Corbin, & Brownell, 2009) are widely used (see Table 1 for summary of these criteria). Symptoms of FA include a loss of control over eating and strong urges and craving to consume highly palatable (high-sugar and high-fat) foods. A recent meta-analysis estimates that prevalence of FA is about 19.9% across studies (Pursey, Stanwell, Gearhardt, Collins, & Burrows, 2014). However, heterogeneity across studies and sample composition was observed. For example, FA was significantly higher among women (12.2%) as compared with men (6.4%). In addition, FA was more common among overweight or obese individuals (24.9%) as compared with healthy weight individuals (11.1%). Evidence related to prevalence in various ethnic groups was not provided. However, at least one study demonstrated comparable prevalence across racial and gender groups (Gearhardt, White, Masheb, & Grilo, 2013). Importantly, as this phenomenon has been observed among lean individuals (Flint et al., 2014; Meule, 2012) as well as overweight/obese individuals, it suggests that it is not exclusively a feature of obesity (Flint et al., 2014).

Support for the construct of FA can be derived from both preclinical and clinical samples. In animal models, rats fed an intermittent diet of sugar develop a pattern of excessive binge-like consumption as well as withdrawal-like symptoms (e.g., aggression, anxiety, teeth-chattering, and head-shaking) following its removal (Avena, Rada, & Hoebel, 2008). In addition, sucrose-dependent rats demonstrate delayed satiation, consume more su-

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Table 1
Possible Criteria for Food Addiction Based on the Yale Food Addiction Scale 2.0

Criteria
1. Food is often taken in larger amounts or over a longer period than was intended
2. There is a persistent desire or unsuccessful efforts to cut down or control certain foods
3. A great deal of time is spent in activities necessary to obtain, use, or recover from the effects of eating
4. Craving, or a strong desire or urge for certain foods
5. Recurrent eating patterns resulting in a failure to fulfill major role obligations at work, school, or home
6. Continued eating patterns despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of food
7. Important social, occupational, or recreational activities are given up or reduced because of eating
8. Recurrent eating in situations in which it is physically hazardous
9. Eating patterns are continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by food
10. Tolerance
a. need for markedly increased amounts of food to achieve desired effect
b. markedly diminished effect with continued use of the same amount of food
11. Withdrawal
a. withdrawal syndrome when refraining from eating specific foods
b. specific foods are eaten to relieve or avoid withdrawal symptoms

Note. Adapted from Meule and Gearhardt (2014).

crose, and show elevated dopamine release in the nucleus accumbens (Davis & Carter, 2009). In humans, FA is associated with higher levels of eating, weight and shape concerns, depression/negative affect, emotion dysregulation, food cravings, and attentional and motor impulsivity (Gearhardt et al., 2012; Meule, Hermann, & Kubler, 2015); some of these features such as negative affect and attentional and motor impulsivities are also observed in other addictive behaviors (MacLaren, Fugelsang, Harrigan, & Dixon, 2011; MacKillop et al., 2014). In addition, FA is associated with similar patterns of neural activation as observed in substance dependence, including elevated activation in reward circuitry in response to food cues and diminished activation in inhibitory regions in response to food intake (Gearhardt et al., 2011). There is also evidence of dopamine signaling strength attenuation among those with FA, such that those with FA are resistant to the usual food suppression effect induced by the dopamine agonist, methylphenidate (Davis, Levitan, Kaplan, Kennedy, & Carter, 2014). Finally, compared with obese individuals without FA, obese individuals with FA were more likely to meet criteria for binge eating disorder, severe depression, and childhood attention deficit hyperactivity disorder (ADHD; another known SUD risk factor; Davis et al., 2011).

