COGNITIVE BEHAVIOUR THERAPY, 2018
https://doi.org/10.1080/16506073.2018.1476580

Routledge
Taylor & Francis Group

Increasing intolerance of uncertainty over time: the potential influence of increasing connectivity

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ABSTRACT

Anxiety levels have increased for several decades, despite objective indicators of historically unprecedented safety. A perceived inability to tolerate uncertainty or distress motivates individuals experiencing anxiety to engage in safety behaviors. Mobile phones provide unrestricted access to safety cues intended to reduce uncertainty and therein anxiety; however, recurrent engagement in reassurance seeking behaviors paradoxically increases anxiety. The current research was designed to assess whether self-reported intolerance of uncertainty (IU) levels may have been increasing and, if so, whether the increases correlate positively with mobile phone penetration and Internet usage. A cross-temporal meta-analysis was conducted using data from 52 North American studies exploring IU as well as social indicator data from several public sources. A statistically significant increase in IU levels occurred from 1999 to 2014, correlated with increases in mobile phone penetration and Internet usage. As hypothesized, IU levels appeared to be increasing over time and the increases correlate positively with mobile phone penetration and Internet usage. The results support the possibility that mobile phones increase reassurance seeking, acting as safety cues, and reducing spontaneous, everyday exposures to uncertainty, which may ultimately potentiate psychopathology by increasing IU and anxiety. Subsequent experimental research to assess for causality appears warranted. Limitations and directions for future research are presented.

ARTICLE HISTORY
Received 2 October 2017
Accepted 9 May 2018

KEYWORDS
Intolerance of uncertainty; meta-analysis; exposure; mobile phones; longitudinal

Introduction

Anxiety manifests when an individual perceives a threat or potentially negative outcome (Barlow, 2002). People with anxiety often cope with or avoid the associated distress by engaging in maladaptive behaviors, such as reassurance seeking, neutralization, and checking, all of which can be called "safety behaviors" (Barlow, 2002; Rector, Kamkar, Cassin, Ayearst, & Laposa, 2011). Safety behaviors are systematic behavioral and cognitive strategies to prevent undesired outcomes, which are maladaptive in the absence of real threat (Clark, 1999; Salkovskis, 1991).

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Reassurance seeking is a common safety behavior observed in persons experiencing difficulties with anxiety (Borkovec, Alcaine, & Behar, 2004; Helbig-Lang & Petermann, 2010). Reassurance can provide temporary reductions in doubt and distress, but negative reinforcement increases the likelihood an individual will continue to engage in reassurance seeking (Salkovskis, Thorpe, Wahl, Wroe, & Forrester, 2003; Tang et al., 2007). Accordingly, reassurance seeking can become habitual and act as a maintaining factor in pathological anxiety (Abramowitz, Schwartz, & Whiteside, 2002; Parrish & Radomsky, 2010).

In reducing doubt and therein distress, reassurance necessarily reduces the perception or aversiveness of uncertainty (Krohne, 1993; Rector et al., 2011) by increasing perceptions of certainty (Carleton, 2012). People experiencing difficulties with anxiety can struggle to accept outcomes that lack complete certainty (Carleton, 2012), particularly for outcomes associated with highly valued areas of life (e.g. knowing if a family member is safe; Carleton, 2016b). Paradoxically, an increase in safety behaviors, such as checking intended to reduce distress, can lead to heightened perceptions of uncertainty and anxiety (Helbig-Lang & Petermann, 2010). For example, engaging in safety behaviors was associated with worsening contamination concerns similar to those of obsessive-compulsive disorder (OCD; Deacon & Maack, 2008), increases in social anxiety (McManus, Sacadura, & Clark, 2008), and increases in health anxiety following recurrent medical information seeking online (Norr, Albanese, Oglesby, Allan, & Schmidt, 2015). Successful treatment of anxiety-related disorders in which reassurance reinforces maladaptive behaviors (e.g. OCD) focuses on resisting safety behaviors (Abramowitz, 2006). People engage with their anxiety-related fears, without using their safety behaviors, so they can disconfirm their own beliefs about the perceived benefits of the behaviors (Salkovskis, 1991). During treatment for specific phobia, the perceived availability of, or access to, safety cues serves as a greater impediment to fear reduction than actual use of safety cues (Powers, Smits, & Telch, 2004). In other words, when safety cues are always available, anxiety worsens and learning imperative for tolerating fear and distress tolerance is hindered.

