



# Testing the Uncertainty-of-Stress Model: Developing the Adolescent Uncertainty Scale for Taiwanese Adolescents

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**Abstract** This study developed an Adolescents' Uncertainty Scale (AUS), with the aim of understanding individual differences in uncertainty among adolescents. In the pre-test phase, 507 ninth-grade students were recruited. After exploratory factor analyses, a 25-item AUS with four dimensions—irresoluteness, instability, lack of self-knowledge, and uncertainty of future—was obtained. During the formal testing phase, 3106 ninth grade students were recruited. The internal consistency reliability of the subscales was between .85 and .90, and the overall reliability was .95. Confirmatory factor analysis also indicated that the four-dimension model had acceptable internal validity. To assess external validity, 1967 ninth-grade students were recruited. Gathering the data of students' test anxiety and academic achievement, the results revealed that uncertainty partially mediated the effect of academic achievement on test anxiety, which is in line with the uncertainty-of-stress model (USM). On the basis of the preliminary results, the scale may be used for counseling and by educators.

**Keywords** Adolescents · Adolescents' Uncertainty Scale · Structural equation modeling · Test anxiety · Uncertainty-to-stress model · Validity

The perception of uncertainty is behind many types of stress responses and anxiety (Berenbaum et al., 2008; Buhr & Dugas, 2002). Dugas et al. (2001) indicate that undetermined situations can lead individuals to undergo stress responses such as anxiety or worry based on an intolerance of uncertainty in the environment. However, many studies to date confuse the anxiety caused by uncertainty, intolerance of uncertainty, and uncertainty itself, so it is important to further distinguish these three concepts. According to the entropy model of uncertainty (EMU) proposed by Hirsh et al. (2012), the more possibilities an individual perceives in a specific situation, the greater their anxiety. For example, if a patient believes that their condition may improve, *or* deteriorate *or* require one of many different medical treatments, they will experience higher levels of anxiety. Thus, we can define uncertainty here as referring to individual's perception of the number of possibilities, i.e., an affect-free experience, rather than the degree of tolerance for uncertainty or the anxious response to uncertainty, both of which involve negative affect.

Does perceived uncertainty affect anxiety levels in adolescents' daily life? The most common source of anxiety in one's teenage years comes from studying and is called test anxiety (Putwain & Daly, 2014). Some researchers have argued that students' test anxiety is caused by high levels of uncertainty (Sung, Chao & Tseng, 2016). Chao and Sung (2019a) went further by indicating that students with medium achievement have greater test anxiety. When asked why they were feeling anxious, the students said they were worried "I won't be able to get into a state school" and "I'm not meeting my own standards." Let us think carefully about these responses. "I won't be able to get into a state school" indicates *uncertainty* about being able to get into a state school, and "I'm not meeting my own standards" suggests uncertainty about being able to meet one's own

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standards. Therefore, these are both examples of student perception of uncertainty. For adolescents, then, uncertainty may be strongly related to facing the unknown, including one's future school and one's aspirations for a future career. Meanwhile, as mentioned above, students face uncertainty in a large number of situations, so knowing how different individuals respond differently to uncertainty may help to reduce their test anxiety through counseling, and even help them to better adapt to life. However, it is currently unknown how individuals differ in their responses to uncertainty owing to the lack of suitable measurement tools. Thus, the main purpose of the present study is to develop an Adolescents' Uncertainty Scale (AUS) based on the above definition of uncertainty.

In defining uncertainty, we have adopted Dugas et al.'s (2001) perspective and the entropy model of uncertainty (EMU) proposed by Hirsh et al. (2012), which considers uncertainty as a function of the number of possibilities an individual is facing in relation to personal preference and situational factors. According to this model, the more possible actions and perceptions an individual anticipates in a particular situation, the more uncertainty they may experience. Adolescents who envision numerous possibilities have higher uncertainty, which may cause more anxiety. In this study, we propose a framework for uncertainty by capturing the concept of the number of possibilities via the interactions between self-related/events-related and internal/external factors. Using this framework, we divide uncertainty into four dimensions: irresoluteness, instability, lack of self-knowledge, and uncertainty about the future. Each of these four dimensions will increase an individual's perceived number of possibilities. Furthermore, we compiled an AUS according to the four dimensions of uncertainty, which underwent pretest and formal testing phases to establish a formal AUS and evaluate the psychometric properties of the scale. This present study can report evidence of internal validity (e.g., confirmatory factor analysis, CFA) and external validity of the AUS. Previous research has implied the uncertainty of adolescents may mediate the relationship between academic achievement and test anxiety (Sung et al., 2016). For students with low to medium achievement, a higher academic achievement may be accompanied by greater uncertainty, which increases test anxiety. However, for students with medium to high achievement, a higher academic achievement reduces their uncertainty, which in turn alleviates their test anxiety. Therefore, we used the Examination Stress Scale (ExamSS) proposed by Sung and Chao (2015) to measure adolescents' test anxiety and the scores from the Comprehensive Assessment Program (CAP), the largest standardized achievement test for junior high school students in Taiwan, to measure students' academic achievement. Structural equation modeling (SEM) was adopted to inspect the mediation model of academic

achievement–uncertainty–test anxiety, which provided evidence of external validity for the AUS. We believe that our new measurement tool for measuring adolescent uncertainty can be used in national educational policy and counseling to facilitate students' adaptation to daily pressures.

