Intolerance of Uncertainty Scale

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Intolerance of Uncertainty Scale: Measurement invariance among adolescent boys and girls and relationships with anxiety and risk taking

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ABSTRACT

Background and Objectives: Adolescence-related increases in both anxiety and risk taking may originate in variability in Intolerance of Uncertainty (IU), rendering the study of IU of importance. We therefore studied the psychometric properties of the Intolerance of Uncertainty Scale—Short version (IUS-12), including its associations with trait anxiety and risk taking, among adolescents.
Methods: A sample of 879 Dutch adolescents, from diverse educational levels, and with an equal distribution of boys and girls, was classically tested. To obtain indices of IU, and self-reported trait anxiety and need for risk taking, questionnaires were administrated; to obtain an index of risk taking behavior, adolescents performed a risk taking task.
Results: Multi-group Confirmatory Factor Analyses revealed that the IUS-12 consists of a Prospective and an Inhibitory IU subscale, which are partially measurement invariant across sex. Cronbach's alphas and item-total correlations revealed that the IUS-12 and its subscales have reasonable-to-good internal consistency. Correlational analyses support convergent validity, as higher IUS-12 scores were related to, respectively, higher and lower levels of self-reported trait anxiety and need for risk taking. However, we found no relationship between IUS-12 scores and risk taking behavior, operationalized by performance on the risk taking task.
Limitations: A community, instead of clinical, sample was included. Also, IU was measured by a paper-and-pencil version of the IUS-12, instead of a computerized version.
Conclusions: The IUS-12 has good psychometric properties and may be a central measure to assess IU, which enables to explain the adolescence-related increase in both anxiety and risk taking.

1. Introduction

To a great extent, human life is unpredictable and thus defined by uncertainty. Being able to tolerate this uncertainty seems pivotal to cope with daily life. This may especially be the case during the period of adolescence, which is characterized by changes in all domains of life (e.g., Braams, van Leijenhorst, & Crone, 2014; Crone & Dahl, 2012) and hence may be accompanied by enhanced uncertainty. In the past decades, the study of the ability to cope with uncertainty has gained increasing attention, via the study of *Intolerance of Uncertainty* (IU[1]; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994; for reviews see, Carleton, 2016a; 2016b). Given

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[1] Abbreviations: ATL, Adolescents Temperament List; DISES, Disinhibition/Experience Seeking subscale of the ATL; IU, Intolerance of Uncertainty; IUS, Intolerance of Uncertainty Scale, comprising 27 items; IUS-12, Intolerance of Uncertainty Scale—Short version, comprising 12 items; IUSC, Intolerance of Uncertainty Scale—-Child version, comprising 27 items; STAI-C, State-Trait Anxiety Inventory for Children; TAS, Thrill and Adventure Seeking subscale of the ATL; ZBV-K, Zelf-Beoordelings Vragenlijst voor Kinderen [State-Trait Anxiety Inventory for Children].

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the high degree of uncertainty faced by adolescents, we aim to gain insight in the measurement of IU in adolescent boys and girls.

IU may be defined as a dispositional characteristic, resulting from negative beliefs about uncertainty and its implications, wherein the possibility of a negative event occurring is considered threatening, irrespective of the probability of its occurrence (cf., Carleton et al., 2016, p. 58)—and the core of which is *fear of the unknown* (Carleton, 2016a, 2016b). Although originally particularly linked to Generalized Anxiety Disorder (e.g., Freeston et al., 1994), IU has now been suggested as an important transdiagnostic feature across anxiety disorders and depression (e.g., Carleton et al., 2012; for reviews see, Carleton, 2016a, 2016b; Hong & Cheung, 2015). Since the prevalence of these internalizing behavior problems sharply increases from adolescence onwards (Costello, Copeland, & Angold, 2011; Costello, Mustillo, Erkanli, Keeler, & Angold, 2003; Kessler, Chiu, Demler, & Walters, 2005), it seems pivotal to study IU, in relationship to anxiety, among adolescents.

In addition to its role in the adolescent-related increase in internalizing behavior problems, IU may be central in risk taking, which is enhanced during adolescence too (e.g., Boyer, 2006; Dahl, 2004; Reyna & Farley, 2006; Steinberg, 2004). That is, taking risks is inherently associated with opting for uncertainty (cf., Defoe, Dubas, Figner, & van Aken, 2015; Smith, Ebert, & Broman-Fulks, 2016; Van Duijvenvoorde et al., 2015), and high IU has been proposed to be related to avoiding risks (e.g., Carleton et al., 2016; Jacoby, Abramowitz, Buck, & Fabricant, 2014; Jacoby, Abramowitz, Reuman, & Blakey, 2016), unless risky choices are associated with less immediate uncertainty (Luhmann, Ishida, & Hajcak, 2011). That is, high IU is associated with increased information intake before (e.g., Jacoby et al., 2014) or increased distress during (e.g., Jacoby et al., 2016) making a decision, as well as slower and less profitable risky choice behavior (Carleton et al., 2016).

Together, we propose IU to be key in understanding the paradoxical increase in internalizing behavior problems as well as risk taking during adolescence. That is, the increase in risk taking seems at odds with the simultaneously growing prevalence of internalizing behavior problems (Costello et al., 2011, 2003; Kessler et al., 2005), since the latter are characterized by a risk avoidant behavioral style (Maner & Schmidt, 2006; Maner et al., 2007). This points to individual differences during adolescence (see, Boyer, 2006; Reyna & Farley, 2006; Somerville, Jones, & Casey, 2010); variability in IU may explain these individual differences.