The topic of FA is still controversial. For example, many authors point out the lack of convincing evidence in humans related to tolerance and withdrawal (Ziauddeen, Farooqi, & Fletcher, 2012). Although cross-sectional studies demonstrate that individuals endorse symptoms of tolerance and withdrawal (Cassin & von Ranson, 2007; Gearhardt et al., 2016), laboratory evidence related to tolerance and withdrawal has yet to be widely demonstrated. A noteworthy exception includes the work of Spring et al. (2008), who conducted a double-blind placebo-controlled study and found evidence to support tolerance. This study, however, did not explicitly recruit participants with FA, and a similarly rigorous study including individuals meeting criteria for FA has yet to be completed. Despite significant discussion related to the presence or absence of these features, it is important to note that based on the current nosology, neither tolerance nor withdrawal are required for a diagnosis of a SUD. Other concerns include some inconsistencies in the expected relationships in preclinical models. More specifically, although studies have demonstrated withdrawal in sucrose-dependent rats (Avena, Rada, & Hoebel, 2008) and obesity in rats fed high-fat and high-sugar foods (Johnson & Kenny, 2010), the evidence related to both of these phenomena (withdrawal and obesity) in a single experimental paradigm is lacking. Finally, although some researchers point out the inherent survival functions of eating food as wholly distinct from drugs of abuse, there is growing research related to clarifying which specific foods may be addictive. Such a conceptualization aligns with a large literature base in pharmacology as well as SUDs that demonstrates that some drugs are addictive (e.g., opiates) whereas others are likely not (e.g., aspirin), despite their similar analgesic properties. In particular, highly refined foods (which contribute to glycemic load) and/or high-fat foods are thought to be more likely to be associated with addictive processes. Schulte, Avena, and Gearhardt (2015) found that individuals completing a forced choice task related to food were significantly more likely to report that highly refined foods and/or high-fat foods were associated with addictive like eating. In addition, the authors found that the number of symptoms on the YFAS was associated with ratings of how problematic participants experienced highly refined and high-fat foods. Although the effect was small, these results represent an important first step in elucidating the possible composition of foods that may be more likely to be associated with FA.

As noted above, the most widely used definition and scale for assessing FA addiction is the YFAS. Originally developed in 2009, the measure parallels the diagnostic criteria used for substance dependence in the Diagnostic and Statistical Manual of Mental Disorders (*DSM–IV-TR*; American Psychiatric Association, 2000). The YFAS was validated across several populations, demonstrating adequate internal reliability, and discriminant, convergent, and incremental validity (Gearhardt et al., 2009, 2011, 2012; Clark & Saules, 2013). Despite the strong psychometric properties of the previous version of the YFAS, an updated version (YFAS 2.0) was recently published (Gearhardt et al., 2016) to appropriately align with the changes made to the substance-related and addictive disorders (SRAD) section in *DSM–5* (American Psychiatric Association, 2013). In the initial validation study, the YFAS 2.0 demonstrated good internal consistency, and convergent, discriminant, and incremental validity (Gearhardt et al., 2016). The original YFAS and the YFAS 2.0 have both been shown to have a one-factor structure (Gearhardt et al., 2009, 2016), but the extent to which this factor structure holds across racial groups and gender groups is unknown. In addition, little is known about the phenomenology of FA in heterogeneous samples.

Some data, however, suggest that there may be important considerations with respect to racial and gender diversity. With respect to potential differences across racial and ethnic groups, the extant literature frequently studies eating disorder symptoms in Black

women with the same measures that have been predominantly developed in samples of White women. A comprehensive review of available self-report measures of disordered eating reveals some important differences with respect to construct validity in White and Black women (Kelly et al., 2012). In particular, several prominent measures were found to be noninvariant across racial groups, including the Binge Eating Scale, Eating Disorder Diagnostic Scale, Eating Attitudes Test–26 (EAT-26), and Eating Disorder Inventory (EDI). Notably, the YFAS was not included in this review. Another study (Belon et al., 2015) assessed measurement invariance of the EDI in a sample of Hispanic and White women, finding that the factor loadings for the EDI subscales varied between groups.

