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Distinguishing trait and state competitiveness in university students using generalizability theory

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Abstract
During transition to adulthood, competitiveness can significantly influence an individual's success in academic, professional, and social contexts. This study applied the Revised Competitiveness Index (RCI) to a sample of 227 individuals aged 18 to 29, measuring competitiveness across three time intervals, each separated by three weeks, to assess the stability of this trait using generalizability theory. Findings indicate that competitiveness, as measured by the RCI, exhibits significant consistency across time points, underscoring its presence as a stable trait rather than a fluctuating state. The results suggest that competitiveness remains a persistent characteristic within this demographic, potentially aiding in identifying individuals with a natural disposition toward competitive environments. Efforts to delineate state competitiveness through the index items proved less fruitful. This research accentuates the importance of considering competitiveness trait within young adults, with implications for designing educational and professional interventions aimed at recognising and nurturing competitive strengths in youth.

Keywords Competitiveness, Youth, Revised competitiveness index, Generalizability theory, State, Trait

1 Introduction

In the transition from adolescence to adulthood, competitiveness—defined as the drive to win or excel in interpersonal scenarios—emerges as a critical factor shaping educational, career, and social outcomes. This period, spanning ages 18 to 29 years, is especially formative as individuals confront academic and professional demands that often necessitate competitive engagement [1, 2]. While competitiveness has been widely recognized for its impact on achievement, less is known about whether competitiveness functions as a stable trait within individuals or as a dynamic response to situational factors, particularly during this developmental stage [3].

China's educational system presents a challenging paradox for competitiveness research, as it simultaneously promotes collective harmony while fostering fierce academic rivalry. Traditional Confucian ideologies prize both social cohesion and scholarly

excellence, yet these seemingly contradictory values coexist within contemporary Chinese education [4]. Students navigate environments where examination performance carries extraordinary weight—determining not merely university placement but entire career trajectories. Such pressures may trigger competitive responses that vary considerably from an individual's baseline disposition. This cultural tension between communal values and individual striving raises compelling questions about whether competitive behaviours represent stable personality traits or adaptive responses to environmental demands, making this population particularly valuable for state-trait research in educational contexts.

This distinction between a stable *trait competitiveness* and a fluctuating *state competitiveness* is essential to understanding how competitiveness shapes behaviour. Trait competitiveness reflects a deeply ingrained, consistent drive to compete, while state competitiveness is more situational, arising in response to competitive environments [5]. Evidence suggests that highly competitive individuals may view situations through their own competitive lens, creating a ripple effect that heightens competition for others as well [6]. Internal psychological characteristics can be changeable and adaptable under different environments. Person–environment fit theory suggests that individuals adjust behaviours while actively interacting with the environment [7]. Thus, individuals could show a competitive attitude and behaviour in a competitive workplace in order to meet the job demands, even though they may not have an overall high level of trait competitiveness.

State competitiveness manifests as temporary changes in competitive behaviour triggered by specific circumstances. Consider a student who typically avoids confrontation but becomes intensely competitive during final examinations, or someone who remains passive in most social situations yet fights fiercely for a coveted scholarship. These responses emerge from environmental pressures rather than underlying personality. Trait competitiveness, however, reflects an enduring personal orientation such as individuals who are naturally attracted to competitive situations, interpret neutral interactions as contests, and maintain this outlook whether in classrooms, sports fields, or casual conversations. The key difference lies in consistency: those high in trait competitiveness compete because it aligns with their fundamental personality trait, while state-driven competition represents adaptive responses to external demands. From a measurement perspective, trait competitiveness should demonstrate stability across assessment occasions, whereas state competitiveness creates person-by-occasion variance as individuals respond differently to changing circumstances.

In competitive academic settings, this may lead to state-like competitive responses even among individuals with lower trait competitiveness. Whether stable personality traits, characteristics of situations, or interactions of traits and situation are more relevant to psychological reactions and related behaviour has been debated for decades [8]. Yet, due to a predominant focus on cooperative and collaborative learning models, research on competitiveness—particularly in educational contexts—has often been overlooked. Understanding the dynamics of competitiveness during early adulthood is therefore important for educators and policymakers, who must navigate the balance between fostering healthy competition and supporting collaborative learning.