Originally, a 27-item questionnaire to measure IU has been developed—the Intolerance of Uncertainty Scale (IUS; Freeston et al., 1994). Using this measure, four studies have shown that, like in adults (e.g., Carleton et al., 2012), IU among adolescents is related to indices of anxiety, especially worry (Barahmand, 2008; Dugas, Laugesen, & Bukowski, 2012; Laugesen, Dugas, & Bukowski, 2003) and health anxiety (Wright, Adams, Lebell, & Carleton, 2016).[2] As girls, compared to boys, have shown to be more anxious (for a review see, e.g., Beesdo, Knappe, & Pine, 2009), and IU has been shown to be related to indices of anxiety (for reviews see, e.g., Carleton, 2016a; 2016b), sex differences in IU might be expected. However, in three of the studies among adolescents, boys and girls did not differ in IU (Dugas et al., 2012; Laugesen et al., 2003; Wright et al., 2016). In the fourth study (Barahmand, 2008), in a sample of Iranian high school students, boys had higher IU than girls, a finding that was attributed to cultural influences, in that in Iran social pressure and expectations are higher for boys compared to girls (cf., Barahmand, 2008, p. 781). In addition, child- and parent-report forms of the IUS have been developed (Comer et al., 2009). These scales contain items that only slightly differ in wording from the items of the original, 27-item questionnaire; these scales were shown to be valuable in assessing IU among children and adolescents aged between 7 and 17 years (Comer et al., 2009; Read, Comer, & Kendall, 2013).

More recently a shortened version of the IUS—the IUS-12, consisting of 12 items—has been developed (Carleton, Norton, & Asmundson, 2007). Studies in adult samples generally support the sound psychometric properties of this scale (Carleton et al., 2007; Helsen, van den Bussche, Vlaeyen, & Goubert, 2013; for a review see, Birrell, Meares, Wilkinson, & Freeston, 2011). That is, the IUS-12 consists of a stable two-factor structure, encompassing a Prospective and an Inhibitory IU factor (McEvoy & Mahoney, 2011; also see, Birrell et al., 2011; Hong & Lee, 2015). Both factors are conceptualized as responses to uncertainty, such that Prospective IU is referred to as a desire for predictability and represents the negative cognitive appraisals of possible future uncertainty, and Inhibitory IU is referred to as uncertainty paralysis and represents the behavioral inhibition related to uncertainty. In addition, the IUS-12 seems to tap similar constructs in adult males and females (Carleton et al., 2012; Helsen et al., 2013). That is, measurement invariance (Meredith, 1993) across sex was established, which is a prerequisite to conclude that, in case differences between males and females in IUS-12 scores are found (see, e.g., Carleton et al., 2012; Helsen et al., 2013), these reflect true sex differences in IU, instead of differences in the way the IUS-12 assesses IU in males versus females. However, thusfar, findings with respect to sex differences in IU have been mixed, with divergent findings across studies that established measurement invariance across sex. That is, Carleton et al. (2012) reported higher levels of Inhibitory IU in males than females from a community sample, while Helsen et al. (2013) reported the reverse among a sample of undergraduate students. Furthermore, reliability of the IUS-12 was supported by excellent internal consistency (Helsen et al., 2013). Finally, convergent validity of the scale and its factors has been established, with a particularly strong relationship between general IU and worry (Helsen et al., 2013).

However, notwithstanding the advantages of a brief measure, only one study used the IUS-12 to investigate IU among adolescents. This study, among a sample of Dutch adolescents, from higher educational levels, aged between 14 and 18 years (Boelen, Vrinssen, & van Tulder, 2010), confirmed that the Dutch scale consists of a Prospective and an Inhibitory IU factor. The factors differed slightly in content from the factors that were found among adults (Carleton et al., 2007; Helsen et al., 2013). In addition, the study demonstrated that the IUS-12 has good internal consistency among adolescents and—while controlling for negative affectivity, sex, and age—adolescents' levels of IU correlated to worry and social anxiety, but not depression. Finally, boys and girls similar levels of IU.

Given the potential of the IUS-12 as a brief measure to assess IU among adolescents, we here aim to replicate and extend the early study by Boelen et al. (2010). That is, we study the factor structure of the IUS-12 (Boelen et al., 2010) in a large community sample of Dutch adolescents, from diverse educational levels, and with an equal distribution of boys and girls.[3] In addition, as this is a crucial

[2] Also see, Fialko, Bolton, and Perrin (2012), who used a five-item, abbreviated version of the IUS, by selecting one item from each of the five subscales that comprise the original, 27-item questionnaire.

[3] We opted to study the IUS-12, instead of full-length IUS or IUSC, because (1) the IUS-12, compared to full-length IUS, has been shown to have better psychometric properties in adults (Hong & Lee, 2015); (2) the IUS-12 is shorter than the full-length IUS or IUSC (12 versus 27 items), reducing the burden placed on our participants; (3) items of the IUSC, compared to IUS or IUS-12, may appear childish to the older adolescents in our sample; and (4) a Dutch version of the IUS-12, but not IUSC, was already available (Boelen et al., 2010).

step in establishing the sound psychometric properties of the scale and a prerequisite to meaningfully compare IU in boys versus girls, we test whether the factor structure of the IUS-12 is measurement invariant across sex. Furthermore, we study the internal consistency of the IUS-12 (Boelen et al., 2010) and extend research on construct validity of the scale (Boelen et al., 2010), by not only assessing the relationship of IUS-12 scores to anxiety, but also to risk taking. Together, these steps enable us to test whether IU, as assessed by the IUS-12, might be valuable in understanding individual differences in anxiety as well as risk taking among adolescents.