## Literature Review

### Uncertainty

The word “**uncertainty**” is reflexive and has many meanings. Environmental uncertainty refers to properties of external stimuli, such as ambiguousness in the environment, and such stimuli generally have unpredictable, complex, and insoluble characteristics. For example, Mathot et al. (2012) explained, from an evolutionary perspective that animals respond using different methods when in uncertain environments (e.g., storing food in response to possible food shortages). The uncertainty here refers to the unpredictability of the environment. Dugas et al. (1998) explained that uncertainty refers to an individual's cognitive, emotional, and behavioral responses to ambiguous situations. Dugas et al. (2001) noted that uncertainty can be regarded as a tendency of humans; an individual can feel stressed and unpleasant due to uncertain matters or things and reject events that they cannot master. The Intolerance of Uncertainty Scale proposed by Buhr and Dugas (2002) also contains anxiety responses, such as “stressful” and “upsetting.” Carleton et al. (2007) also indicate that anxiety sensitivity such as illness sensitivity, fear of negative evaluation, and fear of pain seem to share a basis in fearing unknown consequences with intolerance of uncertainty. Worry is another type of intolerance of uncertainty in the environment. Berenbaum et al. (2008) verify a positive correlation ( $r=0.70$ ) between intolerance of uncertainty and worry. Bakioğlu et al. (2021) inspect the relationship between intolerance of uncertainty and other negative affects, such as depression, anxiety, and stress under the COVID-19 pandemic. Most previous studies ultimately use definitions of uncertainty to refer to negative emotions generated within an individual in response to environmental ambiguity. This makes it hard to differentiate the concept of uncertainty from negative responses such as fear, anxiety, and worry. Thus, in using the above-mentioned tool to measure uncertainty, we may in fact have captured the degree of anxiety or worry, rather than uncertainty itself. According to the EMU proposed by Hirsh et al. (2012), an individual is likely to experience greater stress as the number of possible choices increases. Additionally, the uncertainty-to-stress model proposed by Sung et al. (2016), students with medium academic achievement encounter more possibilities (higher uncertainty), which may cause their test anxiety to be greater than that of students with higher or

lower academic achievement. From this perspective above, uncertainty can be defined as the degree to which students perceive uncertainty. This raised the question of whether students perceive more possibilities purely because of objective external factors (how many people are competing for a school's enrollment quota), without personal internal factors. Students with decision-making difficulty or who do not know what academic courses suit them may also perceive more possibilities (choices of future admission), indicating that greater uncertainty is generated. Chao and Sung (2019b) also regarded uncertainty as a personal characteristic that may expose students to more possibilities. For example, students that have difficulty making decisions generally have greater anxiety. Therefore, we refined the new dimensions of uncertainty and divided them into interactions of "self-related and events-related" and "internal and external factors" (Table 1). Regarding internal and external, we distinguished whether the uncertainty was derived from the internal characteristics of an individual, which we called "indecisive," or from not understanding actual situations, which we termed "unclear." The EMU proposed by Hirsh et al. (2012) emphasized that an individual who encounters an ambiguous and unknown situation, whether it is indecisive or unclear, may be exposed to more possibilities. An indecisive adolescent tends to perceive more possibilities from irresolution when ordering a meal, for example. By contrast, under the same context, other possibilities disappear quickly for an adolescent who is not indecisive (i.e., they can immediately decide what to order for dinner). Indecisive individual difference is also in accord with the description in the EMU, in which it increases or decreases uncertainty. Nonetheless, being unclear about a situation is an actual state rather than a personal trait or tendency. Individuals in this state perceive more possibilities. Dugas et al. (2001) affirmed that individuals who encounter unclear situations often have stress reactions and feel unpleasant. For instance, haunted houses in amusement parks are dimly lit to generate an unclear state because this can make people perceive more possibilities (e.g., it allows people to imagine that something is hiding in a corner or will suddenly appear), and it makes them nervous and afraid. The same may be true in the context of education. Chao and Sung (2019a) and Sung et al. (2016) have both demonstrated that students

who are unclear about the future enrollment, that is, they are unclear about their further studies, have greater test anxiety. In summary, the two classification methods of uncertainty in this study were designed according to classifications of objects and causes as internal or external, and four dimensions for uncertainty were proposed.

In Table 1, uncertainty is classified into four types. The first is irresoluteness, in which uncertainty tends to be indecisive (in its conceptual classification) and self-related (in its object classification). Irresolution signifies that an adolescent has difficulty making decisions and cannot make them swiftly. Adolescents with difficulty making decisions generally face more possibilities, which can lead to higher uncertainty. An irresolute tendency is frequently related to anxiety. For example, Fabio et al. (2013) noted that the irresolute tendency was negatively correlated with extraversion and neuroticism (lack of positive expression) among the Big Five personality traits. Saka et al. (2008) mentioned that an irresolute tendency may also cause students to have difficulties in career decision making. Moreover, the research results of Chao and Sung (2019b), who used latent class analysis to classify students according to their personal characteristics and test anxiety, echoed those of Fabio et al. The findings suggested that irresolute uncertainty may indeed be accompanied by higher test anxiety.

The second type of uncertainty is instability. This type of uncertainty tends to be indecisive in its conceptual classification and is event-related in its object classification. Instability refers to students' feelings of being uneasy or regretful about something that has been determined, regardless of whether the matter was decided by themselves or by others. An example is deciding how to spend an afternoon. If the decision is an amusement park, instable people will worry about the occurrence of a thundershower, and suggest going to a museum; if the decision is to go to the museum, instable people will worry that the exhibits will be boring and suggest going to the amusement park. People with higher instability may often engage in counterfactual thinking at the cognitive level (Epstude & Roese, 2008). For example, irresolute people often develop the what-if thoughts. Moreover, people who often engage in counterfactual thinking also have fear of commitment (Betz & Serling, 1993). They frequently worry about unsatisfactory choices or that they missed more favorable opportunities (Gati et al., 2011). Betz and Serling (1993) indicated the correlation between fear of commitment and trait anxiety is 0.66. Thus, irresolute students may perceive more possibilities, which might lead to higher anxiety.

The third type of uncertainty is lack of self-knowledge. This type of uncertainty is unclear (its conceptual classification) and is self-related (its object classification). Lack of self-knowledge refers to students being unclear about themselves, where their self-concepts are ambiguous or unstable.

**Table 1** Classification of the uncertainty of adolescents

	Internal or external	
	Indecisive	Unclear
<i>Object</i>		
Self-related	Irresoluteness	Lack of self-knowledge
Event-related	Instability	Uncertainty regarding future

For instance, a problem that adolescents often encounter is that they cannot identify their aptitudes or interests. Sung, Cheng, and Hsueh (2017) noted that approximately 45% of junior high school students exhibited low differentiation regarding their interests, indicating that nearly half do not know what they are interested in. Lack of self-knowledge is the opposite of self-concept clarity (Campbell et al., 1996). Campbell et al. stated that self-concept clarity may have a positive relationship with self-esteem but is negatively related to neuroticism. In addition, Richman et al. (2016) suggested that unclear self-concept may also lead to depression. Therefore, students who lack self-knowledge may also have greater test anxiety.

