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Development and Validation of the Climate Change Hope Scale for High School Students

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Abstract

Hope is an important component that helps engage people in solving problems. The development of an instructional model on climate change and forests provided an opportunity to design and test a measurement tool to assess hope about climate change. In this article, we described the process and determined the reliability and validity of a newly developed 11-item Climate Change Hope Scale (CCHS). The study involved high school students from the southeastern United States during fall of 2013 and spring of 2015 (*N* = 1,902, 14-18 years old). The factor analysis confirmed a three-factor solution with good model fit: (a) collective-sphere willpower and waypower, (b) personal-sphere willpower and waypower, and (c) lack of willpower and waypower. This study suggests that the CCHS is a valid, reliable, and feasible tool to measure hope in the context of climate change among U.S. high school students.

Keywords

reliability, validity, hope concerning climate change, high school students, factor analysis

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Background

Hopefulness in the face of climate change is increasingly important for moving people beyond despair and helplessness to mitigate and adapt to climate change (Center for Research on Environmental Decisions, 2009; Farran, Herth, & Popovich, 1995; Lueck, 2007; Ojala, 2012, 2015, 2016; Pettit, 2004; Swim & Fraser, 2013). Hope is one's belief in the ability to pursue goals. Lynch (1974) described hope as an individual's best resource "always there on the inside, making everything possible when he is in action, or waiting to be illuminated when he is ill" (Lynch, 1974, p. 31). Hope can be detected when an individual has the motivation to remain engaged with a future outcome and can anticipate and generate alternative ways to reach that outcome (Snyder, Rand, & Sigmon, 2001).

Although there are similarities between hope, optimism (Scheier & Carver, 1985; Seligman, 1991), self-efficacy (Bandura, 1982, 1997) self-esteem, and problem solving (Heppner & Hillerbrand, 1991), the scientific construct of hope is slightly different from these constructs (Snyder, Rand, & Sigmon, 2002). Self-efficacy, by definition, refers to an individual's belief in his or her capacity to control one's own behavior to produce specific performance-based attainments (Bandura, 1977, 1982, 1997) The concept of self-efficacy plays a major role in understanding how people perceive their own abilities in response to specific situations, whereas, hope reflects not only a general belief about their capacities to reach outcomes but also that they can find ways and long-term solutions to solve problems. Optimism is a disposition or tendency to look on the more favorable side of events and conditions and to expect the most favorable outcome (Seligman, 1991). Outcome expectancy is a person's expectations about the consequences of an action. For example, in a study of reading and writing (Shell, Murphy, & Bruning, 1989) students were asked to rate the importance of reading and writing for getting a job, having friends, or going to college. Our definition of hope, like Snyder et al.'s (2001) combines goals, willpower, waypower, the disposition of self-efficacy, and optimism into one positive psychological concept.

The complex issues surrounding climate change present teachers with not only a valuable opportunity but also a challenge for teaching this topic in science classrooms (Plutzer et al., 2016). To achieve the goals of "an informed society anticipating and responding to climate and its impacts" (National Oceanic and Atmospheric Administration, 2011, p. 1) and "empowering, enabling, motivating, informing, and educating the public on not just the technical but also the political and social dimensions of climate change" (Nisbet, 2010, p. 2), teachers must do more than provide information. Students should also gain skills in problem solving and be empowered to act,

and hope is one prerequisite for the ability to work on complex environmental issues (Hayden et al., 2011; Schreiner & Sjoberg, 2005).

Although some educational resources have been developed that aim at building hope concerning climate change and empowering students to make a difference (Alliance for Climate Education, 2016; Bromberg & Niblett, 2007; Stanford Climate Change Education Project, 2009), few studies have empirically evaluated the effectiveness of those educational programs on students' hopefulness. Perhaps one of the reasons is the lack of a psychometrically sound and appropriate tool.

Measuring Hope

In psychiatric literature, a number of versions of tools to measure hope have been developed and tested (Schrank, Stanghellini, & Slade, 2008), but they define hope as a general indicator of mental wellness. These tools are designed for clinicians and include general questions such as "I look forward to doing things I enjoy" and "I intend to make the most of life" (Schrank, Woppmann, Sibitz, & Lauber, 2011). Nevertheless, an exploration of these tools provides insights into how hope could be measured in the context of climate change.