Our hypotheses are threefold. Firstly, we expect that, as in adults, the IUS-12 has a two-factor structure—consisting of a Prospective and an Inhibitory IU factor (cf., Carleton et al., 2007; for a review see, Birrell et al., 2011) (H1a), that is measurement invariant across sex (cf., Carleton et al., 2012; Helsen et al., 2013) (H1b). Secondly, we expect that the IUS-12 has high internal consistency among adolescents (H2). Thirdly, we expect higher IU to be associated with higher self-reported trait anxiety (cf., Birrell et al., 2011; Carleton, 2016a; 2016b) (H3a) and less self-reported need for risk taking (H3b), as well as less risk taking behavior as assessed by performance on a risk taking task (cf., Carleton et al., 2016) (H3c). Finally, after establishing the psychometric properties of the IUS-12, we explore sex differences in IU. Moreover, as we have tested a large sample of adolescents from a diverse educational background, we provide norm scores on the IUS-12, which can be used to assess whether individual adolescents deviate in IU from adolescents from a community sample.

2. Methods

2.1. Participants

Through high schools in the Netherlands, two unselected samples of Dutch adolescents ($N = 221$; $N = 658$) were recruited. The combined sample was aged between 13 and 17 years ($M_{AGE}[SD] = 15.30[1.39]$), consisted of 47.67% females, was recruited from five grade levels (second grade, 37.76%, $M_{AGE}[SD] = 13.95[0.58]$; third, 18.20%, 14.97[0.70]; fourth, 15.70%, 15.92[0.62]; fifth, 16.95%, 16.72[0.51]; sixth, 11.38%, 17.36[0.48]), and from both low-to-medium (vocational) (34.00%) and high level educational tracks (66.00%).[4] Prior to inclusion, primary caregivers were informed about the study and provided with an opportunity to exempt their child from participation. All procedures were approved by the Ethics Committee of the University.

2.2. Materials

2.2.1. Intolerance of Uncertainty Scale—Short version (IUS-12)

IU was measured by the Dutch Intolerance of Uncertainty Scale—Short version (IUS-12; Boelen et al., 2010; Carleton et al., 2007). This measure consists of 12 items on which participants have to indicate on a five-point Likert scale how strongly they endorse each item, with 1 referring to “Not at all characteristic of me”, 3 referring to “Somewhat characteristic of me”, and 5 referring to “Entirely characteristic of me”; higher scores indicate higher IU. An example item reads: “Unforeseen events upset me greatly”. Of all participants, 872 validly filled out the IUS-12. For details on in- and exclusion of participants and imputing missing values of the remaining participants, please see, *Online Supplementary Material, S1 Data Cleaning*.

2.2.2. State-Trait Anxiety Inventory for Children (STAI-C)

Trait anxiety was measured by the trait part of the Dutch State-Trait Anxiety Inventory for Children (STAI-C; Spielberger & Edwards, 1973; ZBV-K; Bakker, van Wieringen, van der Ploeg, & Spielberger, 1989). This measure consists of 20 items on which participants have to indicate on a three-point Likert scale how often they experience anxiety, with 1 referring to “Hardly-ever”, 2 referring to “Sometimes”, and 3 referring to “Often”; higher scores indicate higher trait anxiety. An example item reads: “I am afraid of doing things wrong”. The STAI-C has been shown to have good psychometric quality for usage in research (Evers et al., 2009-2012). Of all participants, 874 validly filled out the STAI-C. For details, again please see, *Online Supplementary Material, S1 Data Cleaning*.

2.2.3. Adolescents Temperament List (ATL)

Self-reported risk taking was assessed by two subscales of the Adolescents Temperament List (ATL; Feij & Kuiper, 1984). The ATL consists of five subscales with a total of 77 statements on which participants have to indicate whether or not these are true for them (i.e., “true” vs. “untrue”). Scores on two subscales were used as indicators of self-reported need for risk taking. That is, the 11-item Thrill and Adventure Seeking (TAS) subscale is intended to measure the need for risky, physical experiences, like water-skiing, with higher scores indicating increased need. An example item, that should be reverse scored, reads: “I do not often participate in dangerous things: I am not a daredevil”. The 8-item Disinhibition/Experience Seeking (DISES) subscale is intended to measure need for risky, unaccepted experiences, like using drugs, with higher scores again indicating increased need. An example item reads: “I would like to once experience how it feels to use drugs”. The ATL has reasonable-to-good psychometric quality, and the TAS and DISES subscales have been proposed as valid indicators of risk taking in daily life (cf., Evers et al., 2009-2012; Feij & Kuiper, 1984). That is, in validation research, higher scores on both the TAS and DISES subscale have been found to be associated with more complaints of youths about their parents and school, and with less social anxiety and social inhibition. Sex differences (cf., Evers et al., 2009-2012) have given rise to sex-specific norms (Feij & Kuiper, 1984). The ATL was administered to the second sample only, of which 632 adolescents validly filled it out. For details, again please see, *Online Supplementary Material, S1 Data Cleaning*.

2.2.4. Risk taking task

The risk taking task was a paper-and-pencil task, based on De Martino, Kumaran, Seymour, and Dolan (2006), and consisted of a booklet containing eighty decision making items. On each item (see, Fig. 1), participants were presented with an initial amount of money and then asked to make a choice between a sure and a risky option. Sure options were presented in either the *gain* ($n_{items} = 40$) or *loss* ($n_{items} = 40$) frame. That is, in sure options, participants were informed about the amount of money that they could, respectively, *keep* or *lose* for sure. In risky options of all items, participants were informed about the *probability* that they could keep versus lose the full initial amount of money.

The task consisted of ten item types (see, *Online Supplementary Material S2, Item characteristics of the risk taking task*). In both the *gain* and *loss* frame, all item types were repeated four times in pseudo-random order, twice with the sure and risky option in, respectively, the upper and lower position, and twice vice versa. The item types encompassed eight test items and two catch items.

[4] In the Netherlands, numbering of grades restarts after primary school, which most students complete at the age of 12. The grading system then encompasses four, five, or six grades, depending on the level—respectively, low, medium, high—of the educational track. Roughly, adolescents aged 12to13 years are in their first grade of secondary school, 13to14 years in second grade, 14to15 years in third grade, 15to16 years in fourth grade, 16to17 years in fifth grade and 17to18 years in sixth grade.