The fourth type of uncertainty is uncertainty of future. This type of uncertainty is unclear (conceptual classification) and event-related (object classification). Uncertainty of future denotes that an adolescent cannot be sure about the future. For example, junior high school students may be uncertain about their performance in the next final examination or what school and academic department they will enter in the future. Sung et al. (2016) mentioned that middle-achieving students were more uncertain about whether they can enter public or private schools, which caused them to have greater test anxiety. Chao and Sung (2019a) further determined that among the causes of test anxiety in middle-achieving students, the proportion for “unable to further their education in public schools” was higher than that for high-achieving and low-achieving students. Therefore, junior high school students who feel more uncertain about the future may tend to feel greater test anxiety.

### Test Anxiety and the Uncertainty-of-Stress Model

Test anxiety is a long-term stress response of students those facing to a standardized test (Chao & Sung, 2019a), including the state of physiological anxiety and negative thoughts about tests (Stöber, 2004), and the perceptions of social expectations and social comparisons (Sung & Chao, 2015). Most relevant studies have regarded test anxiety as cause and academic achievement as result. Under such a causal relationship, two models can be used to explain the linear correlation. The cognitive interference model refers to a test anxiety response that interferes with the cognitive ability of a student, making the student’s performance drop due to test anxiety (von der Embse et al., 2018). As shown in Fig. 1, the model indicated that greater test anxiety leads to greater cognitive interference, which in turn causes a decline in academic achievement. Putwain (2019) also demonstrated that students’ locus of control and emotional regulation may affect the degree of worry, reducing test performance.

In the motivational enhancement model, conversely, the learning motivation of students may increase due to test anxiety, or they become more focused during the test,

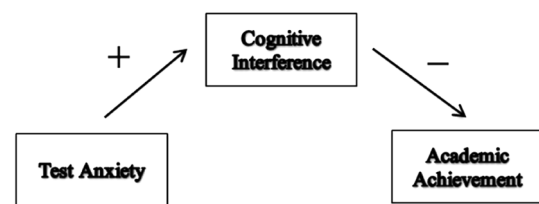


Fig. 1 Cognitive interference model of test anxiety

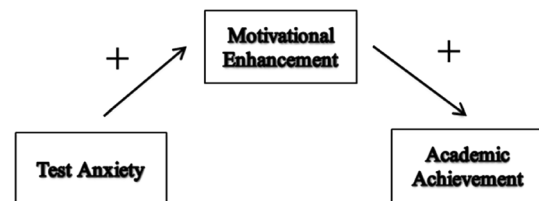


Fig. 2 Motivational enhancement model of test anxiety

which in turn improves their performance (Fig. 2). A few studies have suggested that test anxiety is positively correlated with academic achievement. For example, Banu et al. (2015) reported that Indian college students with excellent academic achievement had higher perceived academic stress. These results may be related to motivational enhancement. Macher et al. (2013) also argued that the statistics anxiety of students had a positive effect on their academic achievement which may be that statistics anxiety induced learning motivation.

In contrast to these two models above, Carey et al. (2016) claimed that test anxiety and academic achievement may have a bidirectional relationship, such as a chicken-and-egg conundrum. Sung et al. (2016) further indicated that middle-achieving students in Taiwan have the highest test anxiety, and this phenomenon cannot be fully explained by the aforementioned models. Therefore, the uncertainty-to-stress model (USM) may explain the inverted U-shaped phenomenon (Chao & Sung, 2019a; Sung et al. 2016). In USM, test anxiety is regarded as an outcome, where the degree of test anxiety may be associated with the level of uncertainty students perceived (Fig. 3). Moreover, differences in academic achievement may have caused differences in uncertainty level, which then affected students’ test anxiety (Fig. 4). In the upper part of Fig. 4 are students of below average academic achievement. For these students, perceived uncertainty increases with academic achievement, and the increase in uncertainty causes increased test anxiety. The bottom half refers to students with above average academic achievement. Their perception of uncertainty should decrease as their academic achievement increases, and test anxiety decreases with uncertainty (Fig. 4).

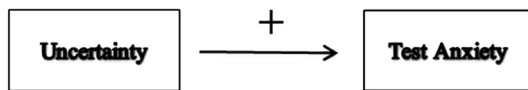


Fig. 3 Uncertainty-of-stress model of test anxiety (1)

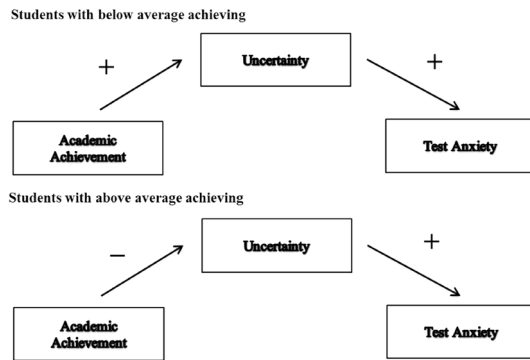


Fig. 4 Uncertainty-of-stress model of test anxiety (2)

## Research Objectives

This study's main objective was to redefine the concept of uncertainty and compile an AUS that measures uncertainty levels in adolescents through four dimensions. In school counseling, an AUS can be used to identify students with higher tendencies to greater uncertainty and enable them to make better adjustments to school life. In the evidence for the validity of the AUS we compiled, in order to determine whether the results were consistent with the USM, in addition to verifying internal validity, we also had to verify that the scores obtained mediate the relationship between academic achievement and test anxiety. Therefore, in addition to the pretest and formal testing phases, we also conducted additional data collection, including for test anxiety (measured by the ExamSS) and academic achievement (represented by CAP score). The uncertainty-to-stress model was then tested directly to provide evidence of external validity.

## Method

### Participants

In the pretest phase, purposive sampling was used to recruit 507 Taiwanese ninth-grade students constituted of 273 males (53.8%), 233 females (46%), and 1 of unstated gender (0.2%). During the formal testing phase, stratified random sampling was employed from northern, central, southern, and eastern Taiwan at a ratio of 3:2:2:1, to recruit a total of 3106 Taiwanese ninth-grade students, with 1544 male

(49.7%), 1552 female (50%), and 10 unstated gender (0.3%) student respondents. The formal sampling covered junior high schools in every region of Taiwan and students of various levels of academic performance in Taiwan, so the sample is representative.