Recent empirical work has applied Generalizability theory (G-theory) as an advanced statistical approach to differentiate between state and trait aspects of psychometric

measurements [9]. Classical Test Theory (CTT), while foundational to psychometric assessment, has limitations in distinguishing between these stable trait and dynamic state components because it treats all measurement error as a single, undifferentiated source of variance. In contrast, G-theory extends CTT by decomposing variance into multiple identifiable sources, including person variance (representing stable traits), occasion variance (representing temporal effects), and person-by-occasion interactions (representing state-like variability).

Developed by Cronbach et al. [10], G-Theory expands on CTT by examining multiple error sources, yielding a more precise reliability assessment across varied conditions [11, 12]. Unlike CTT, which treats error as a single value, G-Theory examines facets such as persons tested, items, and occasions, allowing it to differentiate stable traits from context-driven states [13]. G-Theory's analysis generally proceeds in two stages: a Generalizability study (G-study) that calculates the generalizability coefficient (G-coefficient), reflecting the measure's consistency, followed by a Decision study (D-study), which adjusts the design to reduce measurement errors [14, 15]. This facet-based approach surpasses CTT by capturing interactions that clarify both stable and transient elements of a construct [16, 17].

Applying G-Theory to the Revised Competitiveness Index (RCI) [18] within a sample of Chinese students offers a unique cultural perspective. The competitive academic environment in China, where students regularly face intense pressure to outperform peers for academic and career opportunities, provides a particularly relevant context for exploring competitiveness as a potential trait or state [19]. Additionally, Chinese university graduates face significant post-graduation employment challenges, further amplifying the importance of competitiveness in academic and extracurricular activities as students strive to secure a competitive edge [20]. Given the cultural and contextual factors shaping competitiveness in non-Western settings, this study seeks to evaluate the extent to which competitiveness is an enduring trait or a responsive state in Chinese academic settings.

1.1 Hypothesis development

1.1.1 Hypothesis 1: high generalizability across persons and occasions

The RCI has shown strong temporal stability in previous psychometric evaluations, with the Chinese version demonstrating good reliability [21]. Previous G-theory applications to psychological constructs have demonstrated that trait-like characteristics typically exhibit high generalizability coefficients exceeding 0.80, while state measures show significantly lower values [9, 12]. Furthermore, competitiveness as a personality characteristic has been conceptualized as relatively stable across situations in achievement contexts [6]. The stability of competitiveness across time and contexts suggests it functions primarily as a trait rather than a state-dependent characteristic. Based on this theoretical and empirical foundation, we hypothesize:

Hypothesis 1 The RCI will demonstrate high generalizability coefficients ($G > 0.80$) across persons and occasions, indicating that competitiveness as measured by the RCI is primarily trait-like rather than state-dependent.

1.1.2 Hypothesis 2: person variance dominance

G-theory decomposes total variance into distinct sources, with person variance representing stable individual differences—the hallmark of trait measures [13]. Research applying G-theory to personality and psychological traits consistently shows that person variance accounts for the majority of total variance when traits are measured across time [17]. For trait measures, person variance typically exceeds 70% of total variance, while person-by-occasion interaction remains minimal [14]. Given that competitiveness has been conceptualized as a stable personality disposition [5] and shows consistent individual differences across competitive situations [22], we expect similar variance decomposition patterns:

Hypothesis 2 Person variance will account for the majority of total variance in RCI scores, with minimal person-by-occasion interaction variance, supporting the trait conceptualization of competitiveness.

1.1.3 Hypothesis 3: trait versus state component indices

The Trait Component Index (TCI) and State Component Index (SCI) provide quantitative metrics for determining whether a measure assesses primarily trait or state characteristics [12]. Research has established that trait measures typically exhibit TCI values exceeding 0.80 and SCI values below 0.30 [16]. These indices have been validated across various psychological constructs, with trait measures consistently showing this pattern in repeated measurement designs [14]. The RCI's development as a measure of dispositional competitiveness [18] and its demonstrated temporal stability in both Western and Chinese populations [21] suggest it should exhibit similar trait-dominant indices:

Hypothesis 3 The Trait Component Index (TCI) will exceed 0.80 for the total RCI and subscales, while the State Component Index (SCI) will be below 0.30, indicating predominant trait characteristics.