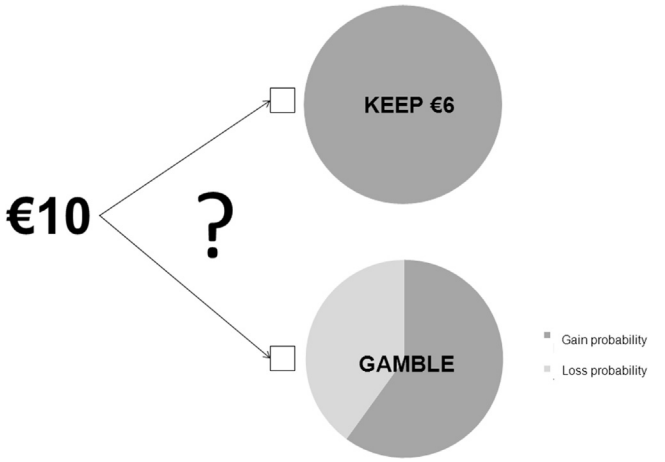

Fig. 1. Example of an item of the risk taking task. Note: In each item, participants were presented with an initial amount of money (€10) and then asked to make a choice between a *sure* (€6,-; upper position) and *risky* (lower position) option. In half of the items, the sure option was, as illustrated here, presented in the *gain frame*, in which participants were informed about the amount of money that they could *keep* in case they would chose for this option. In the other half of the items, the sure option was presented in the *loss frame* (not shown), in which participants were informed about the amount of money that they could *lose* in case they would chose for this option. In the risky option of all items, participants were informed about the probability that they could keep or the probability that they could lose the full initial amount of money.

In test items, sure and risky options were associated with an identical expected value (EV), favoring neither of them. In catch items, EVs of the sure and risky option were markedly different, clearly indicating which option would be most profitable. Catch items were of non-interest and only included to verify that participants understood and paid attention to the task, and that no effects of boredom or tiredness were present.

Of all participants, 843 provided valid data on the risk taking task. For details again please see, *Online Supplementary Material, S1 Data Cleaning*. Risk taking behavior was defined as the number of test items on which participants chose the risky instead of sure option; scores ranged from 0 (no risky choices) to 64 (all risky choices), for gain and loss frames together.

2.3. Procedure

Participants were classically tested during a one-hour session led by one or two trained assistants. After a short introduction, participants received instructions to the risk taking task; were guided through two examples; and told that after completion of the study, one pupil in each class would receive a cinema coupon, which value would depend on performance on four randomly selected items. Participants were then asked to fill out the risk taking task booklet. After all participants were finished, classical instructions to the questionnaires were provided and participants were asked to fill out the STAI-C, IUS-12 (both the first and second sample), and ATL (second sample only), respectively. At the end of the session, participants were thanked for their participation and received candy.

3. Results

3.1. Hypotheses 1a & 1b: factor structure and measurement invariance

To test whether the factor structure of the IUS-12 is measurement invariant across sex, we carried out a series of Confirmatory Factor Analyses (CFAs), as recommended by Van de Schoot, Lugtig, and Hox (2012), using the lavaan package (Rosseel, 2012) in R (https://cran.r-project.org). That is, at each step a model was estimated in which the number of model parameters constrained equal across sex differed from the previous step. It was then tested whether constraining of certain parameters did not lead to a significant worsening in model fit, using indices of comparative model fit (i.e., AIC, BIC [first step; see, *Online Supplementary Material, S3 Hypotheses 1a & 1b: Factor structure and measurement invariance*], Chi-square difference test [second to fifth step]).

Results (i.e., non-comparative and comparative model fit) of the series of CFAs are presented in Table 1 and Table 2.[5] In a first step, we tested whether the number of factors as well as (in case of two factors) the pattern of relationships between items and factors is equal across sex (i.e., *configural invariance*; model I, model II-A, model II-B in Table 1). Results reveal that this was indeed the case. That is, in boys as well as girls, a model, encompassing two factors, comprised of the same items as initially found by Carleton et al. (2007) (i.e., model II-A in Table 1), best fitted the data. Consistent with the literature (e.g., Birrell et al., 2011), we coined these factors Prospective and Inhibitory IU. In a subsequent series of CFAs, we tested whether—compared to a baseline model in which all parameters were freely estimated across boys versus girls (i.e., model II-Baseline in Table 2)—factor loadings of all items (i.e., *metric invariance*; model II-FacLoad in Table 2), intercepts of all or a subset of items (i.e., model II-Interc, model II-Interc-7 in Table 2), both factor loadings and a subset of intercepts (*partial scalar invariance*; model II-FacLoad-Interc-7 in Table 2), and residual variances (i.e., *measurement error invariance*, model II-ResidVar in Table 2) could be constrained equal across sex. Based upon this series of CFAs, a *partial scalar invariant* model (i.e., model II-FacLoad-Interc-7 in Table 2) was retained, in which not only the number and structure (i.e., pattern of relationships between items and factors), but also factor loadings of all items, and intercepts of items 5, 8, 9, 11, and 12 were constrained equal across sex. The factor structure, standardized factor loadings, intercepts, and residual variances of this model, for boys and girls, are presented in Table 3. Together, these results suggest that, as factor loadings as well as at least two intercepts can be constrained equal across sex, the minimal conditions are met (cf., Cheung & Rensvold, 2009) to meaningfully compare IUS-12 total and Prospective and Inhibitory subscales scores between boys versus girls.