A growing body of literature suggests that hope is a multidimensional construct (Landeen, Pawlick, Woodside, Kirkpatrick, & Byrne, 2000; Miller & Powers, 1988; Schrank et al., 2011; Snyder, Irving, & Anderson, 1991). The most frequently used scales in psychiatric research include the Snyder State Hope Scale (Snyder et al., 1991), Herth Hope Index (HHI; Herth, 1992), Miller Hope Scale (MHS; Miller & Powers, 1988), Zimmerman Hope Scale (Zimmerman, 1990), Beck Hopelessness Scale (Beck, Weissman, Lester, & Trexler, 1974), and Integrative Hope Scale (IHS; Schrank et al., 2011). These tools overlap considerably but differ in important areas. The Snyder State Hope Scale measures the extent to which individuals present a thinking process in which they express willpower (also called agency thinking) and waypower (also called pathways thinking). The HHI was designed for elderly patients with cancer and is the only one that explicitly focuses on spiritual aspects of hope. The three factors in the HHI are (a) temporality and future, (b) positive readiness and expectancy, and (c) interconnectedness. The MHS was developed after a comprehensive literature review and has the largest number of items (40 items). Three factors in MHS are (a) satisfaction with self, others, and life; (b) avoidance of hope threats; and (c) anticipation of a future. The Beck Hope Scale and the Zimmerman Hope Scale draw heavily on negative aspects of hopelessness, whereas the Integrated Hope Scale was designed for use in people with mental illness. The suggested factors identified in all these scales

overall include willpower and waypower, positive future orientation, lack of perspective, social relations and personal value, trust and confidence, and efficacy. All these scales defined hope in a generic context in terms of solving personal problems and moving toward a positive future. Positive future orientation captures to what extent individuals perceive that the future will be better. Lack of perspective measures to what extent they feel hopeless about some parts of their life. Social relations and personal value reflect to what extent the individuals feel loved and supported by others. Self-efficacy (Bandura, 1997), trust, and confidence measure a deep inner strength that will help them cope with difficulties (Miceli & Castelfranchi, 2010). To further explain the differences among these constructs, see examples of items (Table 1).

In designing a scale to examine hope concerning climate change, we draw on the hope theory (Snyder, 1994) because the framework allows us to test whether or not the willpower and waypower are applicable in solving environmental issues. Willpower explains to what extent individuals believe that they are able to meet the life goals that they set for themselves. Waypower measures to what extent they can think of ways to overcome a problem. Snyder's hope scale offers insights on how to measure personal-sphere willpower and waypower (PW) to solve individual issues. Because the measures of hope from the Snyder State Hope Scale (Snyder et al., 1991) reflect individuals' perceptions of solving individual problems, they present a limitation when faced with global environmental problems that cannot be solved by an individual. One way to address this problem is to add a collective-sphere of willpower and waypower to the instrument.

A Swedish researcher developed a Hope Concerning Climate Change Scale for adolescents (Ojala, 2012, 2015), and defined hope to include trust in other actors, trust in laypeople's effort, and positive reappraisal. Although this seems like a reasonable solution, differences in social norms and media messages suggest, however, that a scale developed in Sweden would need to be tested for reliability and validity in other countries (Leiserowitz, Smith, & Marlon, 2011; Simonsson, Swartling, André, Wallgren, & Klein, 2011). Ojala's (2012) scale was measured with 10 items representing different sources of hope. Three of the items represent the factor of trust in others, such as trust in technology and trust in environmental organizations. Two of the items represent the factor of trust self, such as I can contribute and I can influence. Four of the items represent the factor of positive reappraisal, such as awareness has increased. One item represents denial's response. Ojala's (2012) work suggests that the sources of hope consist of two levels of trust, personal, that is, trust in one's own ability to contribute, and collective. Ojala revised the hope scale in 2015 by keeping nine items from the 2012 version of the hope scale and adding three new items to empirically capture hope

Table 1. Examples and Sources of Relevant Constructs in Measuring Hope.