Studies of invariance for measures of disordered eating in men and women provide greater support for the construct validity in these groups, although less data are available. In particular, Boerner, Spillane, Anderson, and Smith (2004) found that the Bulimia Test—revised, the Eating Expectancy Inventory, and the Three Factor Eating Questionnaire were invariant across genders. In addition, the EAT-26 was generally invariant with the exception of item variances. In contrast, a modified Structured Clinical Interview for *DSM–IV* anorexic symptoms was variant across genders. In another study, Forbush et al. (2013) extracted 160 items from existing measures of disordered eating during their development and validation of the Eating Pathology Symptom Inventory. A subset of 49 items were subjected to invariance testing, which demonstrated that most items and scales were invariant across genders. However, the factor loadings and thresholds for items that comprised the Body Dissatisfaction factor, and the latent factor means for Body Dissatisfaction and Muscularity were estimated to be unequal across genders.

Because of the recent development of the YFAS 2.0 and the existing gaps in the literature, the current study assessed the measurement invariance of the YFAS 2.0 across White and Black samples, as well as in samples of men and women. Based on the literature, it was hypothesized that the current measure would be noninvariant across Black and White samples and invariant across men and women.

Methods

Sample

Participants (N = 642) were college students recruited from introductory psychology courses at a midsize Midwestern university. Students were eligible to participate if they were 18 years of age or older and provided at minimum background demographic characteristics (e.g., gender and racial/ethnic identity). For the purposes of these analyses, only those who identified as men or women and White or Black were included. The sample was 77.7% White, and 66.5% were women, with a mean body mass index (BMI) of 25.33 (SD = 5.51). The size of the Black sample (n = 148) in our study was relatively small compared to the White sample, although this sample size was still consistent with traditional guidelines, which recommend at least 10 observations per indicator in the model (Nunnally, 1967). All participants provided informed consent prior to their participation. Participants completed a Web based assessment related to a range of risk behaviors, including possible FA symptoms. Participants were given course credit upon completion of the Web-based survey. This study was approved by the Eastern Michigan University Internal Review Board.

Measures

FA. FA symptoms were assessed using the YFAS 2.0 scale, a 35-item self-report measure of eating behavior in relation to high-sugar and/or high-fat foods. The decision to exclusively focus on high-sugar and/or high-fat food was based on earlier research demonstrating that foods with this macronutrient profile are most often reported during food binges (e.g., Allison, & Timmerman, 2007; Dalton, Blundell, & Finlayson, 2013). The items assess a range of behaviors and were developed through adapting the *DSM–5* SRAD criteria. In brief, some of the most important changes from the orginal YFAS scale to the current version include adapting the new *DSM–5* perspective that does not distinguish between abuse and dependence and assessing for craving. All items on the YFAS 2.0 are continuous, indicating the frequency of a given behavior ranging from 0 (*never*) to 7 (*every day*). However, to reflect diagnostic thresholds, a cut-off for each item was established ngusi receiver operator characteristic curves. Based on these thresholds, dichotomous diagnostic indicators are calculated, where diagnostic criteria are considered to be met if one or more of the relevant questions for each criterion meet the threshold. Based on the scoring system, modeling of dichotomous indicators was used in the current work. The use of dichotomous indicators aligns with large-scale studies investigating the factor structure of substance use disorders (e.g., Hasin et al., 2013), as well as the previously published factor analysis for this measure (e.g., Gearhardt et al., 2016).

Data Analysis

To examine the measurement invariance across gender and racial groups, structural equation modeling (SEM) via Mplus 7.0 was used, with weighted least squares means and the variance adjusted (WLSMV) estimator. The WLSMV estimation was chosen due to its suitability for conducting confirmatory factor analyses (CFA) with ordered categorical variables. First, independent CFAs were conducted to investigate the model fit for each of the identified groups (White and Black samples as well as samples of men and women). Next, multigroup CFAs were conducted sequentially, where the parameter estimation was carried out using the least constrictive (all parameters are freely estimated) estimation initially, followed by more constrictive steps (all factor loadings, intercepts, and residuals are constrained to be equal). This procedure consisted of testing configural invariance, scalar invariance, and strict invariance. Configural invariance was tested by constraining the unidimensional factor model with 11 observed indicators to be invariant, freely estimating the factor loadings and item thresholds, fixing the residual variances equal to one in both groups, and fixing the factor means to be equal across groups. Scalar invariance was tested by constraining the unstandardized item factor loadings and unstandardized item thresholds to be invariant, fixing residual variances to one in the reference group and freely estimating the residual variances in the alternative group, and fixing the factor means to 0 in the reference group and freely estimating the factor means in the alternative group (Mer-

edith, 1993). And finally, strict invariance was tested by constraining the parameters constrained in prior steps, fixing the residual variances to be invariant and keeping the factor means fixed at 0 in the reference group and freely estimating the factor means in the reference group (Millsap, 1998; Wu, Li, & Zumbo, 2007).