Reassurance seeking has been related to underlying worry about uncertain events or outcomes, as well as perceptions that the distress will overwhelm individual coping capacities (Rector et al., 2011). Intolerance of uncertainty (IU) is a trait-like construct with a role in the development and maintenance of worry (Carleton, 2012; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994). IU is defined as "an individual's dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and sustained by the associated perception of uncertainty" (Carleton, 2016b, p. 31). Like worry, IU has been associated with the onset and maintenance of anxiety (Boswell et al., 2013; Carleton, 2016b) and there is growing evidence implicating IU as a key causal factor for pathology (e.g. Mahoney & McEvoy, 2012; McEvoy & Erceg-Hurn, 2016; McEvoy & Mahoney, 2012). People with higher IU are more likely to attempt to reduce their anxiety by engaging in reassurance seeking by acquiring additional information (Rosen, Knäuper, & Sammut, 2007); moreover, IU appears broadly transdiagnostic (Carleton, 2016b), normally distributed throughout clinical and non-clinical portions of the population (Carleton et al., 2012), and fundamental to human experiences (Carleton, 2016a).

Contemporary mobile phones can be safety cues that offer users immediate perceptions of certainty, gratification, and even anxiety relief (Hirschman, 1992; Roberts & Pirog, 2013). Mobile phones offer immediate access to emergency services, attachment figures,

and sources of information (Katz & Aakhus, 2002). The perceptions of certainty provided by mobile phones facilitate feelings of security and safety (Wei, 2008), as well as distractions potentiating escape from anxiety and boredom (Walsh, White, & Young, 2008), particularly with the rise of continuous mobile access to the Internet. The inherent reward for engaging in tactile contact (Peck & Childers, 2003) also provides satisfaction through the haptic system used by mobile phones (e.g. unlocking the screen, activating screen saver), which can be intrinsically gratifying and lead to perpetual engagement with the devices (Oulasvirta, Rattenbury, Ma, & Raita, 2012). People engaging in excessive mobile phone use demonstrate preoccupation with the phone, increased time spent using the phone to achieve the previous levels of satisfaction, unsuccessful attempts to reduce phone use, and use of the phone to relieve anxiety (Lee, Chang, Lin, & Cheng, 2014). Increased anxiety and discomfort from being out of contact with a mobile device have become so pronounced that some researchers have argued the symptoms can become psychopathological (King et al., 2013). Higher daily phone use appears associated with significantly higher anxiety over time (Cheever, Rosen, Carrier, & Chavez, 2014); however, such increases were not observed for moderate daily users, as long as they were allowed to keep their mobile phones close by and powered off (Cheever et al., 2014).

Daily mobile phone use may be analogous to, or correlated with, reassurance seeking behaviors from a tangible safety cue. More than 60% of young mobile phone users check for notifications (e.g. email, text message, social media) multiple times per hour (Rosen, Cheever, & Carrier, 2012). The mobile phone provides constant and direct access to family or friends, as well as entertainment and information (Katz & Aakhus, 2002). When people cannot check their phones, about 50% of people born during the 1980s and 1990s report experiencing anxiety, as compared to 25% of people born between 1965 and 1979; similarly, taking away the mobile phone from regular users increases their anxiety (Cheever et al., 2014) and causes active preoccupation (Walsh et al., 2008), paralleling reactions associated with separation anxiety (Kins, Soenens, & Beyers, 2013). Overall, the mobile phone appears to be serving as a powerful safety cue, akin to a talisman or secure attachment figure, associated with reassurance-seeking, perceptions of certainty, and reductions in anxiety (Cheever et al., 2014; Helbig-Lang & Petermann, 2010).