To assess external validity, an online system was used to randomly recruit 1967 Taiwanese ninth-grade students; their uncertainty and test anxiety were measured, and their CAP scores were obtained. Students were not required to identify with a gender in the online questionnaire. With regard to place of residence, approximately 42.2% of the students lived in the north, 32.0% in the west, 23.2% in the south, and 2.6% in the east and offshore islands, which roughly corresponded to the population distribution of Taiwan. In the pretest and formal testing phases, all participants had to return an informed consent form explaining the scope of data access before data collection began. For the third sample, the informed consent form was again presented to the participants before the survey. All participants in this study were ninth-grade students, with ages between 14 and 15.

## Research Materials

### AUS

The AUS established in this study has four dimensions according to the interaction between object and factor: irresoluteness, instability, lack of self-knowledge, and uncertainty about the future. After determining the dimensions, we constructed items for each. We first drafted 10 to 12 items for each dimension in accordance with the definition of the four dimensions of the AUS, and then we conducted a subject matter expert meeting. All items were rigorously reviewed by domain-subject experts and testing experts to determine whether the item descriptions fitted the definitions of the dimension content. After reviewing the items, we retained eight items for each dimension for the pretest phase. In the pretest phase, eight declarative sentences for each of the four dimensions were included. A 5-point scale was employed, and higher agreement with these statements indicated higher uncertainty. Participants could select one of the five options of *strongly disagree* (1 point), *disagree* (2 points), *partially agree* (3 points), *agree* (4 points), and *strongly agree* (5 points) based on the respondent's agreement with the declarative. Total scores for each subscale and the entire AUS were obtained. In the pretest AUS, each dimension had a minimum of 8 and a maximum of 40 points; the total score was a minimum of 32 points and a maximum of 160 points. Again, for all subscales and the total score, a higher score signified higher uncertainty. Principal axis factoring and oblique rotation were adopted to perform exploratory factor analysis (EFA) of the pretest results to understand the distribution of items in all dimensions. Four



factors were obtained through factor analysis, which could explain 59.04% of the variance for factors in the four dimensions. Subsequently, discrimination index of the items was analyzed. Items are generally considered to be of acceptable quality if the discrimination index exceeds 0.40 (Ebel & Frisbie, 1991). In the present study, a pretest item was deleted if its factor loading in the original dimension was less than 0.40 and did not exceed 0.50 in other dimensions. Items were also removed if their discrimination index was below 0.4. According to these criteria, seven items were deleted in total. Therefore, a 25-item version of the AUS was created, with 7 items for *irresoluteness*, 6 items for *instability*, 5 items for *lack of self-knowledge*, and 7 items for *uncertainty of future*, was constructed, as shown in Table 2.

### ExamSS

The external validity of the AUS was assessed using the ExamSS (Sung & Chao, 2015), as the criterion. On the basis of the 1,967 responses, the Cronbach's  $\alpha$  coefficients for the three dimensions and total score were between 0.90 and 0.96. Regarding the CFA model fitting, the comparative fit index (*CFI*), Tucker–Lewis index (*TLI*), and root-mean-square error of approximation (*RMSEA*) were 0.87, 0.86, and 0.08, respectively. These results implied that the ExamSS exhibited an acceptable internal validity in the present study.

### CAP 2017

To further test the USM, the CAP 2017 scores of the participants were also collected to establish evidence of external validity. After obtaining the students' consent, the Research Center for Psychological and Educational Testing (RCPET) at National Taiwan Normal University, organizer of the CAP, was applied to for the participants' CAP scores. The CAP is divided into subjects such as writing assessment, Mandarin Chinese, English (reading), English (listening), mathematics, social studies, and natural science. The writing assessment is graded at Levels 1 to 6; the scores of other subjects are categorized into proficient (Level A), basic (Level B), and requires improvement (Level C), and the scores for English reading and listening can be combined. The CAP is currently the largest academic achievement test in Taiwan, and the test results are used to monitor academic attainment. Each item was reviewed by subject and test experts and was included in the item bank after pretest. In the present study, RCPET researchers were invited to convert the respondents' answers to a scale score which range of each subject was set between 1 and 80 points, and each level of the writing assessment can be converted into a scale score of 2 points, for a total score out of 412 points (Sung et al. 2016). Subsequently, the scores were converted to percentile rank (PR)

for the comparison of high-achieving (PR 50–99) and low-achieving students (PR 1–49).

### Procedure and Data Analysis

Regarding the preparation of the AUS, pretest and formal testing phases were set, and the procedures for the two phases were alike. The administrators were trained employees of [name deleted to maintain the integrity of the review process]. During the testing process, the administrators first explained to the students the purpose of the questionnaire, the students' rights, and the answering method. After the participants completed the questionnaire, the administrators again explained information confidentiality and how their information would be used. The AUS required 15–25 min to complete in both phases.

The following explains the data collection for assessment of the external validity of the AUS. CAP 2017 was conducted on a weekend in May, and the six multiple-choice subjects and the writing assessment were administered within 2 days. The test time and process were governed by a strict, standardized procedure. Subsequently, the researchers conducted online data collection by using the ExamSS and AUS in June of the same year. Before answering the questionnaire, students were informed of the research objectives, their rights, data usage methods, and data confidentiality. Students were provided the questionnaire only if they agreed to provide consent. Students were instructed on how to complete the ExamSS and AUS before answering the questionnaire. Later, the researchers requested the students' CAP 2017 scores from RCPET.

Regarding data analysis, the pretest analysis and deletion of items in the AUS have been mentioned above. During the formal testing phase, internal consistency analysis of the total scale and four subscales was first conducted to review their reliability. For internal validity, the CFA was analyzed and the one-dimensional model, two-dimensional model (internal and external), and four-dimensional measurement model of the AUS were compared to examine whether uncertainty should be regarded as a single dimension, two dimensions (internal and external), or four dimensions as classified in this study. The statistical software *Mplus 8.0* was used for analysis of these models (Muthén & Muthén, 2018). As model indicators, *CFI*, *TLI*, *RMSEA*, standardized root-mean-square residual (*SRMR*), Akaike information criterion (*AIC*), Bayesian information criterion (*BIC*), and *adjusted BIC* were compared. In addition, two indicators, composite reliability and average variance extracted (*AVE*), were employed to examine the convergent validity of each sub-dimensions.