3.2. Hypothesis 2: internal consistency

As hypothesized, internal consistency of the total scale and Prospective and Inhibitory IU subscales in the total sample (i.e., boys and girls together; $N = 872$) was reasonable-to-good, with Cronbach's alphas of, respectively, 0.85, 0.77, and 0.75, and item-total correlations ranging from, respectively, 0.36 to 0.61, 0.44 to 0.53, and 0.30 to 0.60.

3.3. Hypotheses 3a-c: relationships between IU, self-reported trait anxiety, self-reported need for risk taking, and risk taking behavior

Relationships between general, Prospective, and Inhibitory IU; self-reported trait anxiety; self-reported need for risk taking; and risk taking behavior were studied by calculating Pearson

[5] As our goal was to attain the best fitting model, by comparing a series of models of interest against a baseline model (cf., Schermelleh-Engel, Moosbrugger, & Müller, 2003), the focus is on comparative model fit. Since indices of non-comparative model fit are sensitive to a wide range of factors (Schermelleh-Engel et al., 2003), these indices are provided, in Tables 1 and 2, for completeness only.

Table 1
Non-comparative and comparative model fit of Confirmatory Factor Analyses to study factor structure separated by sex.

	χ^2	*df*	*p*	CFI	TLI	RMSEA	90% CI RMSEA	BIC	AIC
Boys									
model I	228.90	54	< 0.001	0.867	0.838	0.084	0.073–0.096	14991.96	14893.07
model II-A	132.96	53	< 0.001	0.939	0.925	0.058	0.045–0.070	14902.15	14799.14
model II-B	184.27	53	< 0.011	0.901	0.876	0.074	0.062–0.086	14953.45	14850.44
Girls									
model I	339.98	54	< 0.001	0.826	0.788	0.113	0.101–0.124	14575.17	14478.37
model II-A	214.60	53	< 0.001	0.902	0.878	0.086	0.074–0.098	14455.81	14345.98
model II-B	264.37	53	< 0.001	0.872	0.840	0.098	0.086–0.110	14505.59	14404.76

Notes: $N_{BOYS} = 455$, $N_{GIRLS} = 417$. Please see, *Online Supplementary Material, S1 Data Cleaning,* for exclusion of participants and imputing missing data. A detailed description of all models is provided in *Online Supplementary Material, S3 Hypotheses 1a & 1b: Factor structure and measurement invariance*. Model I, one-factor model; model II-A, two-factor model consistent with Carleton et al. (2007); model II-B, two-factor model consistent with Boelen et al. (2010). Fit measures were chosen from the measures available in the lavaan package (Rosseel, 2012), and following recommendations of Cheung and Rensvold (2009) and Van de Schoot et al. (2012). χ^2, chi-square test-statistic; CFI, Comparative Fit Index, CFI > 0.900 indicates good model fit; TLI, Tucker-Lewis Index, TLI > 0.900 indicates good model fit; RMSEA, Root Mean Square of Error Approximation, RMSEA < 0.900 indicates satisfactory model fit, RMSEA < 0.500 indicates good model fit; 90% CI RMSEA, 90 percent Confidence Interval of Root Mean Square of Error Approximation; BIC, Bayesian Information Criterion, lower values indicate better model fit; AIC, Akaike Information Criterion, lower values indicate better model fit.

Table 2
Non-comparative and comparative model fit of multi-group Confirmatory Factor Analyses to study factor structure and test for measurement invariance.

	χ^2	*df*	*p*	CFI	TLI	RMSEA	90% CI RMSEA	BIC	AIC	ΔCFI	$\Delta\chi^2$	Δdf	*p*
model II-Baseline	347.56	106	< 0.001	0.919	0.899	0.072	0.064–0.081	29555.16	29202.12	NA	NA	NA	NA
model II-FacLoad [a]	365.44	116	< 0.001	0.916	0.904	0.070	0.062–0.078	29505.33	29200.00	0.003	17.88	10	0.057
model II-Interc [a]	440.46	116	< 0.001	0.891	0.876	0.080	0.072–0.088	29580.35	29275.02	0.008	92.90	10	< 0.001
model II-Interc-7 [a]	352.00	109	< 0.001	0.918	0.901	0.072	0.063–0.080	29539.29	29200.56	0.000	4.44	3	0.218
model II-FacLoad-Interc-7 [b]	369.83	119	< 0.001	0.915	0.906	0.070	0.062–0.078	29489.41	29198.39	0.000	4.39	3	0.222
model II-ResidVar [c]	440.49	131	< 0.001	0.896	0.895	0.074	0.066–0.081	29478.82	29245.05	-0.004	70.66	12	< 0.001

Notes: $N_{BOYS} = 455$, $N_{GIRLS} = 417$. Please see, *Online Supplementary Material, S1 Data Cleaning,* for exclusion of participants and imputing missing data. A description of all models is provided in the main text and in *Online Supplementary Material, S3 Hypotheses 1a & 1b: Factor structure and measurement invariance*. Fit measures were chosen from the measures available in the Lavaan package (Rosseel, 2012), and following recommendations of Cheung and Rensvold (2009) and Van de Schoot et al. (2012). ΔCFI, delta Comparative Fit Index, a higher value favors the more over the less parsimonious model; $\Delta\chi^2$, delta chi-square test-statistic, a non-significant test favors the more over the less parsimonious model. For a description of other model fit indices, please see the notes to Table 1.

[a] Comparative model fit after comparison to model II-Baseline.
[b] Comparative model fit after comparison to model II-FacLoad.
[c] Comparative model fit after comparison to model II-FacLoad-Interc-7.

Table 3
Standardized parameter estimates of the selected model, separated by sex.