The increasingly pervasive and continuous access to mobile phones and the Internet may be having a deleterious effect (Katz & Aakhus, 2002; Walsh et al., 2008); specifically, mobile phones may be facilitating reassurance seeking, acting as safety cues, increasing IU, and therein facilitating increased anxiety on an unprecedented level. Understanding how changes in IU relate to changes in anxiety over time can better inform the causal relationship among these constructs. The positive association between mobile phone use and anxiety has already been reported in American (Lepp, Barkley, & Karpinski, 2013) and Taiwanese (Hong, Chiu, & Huang, 2012) university samples (see also (Twenge, Joiner, Rogers, & Martin, 2018), for increases in depression/suicide and associated with increased time spent using social media); however, associations between mobile phones and IU have not been assessed. The current study was designed to assess (1) whether self-report IU has been rising since 1999, which would parallel the rise of mobile phone access; and (2) if IU has been increasing, whether the increase correlates positively with mobile phone market penetration. A supplementary analysis was conducted to determine in what manner IU has been changing over time using worry as a quantifiable marker of anxiety.

Methods

Measures

Intolerance of Uncertainty Scale (IUS; Freeston et al., 1994). The IUS is a 27-item scale designed to assess emotional, cognitive, and behavioral reactions to uncertainty. Items are rated on a 5-point Likert scale ranging from 1 (*not at all characteristic of me*) to 5 (*entirely characteristic of me*). The IUS was selected for the current assessment because of its long-standing popularity (Gentes & Ruscio, 2011); furthermore, the short form (Carleton, Norton, & Asmundson, 2007) and more recent measures (e.g. the Intolerance of Uncertainty Index (IUI; Carleton, Gosselin, & Asmundson, 2010; Gosselin et al., 2008) do not yet have sufficient longevity for addressing the hypotheses. The IUS has good internal consistency, convergent validity, divergent validity, and 5-week test-retest reliability (r = .78) (Buhr & Dugas, 2002; Dugas, Freeston, & Ladouceur, 1997; Freeston et al., 1994).

Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990). The PSWQ is a 16-item scale designed to measure worry. Items are rated on a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely). Research has supporter the validity and reliability of the PSWQ (Brown, Antony, & Barlow, 1992; Meyer et al., 1990; van Rijsoort, Emmelkamp, & Vervaeke, 1999).

Identifying studies

Relevant studies were identified via Web of Science, Medline (PubMed), and EbscoHost (Francis) searches through March 2016 using combinations of the following keywords: *Intolerance*, *Uncertainty*, *Intolerance of Uncertainty*, and *Intolerance of Uncertainty Scale*. Searches were limited to studies that were published between January 1994 and March 2016. Papers were considered for inclusion if they were written in English, sampled from non-clinical and undergraduate populations, published in peer-reviewed journals, and provided data on the English version of the 27-item Intolerance of Uncertainty Scale (IUS-27). Papers were excluded if they (1) sampled clinical populations, (2) sampled non-undergraduate populations, (3) had missing data, (4) used a non-English translated version of the IUS, or (5) used an abridged or modified version of the IUS. Papers with duplicate samples were also excluded from the meta-analysis.

The Web of Science search identified 510 papers, each of which was reviewed for relevance. Among the 510 studies, 286 were excluded because no data was provided for the IUS. An additional 170 were excluded because the sample was entirely clinical (n = 74), the sample used non-undergraduate populations (n = 51), did not report means or standard deviations (n = 5), used a non-English translation of the IUS (n = 21), used a modified version of the IUS (n = 6), were a meeting or conference abstract (n = 8), or were reanalysis of samples already included (n = 5). The final sample included 54 papers from this search for the current meta-analysis.

The Medline (PubMed) search identified 318 papers, each of which was reviewed for relevance. Among the 318 papers, 163 were excluded because they did not use the IUS. An additional 121 were excluded because the sample was entirely clinical (n = 65), the sample used non-undergraduate populations (n = 36), did not report means or standard deviations (n = 3), used a non-English translation of the IUS (n = 9), used a modified version of the IUS (n = 6), or were reanalysis of samples already included (n = 2). The

final sample included 34 papers from this search for the current meta-analysis; however, of those 34 papers, 30 were already included in the meta-analysis from the Web of Science search, meaning the Medline (PubMed) search produced only 4 novel articles for the current meta-analysis.