Regarding external validity, three analyses were conducted, including correlation analysis and mediation analysis. The correlation coefficients between ExamSS and AUS

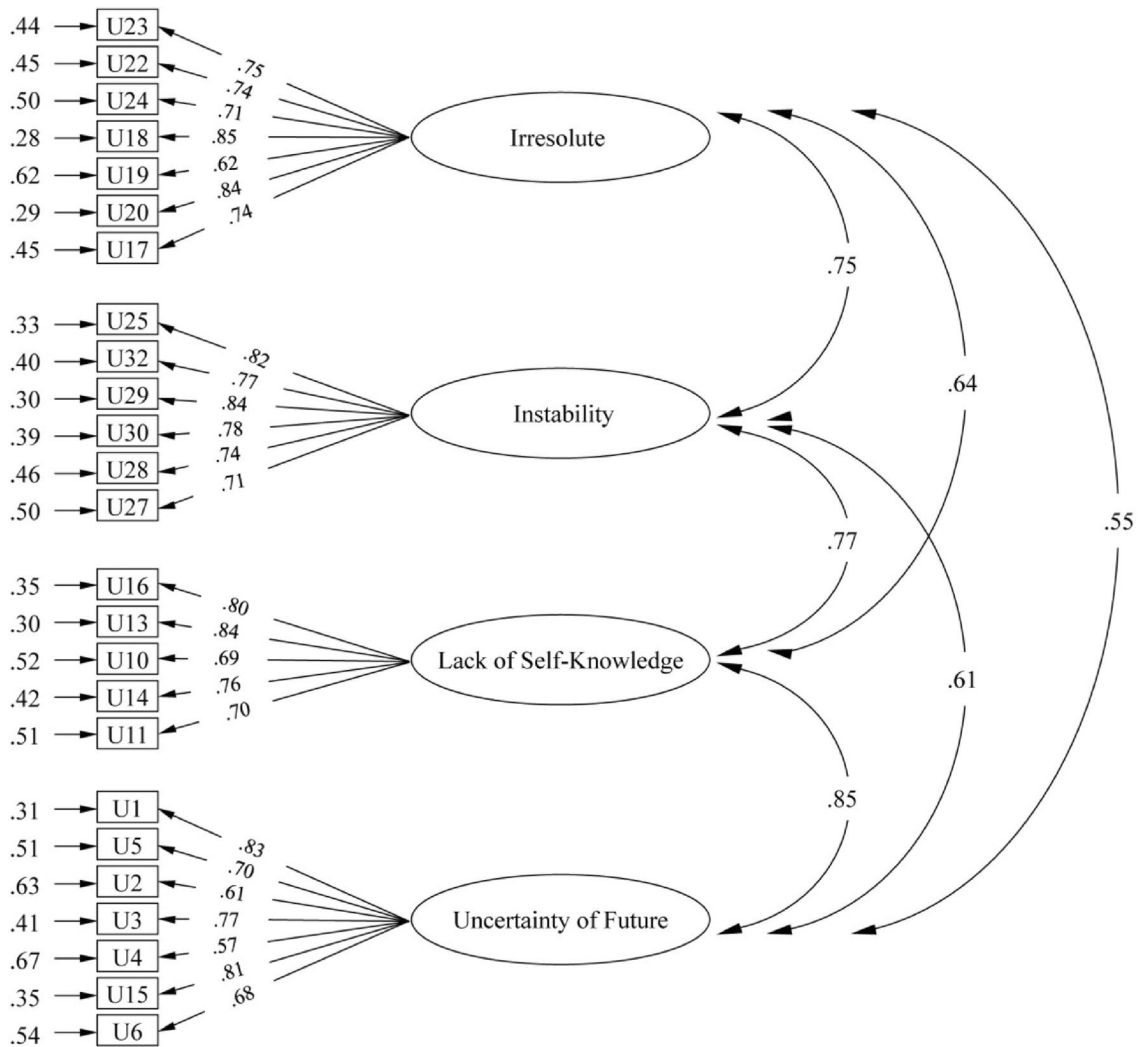
**Table 2** Results of the AUS pretest

Original NO	Items	Factor loadings (N = 507)				Discrimination index (N = 507)	Subscale reliability (N = 3106)	Total scale reliability (N = 3106)
		IR	IS	LS	UF			
u23	I cannot make a quick decision	.90				.76	.90	.95
u22	I am often indecisive	.83				.73		
u24	I cannot make a decision with multiple options	.79				.67		
u18	I need to consider anything for a long time before making a decision	.71				.76		
u19	I take a long time to look at a menu	.70				.59		
u20	Making decisions is difficult for me	.57				.74		
u17	I have difficulty making decisions, even for trivial matters	.55				.65		
u25	I often regret decisions		.97			.78	.90	
u32	I often make decisions that I regret immediately		.82			.69		
u29	I often feel unsatisfied with my choices		.62			.78		
u30	I often make decisions that I regret		.58			.71		
u28	I often think about what-ifs		.47			.64		
u27	I often feel that other people can make better decisions than me		.42			.65		
u16	I do not know what kind of person I am			.78		.77	.87	
u13	Overall, I do not know myself well			.71		.76		
u10	I do not know what advantages I have			.62		.62		
u14	I do not know what I want to pursue			.40		.67		
u11	I do not know what interests I have			.43		.62		
u1	I am unsure what I should study in the future				.87	.77	.88	
u5	I am unsure which school I will attend in the future				.72	.72		
u2	I am unsure whether I will study in general or vocational programs				.68	.62		
u3	I cannot imagine what job I will do in the future				.67	.69		
u4	I am unsure whether I will go to public or private schools in the future				.67	.56		
u15	I am unsure what type of career I would like to have				.61	.66		
u6	I am unsure whether I will get into my desired school				.60	.67		
Deleted items								
u21	I am more used to letting others decide things when in a group		<.20	.45				
u12	I do not know which subjects I am good at			.35	.21			
u8	I cannot imagine my future school life		.25		.35			
u7	I do not know what advantages I have	.45			.36			
u31	I often worry that I have made the wrong decision	.44	<.20	.36				
u26	I often envy what others have	.25	.21					
u9	I do not know if my grades are better than others'		.39					