Construct	Source	Statements
Willpower	The Snyder Hope Scale (Snyder, Irving, & Anderson, 1991)	• I energetically pursue my goals. • My past experiences have prepared me well for my future. • I've been pretty successful in life. • I meet the goals that I set for myself.
Waypower	The Snyder Hope Scale (Snyder et al., 1991)	• I can think of ways to get out of a jam. • There are lots of ways around any problem. • I can think of many ways to get the things in life that are important to me. • Even when others get discouraged, I know I can find a way to solve the problem.[a]
Positive future orientation	The IHS (Schrank et al., 2011)	• There are things I want to do in life. • I look forward to doing things I enjoy. • I make plans for my own future. • I intend to make the most of life.
	Schizophrenia Hope Scale (Choe, 2014) HHI (Herth, 1992)	• There is a better future ahead of me. • I will be happy in the future. • I am getting better every day. • My future is bright. • I have a positive outlook toward life.
Lack of perspective	The IHS (Schrank et al., 2011)	• It is hard for me to keep up my interest in activities I used to enjoy. • It seems as though all my support has been withdrawn. • I am bothered by troubles that prevent my planning for the future. • I am hopelessness about some parts of my life.
Social relations and personal value	The IHS (Schrank et al., 2011)	• I feel loved. • I have someone who shares my concerns. • I am needed by others. • I am valued for what I am.
Efficacy, trust, and confidence	The IHS (Schrank et al., 2011) HHI (Herth, 1992)	• I have deep inner strength.[a] • Even when others get discouraged, I know I can find a way to solve the problem.[a] • I have a sense of direction. • I can see possibilities in the midst of difficulties.[a]

Note. IHS = Integrative Hope Scale; HHI = Herth Hope Index.
[a]The items appeared in two different constructs.

based on denial. But the lack of representation in individuals' willpower—the extent to which individuals are willing and empowered to take actions—makes it a less appropriate framework than the Snyder scale. Concerning hope in relation to climate change, sometimes hope is used as a form of wishful thinking, rather than as an aspect helping people to face problems and taking actions (Hornsey & Fielding, 2016; Snyder et al., 2002). We believe that hopeful thinking is different from denial's wishful thinking (Snyder et al., 2002). We argue that the statements of individuals' willingness to take actions to solve problems caused by climate change differentiate hopeful thinking from denial's wishful thinking (Lewandowsky, Oreskes, Risbey, Newell, & Smithson, 2015; Markowitz & Shariff, 2012). Because none of the items from Ojala's (2012, 2015) hope scale captures individuals' willingness to take actions, we adapted Snyder's willpower statements and added statements such as "I am willing to take actions to help solve problems caused by climate change." To capture the waypower in the context of climate change, we adapted a statement from Ojala's (2012) hope scale ("I feel hope concerning climate change because I know that there are a number of things that I myself can do to contribute to the improvement of the climate change problem") that was inspired from Snyder's waypower statements.

We hypothesized that an effective Climate Change Hope Scale (CCHS) should capture the extent individuals believe that they and society in general can generate pathways and are able to execute the pathways to solve problems caused by climate change. The factor structure of CCHS should include the personal-sphere and collective-sphere willpower and waypower (CW) in solving problems caused by climate change. We hypothesized climate change hope would correlate with trust (Miceli & Castelfranchi, 2010). There is a clear need for a high-quality and easy-to-use instrument to measure hope concerning climate change. In this article, we described the development and reported the testing results of a CCHS in the United States.

Objectives

The objectives of this study are to assess the reliability and validity of the CCHS by (a) evaluating the content-based validity, (b) providing evidence of the appropriateness of response-process evidence, (c) assessing the validity of internal structure by conducting exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to determine the dimensionality and psychometric properties of the items, (d) estimating internal consistency by using a factor analysis–based method, and (e) discussing the appropriate use of the scale. The information included in this article could be useful for environmental education researchers, curriculum evaluators, environmental psychology researchers, extension agents,

educators, and program developers who wish to use this scale to provide evidence-based empirical research as well as evaluate the effectiveness of climate change education programs.