The EbscoHost (Francis) search yielded 160 papers, each of which was reviewed for relevance. Among the 160 papers, 52 were excluded because they did not use the IUS. An additional 77 were excluded because the sample was entirely clinical (n = 36), the sample used non-undergraduate populations (n = 24), did not report means or standard deviations (n = 4), used a non-English translation of the IUS (n = 7), used a modified version of the IUS (n = 3), or were reanalysis of samples already included (n = 3). The final sample included 31 papers from this search for the current meta-analysis; however, all of those 31 papers were already included in the meta-analysis from the Web of Science and Medline (PubMed) searches. Lastly, six additional studies were identified by searching reference lists from retrieved articles for additional studies. Table 1 presents the information coded from the included 64 samples from 61 studies.

For the supplementary analysis comparing changes in Penn State Worry Questionnaire (PSWQ) over time, only articles in the original IUS meta-analysis were considered. There were 28 studies reporting PSWQ scores included in the final sample. Subgroup means were averaged so no study contributed more than one PSWQ mean score to parallel the meta-analysis for IUS.

Data analysis

Cohort changes in IUS mean scores were investigated via cross-temporal meta-analysis (CTMA; see (Twenge, Konrath, Foster, Campbell, & Bushman, 2008) where the relation between the mean scores and the year of data collection was examined. Unless explicitly stated in the study, we estimated the year of data collection to be two years prior to the publication year (consistent with previous CTMAs). As in most CTMA, means were weighted by sample size to derive more precise estimates of the population mean for each year. Fewer studies were reported in the 1990s when IUS was first developed then the subsequent years. As there were only five studies between 1992 and 1999, the means from these studies were weighted to obtain an average IUS score. A significant correlation between weighted IUS mean scores and year would allow us to obtain a simple regression equation, $y = bx + a$, where y = the predicted IUS mean score, b = unstandardized regression coefficient, x = year, and a = the intercept.

The average standard deviation—an estimate of the average variability of the IUS scores in a sample of individuals—was obtained by averaging the within-study standard deviations. The average standard deviation was used to compute the magnitude of the difference (i.e. d) between cohorts of IUS mean scores, rather than using the standard deviation of the means. Using the average standard deviation circumvents the *ecological fallacy*—an erroneous interpretation of data where inferences about individuals are deduced from inferences for the group in which the individuals are members. The regression coefficients obtained were ecological or alerting correlations (Rosnow, Rosenthal, & Rubin, 2000) because coefficients identify group-level, rather than individual-level, changes. The coefficients tend to be larger as there is less variance among means than among individuals. Therefore, variation among individuals was used to estimate the magnitude of individual-level change.

Table 1. Mean IUS-27 scores and other information coded from primary studies.