1.1.4 Hypothesis 4: item-level variability in state-trait properties

While overall measures may demonstrate trait properties, individual items often show differential susceptibility to situational influences [12]. Previous G-theory research has identified that even within predominantly trait measures, certain items exhibit higher state-like variance [9]. This item-level variability is particularly relevant in competitiveness research, as specific competitive behaviors may be more context-dependent than others [5]. For example, items assessing satisfaction from competition might be more stable than items about avoiding arguments, which could vary with social context [8]. The person-environment fit theory suggests that while core competitive orientation remains stable, specific behavioral manifestations may adapt to environmental demands [7]. This theoretical consideration leads to our final hypothesis:

Hypothesis 4 Individual items will show varied state-trait profiles, with some items being more susceptible to situational influences than others, as indicated by differential SCI values across items.

2 Method

2.1 Participants

The convenience sample consisted of 227 students enrolled from various faculties at universities in People's Republic of China. 53% of the students were in their second year of four-year degree studies and the rest were in their third year. The mean age was 19.6 years ($SD = 1.07$), with a range of 18 to 29 years, and 84.6% of the students were female. As most participants were from a teacher education institute, a high proportion of female participants was not unexpected. The sample size ($n = 227$) exceeded the required minimum sample size ($n = 116$) for repeated ANOVA over three times necessary to achieve the power (1-β) of 0.95 to detect small effect size of 0.15 under p-value of 0.05.

2.2 Procedure

Data were collected face-to face at three occasions separated by a 3-week interval, during tutorials. Ethical approval was obtained from the Central China Normal University Ethics Committee (Reference number: CCNU-IRB201709023) and the study was conducted in compliance with the guidelines of the Central China Normal University Ethics Committee. Participants provided their informed consent prior to data collection. The study is not registered as a clinical trial.

2.3 Measures

The Chinese version of the RCI had been recently translated and validated [21]. Respondents rate their agreement with the statements expressed by 14 items on a 5-point Likert scale ranging from "*strongly disagree* = 1" to "*strongly agree* = 5". The instrument is scored as two subscales: Enjoyment of Competition (nine items) and Contentiousness (five items). Of the former subscale, four items are negatively worded, whereas all items of the Contentiousness scale are negatively worded. Prior to analyses, these items (4, 6, 7, 8, 10, 11, 12, 13, and 14) were reverse coded so that higher scores on each item indicate higher levels of competitiveness. The Chinese version of the RCI has been shown to have good reliability, with Cronbach's alpha of 0.86 for Enjoyment of Competition and 0.74 for Contentiousness.

2.4 Data analyses

There was a negligible number (< 1%) of responses to the mid categories (e.g., between 2 and 3) that were considered as missing and replaced using person mean imputation at that specific time point (Huisman, 2000; Paterson et al., 2017). When participants missed one of the three assessment occasions, the entire data for that participant were deleted as the analyses required a complete set of data from three occasions for each participant. Even though the RCI is typically scored in terms of two subscales, the present analyses also analysed the scale as a unidimensional profile, solely for the present purpose of exploring the stability of the items and not to suggest an alternatively scoring system.

Data was analyzed using IBM SPSSv25 and G-analyses were conducted utilizing EduG 6.1-e software following guidelines published elsewhere [12]. In line with these guidelines, a random effects repeated-measures design was implemented for G-study and D-study defined as person (P) by item (I) by occasion (O) (P x I x O). Facets P and O facets were defined as infinite while I was a fixed facet because the same set of items

were used across persons and occasion. The object of measurement was a person, which represented a true variance and not a source of error. The generalizability/reliability was assessed by G coefficient as follows: (G = True person variance / (True person variance + Error variance). G- coefficient of 0.80 and higher would indicate an acceptable reliability meaning that true variance is accounted for at least 80% of the total variance in the data, with the remaining variance attributed to the measurement error. The effects for all facets and relevant variance components were computed by the G-study based on formulas described by Shavelson et al. [13] as follows:

μ = grand mean of X (observed score), *p* = persons, o = occasions, i = items
$X = \mu + X_p + X_o + X_i + X_{pi} + X_{po} + X_{oi} + X_{residual}$ where:
$X_p = \mu_p - \mu$ (person effect)
$X_o = \mu_o - \mu$ (occasion effect)
$X_i = \mu_i - \mu$ (item effect)
$X_{po} = \mu_{po} - \mu_p - \mu_o + \mu$ (person x occasion effect)
$X_{pi} = \mu_{pi} - \mu_p - \mu_i + \mu$ (person x item effect)
$X_{oi} = \mu_{oi} - \mu_o - \mu_i + \mu$ (occasion x item effect)
$X_{residual} = X_{poi} - \mu_{pi} - \mu_{po} - \mu_{oi} + \mu_p + \mu_i + \mu_o - \mu$
MS = mean square of effect, *n* = facet sample size
$\sigma^2_p = (MS_p - MS_{pi} - MS_{po} + MS_{poi})/n_i n_o$; Person variance component
$\sigma^2_o = (MS_o - MS_{io} - MS_{po} + MS_{poi})/n_i n_p$; Occasion variance component
$\sigma^2_i = (MS_i - MS_{pi} - MS_{io} + MS_{poi})/n_p n_o$; Item variance component
$\sigma^2_{po} = (MS_{po} - MS_{poi})/n_i$; Person x occasion variance component
$\sigma^2_{pi} = (MS_{pi} - MS_{poi})/n_o$; Person x item variance component
$\sigma^2_{io} = (MS_{io} - MS_{poi})/n_p$; Item x occasion variance component
$\sigma^2_{pio} = MS_{poi}$; Residual (person x occasion x item) variance component

There are relative G-coefficient (Gr) and absolute G-coefficient (Ga). Gr considers only error sources that impact rank-ordering of scores, which are useful for relative decisions (Shavelson et al. 1989):

$$Gr = \frac{\sigma^2_p}{\sigma^2_p + \sigma^2_\delta}\ ;\ \sigma^2_\delta = \frac{\sigma^2_{pi}}{n_i} + \frac{\sigma^2_{po}}{n_o} + \frac{\sigma^2_{pio}}{n_i n_o};$$

(Here n_i is *the* number of items and n_o is *the* number of ocassions)

Ga is computed by including the absolute error variance that accounts for all sources of error variance that can affect scores directly or indirectly.
$\left(\sigma^2\Delta = \frac{\sigma o}{\eta_o} + \frac{\sigma^2_i}{\eta_i} + \frac{\sigma^2_{pi}}{\eta_i} + \frac{\sigma^2_{po}}{\eta_o} + \frac{\sigma^2_{io}}{\eta_i \eta_o} + \frac{\sigma^2_{pio}}{\eta_i \eta_o}\right)$ (Cardinet et al., 2010):

$$G_a \simeq = \frac{\sigma^2_p}{\sigma^2_p + \sigma^2_\Delta}$$

A trait component index (TCI) and a state component index (SCI) were also estimated that represent the relative proportion of variance attributed to a trait and a state components assessed by an instrument (Medvedev et al., 2017a):

$$SCI = \frac{\sigma^2_{po}}{\sigma^2_{po} + \sigma^2_p}; TCI = \frac{\sigma^2_p}{\sigma^2_{po} + \sigma^2_p}$$

SCI values were estimated for each individual item in D-study. Items with high SCI (i.e.≥0.80) are generally considered as measuring a state, while items with low SCI (i.e.<0.30) are reflecting a trait [12]. D-study involved experimenting with measurement design by varying the number of items and their content aiming at optimizing the

assessment of competitiveness. The data from this study is available upon request from the corresponding author.