Method

This reliability and validity study was conducted in three phases: instrument development (Phase 1), revising and piloting scale (Phase 2), and testing the final Climate Hope Scale (Phase 3). During Phase 1, we developed the first version of CCHS (CCHS-A), pilot tested with high school students during the summer of 2013, revised it as CCHS-B and conducted an EFA with data from 924 high school students. During Phase 2, we revised CCHS-B and proposed CCHS-C based on the EFA results. We assessed the content validity and the appropriateness of response-process validity with CCHS-C. We also asked a panel of experts to review the content and conducted a focus group study with 12 high school students for response-process validity for CCHS-C. During Phase 3, we revised CCHS-C and proposed a 15-item CCHS-D. We conducted a CFA with 978 students from 28 secondary high schools of the factor structure of CCHS-D and selected the most valid items. The final version, CCHS, contains 11 items. The convergent reliability and internal consistency was tested on CCHS by using self-efficacy and trust based on research finding that hope is positively correlated with self-efficacy (O'Sullivan, 2011) and trust theoretically (Miceli & Castelfranchi, 2010).

Phase 1: Instrument Development

Procedure. The CCHS-A included nine items on a five-point scale (1 = *strongly disagree* to 5 = *strongly agree*). In pilot testing the CCHS-A, we divided 89 high school students into two groups and provided training to four volunteers to standardize the pilot testing process. Participants were first asked to complete the CCHS-A and then were provided with a separate comment worksheet and red pens to circle any confusing words. The volunteers timed the process and collected student feedback. A meeting with four volunteers enabled researchers to learn how participants responded to scale items and checked whether they understood them. Qualitative data were analyzed by quantifying frequency of wording issues.

One change from CCHS-A to CCHS-B was converting the term "climate change" to "global warming" in response to student comments that climate has been changed since the Ice Age, which is broader than what we mean to measure, anthropogenic climate change. In addition, global warming is associated with greater public understanding, emotional engagement, and support

for personal and national action (Leiserowitz et al., 2014). We also changed the five-point scale to seven points to increase sensitivity of the measurement. Table 1A in the online appendix presents the rationale behind the detailed revisions from CCHS-A to CCHS-B. The CCHS-B was sent to 32 high school teachers to implement with their students. Twenty-four high school teachers administered the CCHS-B to their students. Nine hundred twenty-four participants completed the CCHS-B and provided parental consent forms. Slightly more males (51%) responded. The majority identified as White (70%) and non-Hispanic (86%). All were from the southeastern United States: Florida (43%), Virginia (24%), Kentucky (19%), North Carolina (10%), Georgia (2%), and Arkansas (1%).

Analysis. The data obtained from Phase 1 allowed us to empirically predetermine the internal factor structure, estimate the Cronbach's alpha of the reliability coefficient of the scores, and propose a revision of the scale. We performed EFA with promax rotation on eight items. We used maximum likelihood (ML) to address missing data in IBM SPSS (3.51% missing data; Rubin, Witkiewitz, Andre, & Reilly, 2007). Items were flagged for further analysis if they met either of the following criteria: (a) factor loadings were less than absolute .35 or (b) more than one factor loading was above absolute .35 (Gorsuch, 1983). Assumptions of sphericity and sampling adequacy were examined by looking at the Kaiser–Meyer–Olkin (KMO) and Bartlett's Test. We expected that the latent factors would be correlated based on the hope theory (Snyder, Rand, & Sigmon, 2001), so we used oblique rotation. The results from EFA helped us predetermine the number and nature of underlying latent factors. We calculated the standard deviation between CCHS-A and CCHS-B to learn whether or not the seven-degree scale improved its sensitivity.

Phase 2: Revising and Piloting

Procedure. We significantly revised two items because they were ambiguous, deleted one item as it was too specific compared with other statements, and added three items to capture the lack of hopefulness and two items to measure collective-sphere waypower as it was weak in CCHS-B (see Table 2A in the online appendix). The CCHS-C includes 11 items on a seven-degree scale. The aim of this phase was to examine the content-based and response-process validity evidence.

Regarding content-based validity, the researcher gathered a panel of experts including four graduate students, one postdoc, and one faculty member who study environmental psychology, natural resources, and sociology.

We asked them to rank each item against the factors from 5 (*highly representative of the construct*) to 1 (*irrelevant to the construct*) and used the average of their responses to determine whether any items should be revised or eliminated. For response-process validity, we conducted two rounds of focus group discussions about the appropriateness of the scale with 12 high school students in January 2015.

Analysis. We used the descriptive statistics for conducting the analysis for Phase 2. We calculated the mean and standard deviation of each item based on the panel of reviewers' ranking score. We used the qualitative data analysis to analyze the focus group responses.