Study Authors	Pub. Year	Coll. Year	*N*	Prop. Female	Mean	*SD*	Region
Freeston et al., 1994;	1994	1992	154	0.71	51.84	12.48	1
Ladouceur, Blais, Freeston, & Dugas, 1998;	1998	1996	29	0.79	64.39	18.54	1
Lachance, Ladouceur, & Dugas, 1999;	1999	1997	275	0.88	54.20	14.50	1
Gosselin, Dugas, Ladouceur, & Freeston, 2001;	2001	1999	352	0.78	51.93	16.32	1
Dugas, Gosselin, & Ladouceur, 2001	2001	1999	347	0.78	51.64	16.79	1
Buhr & Dugas, 2002;	2002	2000	276	0.77	54.78	17.44	1
Sexton, Norton, Walker, & Norton, 2003;	2003	2001	91	0.65	58.24	18.05	1
Robichaud, Dugas, & Conway, 2003;	2003	2001	317	0.68	57.02	18.80	1
Dugas, Schwartz, & Francis, 2004	2004	2002	240	0.79	55.54	17.72	1
Norton, 2005;	2005	2003	540	0.57	54.88	18.71	1
Dugas et al., 2005 Study 1	2005	2003	101	0.80	52.98	14.97	1
Dugas et al., 2005 Study 2	2005	2003	148	0.77	57.46	18.32	1
Rassin & Muris, 2005;	2005	2003	50	1.00	66.06	12.85	2
Crittendon & Hopko, 2006;	2006	2004	183	0.69	57.30	19.40	1
de Bruin, Rassin, & Muris, 2007 Study 1	2006	2004	40	0.78	65.21	11.38	2
de Bruin et al., 2007 Study 2	2006	2004	50	0.88	67.60	7.05	2
Holaway, Heimberg, & Coles, 2006;	2006	2004	505	0.69	54.37	16.51	1
Buhr & Dugas, 2006;	2006	2004	197	0.77	61.25	18.98	1
Butzer & Kuiper, 2006;	2006	2004	166	0.61	58.32	–	1
Abramowitz, Deacon, & Valentiner, 2007;	2007	2004	442	0.61	50.21	16.64	1
Norton & Mehta, 2007;	2007	2005	650	0.71	55.94	19.89	1
Carleton et al., 2007;	2007	2005	254	0.76	50.28	17.22	1
de Bruin et al., 2007;	2007	2005	98	0.83	61.19	15.94	2
Riskind, Tzur, Williams, Mann, & Shahar, 2007	2007	2005	216	0.60	59.40	–	1
Basevitz, Pushkar, Chaikelson, Conway, & Dalton, 2008;	2008	2006	106	0.59	62.24	16.77	1
Simmons, Matthews, Paulus, & Stein, 2008;	2008	2006	14	0.71	58.60	19.30	1
Drews & Hazlett-Stevens, 2008	2008	2006	391	0.66	56.15	19.00	1
Koerner & Dugas, 2008;	2008	2006	199	0.70	58.61	11.45	1
White & Mansell, 2009	2009	2007	24	0.96	54.73	18.80	2
Fergus & Valentiner, 2009;	2009	2007	244	0.64	49.86	16.77	1
Zlomke & Young, 2009;	2009	2007	174	0.80	61.08	20.94	1
Khawaja & Yu, 2010;	2010	2008	56	0.79	66.58	21.00	3
Aldao, Mennin, Linardatos, & Fresco, 2010;	2010	2008	783	0.62	52.81	18.11	1
Fergus & Wu, 2010;	2010	2008	414	0.56	55.40	20.46	1
Rucker, West, & Roemer, 2010;	2010	2008	77	0.64	56.65	19.98	1
Chen & Hong, 2010;	2010	2008	130	0.76	57.95	18.18	1
Konstantellou & Reynolds, 2010	2010	2008	116	0.80	56.52	13.27	2
Nelson & Shankman, 2011;	2011	2009	69	0.77	58.23	19.47	1
Luhmann, Ishida, & Hajcak, 2011;	2011	2009	50	–	61.12	14.32	1
Fergus & Wu, 2011;	2011	2009	725	0.52	59.55	19.44	1
Liao & Wei, 2011	2011	2009	332	0.52	56.70	–	1
Byrne, Hunt, & Chang, 2015;	2015	2009	104	0.74	61.50	18.30	3
Fergus & Valentiner, 2011;	2011	2009	412	0.64	58.52	20.64	1
De Los Reyes, Aldao, Kundey, Lee, & Molina, 2012;	2012	2010	48	0.65	52.73	15.09	1
Cougle et al., 2012	2012	2010	173	0.82	55.45	17.94	1
Gerolimatos & Edelstein, 2012;	2012	2010	117	0.51	63.55	22.06	1
Buhr & Dugas, 2012;	2012	2010	176	–	61.44	18.48	1
Oglesby et al., 2013	2013	2011	279	0.65	53.36	17.80	1
Pawluk & Koerner, 2013;	2013	2011	140	0.82	69.49	20.36	1
Helsen, Goubert, & Vlaeyen, 2013;	2013	2011	60	1.00	67.53	10.71	2
Reuther et al., 2013;	2013	2011	475	0.82	53.02	19.61	1
Norr et al., 2013 Study 1	2013	2011	217	0.69	49.09	18.01	1
Norr et al., 2013 Study 2	2013	2011	241	0.77	54.76	17.43	1
Fergus & Wu, 2013	2013	2011	1,486	0.51	57.00	19.09	1

(*Continued*)

Table 1. (*Continued*).