The changes in model fit from least restrictive models to more restrictive ones were evaluated by the DIFFTEST $\chi^2(df)$ difference testing procedure, which tests for decreases in fit as the models become more stringent, such that a nonsignificant ($p > .05$) χ^2 difference test result indicated that model fit did not worsen after imposing more constraints (Sass, 2011). The comparative fit index (CFI; Bentler, 1990), Tucker-Lewis index (TLI; Tucker & Lewis, 1973), and root mean square error of approximation (RMSEA; Browne & Cudeck, 1993) were used to evaluate model fit. Both TLI and CFI are comparative indices that evaluate the model fit by comparing the chi square value of the observed model to the null model in which all observed variables are uncorrelated (Hooper, Coughlan, & Mullen, 2008). The RMSEA is an absolute fit index (McDonald & Ho, 2002) that evaluates differences between the observed covariance matrix and hypothesized covariance matrix per degrees of freedom in the model (Chen, 2007). As per recommendations of Hu and Bentler (1999), a value of .95 or higher was accepted as good fit for CFI and TLI, whereas a value of 0.06 or lower was considered good fit for RMSEA.

Because of the use of the WLSMV estimator, issues of nonnormality were not pertinent for these analyses. Missing data (less than 2%) were estimated using regression imputation, where the missing observations serves as a dependent variable and other relevant variables in the data set are used to predict the missing value (Tabachnick & Fidell, 2013).

Results

Prevalence of FA Across Gender and Racial Groups

Overall, 18.8% of the sample met YFAS 2.0 criteria for FA. The prevalence of Black versus White participants who met criteria for FA was 18.9% and 18.8%, respectively, $\chi^2(1) = .00$, $p = .99$. Mean (*SD*) number of FA symptoms for Black versus White participants was 1.97 (2.84) versus 1.87 (2.77), respectively, $t(640) = .37$, $p = .71$. The prevalence of men versus women who met criteria for FA was 14.0% and 21.3%, respectively, $\chi^2(1) = 5.06$, $p = .024$. Mean (*SD*) number of FA symptoms for men versus women was 1.71 (2.72) versus 1.98 (2.82), respectively, $t(640) = 1.15$, $p = .25$. Notably, although men and women had comparable overall symptom counts, the increased number of women meeting FA criteria was accounted for by their greater likelihood of endorsing the symptom distress criterion (14.4% vs. 23.9%), $\chi^2(1) = 7.81$, $p = .005$.

Measurement Invariance Across Samples of White and Black Groups

Independent CFAs in White and Black Groups. The results of separate CFAs showed that the unidimensional factor pattern of the YFAS measured by 11 observed dichotomous indicators generally held in both samples (see Table 2); however, a single fit index (RMSEA) indicated only marginal fit for both samples. Given that two of the three fit indices demonstrated good model fit, invariance testing was carried out in subsequent steps. Notably, this same fit pattern for the RMSEA was observed in the YFAS 2.0 validation sample (Gearhardt et al., 2016), wherein comparison to a two-factor solution (i.e., dependence/craving and abuse criteria as two separate factors) did not result in noticeably improved fit; therefore, the one-factor solution was retained for the YFAS 2.0, and it will be explored as such here. Importantly, the unequal group sizes influence all interpretations based on chi-square (e.g., CFI and parameters; Brown, 2006), and may increase possible Type I errors (Chen, 2007). Adequate sample size within groups may minimize potential bias (Hox & Maas, 2001), but results may be interpreted cautiously.