3 Results

Table 1 presents descriptive statistics for all three measurement occasions for the overall RCI (sum of all items) as well as the two subscales. Cronbach's alpha values ranged from 0.73 to 0.84. Test-retest reliability (Occasion 2 versus 1 and Occasion 3 versus 1) ranged from 0.61 to 0.71, with the lowest values for Contentiousness (0.61 and 0.65, respectively). Skewness and kurtosis was of no concern, both being well within the range of -1.00 to 1.00. Mean scores for the total scale did not change significantly but significantly decreased across occasions for Enjoyment of Competition and increased significantly for Contentiousness.

3.1 G-study

Generalizability coefficients (relative and absolute) as well as state and trait component indices are shown in Table 2 for the entire RCI and also separately for the two subscales. The estimated variance components have already been divided by the number of levels of the facet (the number of items in the scale, and the number of occasions administered), and the final two rows of the table indicate the estimated generalizability for the full RCI, a 9-item (competition) and 5-item (contentiousness) subscales administered on 3 occasions.

High reliability and generalizability of scores across persons and occasions was found for the total RCI, with both relative and absolute G coefficients (G_r and G_a) of 0.85 and the remaining 15% of variance fully attributed to state competitiveness, which is person-occasion interaction (PxO). Gr and Ga values were slightly lower for the Contentiousness subscale: 0.81 and 0.78, respectively, while merely 11.5% of variance was explained

Table 1 Means, standard deviation (SD), cronbach's alpha, test-retest coefficients (Pearson's *r*), skewness and kurtosis values for the total RCI as well as its two subscales enjoyment of competition and contentiousness

Domain/Assessment	Occasion 1	Occasion 2	Occasion 3	*p*-value
Overall				
Mean (SD)	40.67 (7.29)	40.58 (6.98)	40.47 (6.83)	0.85
Cronbach's alpha	0.84	0.83	0.82	
Test-retest	--	0.73**	0.72**	
Skewness	0.28	0.26	0.36	
Kurtosis	-0.25	-0.26	-0.05	
Enjoyment of Competition				
Mean (SD)	27.64 (5.30)	27.13 (4.82)	26.99 (4.68)	0.03*
Cronbach's alpha	0.82	0.79	0.76	
Test-retest	--	0.71**	0.69**	
Skewness	0.16	0.16	0.46	
Kurtosis	-0.28	-0.61	0.18	
Contentiousness				
Mean (SD)	13.02 (3.19)	13.44 (3.24)	13.48 (3.25)	0.02*
Cronbach's alpha	0.73	0.76	0.78	
Test-retest	--	0.61**	0.65**	
Skewness	0.30	0.10	0.31	
Kurtosis	0.24	-0.08	0.13	

The column labelled *p*-value refers to results from a repeated-measures ANOVA comparing mean scores across occasions.
*$p < 0.05$; ** $p < 0.01$

Table 2 G-study estimates for the total RCI and the two subscales enjoyment of competition and contentiousness

	Total RCI		***Enjoyment of Competition***		***Contentiousness***	
Domains	σ^2	%	σ^2	%	σ^2	%
P	0.064	85.0	0.088	76.0	0.181	78.0
I	0.000	0.0	0.000	0.1	0.000	0.0
O	0.000	0.0	0.000	0.0	0.000	0.0
PxI	0.000	0.0	0.006	5.6	0.009	3.9
PxO	0.011	15.0	0.00	9.4	0.008	3.2
IxO	0.000	0.0	0.04	1.6	0.008	3.3
PxIxO	0.000	0.0	0.01	7.3	0.027	11.5
SCI	0.06		0.09		0.18	
TCI	0.94		0.91		0.82	
Gr	0.85		0.77		0.81	
Ga	0.85		0.76		0.78	

Shown are Coefficient G relative (G_r), Coefficient G absolute (G_a), Trait Component Index (TCI), State Component Index (SCI), grand mean (GM), variance components (in %), and for the Person (P) x Occasion (O) x Item (I) design including interactions ($n = 130$). Grand mean = 2.90

by interaction between person, item and occasion (PxIxO) representing the major source of error for this subscale. Generalizability values were the lowest for the Enjoyment of Competition subscale (Gr = 0.77 and Ga = 0.76), but were still acceptable for a trait measure with 9.4% of variance accounted for state variability (PxO) and remaining 15% due to others sources of error (Table 2). A state component index (SCI) and trait component index (TCI) are inversely related such that TCI = 1-STC. The former expressed the extent to which a measure reflects the ability to reliably assess a trait, while the latter expresses the extent to which a measure is a state (Medvedev et al., 2017). For the total RCI and the two subscales, TCI scores are clearly reflective of a trait measure. For the total score and the Enjoyment of Competition subscale, TCI was 0.94 and 0.91, respectively. With 0.82, TCI was slightly lower for Contentiousness, although it still indicated that this subscale measures a trait rather than a state.