	Factor loadings	Item intercepts		Residual variances	
	Boys & Girls	Boys	Girls	Boys	Girls
Factor 1– Prospective IU					
Unforeseen events upset me greatly (1).[a]	1.000	1.929	2.210	0.459	0.681
It frustrates me not having all the information I need (2).	0.928	2.807	3.010	0.862	1.009
One should always look ahead as to avoid surprises (4).	0.824	2.723	2.285	1.113	0.961
A small unforeseen event can spoil everything, even with the best planning (5).	1.108	2.259		0.904	0.873
I always want to know what the future has in store for me (8).	0.952	2.830		1.307	1.120
I can't stand being taken by surprise (9).	0.941	1.831		0.677	0.725
I should be able to organize everything in advance (11).	1.007	2.359		0.960	0.941
Factor 2–Inhibitory IU					
Uncertainty keeps me from living a full live (3).	1.000	1.994	2.187	0.504	0.734
When it's time to act, uncertainty paralyzes me. (6)	0.914	1.702	1.895	0.417	0.608
When I'm uncertain, I can't function very well (7).	1.048	2.328	2.369	0.772	0.717
The smallest doubt can stop me from acting. (10)	1.032	1.936	2.094	0.415	0.751
I must get away from all uncertain situations (12).	1.043	2.081		0.664	0.668

Notes: $N_{BOYS} = 455$, $N_{GIRLS} = 417$. Please see, *Online Supplementary Material, S1 Data Cleaning,* for exclusion of participants and imputing missing data.
Results refer to the best fitting model, i.e., model II-FacLoad-Interc-7.

[a] Numbers in parentheses refer to item numbers in the administered version of the IUS-12.

correlations, which are reported in Table 4. Given previously reported (ATL; Feij & Kuiper, 1984) and currently found sex differences (see, *Online Supplementary Material, S1 Data cleaning* and *3.4 Exploratory analyses: Effect of sex and norms*), for IUS-12 total, Inhibitory IU subscale, STAI-C (self-reported trait anxiety), and ATL subscales (self-reported need for risk taking) scores, correlations with sex-specific deciles are reported.

In accordance with our hypothesis (H3a), IUS-12 total and subscales scores were significantly positively related to STAI-C scores, indicating that higher general, Prospective, and Inhibitory IU are associated with higher self-reported trait anxiety. Also in accordance with our hypothesis (H3b), were the significant negative relations between IUS-12 total and subscales scores and scores on the ATL TAS subscale, indicating that higher general, Prospective, and Inhibitory IU are associated with higher self-reported thrill and adventure seeking. However, inconsistent with our hypothesis,

Table 4
Pearson correlations between all study measures.

	2	3	4	5	6	7	8	9.	10.
1. General IU	0.888**[a]	0.826**[a]	0.603**[b]	0.477**[c]	-0.141**[c]	-0.007[c]	-0.265**[c]	-0.241**[c]	-0.028[d]
2. Prospective IU	–	0.559**[a]	0.453**[b]	0.336**[c]	-0.114**[c]	0.012[c]	-0.154**[c]	-0.233**[c]	-0.049[d]
3. Inhibitory IU	–	–	0.659**[b]	0.539**[c]	-0.164**[c]	-0.028[c]	-0.360**[c]	-0.187**[c]	-0.007[d]
4. Trait anxiety	–	–	–	0.642**[c]	-0.190**[c]	0.040[c]	-0.328**[c]	-0.129**[c]	-0.031[e]
5. Emotionality	–	–	–	–	-0.151**[g]	-0.020[g]	-0.332**[g]	-0.220**[g]	-0.092*[f]
6. Thrill and Adventure Seeking	–	–	–	–	–	0.538**[g]	0.370**[g]	0.268**[g]	0.192**[f]
7. Disinhibition/Experience Seeking	–	–	–	–	–	–	0.315**[g]	0.327**[g]	0.168**[f]
8. Extraversion	–	–	–	–	–	–	–	0.319**[g]	0.082*[f]
9. Impulsivity	–	–	–	–	–	–	–	–	0.172**[f]
10. Risk taking behavior	–	–	–	–	–	–	–	–	–

Notes: *P*-values < 0.05 are indicated by *; *p*-values < 0.01 are indicated by **.
[a] $N = 872$.
[b] $N = 870$.
[c] $N = 631$.
[d] $N = 839$.
[e] $N = 842$.
[f] $N = 615$.
[g] $N = 632$.

Table 5
Cut points for deciles, for general Intolerance of Uncertainty (IU), Inhibitory IU, and Prospective IU.

	General IU [a]		Inhibitory IU [b]		Prospective IU [c]
Decile	Girls	Boys	Girls	Boys	Girls & Boys
1	16.00	16.00	5.00	5.00	10.00
2	20.00	18.00	7.00	6.00	12.00
3	22.00	20.00	7.00	6.00	13.00
4	24.00	22.00	8.00	7.00	15.00
5	26.00	24.00	9.00	8.00	16.00
6	29.00	26.00	10.00	9.00	17.00
7	31.00	29.00	12.41	10.00	19.00
8	35.00	32.00	15.00	12.00	21.00
9	39.00	35.00	17.20	14.00	23.00

Note:
[a] Scores on the IUS-12 total scale range from 12 to 60.
[b] Scores on the Inhibitory IU subscale range from 5 to 25.
[c] Scores on the Prospective IU subscale range from 7 to 35. Girls' and boys' scores did not differ with respect to Prospective IU.

neither IUS-12 total or subscales scores were significantly correlated to scores on the ATL DISES subscale (H3b) nor with performance on the risk taking task (H3c).[6]