Phase 3: The Final CCHS

Procedure. The aim of this phase was to select the most valid and reliable items from the CCHS-D and examine the internal factor structure of the prior model by using CFA. The hypothesized model built on the EFA emerged by adding the third factor, lack of willpower and waypower. Internal consistency as well as the convergent validity of the model was tested. Convergent reliability estimates to what extent the measures of constructs relate to other instruments that are theoretically correlated. In selecting constructs to test the convergent reliability of CCHS, we used a self-efficacy scale and a trust scale because research has shown that hope is positively related to self-efficacy (Magaletta & Oliver, 1999; Snyder et al., 2001) and trust (Miceli & Castelfranchi, 2010; Ojala, 2012). The lack of published studies measuring trust in the context of climate change among high school students required us to develop and pretest our own trust scale. The Cronbach's alpha of trust scale was .76 and the self-efficacy scale was .80 (Table 2).

Participants were 978 (42% male and 58% female) students from 28 secondary high schools throughout the southeastern United States. Participants voluntarily completed the CCHS-D, a self-efficacy scale, and a trust scale during regular class time. The trust scale included six items on a five-degree scale (1 = *not at all* to 5 = *a great deal*) and asked to what extent respondents believe that different professionals can help address problems caused by climate change (see Online Appendix B). The self-efficacy scale included three items on a five-degree scale (1 = *not at all* to 5 = *a great deal*) and was developed by researchers based on Bandura's self-efficacy theory (1977, 1982).

Analysis. Thirty-two climate change doubters (3.2%) who selected the eighth option "I do not think climate is changing" were removed from the sample for a separate analysis. This resulted in a sample size of 946 for CFA. We

Table 2. Descriptive Statistics, Omega Coefficients, and Cronbach's Alpha of CCHS, Trust, and Self-Efficacy.

Instruments	Omega coefficients	Cronbach's alpha	No. of items	Range	*M*	*SD*	*n*
CCHS	—	—	11	11-77	56.14	9.75	906
CW	.83	.73	5	5-35	26.78	4.47	932
PW	.75	.68	3	3-21	14.98	3.40	921
LW (reverse)	.75	.78	3	3-21	14.26	4.27	922
Trust	—	—	6	0-30	21.59	5.35	899
Trust In leaders	—	.76	3	0-15	9.78	3.59	913
Trust in professionals	—	.72	3	0-15	11.8	2.88	910
Self-efficacy	—	.80	3	0-15	8.30	3.01	918

Note. All correlations are significant at the $p < .05$ level. CCHS = Climate Change Hope Scale; CW = collective-sphere willpower and waypower; PW = personal-sphere willpower and waypower; LW = lack of willpower and waypower.

randomly separated the 946 responses into three data sets for analysis. We treated the variables as categorical and calculated with the statistical calculator called Weighted Least Square Means and Variance Adjusted Estimation (WLSMV). We used WLSMV because the magnitudes of the factor loadings are more precisely estimated when the variables are categorical (Beauducel & Herzberg, 2006). We used one set to establish a preliminary CFA model and then tested whether or not this model could be extended across the other two data sets. We used Mplus Version 7.11 (Muthén & Muthén, 1998-2012) to conduct the analysis.

After conducting CFA analysis, the data were compiled for estimating the omega coefficient—the test of congeneric of each dimensionality,

$$\hat{\rho}_{X,omega} = \frac{\left(\hat{a}_1 + \ldots + \hat{a}_p\right)^2}{\left(\hat{a}_1 + \ldots + \hat{a}_p\right)^2 + \left(\hat{\sigma}_{u1} + \ldots + \hat{\sigma}_{up}\right)^2}, \tag{3-1}$$

where $\hat{\rho}_{X,omega}$ represents the omega coefficient of reliability, $\hat{a}_1 \ldots \hat{a}_p$ represent the factor loadings for each items, and $\hat{\sigma}_{u1} \ldots \hat{\sigma}_{up}$ represent the calculated r^2 for each item in this model. The omega coefficient is used because it does not require a tau-equivalence or a parallel model. It is more accurate than Cronbach's alpha if the items fit into a congeneric model, which assumes that individual items measure the same latent variable, with possibly different scales, with possibly different degrees of precision, and with possibly different amounts of error (Raykov, 1997a, 1997b). Because our items only meet

the congeneric model, the Cronbach's alpha is not appropriate as an estimate of scores' reliability, but omega coefficient is.