Configural invariance. The results for all invariance testing for White and Black groups are presented in Table 2. In the configural model and subsequent invariance models, White participants were chosen as the reference group and Black participants were considered the alternative group, though identifying either sample as the reference group yields the same results in invariance testing. The configural model constituted the baseline model, which imposed an invariant factor pattern in Whites and Blacks by constraining the unidimensional pattern to be equal across groups. In line with guidelines in invariance testing with categorical indicators (Muthén & Muthén, 2015), the configural model allowed the factor loadings and item thresholds to be freely estimated, while setting the factor mean to 0 and factor variances and residual variances to 1 in both groups for model identification. The results of this procedure showed that the single factor pattern of the YFAS

Table 2
Yale Food Addiction Scale 2.0 Baseline Model Fit Results and Tests of Measurement Invariance for Whites and Blacks

	Overall fit indices					Comparative fit indices
Independent CFAs	$\chi^2(df)$	CFI	TLI	RMSEA (90% CI)	a	χ^2 dif. testing
Black	92.516 (44), $p < .001$	.99	.99	.087 (.062–.112)	.88	—
White	292.260 (44), $p < .001$	.98	.98	.106 (.094–.117)	.88	—
Measurement invariance						—
Configural (weak) invariance	364.437 (89), $p < .001$	.99	.98	.098 (.087–.108)	—	—
Scalar (strong) invariance	365.387 (97), $p < .001$	.99	.98	.092 (.082–.103)	—	3.896 (8), $p = .866$
Strict invariance	341.722 (108), $p < .001$	.99	.99	.082 (.072–.092)	—	12.037 (11), $p = .361$

Note. CFAs = confirmatory factor analyses; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; CI = confidence interval; χ^2 dif. testing = the DIFFTEST procedure, where changes in model fit are evaluated when moving from the least restrictive (baseline) to the most restrictive model (strict invariance).

consisting of 11 indicators was invariant across the two ethnic groups. Specifically, both CFI (0.99) and TLI (0.98) indicated excellent fit for the model, whereas the RMSEA (0.10 [0.09–0.11]) indicated a marginal fit. Since configural invariance held in both groups, further steps were taken to examine the invariance of a more stringent model.

Scalar invariance. Scalar invariance was examined by imposing further equality constraints on the unstandardized item factor loadings and item thresholds in White and Black samples. Whites were the reference group. Accordingly, the residual variances were set to be equal to 1 in Whites as the reference group and freed in the Black alternative group, as per invariance testing guidelines (Muthén & Muthén, 2015). Similarly, the scalar model required setting the factor mean to be equal to 0 and factor variance to be equal to 1 in the White reference group, while freely estimating them in the Black reference group (Muthén & Muthén, 2015). Results of the DIFFTEST, $\chi^2(8) = 3.896$, $p = .866$, showed that the equality constraints on the item factor weights and item thresholds did not result in significant worsening of model fit. The estimates of fit indices for the scalar model was also comparable to those of the configural model with slight improvement in the RMSEA (CFI = 0.99, TLI = 0.98, RMSEA = 0.09 [0.08–0.10]). Given that scalar invariance was established, the most stringent model was examined in the final step.

Strict invariance. The most stringent model was tested by placing further equality constraints on residual variances to be equal across Whites and Blacks. This was done by setting the residual variances to be 1 in both groups, while retaining the constraints of the scalar model. DIFFTEST results, $\chi^2(11) = 12.037$, $p = .361$, showed that invoking additional constraints on residual variances did not result in significant worsening of model fit. This indicates that the error variances were invariant across White and Black samples, providing robust support for the measurement invariance of the YFAS in two ethnic groups. The CFI (0.99) and TLI (0.99) continued to indicate excellent fit of the data to the model, whereas RMSEA (0.08 [0.72–0.92]) now indicated acceptable fit.