3.4. Exploratory analyses: effects of sex and norm scores

Exploratory *t*-tests revealed that girls obtained higher scores than boys on the IUS-12 total scale ($M_{GIRLS}[SD] = 27.40[8.92]$; $M_{BOYS}[SD] = 25.10[7.53]$; $t(816.85) = 4.09$, $p < 0.001$, $d = 0.28$) and Inhibitory IU subscale ($M_{GIRLS}[SD] = 10.63[4.62]$; $M_{BOYS}[SD] = 8.78[3.48]$; $t(770.20) = 6.62$, $p < 0.001$, $d = 0.45$), but not Prospective IU subscale ($M_{GIRLS}[SD] = 16.77[5.40]$; $M_{BOYS}[SD] = 16.32[5.07]$; $t(870) = 1.28$, $p = 0.20$, $d = 0.09$). Norm scores for the IUS-12 total scale and Prospective and Inhibitory IU subscales are provided in Table 5. This table shows the cut points for converting IUS-12 scores into (sex-specific) deciles. Deciles divide the range of obtained scores within the sample, such that the first decile refers to the range of scores that is obtained by the 10% lowest scoring individuals in the sample, the second decile refers to the range of scores obtained by the 11–20% lowest scoring individuals in the sample, etc. Sex-specific deciles are based on the range of scores of boys and girls separately. As sex effects were present for general and Inhibitory IU but not Prospective IU, we constructed sex-specific norms for the total scale and Inhibitory IU subscale only. These (sex-specific) deciles can be used to compare IUS-12 total and subscales scores of individual adolescents to those of their (same-sex) peers.

4. Discussion

Given the potential of IU to explain the paradoxical, adolescence-related increase in anxiety as well as risk taking, gaining insight in the measurement of IU among adolescent boys and girls is pivotal. We therefore aimed to study the psychometric properties of the IUS-12 in a large community sample of Dutch adolescents, from diverse educational levels, and with an equal distribution of boys and girls, by investigating the factor structure, internal consistency, and convergent validity of the scale. With respect to the factor structure of the IUS-12, we tested whether the scale is measurement invariant (Meredith, 1993) in that it measures the same construct across sex. With respect to the convergent validity of the IUS-12, we tested whether IU relates to individual differences in anxiety as well as risk taking among adolescents.

Our results provide support for usage of the IUS-12 as a measure of IU among adolescents. Firstly, a series of CFAs provided evidence for the anticipated (H1a) two-factor structure—consisting of a

[6] Note that IUS-12 total and subscales scores also correlated in a theoretically to be expected way to ATL subscales Emotionality (positive correlation), Extraversion, and Impulsivity (both negative correlations). Also note that scores on the ATL TAS and DISES subscales correlated positively with performance on the risk taking task, indicating self-reported need for risk taking to be associated with risk taking behavior as measured on a risk taking task.

Prospective and an Inhibitory IU subscale—identical to the structure that was initially found in adult samples (e.g., Carleton et al., 2007; Helsen et al., 2013). However, the pattern of relationships between items of the IUS-12 and its factors slightly deviated from the pattern that was previously observed in a sample of adolescents by Boelen et al. (2010), in that items 1 and 2 of the administrated version of the IUS-12 were found to load on the Prospective, instead of Inhibitory, IU factor. Compared to the study of Boelen et al., youth in our sample were, on average, slightly younger ($M = 15.31$ vs. $M = 16.09$) and from more diverse educational levels (from low, medium, and high educational tracks vs. all from high educational tracks). Since we have no ready explanation for the slight difference in factor structure, future studies are needed to elucidate whether the deviation across studies is meaningful.

In addition, our results reveal the IUS-12 to be partially measurement invariant across sex. That is, the number of factors, and the pattern as well as strength of relationships between items of the IUS-12 and these factors were the same for boys and girls. However, intercepts of seven out of 12 items and residual variances were found to differ across sex. Thus, our hypothesis (H1b) (see, Carleton et al., 2012; Helsen et al., 2013) was partially supported, in that we could establish *partial scalar invariance*, but not *full measurement invariance*, of the IUS-12 across adolescent boys and girls. By establishing partial scalar invariance, the minimal conditions are met to be able to meaningfully interpret the observed sex differences (see below) on IUS-12 total and Inhibitory IU subscale scores (cf., Cheung & Rensvold, 2009). That is, it has been shown that under partial intercept variance it is still valid to compare total scale or subscale means between (sub)groups, assuming that the non-invariant items (i.e., the items of which intercepts differ across (sub)groups) will not affect this comparison at a great extent (Byrne, Shavelson, & Muthén, 1989; cf., Cheung & Rensvold, 2009, p. 238).

Secondly, although we found evidence for two subscales, the anticipated high internal consistency of the total scale (H2) was confirmed and suggests that IUS-12 sum scores might be reliably interpreted. Thirdly, our findings render support for convergent validity of the IUS-12 among adolescents. That is, consistent with our hypothesis, higher general, Prospective, and Inhibitory IU were associated with higher self-reported trait anxiety (H3a), a finding in line with previous reports on relationships between IU and various indices of anxiety among both adults (e.g., Freeston et al., 1994; for reviews see, Birrell et al., 2011; Carleton, 2016a, 2016b) and adolescents (Boelen et al., 2010; also see, Barahmand, 2008; Dugas et al., 2012; Laugesen et al., 2003; Wright et al., 2016). Also consistent with our hypothesis, higher general, Prospective, and Inhibitory IU were associated with lower self-reported need for thrill and adventure seeking (H3b). However, contrary to our hypothesis, neither general, Prospective, or Inhibitory IU were related to self-reported disinhibition and experience seeking (H3b). Together, this pattern of findings suggests IU to be related to the need for societally accepted, but not unaccepted, risk taking. Future studies are needed to test this proposal and complete the picture of what constructs are related to these different types (i.e., societally accepted vs. unaccepted) of need for risk taking. However, to our knowledge, no other studies reported the currently observed relationship between IU and *self-reported need for risk taking* (in terms of need for thrill and adventure seeking). The ATL subscales, which we used to assess self-reported need for risk taking, can be taken as valid indicators of risk taking in daily life (cf., Evers et al., 2009-2012; Feij & Kuiper, 1984). Therefore, the observed relationship between IU and need for thrill and adventure seeking, as measured by the ATL, suggests that IU plays a role in individual differences in need for risk taking in daily life.