Model-fit indices. Goodness of fit was examined by looking at the chi-square test, root mean square error of approximation (RMSEA), Bentler's comparative fit index (CFI), and Tucker–Lewis index (TLI). These are commonly used criteria in the context of CFA. The chi-square test is used to determine whether the model fits the data exactly. Because the chi-square test is sensitive to sample size (any target model will only fit a large data set approximately), it is suggested that the chi-square test not be the only criterion to assess model fit. RMSEA measures the size of the discrepancy between the model-implied covariance matrix and the actual covariance matrix, so larger values indicate worse fit. A common criterion for goodness of fit by RMSEA is ≤.06. CFI measures how much fit has improved as we change from the null model to the target model, specifically the proportion of the possible improvement from the null to saturated model that is achieved by using the target model. TLI can be interpreted as CFI and penalizes for complexity; if two models have the same CFI, the more complex model will have a lower TLI. Based on the criticism for the previously accepted value of .90, a common criterion for goodness of fit by CFI and TLI is ≥.95 for latent variable models (Yu, 2002).

To improve model fit, we can add additional parameters that are not functions of other parameters to the model. However, if we add a sufficient number of additional free parameters, the model covariance and model-implied covariance will be the same. The result is called a saturated model. Saturated models fit the data perfectly but are too complex to interpret. To reasonably add additional free parameters, we requested a list of modification indices (MIs) from Mplus output. If an MI is 3.84 or greater for a model misspecification, making the recommended change will reduce (χ^2) by a statistically significant amount and increase the goodness of fit. We conducted post hoc analysis by changing or removing one item at a time and compared the goodness-of-fit indices. We considered reparamaterization of the model only on the basis of MI and if the change made sounds theoretical sense (Byrne, 1998). We tested the alternative hypothesis against the null hypothesis by using the chi-square test of model fit.

Results

Phase 1

EFA is used to uncover the underlying structure for a relatively new instrument and serves to identify a potential factor structure for a set of variables. The KMO coefficient for this data set was 0.80 and the Bartlett test of sphericity

Table 3. Correlation Matrix for EFA Analysis (N = 924).

Variables	1	2	3	4	5	6	7	8
1. I believe people will be able to fix global warming.	1.00							
2. I believe that research and technical solutions will help fix global warming.	.585	1.00						
3. Forest landowners can make a difference in the climate by practicing good forest management strategies.	.276	.387	1.00					
4. Because people can change their behavior, we can influence global warming in a positive direction.	.380	.459	.458	1.00				
5. I am hopeful about resolving global warming because more people are taking global warming seriously.	.179	.148	.176	.189	1.00			
6. I know that there are a number of things that I can do to contribute to global warming solutions.	.261	.295	.417	.370	.242	1.00		
7. I am hopeful about global warming because I can think of many ways to resolve this problem.	.287	.324	.324	.431	.291	.523	1.00	
8. Global warming is such a huge problem and I don't think people can change it.	.343	.248	.144	.232	.046	.174	.191	1.00

Note. All correlations are significant at the $p < .05$ level. EFA =exploratory factor analysis.

was statistically significant ($\chi^2 = 83.72$, $df = 13$, $p < .001$), indicating that it is acceptable in terms of sampling adequacy. Properties of the correlation matrix justified the factor analysis (Table 3). Oblique factor rotation, with promax rotation and Kaiser Normalization using ML extraction method identified two latent factors with a simple structure. Extraction of factors was based both upon Kaiser's criterion for eigenvalues equal to or greater than one.

EFA results captured the two factors presented in Table 4. Factor 1 was labeled personal-sphere willpower and waypower and included items such as

Table 4. Item Factor Loadings for the CCHS-B From EFA With Oblique Rotation.