3.2 D-study

In D-study, we have systematically removed items and occasion levels and evaluate generalisability of the full scale and its subscales, which showed no improvement of the overall reliability and generalisability of the assessment scores with all G coefficients below those reported in the G-study. These results suggest that the full scale and its subscales are optimal in the current measurement design. However, it appears that some items are more likely to be affected by external context than others (Table 3), particularly Item 5 "I get satisfaction from competing with others" and Item 10 "I try to avoid arguments", which demonstrated the highest SCI values (0.75), indicating they are the most state-like components of the scale and thus most susceptible to environmental influence and situational variability.

In addition, analyses were conducted to explore whether there is a relationship between item location on the state-trait continuum and the extent to which an item is easy or difficult to shift. Location on the state-trait continuum is measured by SCI values (Table 3). Values of item difficulty were obtained from the results of a Rasch analysis by Krägeloh et al. [21]. This analysis was based on a dataset that was partially identical to the one used for the present G-Theory study. Krägeloh et al. [21]conducted their psychometric evaluation of the Chinese RCI using a sample of 585 students at Occasion 1. Of

Table 3 Variance components of person (P), occasion (O), and person-occasion interaction (PxO) together with state component index (SCI), for each individual item of the RCI

Items	*P*	O	PxO	SCI	Location
1. I like competition	0.30	0.02	0.14	0.32	0.22
2. I am a competitive individual	0.23	0.01	0.21	0.48	-0.03
3. I enjoy competing against an opponent	0.18	0.04	0.24	0.56	-0.05
4. I don't like competing against other people	0.38	0.02	0.15	0.28	0.14
5. I get satisfaction from competing with others	0.09	0.02	0.26	**0.75**	0.16
6. I find competitive situations unpleasant	0.23	0.04	0.17	0.42	0.13
7. I dread competing against other people	0.20	0.03	0.20	0.50	-0.45
8. I try to avoid competing with others	0.11	0.12	0.22	0.66	0.08
9. I often try to out perform others	0.34	0.05	0.17	0.33	-0.20
10. I try to avoid arguments	0.07	0.03	0.22	**0.75**	0.26
11. I would do almost anything to avoid an argument	0.31	0.01	0.15	0.33	0.25
12. I often remain quiet rather than risk hurting another person	0.32	0.04	0.17	0.35	0.35
13. I don't enjoy challenging others even when I think they are wrong	0.13	0.11	0.22	0.62	-0.62
14. In general, I will go along with the group rather than create conflict	0.38	0.04	0.18	0.32	-0.24

Item location values are from Krägeloh et al. (2018), using the same dataset but with all participants who had completed the measure at Occasion 1. Bold type font signifies high SCI (> 0.70); Location values are an indicator of item difficulty, where 0 is the average and higher values signify lower likelihood to endorse an item. Items with negative item location are thus classified as relatively easy items and items with positive values as relatively difficult items.

these, only 227 completed the survey at all three occasions, which was required for the G-Theory analyses. There was no association between item difficulty as identified by the Rasch analysis and the SCI values obtained here (Spearman's rho = -0.04, $p = 0.88$).