Study Authors	Pub. Year	Coll. Year	*N*	Prop. Female	Mean	*SD*	Region
Fracalanza, Koerner, Deschênes, & Dugas, 2014;	2014	2012	233	0.80	62.58	–	1
Norr, Capron, & Schmidt, 2014;	2014	2012	52	0.65	55.62	17.17	1
Logan, Steel, & Hunt, 2015	2015	2013	140	0.67	56.63	17.11	3
MacDonald, Pawluk, Koerner, & Goodwill, 2015	2015	2013	217	0.84	64.09	16.47	1
Kraemer, McLeish, & O'Bryan, 2015	2015	2013	389	0.72	66.53	20.32	1
R. Y. Hong & Lee, 2015 Sample 1	2015	2013	565	0.74	63.01	18.80	3
R. Y. Hong & Lee, 2015 Sample 2	2015	2013	898	0.72	65.57	20.44	3
Deschênes, Dugas, & Gouin, 2016	2016	2014	76	0.86	60.29	21.03	1
Wheaton, Abramowitz, Jacoby, Zwerling, & Rodriguez, 2016;	2016	2014	456	0.57	58.94	17.72	1
Chin, Nelson, Jackson, & Hajcak, 2016	2016	2014	35	–	57.64	15.83	1

Note: Pub. Year, Year of publication; Coll. Year, Year of data collection; Prop. Female, Proportion of females in sample; Region, Geographical region of the sample (1 = North America; 2 = Europe; 3 = Others).

Results

The correlation between the year of data collection and IUS mean scores was .73, $p < .001$. A scatterplot of this relation is depicted in Figure 1. Based on the simple regression equation (i.e. predicted IUS mean score = .445 × year—835.961), the year 1994 would yield an IUS mean score of 51.37 whereas the year 2014 would produce a score of 60.27. The results indicate a difference of 8.90 in IUS mean score among college students over a 20-year period from 1994 to 2014. The average within-study standard deviation across all studies was 17.44. Therefore, IUS scores increased 0.51 standard deviation from 1994 to 2014, a medium effect size according to Cohen's (1977) guidelines. In other words, the average college student in 2014 would have scored at the 69.5 percentile on a normal distribution calibrated based on the mean 1994 score as the median.

The effects of possible confounding variables on the relation between year and IUS scores were also explored. The proportion of women in each study was weighted by sample size, similar to the procedure done with IUS scores. The weighted proportion (of females) was then included as a covariate in the regression of IUS mean scores on year. The covariate variable was not significant ($\beta = .20$, $p = .345$), indicating that proportion of women did not account for meaningful variance in IUS mean scores. The possibility of cross-cultural differences in IUS mean scores was also considered. Exploratory analyses suggested that studies done outside of North America (i.e. Europe and other regions) reported higher IUS means than those within North America, $F(2, 61) = 7.60$, $p < .001$. Mean IUS score was 57.14 ($SD = 4.36$) for North America, 62.66 ($SD = 5.31$) for Europe, and 62.69 ($SD = 3.93$) for other regions. Due to the small number studies outside of North America ($k = 12$), we reran the CTMA comprising only studies from North America ($k = 52$). The results based on weighted means remained very similar to the original findings, with the equation predicting an IUS mean score being = .476 × year—898.877, $\beta = .70$, $p = .003$, $d = .54$.

The associations of the mean IUS scores with mobile phone penetration and Internet usage were also considered. The analyses were restricted to North American studies because (a) most of the IUS studies examined were from North America and (b) Canada and the US have many similar sociocultural environmental conditions. The mobile penetration rate and Internet usage rate from 1999 to 2014 was collected from Cartesian (www.cartesian.