AUS Adolescents' Uncertainty Scale, IR irresoluteness, IS instability, LS lack of self-knowledge, UF uncertainty of future

**Table 3** Comparison of the measurement models of the Adolescents' Uncertainty Scale ( $N=3106$ )

	One-dimensional model	Two-dimensional model	Four-dimensional model	Four-dimensional model (modified)
Degree of freedom	275	274	269	255
Chi-square value	16,749.67	10,979.44	6905.35	3011.57
$p$ value of the chi-square value	< .01	< .01	< .01	< .01
comparative fit index (CFI)	.68	.79	.87	.95
Tucker–Lewis index (TLI)	.65	.77	.86	.94
root-mean-square error of approximation (RMSEA)	.14	.11	.09	.06
standardized root-mean-square residual (SRMR)	.09	.07	.05	.05
Akaike information criterion (AIC)	211,833.92	206,065.69	202,001.60	198,135.81
Bayesian information criterion (BIC)	212,286.71	206,524.52	202,490.61	198,709.35
Adjusted BIC	212,048.41	206,283.03	202,233.24	198,407.49

**Fig. 5** Confirmatory factor analysis of the four uncertainty dimensions ( $N=3106$ )



**Table 4** Descriptive statistics and correlation coefficients for the AUS and ExamSS (N = 1967)

	1	2	3	4	5	6	7	8	9
1. IR	–								
2. IS	.74	–							
3. LS	.67	.78	–						
4. UF	.57	.68	.80	–					
5. AUS	.85	.90	.91	.87	–				
6. PA	.51	.56	.46	.45	.56	–			
7. CB	.44	.48	.37	.35	.47	.72	–		
8. SS	.49	.53	.46	.45	.55	.72	.70	–	
9. ExamSS	.54	.58	.48	.47	.59	.92	.89	.90	–
<i>Mean</i>	21.88	17.32	13.64	18.06	70.91	27.02	26.00	28.35	81.37
<i>SD</i>	7.66	6.68	5.81	7.46	24.31	10.62	8.35	9.60	25.72

The significance of all correlation coefficients was  $p < .01$

*IR* irresoluteness, *IS* instability, *LS* lack of self-knowledge, *UF* uncertainty of future, *AUS* Adolescents' Uncertainty Scale, *PA* physiological anxiety, *CB* cognitive and behavioral, *SS* social expectations and social comparisons, *ExamSS* Examination Stress Scale, *SD* standard deviation

scores were conducted as an estimate of the correlation between the test anxiety and uncertainty. Subsequently, SEM was used to test the mediating effect of uncertainty between academic achievement and test anxiety to verify the USM. The students' PRs, obtained in CAP 2017, were divided into a high-achieving group (PR50–99,  $n = 1462$ ) and a low-achieving group (PR1–49,  $n = 505$ ). SEM was conducted for each group, as shown in Fig. 4. *Mplus 8.0* was used for the model estimation.

## Results

### Reliability Analyses

Items were deleted according to the results of the EFA. After the formal testing phase, we analyzed the internal consistency of each subscale and the total scale with the remaining items (Table 2). The Cronbach's  $\alpha$  of the four dimensions of AUS, *irresoluteness* (seven items), *instability* (six items), *lack of self-knowledge* (five items), and *uncertainty of future* (seven items) was 0.90, 0.90, 0.87, and 0.88, respectively. The reliability of the total scale was 0.95. Overall, the AUS exhibited satisfactory reliability in the four subscales and the scale in its entirety.

### Model-Fit Analyses

Model-fit results revealed that the four-dimension measurement model had better fit than the one- and two-dimension models (as shown in Table 3), with *CFI*, *TLI*, *RMSEA*, and *SRMR* being 0.87, 0.86, 0.09, and 0.05, respectively. In addition, compared with the one-dimension and two-dimension models, the four-dimension model exhibited a large decline

in *AIC*, *BIC*, and *adjusted BIC*, indicating that it outperformed the other models. These results revealed an evidence of discriminant validity for AUS. However, the model-fit indices of the four-dimension model were merely moderately satisfactory, as the values of *CFI* and *TLI* were less than 0.90. In fact, excessive sample size, a large number of items, and, especially, the strong correlation between variables may explain the decreased chi-square relative values (Kline, 2010). Thus, we re-ran the four-dimension model by considering the strongest correlations between items (error terms); for example, the modified model estimated the correlations among the error terms of *u22*, *u23* and *u24* (see Table 2). This indicated that the model-fit indices of the modified four-dimension model were more favorable, with *CFI*, *TLI*, *RMSEA*, and *SRMR* being 0.95, 0.94, 0.06 and 0.05, respectively (see Table 3).

### Convergent Validity Analyses of the Measurement Model

For the convergent validity, composite reliability and *AVE* were adopted. Composite reliability of 0.90, 0.90, 0.87, and 0.88 was obtained for the four subscales, all of which are greater than 0.80; and the *AVE* for the four subscales was 0.57, 0.60, 0.58, and 0.51, all greater than 0.50. The above results indicate that each item measures the same sub-construct in each dimension; that is, items reflect their corresponding dimensions very well, providing strong evidence of convergent validity for the subscales. Having gathered evidence of discriminant validity and convergent validity, the results of the measurement model suggest that AUS has acceptable construct validity (Bagozzi & Yi, 1988).