4 Discussion

In the evolving narrative of young adults' journeys, understanding competitiveness becomes pivotal. The aim of the present study was to differentiate between state and trait components in the RCI [18] and to examine the temporal stability and generalizability of this instrument using G-Theory. The Chinese version of the RCI has recently been shown to have strong psychometric properties [21]. Using a dataset of 227 university students who completed the Chinese RCI at three occasions, the results indicated that the total RCI as well as the two subscales Enjoyment of Competition and Contentiousness reliably measure trait competitiveness with G coefficients indicating that scores are generalizable across persons and occasions. In contrast, the SCI derived from measures including all state items was below acceptable cut-off point for a state measure (SCI >0.60). This suggests that the proportion of variance attributed to state component in a measure of competitiveness indexed by the RCI is minimal. The total RCI scale demonstrated the highest generalizability of scores and temporal stability with only 15% of variance attributed to state competitiveness and no other sources of error were identified. Enjoyment of Competition subscale had lower generalizability with about 10% of variance in scores explained by state competitiveness and contained measurement error due to other sources. Unlike the total RCI and Enjoyment of Competition subscale, no variance in Contentiousness subscale was attributed purely to the state competitiveness, suggesting that contentiousness has more pronounced trait nature.

It should be noted that subscale scores of competitiveness changed significantly over time. Enjoyment of Competition was gradually reduced while Contentiousness was increased. Although actual reasons for the observed changes in subscales scores were not very clear, it might be related to either stage change or interactions between person, items and occasion where individual respond to specific items depending on external

circumstances (e.g., reduction of state competitiveness is related to state changes, and potential error in contentiousness might be due to interaction between person, item and occasion increasing the scores). For example, an individual may score higher on some items in a competitive environment but lower on some other items while hiking. This is a complex interaction and can be considered as measurement error in this case. Our findings implicate that subscale scores, even though they are trait measures, do have some vulnerability to variations in external contexts and usage of the full scale is encouraged as it can resolve such measurement issues. In the present study, such external influences are not uncommon and might be related to a gradual and systematic increase in the workload, e.g., coursework, assignments, and exams, over a period of time at universities.

When it comes to the RCI, it appears that some items are more likely to be affected by the external context than others (Table 3), such as the Item 13 "I don't enjoy challenging others even when I think they are wrong", and the Item 7 "I dread competing against other people". In contrast, two particular items of the RCI, the Item 5 "I get satisfaction from competing with others" and the Item 10 "I try to avoid arguments", appear the most stable traits measures that cannot be easily modified by the environment. Thus, when the RCI is applied in either research or practical settings, the features of these individual items should be taken into consideration.

To best of our knowledge, the relationship between item difficulty and temporal stability had not been previously explored. For that purpose, comparisons were made with the results from a previous Rasch analysis of the scale [21]. This study had reported item locations of the RCI, which indicates how easy an item is prone to change when competitiveness changes. A so-called easy item would change very quickly as a person's latent trait changes, whereas difficult items require a person to possess a higher level of the latent trait for any scores increases to be noticeable. While it appears plausible to expect that state items are also those items with a low item location and thus easy to change, our results did not find an association between item difficulty and stability. Further research will need to confirm the lack of this relationship with other questionnaires and in different contexts.

While G-theory can be applied to quantify a person's amount of state and trait competitiveness, this may need data with a large sample of individual measurements scores over time, analogous to a single-case design, to achieve acceptable reliability. For instance, weekly measurements over 6 to 12 months can satisfy a required number of responses (e.g. 50 responses per item) to ensure the generalizability of state and trait estimates. This approach can open avenues for new research that involves application of G-theory at personal level.

The following limitations need to be acknowledged. Firstly, the current study was conducted in tertiary institutions in China. While the sample size was comparatively large for this type of study and distribution of scores showed evidence of a large range of individual scores, the study was restricted to educational settings in China. Secondly, the majority of the current samples were females which might introduce some bias to our results, as there are gender differences in competitiveness [22]. Further studies will need to explore the temporal stability of competitiveness in a sample with a balanced gender mix in other contexts, such as sports or work related. Admittedly, while G-theory promises precision, achieving optimal clarity requires extensive longitudinal data.

By embracing such data-rich paradigms, future endeavors could harness the power of G-theory at a deeply individualized level, painting a more vivid picture of youth's evolving competitiveness landscape.