Contrary to our expectations (H3c), we found no relationship between general, Prospective, or Inhibitory IU and risk taking behavior as indexed by performance on a risk taking task. This finding is inconsistent with the proposal that high IU is associated with avoiding risks, for which some initial support was found by Carleton et al. (2016). These authors revealed that high IU was related to slower and less profitable risky choice behavior on some, *but not all*, popular laboratory tasks to assess risky decision making (also see, Jacoby et al., 2014; 2016). There might be two, not mutually exclusive, explanations for the lack of relationship between IU and risk taking behavior in the current study. Firstly, although some experimental studies have found that risky decision making on laboratory tasks mirrors the adolescent peak in risk taking that emerged from epidemiological studies (Burnett, Bault, Coricelli, & Blakemore, 2010; Figner, Mackinlay, Wilkening, & Weber, 2009), the majority of studies has not (e.g., Crone & van der Molen, 2007; Van Duijvenvoorde, Jansen, Bredman, & Huizenga, 2012; Van Duijvenvoorde, Jansen, Visser, Huizenga, 2010; for a review see, Defoe et al., 2015). It is therefore unknown to what extent risky decision making on laboratory tasks in general, and as used in the current study specifically, is reflective of risk taking in real life situations (cf., Van Leijenhorst, Westenberg, & Crone, 2008). Secondly, and related to the first point, the current risk taking task indexes risky decision making in non-affective situations, in which experienced threat may be low and outcomes of decisions are not immediately experienced (cf., Figner et al., 2009; Figner & Weber, 2011; Van Duijvenvoorde et al., 2010). IU, on the contrary, may be especially associated with risk taking behavior in more affectively laden situations (see, Luhmann et al., 2011), in which stakes are high, immediate feedback on performance is provided, or incentives depend of performance. Together, and in line with suggestions of Shihata and colleagues (Shihata, McEvoy, Mullan, & Carleton, 2016)—who have pointed to the importance of studying the behavioral correlates of variability in IU—these findings indicate that future research on the role of IU in risk taking might be especially valuable. Within this line of research, experimental paradigms may be pivotal, that enable to measure risk taking with high ecological validity, in affectively laden contexts—such as the Balloon Analogue Risk Task (BART; Lejuez et al., 2002)—as well as that enable *in vivo*, and possibly physiological, assessment of information intake before (cf., Jacoby et al., 2014) and distress during (cf., Jacoby et al., 2016) decision making.

We explored sex differences in general, Prospective, and Inhibitory IU. Consistent with results from Boelen et al. (2010), we found that boys and girls did not differ in Prospective IU. However, contrary to their findings, we observed that girls, compared to boys, are higher in general and Inhibitory IU. As stated before, given that we found the IUS-12 to be partially measurement invariant across sex, we may assume (cf., Byrne et al., 1989; Cheung & Rensvold, 2009) these sex differences in general and Inhibitory IU to be reflective of true differences between boys and girls on these constructs. Moreover, we consider these sex differences in general and Inhibitory IU to be informative. That is, girls', compared to boys', higher levels of general and Inhibitory IU match the higher prevalence of internalizing behavior problems among girls, from adolescence onwards (e.g., Costello et al., 2011, 2003; Kessler et al., 2005), and boys' higher levels of risk taking (Byrnes, Millers, & Schafer, 1999; Smith et al., 2016). Higher general and Inhibitory IU in girls, compared to boys, may thus well explain these sex differences in internalizing behavior problems and risk taking in adolescence. Future studies are needed to replicate and extend our findings with respect to the partially measurement invariance of the IUS-12 as well as the interpretation of sex differences in general and Inhibitory IU and their explanatory value.

At least two limitations of the current study should be

mentioned. Firstly, we included a community, instead of clinical, sample of adolescents. Given that IU has been proposed as an important transdiagnostic feature (Carleton et al., 2012; for reviews see, Carleton, 2016a, 2016b; Hong & Cheung, 2015), its explanatory power might, however, be especially high in samples with high variability in IU-related clinical symptoms, like anxiety and depression (Carleton et al., 2012; for reviews see, Carleton, 2016a, 2016b; Hong & Cheung, 2015), and possibly risk taking. Therefore, future studies may seek to explore the potential of IU in explaining individual differences in anxiety and risk taking among *both* typically developing adolescents *and* adolescents with either internalizing (i.e., anxiety disorders and depression) or externalizing behavior problems. Secondly, IU was measured by the IUS-12. Although our results suggest the psychometric properties of the IUS-12 to be sound, using a self-report measure, in paper-and-pencil version, may have limited the assessment of different aspects of IU. For instance, employing a computerized version of the IUS-12 would have enabled to assess variability in response latency to questions related to uncertainty, which might be taken as an index of variability in IU-related behavior (see, Shihata et al., 2016). In addition, in order to overcome the limitations of a self-report measure and to provide a more full-grained picture of affective and behavioral correlates (see, Shihata et al., 2016) of IU, future studies may focus on designing experimental tasks to get an indication of this construct.

5. Conclusions

The IUS-12 (Carleton et al., 2007; for a review see, Birrell et al., 2011) has good psychometric properties to assess IU among adolescents, as revealed by a stable two-factor structure and reasonable-to-good internal consistency. The fact that the scale was found to be partially measurement invariant across sex enables a (cautious) interpretation of sex differences in IU. The confirmed relationships between IU, self-reported trait anxiety, and self-reported need for thrill and adventure seeking may contribute to the potential of IU in explaining the paradoxical increase in anxiety as well as risk taking during adolescence.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jbtep.2016.11.009.

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