Measurement Invariance Across Samples of Men and Women

Independent CFAs in men and women. The results of separate CFAs showed that the unidimensional factor pattern of the YFAS measured by 11 observed dichotomous indicators generally held in both samples (see Table 3); however, a single fit index (RMSEA) indicated only poor fit for the sample of women (0.12 [0.104–0.126]). Given that two of the three fit indices demonstrated good model fit, invariance testing was carried out in subsequent steps.

Configural invariance. The results for all invariance testing for the sample of men and women are presented in Table 3. The configural model imposed an invariant factor pattern in women and men by constraining the single dimensional pattern to be equal across gender groups. Factor loadings and item thresholds were freely estimated in both groups, while item residual variances were fixed to 1 for model identification in both groups. The configural model also required fixing the factor mean to 0 and factor variance to 1 in both groups for model identification. Results from this procedure showed that the single factor pattern of the YFAS 2.0 consisting of 11 indicators was invariant across two gender groups. Specifically, both CFI (0.99) and TLI (0.98) indicated excellent fit of the data to the model, whereas the RMSEA (0.10 [0.09–0.11]) indicated marginal fit. With the majority of fit indices supporting model fit, a more stringent model was tested in the next step.

Scalar invariance. Scalar invariance was examined by imposing further equality constraints on the unstandardized item factor loadings and item thresholds in men and women. The residual variances were fixed to 1 in the reference group of men and freed in the alternative group of women. Similarly, in the reference group of men, the factor mean was set to 0 and the factor variance was set to 1, although these were freely estimated in the alternative group of women (Muthén & Muthén, 2015). DIFFTEST results, $\chi^2(8) = 16.860$, $p = .0316$, showed that imposing further constraints on the item factor weights and item thresholds resulted in significant worsening of model fit. Accordingly, modification indices were reviewed to identify the model parameters that contributed to poor fit of the data to the model. The examination of modification indices showed that releasing the regression weight of the "cut down" item for women would result in improvement of the model fit. Therefore, partial invariance was tested by estimating the factor weight of the "cut down" item freely in both gender groups. This procedure yielded a nonsignificant DIFFTEST result, $\chi^2(7) = 9.894$, $p = .195$, providing support for partial scalar invariance (Byrne, Shavelson, & Muthén, 1989). Item thresholds were invariant in the partial scalar model, indicating that the distribution cut-offs of the YFAS 2.0 item were equal for men and women. In terms of model fit, CFI (0.99) and TLI (0.98) continued

Table 3
Yale Food Addiction Scale 2.0 Baseline Model Fit Results and Tests of Measurement Invariance for Men and Women

	Overall fit indices					Comparative fit indices
Independent CFAs	$\chi^2(df)$	CFI	TLI	RMSEA (90% CI)	*a*	χ^2 dif. testing
Men	9655.541 (55), $p < .001$	.99	.99	.08 (.064–.099)	.89	—
Women	14430.902 (55), $p < .001$	.98	.97	.12 (.104–.126)	.88	—
Measurement invariance						—
Configural (weak) invariance	436.630 (89), $p < .001$	.99	.98	.10 (.092–.111)	—	—
Partial scalar (strong) invariance	444.284 (96), $p < .001$	.99	.98	.10 (.089–.107)	—	9.894 (7), $p = .195$
Partial strict invariance	399.479 (107), $p < .001$	.99	.99	.085 (.076–.094)	—	11.892 (11), $p = .371$

Note. CFAs = confirmatory factor analyses; CFI = comparative fit index; TLI = Tucker--Lewis index; RMSEA = root-mean-square error of approximation; CI = confidence interval; χ^2 dif. testing = the DIFFTEST procedure, where changes in model fit are evaluated when moving from the least restrictive (baseline) to the most restrictive model (strict invariance).

to indicate excellent fit of the data to the model, whereas RMSEA estimate indicated marginal fit (0.10 [0.089–0.107]). Given that partial scalar invariance was established, the most stringent model was examined in the final step.