### Uncertainty and Test Anxiety

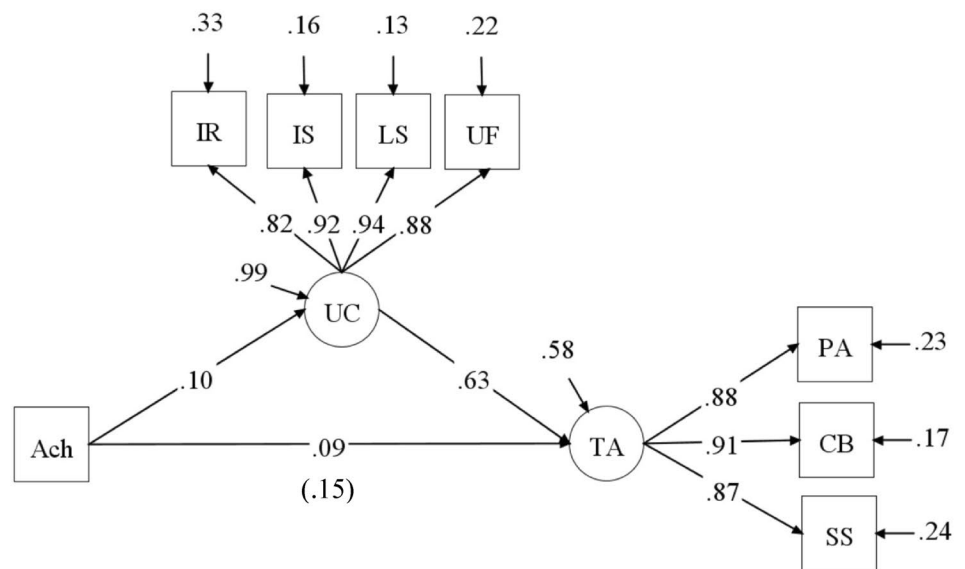
According to the results of product–moment correlation (e.g., Table 4), uncertainty and test anxiety exhibit a significant positive correlation. The overall correlation coefficient was 0.59, which is a moderate positive correlation. The subscales of the AUS and ExamSS also presented a significant positive correlation, with correlation coefficients of between 0.35 and 0.56.

### Mediation Analysis

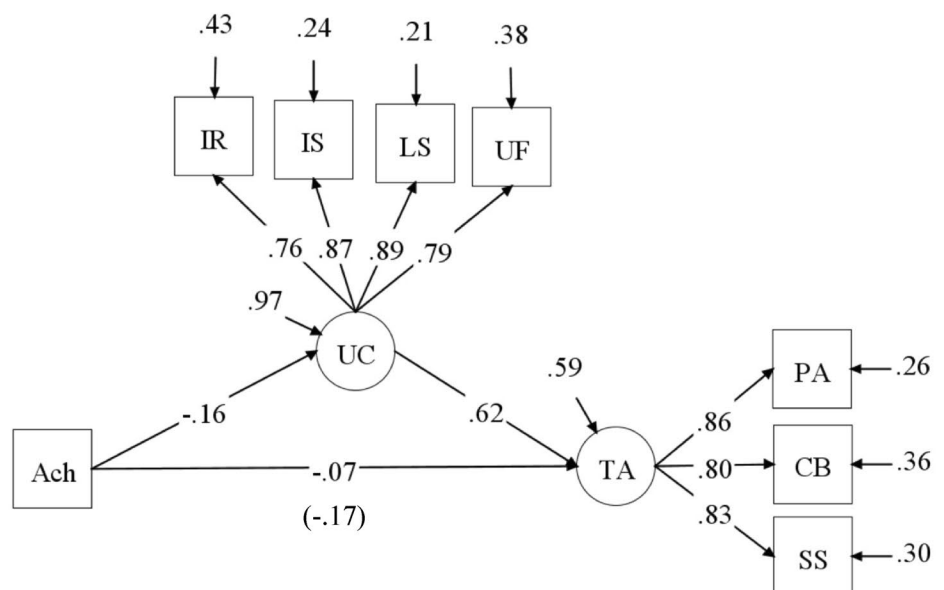
We conducted mediation analysis to verify the USM. For the below average achievement group, in the SEM model-fit results that the *CFI* and *TLI* of the model were 0.94 and 0.90, respectively, and the *SRMR* was 0.04. For the above average achievement group, in the other hand, the *CFI* and *TLI* were 0.94 and 0.91, respectively, and the *SRMR* was 0.04. Both model-fit indices of these two models indicated that the mediation models separating by achievement were acceptable. According to the path coefficient of the model (Fig. 5) (Fig. 6), for the low-achievement group, the path

**Fig. 6** Results of the mediation model among low- and high-achievement groups. Note: The significance of all path coefficients was  $p < .01$ . Ach = achievement; IR irresoluteness, IS instability, LS lack of self-knowledge, UF uncertainty of future, UC Uncertainty, TA test anxiety, PA physiological anxiety, CB cognitive and behavioral, SS social expectations and social comparisons

Low-achievement group ( $n = 505$ )



High-achievement group ( $n = 1462$ )



coefficient of academic achievement and test anxiety was 0.15 ( $p < 0.01$ ) before uncertainty was included. After incorporating uncertainty, the path coefficient of academic achievement to test anxiety was reduced to 0.09 ( $p < 0.01$ ), and the Sobel test for the indirect effect,  $z = 2.25$  ( $p < 0.05$ ). The results suggest that uncertainty partially mediated the effect of academic achievement on test anxiety among below average achievement students. For the high-achievement group, the path coefficient between academic achievement and test anxiety was  $-0.17$  ( $p < 0.01$ ) before the inclusion of uncertainty. After uncertainty was incorporated, the path coefficient of academic achievement to test anxiety was reduced to  $-0.07$  ( $p < 0.01$ ), and the Sobel test for the indirect effect,  $z = -6.06$  ( $p < 0.01$ ). This result denotes that uncertainty also partially mediated the effect of academic achievement on test anxiety among high-achieving students. In line with the USM, we provided an external validity evidence of the AUS.

## Discussion

### Construction of the AUS

We defined uncertainty on the basis of the EMU (Hirsh, 2012), in which uncertainty refers to the number of possibilities an individual confronts. If an individual encounters more possibilities, this represents higher uncertainty. Uncertainty is a subjective mental state in the EMU, and we asserted that the degree of this mental state contains four dimensions formed through the interaction of internal and external factors and involving the object, namely, irresolute-ness, instability, lack of self-knowledge, and uncertainty of future. Concepts similar to the four dimensions of uncertainty have been mentioned in most relevant studies. They may be related to adolescents' adaptation problems, and most of them are negatively related. For instance, irresolute tendencies may cause students to experience difficulty in career decision making (Saka et al., 2008); an instable tendency may cause students to easily become anxious (Betz & Serling, 1993); lack of self-knowledge may cause students to have low self-esteem (Campbell et al., 1996) and depression (Richman et al., 2016); and uncertainty of future may cause students to experience greater test anxiety (Chao & Sung, 2019a). The aforementioned anxiety, depression, or low self-esteem are also positively related to neuroticism (Byrne et al., 1995), and neuroticism is negatively related to other life adaptations, such as life satisfaction (Suldo et al., 2015).