Exclusion of participants who missed any of the three assessment occasions represent another limitation, which may have inadvertently selected for individuals with higher conscientiousness. This potential selection bias may be particularly relevant to state-trait research because conscientiousness itself represents a stable personality trait that could influence both the consistency of competitive responses and the likelihood of completing all assessments. Therefore, our findings regarding the trait-like nature of competitiveness should be interpreted with consideration that our sample may have been pre-selected for individuals with more stable behavioural patterns. Future research should explore whether the trait dominance we observed holds in more diverse samples including individuals with varying levels of conscientiousness and commitment to research participation.

Our measurement design utilized three assessment occasions at 3-week intervals in neutral classroom settings without experimental manipulation of competitive contexts. While this approach provides insights into naturally occurring temporal variability, it may not be optimal for detecting state-like competitive responses that could emerge in more dynamic or experimentally manipulated competitive situations. A more comprehensive assessment of state competitiveness would require more frequent measurements (e.g., daily or weekly assessments over several months) and inclusion of varying competitive contexts or experimental manipulation of competitive demands. Future research should consider ecological momentary assessment approaches or laboratory-based studies with systematic manipulation of competitive contexts to more thoroughly evaluate the state-like components of competitiveness that our current design may have underestimated.

As young adults meander through the transformative university years, factors like academic pressures and environmental dynamics inevitably affect their perceptions and expressions of competitiveness. Our findings hint that certain facets of the RCI might be more susceptible to these external ebbs and flows, particularly in the high-stakes academic backdrop of Chinese tertiary education. Such sensitivities emphasize the necessity of a comprehensive approach, suggesting a preference for the RCI's total scale to mitigate potential external influences.

Our findings have important implications for intervention design in educational and organizational contexts. The identification of predominantly trait-like competitiveness suggests that long-term interventions focusing on gradual attitude change may be more effective than situational manipulations for individuals seeking to modify competitive orientations. However, the identification of specific items with higher state components (Items 5 and 10) suggests targeted intervention opportunities. For example, educational programs could focus on helping students derive satisfaction from collaborative rather than competitive achievements, or training programs could help individuals develop constructive approaches to conflict resolution. In organizational settings, recruitment and team formation could benefit from understanding individual competitive traits, while performance management could leverage the state-like components through environmental design. The modest but meaningful state variance observed suggests that while core competitive orientations remain stable, targeted environmental modifications

and skill-building interventions can influence specific competitive behaviours and responses.

While our study focused primarily on establishing the psychometric properties and state-trait characteristics of the RCI in Chinese youth, we acknowledge that future research should examine how these trait and state components relate to various developmental and performance outcomes. Our findings provide the necessary psychometric foundation for such investigations by demonstrating the temporal stability and generalizability of competitiveness measurements, which is essential for meaningful examination of competitiveness as a predictor or correlate of academic, social, and professional outcomes in this cultural context.

Our results indicate that the RCI captures both enduring trait characteristics and meaningful state-like variability in competitiveness. While the majority of variance reflects stable trait components, the identification of two items with high state characteristics (SCI > 0.70) and six additional items with moderate state variance (SCI 0.40–0.60) suggests that competitiveness contains both stable dispositional elements and situationally responsive components that should be considered in both research applications and practical interventions.

5 Conclusion

In essence, our venture into the realm of competitiveness among young adults elucidates that the RCI, predominantly, taps into enduring facets of competitiveness. These findings not only enrich psychometric endeavors but also accentuate the relevance of understanding competitiveness as young adults navigate academic, professional, and social terrains. This underscores the importance of nuanced assessments of competitiveness in guiding supportive interventions and policies tailored for the youth and early adult populations.

Supplementary Information

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Supplementary Material 1.

Author contributions
ONM, GYW, and CUK wrote the main manuscript text and QZ collected the data. All authors reviewed the manuscript.

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Data availability
This study is preregistered and the data is archived in the Open Science Framework (OSF): [https://osf.io/k9jfv](https:/osf.io/k9jfv)The data will be publicly available upon acceptance of the manuscript for publication.

Declarations

Ethical approval and consent to participate
The study was approved by Central China Normal University Ethics Committee (Reference number: XYZ-IRB201709023). The ethical guidelines of the Central China Normal University Ethics Committee were followed during the study. All participants provided informed consent before participating in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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