Partial strict invariance. In order to examine partial strict measurement invariance, further constraints were imposed on residual variances by setting their values to be equal to 1 in for men and women, while retaining the constraints from the previous model. DIFFTEST results, $\chi^2(11) = 11.892$, $p = .371$, showed the additional constraints on residual variances did not result in worsening of model fit. This finding provides strong support for partial measurement invariance of the YFAS in two genders groups. The CFI (0.99) and TLI (0.99) indicated excellent fit of the data to the model, while the RMSEA estimate (0.09 [0.72–0.92]) indicated marginal fit. Overall, these results suggested that the error variances of all YFAS items were invariant across men and women.

Discussion

There is growing attention related to the phenomenon of FA, including its association with increased body mass, disordered eating, shape and weight concerns, and weight cycling (Gearhardt, Boswell, & White, 2014; Gearhardt et al., 2016), as well as its association with more general forms of psychopathology (e.g., depression, impulsivity, ADHD; Davis et al., 2011; Meule et al., 2015). To date, there is only one psychometrically validated measure operationalizing and assessing the construct of FA, and it recently underwent major revision, based on the changes made to the SRAD section of the *DSM–5*. The prevalence rate of FA in this sample was 18.8%, which is higher than estimates of FA in other college samples (e.g., 11.4%; Gearhardt et al., 2009). This is likely due to the higher average BMI, with our sample showing a mean BMI 3 points higher than the BMI observed in Gearhardt et al. (2009). In particular, research has demonstrated that the prevalence rate of FA is significantly higher in overweight and obese samples (Pursey et al., 2014).

Regarding measurement invariance in racial groups, the data did not support our hypothesis that the measure would be variant across Black and White samples and instead provide strong psychometric support for the use of the YFAS 2.0 across both groups. In particular, the 11 indicators outlined in the *DSM–5* SRAD section and translated for the YFAS 2.0 were all related to a single factor of FA in White and Black samples. In addition, the symptoms of FA were explained by the overall trait of FA similarly across White and Black samples, as evidenced by invariant factor loadings. Item thresholds, or the amount of the trait needed to answer positively and error were also invariant across groups. However, the unequal number of participants in each group influences interpretations. In particular, Brown (2006) writes that although it is permissible to conduct analyses with unequal groups, there is a higher probability of finding no differences, where there are in fact differences (i.e., Type I error). For example, some simulation studies have demonstrated that unequal sample sizes can reduce power to detect mean differences in groups (Kaplan & George, 1995), so this result must be interpreted cautiously.

In considering why invariance was observed when extant literature demonstrated problems for other widely utilized measures of disordered eating behavior, YFAS 2.0 measurement development seems highly salient. In particular, many of the measures of disordered eating that were found to be noninvariant were developed and validated on largely White samples. In contrast, the YFAS 2.0 was developed and validated with a more heterogeneous sample; 6.7% were Asian American, 6.5% were African American, 3.9% were Hispanic, and 5.2% were from other races/ethnicities (Gearhardt et al., 2016). Although this is not representative of a national sample, there is significantly greater diversity than has been observed in other validation studies.

Results only partially supported the hypothesis that the YFAS 2.0 would be invariant across men and women. In general, results broadly provided psychometric support for use of the YFAS 2.0 in both men and women. In particular, the 11 symptoms were all related to a single factor of FA for men and women in this sample. However, the strength of the relationship between each of the symptoms and the trait of FA was different across groups. Examination of modification indices demonstrated that the relationship between attempts to cut down and FA was not equivalent across men and women, with the indicator loading more strongly for women. Items related to this indicator include, "I worried a lot about cutting down on certain types of food, but I ate them anyways" and "I really wanted to cut down or stop eating certain types of foods, but I just couldn't." There are abundant data to support that women are under greater pressure to be thin and have higher rates of dieting and weight cycling than men do, at least in the United States (e.g., Neumark-Sztainer & Hannan, 2000; Paeratakul, York-Crowe, Williamson, Ryan, & Bray, 2002; Pingitore, Spring, & Garfield, 1997). In addition, there is some research that supports the role of restrained or restrictive eating in the development of conditions related to FA, such as bulimia nervosa and binge eating (Schnitzler, von Ronson, & Wallace, 2012; Stice, Presnell, & Spangler, 2002), but other researchers do not replicate these data (Johnson, Pratt, & Wardle, 2012). Interestingly, one study specifically explored the role of dietary restraint for eating pathology in men, and they did not replicate a relationship between restrained eating and binge eating (Dakanalis, Timko, Clerici, Zanetti, & Riva, 2014). This aligns with our finding, that attempts to cut down are more strongly related to FA in women as compared with men. Future research should aim to investigate the role of attempts to cut down in the development or maintenance of FA, particularly among men.