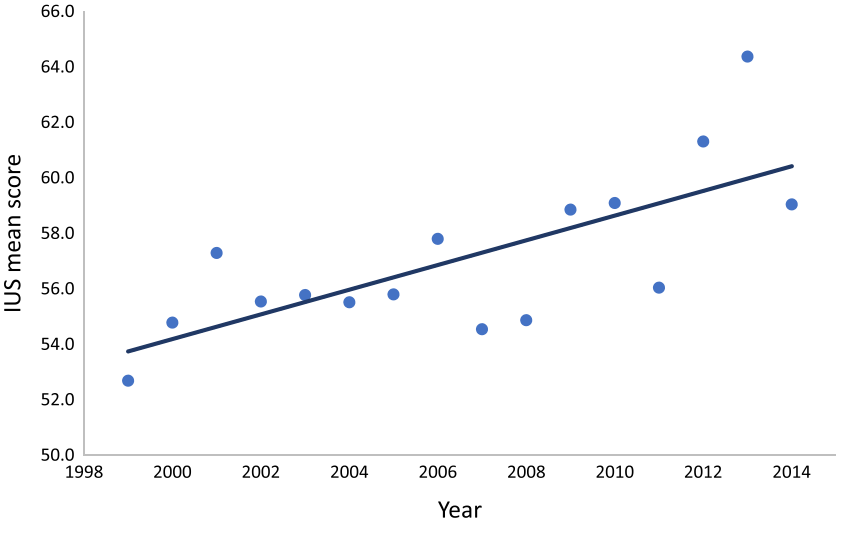

Figure 1. College students' weighted Intolerance of Uncertainty scores from 1999 to 2014.

com), a site dedicated to the collation of such data. For each year, the mobile penetration rate was weighted by the number of Canadian versus US studies. The weighting allowed for adjustments depending on the relative contributions of Canadian versus US studies. The two countries might register very different levels of mobile phone penetration; accordingly, the US social indicators were scaled to match the intercepts (i.e. the levels at 1999) corresponding to Canada. The main focus for the current study was assessing cohort trends over time (i.e. increasing or decreasing) rather than absolute levels. The rescaling procedure was expected to reduce differences in absolute magnitudes, while still retaining the patterns of cohort trends. The correlations between weighted IUS means and each of weighted mobile phone penetration ($r = .58$, $p < .05$) and weighted Internet usage ($r = .54$, $p < .05$) from 1999 to 2014 were positive and statistically significant.

A supplementary analysis was conducted to measure changes in PSWQ over time. Based on the regression equation (i.e. predicted PSWQ mean score = .254 × year—460.899), there is an upward trend of worry from 1999 to 2011. The slope did not reach statistical significance in the available sample. Consistent with analyses for IUS, the CTMA was rerun after removing studies from regions other than North America. The predicted PSWQ scores were comparable to the initial analysis (i.e. predicted PSWQ mean = .250 × year—452.919, $p = .08$).

Discussion

The current study was designed to assess whether self-report IU has been rising since 1999, which would parallel the rise of mobile phone access, and if so, to assess whether the increase correlates positively with mobile phone market penetration. In line with the first hypothesis, the meta-analytic results suggest that IU levels have indeed been steadily rising over the past two decades. The increase in IU from year to year over the past two decades appears to be relatively subtle, but significant. The result is an overall average increase of nearly nine

points for the total score, which amounts to half a standard deviation and a nearly 20 percentile-point increase. The analytic methods suggest against the identified increase being a statistical artefact (e.g. ecological fallacy) or the result of differences in sample demographics (e.g. proportion of women; location of data collection). The substantive increase supports speculation regarding the impact of environmental variables on IU scores.

In line with the second hypothesis, the meta-analytic results support a correlation between the rising IU levels and mobile phone market penetration, and by extension Internet access and usage. The technological advancements since 1999 have rapidly facilitated increased access to real and perceived certainty regarding personal safety, attachment figure safety, and information sources of information (Katz & Aakhus, 2002). The increased engagement with mobile phones offers unprecedented opportunities for rapid, regular, and unfettered reassurance seeking through mobile phones and Internet access and usage; as such, mobile devices may promote reassurance seeking across many domains of daily life (Salkovskis et al., 2003; Tang et al., 2007). The powerful negative reinforcement means the devices may be new and important safety cues acting as risk factors for pathological anxiety (Abramowitz et al., 2002; Deacon & Maack, 2008; McManus et al., 2008; Norr et al., 2015; Parrish & Radomsky, 2010). Research has already provided initial evidence that mobile phones serve as safety cues (Cheever et al., 2014; Helbig-Lang & Petermann, 2010; Kins et al., 2013; Walsh et al., 2008); however, within the context of contemporary IU research and theory (Carleton, 2016a, 2016b), the current results suggest an important causal relationship may exist between uncertainty, reassurance seeking, and mobile phone use, which may be increasing IU and therein anxiety (Carleton, 2016b; Helbig-Lang & Petermann, 2010).