Item number	Item	Factor loading 1	Factor loading 2
Factor 1: Personal-sphere will and way (PW; α = .65)			
6	I know that there are a number of things that I can do to contribute to global warming solutions.	.703	.168
7	I am hopeful about global warming because I can think of many ways to resolve this problem.	.674	.216
3	Forest landowners can make a difference in the climate by practicing good forest management strategies.	.477	.327
5	I am hopeful about resolving global warming because more people are taking global warming seriously.	.337	.110
Factor 2: Collective-sphere will and way (CW; α = .70)			
2	I believe that research and technical solutions will help fix global warming.	.249	.741
1	I believe people will be able to fix global warming.	.180	.723
4	Because people can change their behavior, we can influence global warming in a positive direction.	.479	.447
8 (reverse)	Global warming is such a huge problem and I don't think people can change it.	.143	.353

Note. N = 924; α = .76. EFA = exploratory factor analysis.

"I am hopeful about climate change because I can think of many ways to resolve this problem" and "I know that there are a number of things that I can do to contribute to climate change solutions." Factor 1 accounted for 39.8% of the total variance and had an eigenvalue of 3.12. Factor 2 was labeled as collective-sphere willpower and waypower and included items such as, "I believe people will be able to fix climate change" and "I believe that research and technical solutions will help fix climate change." Factor 2 accounted for 14.1% of the total variance and had an eigenvalue of 1.13. The two factors used eight items and accounted for 53.89% of the total variance within the data set. Table 4 shows the factor structure matrix for the eight items of the index. Two items were removed because one loaded on both factors and the other did not contribute to either. The Cronbach's alpha was .76 for the

overall scale. PW (.65) and CW (.70) are less strong, in comparison with the internal consistency of the overall scale. As a rule of thumb, alpha values of .7 to .8 indicate acceptable reliability; values of .8 of higher indicate good reliability (Nunnally, 1978). Hence, the internal consistency of the overall scale as well as for its collective-sphere willpower and waypower can be considered acceptable.

The increased standard deviation from CCHS-A (M = 29.62/45; SD = 3.76; N = 89) to CCHS-B (M = 36.51/56; SD = 7.61; N = 915) confirmed that the seven-degree scale improved the scale sensitivity.

Phase 2

The panel of reviewers rated each item against the factor. The average score was 4.5 for the overall scale and between 4.0 and 5.0 for each factor. The two outside reviewers overall commented that the phrase "solve climate change" is too wishful. We changed the term to "solve problems caused by climate change" to distinguish the constructive hope from wishful thinking (see Table 3A in the online appendix). Focus group responses resulted in adding, "I do not think climate is changing" as an option. This enabled researchers to separate those who reject mainstream climate science from the other respondents. Another significant change was changing the term "global warming" back to "climate change" as it is preferred by most of the climate scientists to describe the multitude of impacts associated with global warming. But to address the comments we obtained from Phase 2, we adapted and used the definition from Leiserowitz et al. (2014):

> Climate change refers to recent changes in the Earth's climate including changes in temperature, precipitation, and wind patterns over a period of decades or longer. It may cause problems such as changes in sea level, more extreme heat events, fires and drought, more extreme storms, and floods. Scientists project that the problems caused by climate change could affect, for example, forest health, agriculture, freshwater supplies, coastlines, human health, economy, wildlife habitat, and human migration. (p. 6)

CCHS-D included the definition and 15 items on an eight-degree scale.

Phase 3

The correlation matrix of the CCHS-D is reported in Table 4A in the online appendix. CFA based on the correlation matrix of 15-items is reported in Table 5. We compared the goodness-of-fit indices for three models: (a) the 15-item

Table 5. Model-Fit Tests or Indices From CFA of CCHS-D and CCHS With Three Data Sets.

Model-fit tests or indices	Criterion	CCHS-D	CCHS	CCHS-8	CCHS Data Set 1[a]	CCHS Data Set 2[b]	CCHS Data Set 3[c]
χ^2 test of model-fit tests	Nonsignificant goodness-of-fit tests; $p > .05$	1,473.98* $p < .001$	165.51* $p < .001$	152.60* $p < .001$	74.49* $p < .001$	87.70* $p < .001$	83.95* $p < .001$
RMSEA	≤.06	.130 [.12, .14]	.061 [.05, .70]	.092 [.08, .10]	.057 [.04, .08]	.066 [.05, .08]	.063 [.05, .08]
CFI	>.95	.851	.982	.969	.985	.978	.983
TLI	>.95	.820	.974	.949	.978	.967	.974

Note. CFA = confirmatory factor analysis; CCHS = Climate Change Hope Scale. RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker–Lewis index.
[a]$N = 301$.
[b]$N = 300$.
[c]$N = 299$.
*$p < .05$.