Despite the data demonstrating some differences in the relationship of FA and the symptom indicators, additional tests were undertaken to understand any other differences across genders. Thereafter, nonsignificant differences in the measure across men and women were fully supported, with invariant item thresholds and errors. Importantly, however, across most steps, the RMSEA generally indicated only adequate or marginal fit. Although this is a limitation, it is notable that these values are very similar to those published in the original validation paper (Gearhardt et al., 2016).

The purpose of measurement invariance testing is to determine if measures are assessing the same construct across different groups. This is important across a variety of measures and samples, but it is particularly true in the field of eating disorders, where some have theorized that biases have contributed to lower rates of treatment utilization (Becker, Franko, Speck, & Herzog, 2003). At least one study has found that after controlling for scores on measures of disordered eating, Latino and Native American participants were significantly less likely

than White participants to receive a referral for further care (Becker et al., 2003). Such data highlight that independent of measurement issues, potential bias exists, but assessing the validity of measures represents an important contribution to an area of growing attention. The validity of measures assessing undercontrolled forms of eating (e.g., FA or binge eating) may be particularly important. Specifically, some hypothesize that the elevated rates of obesity observed in communities of color (Wang & Beydoun, 2007) could be related to higher incidences of binge eating and/or FA (Grilo, White, Barnes, & Masheb, 2013; Smolak & Striegel-Moore, 2001).

The issues are no less relevant when considering gender. Historically, men were often entirely excluded from studies on eating disorders or when they were included, they were often a substantial minority (Streigel, Bedrosian, Wang, & Schwartz, 2012). With respect to FA, prevalence rates are higher in women than men. However, this discrepancy is much lower than what has been observed for other forms of disordered eating (Davis, 2015; Pursey et al., 2014). A meta-analysis found that approximately 6.4% of men meet criteria for FA, which is greater than the 12-month prevalence rate observed for major depression (Hasin, Goodwin, Stinson, & Grant, 2005) and drug use disorder (Grant et al., 2015). These data indicate that as FA field continues to grow, attention should be paid to its phenomenology in men.

Although this study is the first to investigate measurement invariance of the YFAS 2.0 in White and Black samples, as well as in samples of men and women, its contributions must be considered in the context of the study's strengths and limitations. First, this study included a relatively large proportion of Black participants (n = 143) and men (n = 215). In addition, there is a greater range of BMI (15.62–56.64) than may be typically observed in undergraduate samples. However, the use of this undergraduate sample also has limitations. Most prominently, it is unclear if these findings generalize to other types of populations, such as those with lower levels of educational attainment or lower socioeconomic status. Finally, although this investigation represents an important first step, measurement invariance should also be investigated in additional diverse groups (e.g., Hispanic or Asian American samples).

In addition to exploring construct validity in other racial groups, future studies could investigate a number of other important psychometric properties. Ideally in studies that include both clinical and nonclinical samples, the presence of floor and ceiling effects should be investigated. Information related to temporal stability would also be of interest for supporting validity. A final unique psychometric property is a measure's responsiveness to intervention. In the case of FA, this is an important and largely unexplored area of research. For example, the types of treatment that are efficacious for treating FA and how changes in YFAS scores reflect treatment outcomes remain largely unknown. One study of behavioral weight loss treatment demonstrated that FA symptoms were negatively correlated with weight loss at 7 weeks (Burmeister, Hinman, Koball, Hoffmann, & Carels, 2013), but changes in FA symptoms were not explored. Future studies that test the efficacy of treatments generally supported for SRADs when applied to FA might advance our understanding of the extent to which certain eating behaviors may be best understood from an addictions perspective.

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