Meta-analytic results partially supported the supplementary analysis that increases in IU are correlated with increases in anxiety. There seems to be a trend for increasing worry symptoms, a related measure of emotional distress (Carleton, 2012), that correspond with the increase in IU from 1999 to 2011. Cell phones offer reassurance seeking behavior, a behavioral response to anxiety. Whereas IU is a cognitive bias in anxiety, worry is a cognitive response (Carleton, 2016b). The current results provide preliminary evidence that these cognitive components are increasing concurrently.

There are several important limitations to the current research that offer opportunities for future research. First, the analyses are based on convenience data that, while assessed over time, represents a compilation of cross-sectional samples rather than a true longitudinal sample. Future researchers should consider using true longitudinal data sampling for such assessments. Second, on the basis of these cross-sectional data, there is no way to actually determine causality and the correlations identified could be spurious. There may also be any number of confounding factors that would contribute to the rise in IU; for example, the increased connectivity provides personalized access to a 24 h news cycle that can potentiate perceptions of uncertainty and threat (e.g. Glassner, 2004; Reich & Godler, 2014; Saltzis, 2012). The increasing IU may also be specific to college students and based on increasing tuition costs and economic volatility (Arnett, Žukauskienė, & Sugimura, 2014; Hussain, Guppy, Robertson, & Temple, 2013; Richardson, Elliott, Roberts, & Jansen, 2017). Future researchers could use experimental manipulations to test the influence of common place exposures exposure to uncertainty (i.e. during course of everyday activities, such as having to wait to check in with a loved one) by randomly assigning participants to increasing or decreasing access to technology. Third, the sample data was based on a single self-report measure of IU. Per recent recommendations (Shihata, McEvoy, Mullan, & Carleton, 2016),

future researchers should work to replicate the current results with more diverse self-report measures as well as multimodal measures (e.g. behavioral assessments). Fourth, most of the studies relied on non-clinical samples of undergraduates from Western (i.e. North American) cultures. Future studies should include broader samples as the data become available. Fifth, the inconsistency of previous factor structure presentations for the IUS prohibited assessments of the contemporary two factors (Carleton et al., 2007; Hong & Lee, 2015; Sexton & Dugas, 2009), despite evidence that the factors may differentially relate to difference anxiety-related constructs (Carleton, 2016b; Hong & Lee, 2015). Future researchers should assess the contemporary two factors as the data becomes available over time. Sixth, caution is warranted when interpreting the meta-analytic results for the supplementary analysis due to reduced sample size of studies. The current research was limited to studies that reported both IUS and PSWQ. A comprehensive review of studies that report PSWQ or other anxiety measures may be warranted to understand how anxiety has changed over time with cell phone use.

In summary, there appears to be initial evidence that IU is steadily rising in the population. The increases appear associated with increased mobile phone penetration and Internet usage. There may be a causal relationship between the two in that the constant connectivity increases access to reassurance, meaning the mobile phones are serving as perpetual safety cues that potentiate IU (Carleton, 2016b). Given the importance of exposure for reducing IU and anxiety (Boswell, Thompson-Hollands, Farchione, & Barlow, 2013), there may be even more potential reasons to "unplug" (Thomas, Azmitia, & Whittaker, 2016). In any case, the steady increase in self-report IU appears to warrant additional research attention and may require special considerations for measurement. Finally, clinical researchers now have additional justification for clinical trials of exposures to uncertainty in order to reduce IU.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

R. N. Carleton's research is supported by the Canadian Institutes of Health Research (CIHR) through a New Investigator Award (FRN: 285489).

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