Reducing the uncertainty of adolescents may help them adapt to all aspects of life. Therefore, constructing a psychometrically sound AUS is a task crucial to understanding individual differences in uncertainty among adolescents. In

terms of reliability of AUS, the internal consistency of the four dimensions was between 0.87 and 0.90, suggesting that the AUS has favorable score reliability. In terms of internal validity, the CFA results revealed that the four-dimension model was superior to the two-dimension model and the one-dimension model. This indicates that although, conceptually, each questionnaire item was regarded as an aspect of uncertainty (one-dimensional model), each was conceptually divided into internal personal characteristics and external actual conditions (two-dimensional model). Finally, each item converges to a concept closer to its dimension (four-dimensional model). The results verified the discriminant validity of the AUS in theory and also indicated that the scores of the four subscales can be used to represent uncertainty level in the four dimensions. The composite reliability and the *AVE* also revealed that the four subscales have acceptable convergent validity. In summary, the AUS has satisfactory internal validity.

To assess the external validity of the AUS, we recruited another group of ninth-grade students as a sample and tested the USM. The SEM results revealed that a partial mediating effect was present among both low- and high-achieving students (Fig. 6). First, the correlation between academic achievement and test anxiety (total effect) was 0.15 in the low-achievement group and  $-0.17$  in the high-achievement group, replicating the results of previous research. After incorporating uncertainty, level of academic achievement explained part its effect on test anxiety. For the low-achieving group, higher academic achievement indicated greater uncertainty; for the high-achieving group, higher academic achievement was associated with less uncertainty. The results were consistent with USM, indicating that the AUS can be used to verify the USM and also providing evidence of the construct validity of the AUS.

### Implications and Limitations

We designed an AUS and provided preliminary psychometric evidence. Moreover, the results indicate that uncertainty is moderately correlated with students' test anxiety (the overall correlation was 0.59). This raised the question of why uncertainty is related to test anxiety, particularly for students with high test anxiety who seem to be both irresolute and instable. We argue that students who have difficulty making decisions or who regret easily are more worried about the decisions they make, including future school choices. They more easily feel regretful for "not as expected" outcomes. Therefore, these students may think that they must perform well in the entrance examination to have satisfactory admission results in the future. Uncertainty was evidently determined to be related to test anxiety, according to the results of this study.

In the mediation model, uncertainty and test anxiety were moderately correlated (0.63 for the low-achieving group and 0.62 for the high-achieving group; Fig. 6). Therefore, students' test anxiety would decrease considerably if their uncertainty can be reduced. The main hypothesis of this research is that uncertainty influences students' long-term test anxiety, in line with the uncertainty-of-stress model. Thus, this important discovery can be used as a point of reference by educational authorities in Taiwan and other countries that are increasingly focusing on standardized tests, or those with a social climate that values test results, such as South Korea (Park & Lee, 2021), Singapore (Lowe & Ang, 2012), Australia (Howell, 2017), the United States (Segool, et al., 2013), and the United Kingdom (Hutchings, 2015; Putwain & Daly, 2014). In order to improve adolescents' everyday life, and especially to reduce their test anxiety, governments should consider allocating more resources to career advice for middle-school students. For example, a complete career counseling system for students could be introduced so that they can obtain a better understanding of their aptitudes and interests, and receive information on high schools and university departments. In educational policy, the first point of action should be to gradually change the social climate; for instance, implementing a reward system that encourages students and parents to choose a senior high school close to where they live so as to reduce the social pressure to strive for acceptance to elite schools. If the current social atmosphere can be changed through educational policy, this may improve ninth graders' struggles in school selection ([name deleted to maintain the integrity of the review process]). Meanwhile, to reduce uncertainty deriving from the individual's own disposition, school counselors could develop more specific counseling programs about how to make career decisions and be happy with them to help students reduce anxiety caused by indecision. For example, group counseling programs can be developed to help students to practice decision making, such as listing pros and cons, discussing options with relatives, and reducing counterfactual thinking.

Some of the limitations of this study could be addressed by future research. First, our sample only consisted of ninth-grade Taiwanese students, which may limit generalizability. Future studies could further test the AUS on students in grades 5 to 12 and examine whether elementary school and high school students have lower levels of uncertainty than junior high school students (e.g., whether high school students report being able to make decisions quickly or know themselves better). Second, the mediating effect obtained through path analysis only indicates a possible causal link. The methodology could be changed to use an experimental method and recruit a group of students with equivalent academic achievement and uncertainty levels, and then randomly assign them to an "uncertainty improvement group"

and other intervention groups or a randomized waiting group. Uncertainty and test anxiety could be measured to test whether the group with reduced uncertainty demonstrates lower test anxiety and verify the relevant mediating effects. Third, there are issues of report bias that we have to take into account when using self-report measures. For example, students with little ability to introspect may fail to assess their status correctly, or students with a particular response tendencies (e.g., always choosing responses at the extreme ends or in the middle of the scale) might also skew the results. In the future, researchers could focus on response bias issues, for example, considering implementing a forced-choice format for AUS and making comparisons between the different versions.

## Conclusion

In this study, we define new dimensions for uncertainty, composed of two factors: self-related/events related and internal/external. Based on the interaction of these two factors, we identified four dimensions to represent the degree of uncertainty of adolescents: irresoluteness, instability, lack of self-knowledge, and uncertainty about the future. We then compiled an AUS, with three data-collecting phases: pretest, formal test, and external validation. Through reliability analysis and CFA, empirical evaluation revealed the AUS to be psychometrically sound. We also provided evidence for the uncertainty-of-stress model, i.e., uncertainty being a mediator that influences the correlation between achievement and test anxiety. In this case, the degree of uncertainty may arise by social climate, education policy, and students' own dispositions. Therefore, national educational policy could set itself the goal of decreasing student uncertainty, including support for career exploration, a reward system, and school counseling programs. Most important of all, national education ministries could use AUS to inspect nationwide changes in uncertainty, educators could use AUS to find out which students are having trouble adapting and need further help, and school counselors could use AUS to verify intervention programs. The results of this study show that the compiled AUS can be used to understand individual differences in the response to uncertainty that are distinct from anxiety and the intolerance of uncertainty, which signifies that uncertainty is a variable that requires close attention in order to address adolescents' difficulties adapting to life, such as test anxiety.

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