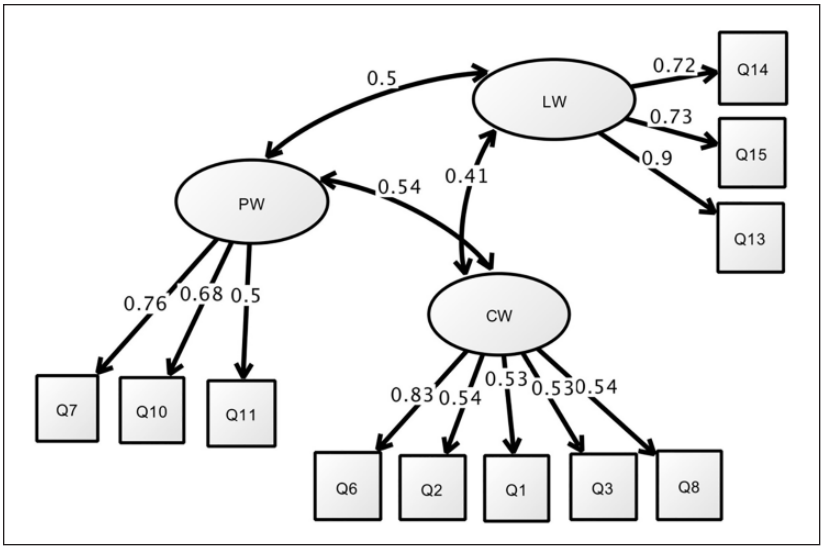

Figure 1. CFA model for the CCHS standardized estimates.
Note. The figure was generated by using Onyx V0.1 software, by von Oertzen, Brandmaier, and Tsang (2012). All the factor loadings are significant at the $p < .001$ level. CFA = confirmatory factor analysis; CCHS = Climate Change Hope Scale; PW = personal-sphere willpower and waypower; CW = collective-sphere willpower and waypower; LW = lack of willpower and waypower.

three-factor structure (CCHS-D), (b) the 11-item three-factor structure (CCHS; Figure 1), and (c) the eight-item two-factor structure (CCHS-8). CFI was appropriate only for the 11-item and eight-item models. The CCHS-D with 11-items (CCHS) was the only model that met RMSEA criteria at .06. The CFI and the TLI were .982 and .974, which are above the recommended .95 level for an adequate fit of the model. Consistent findings across the three data sets confirmed the three-factor model. The goodness of fit for the factor structure for its three dimensions can be considered excellent. In the CCHS model, four items were deleted from CCHS-D as they have large MI values and low factor loadings on its original factor. Goodness of fit was significantly improved by deleting these four items, leaving 11 items in the final version (CCHS; see Online Appendix A).

Table 6 shows the factor parameter estimates and their respective standard errors of CCHS-D and CCHS. The CFA results confirmed the EFA factor structure with the third factor—lack of willpower and waypower. Three factors are (a) PW, (b) CW, and (c) lack of willpower and waypower (LW). An example of LW is "Climate change is beyond my control, so I won't even bother trying to solve problems caused by climate change."

Table 6. Factor Parameter and Standard Errors for CFA of CCHS-D and CCHS.

Items	CCHS-D		CCHS	
	Factor loading	*SE*	Factor loading	*SE*
Factor 1: Personal-sphere will and way (PW)				
7. I am willing to take actions to help solve problems caused by climate change.	.776	.02	.759	.02
10. I know that there are things that I can do to help solve problems caused by climate change.	.714	.02	.683	.02
11. I know what to do to help solve problems caused by climate change.	.648	.02	.496	.03
9. At the present time, I am energetically pursuing ways to solve problems caused by climate change.	.565	.02		
Factor 2: Collective-sphere will and way (CW)				
6. If everyone works together, we can solve problems caused by climate change.	.786	.02	.827	.02
2. I believe that scientists will be able to find ways to solve problems caused by climate change.	.700	.02	.543	.03
1. I believe people will be able to solve problems caused by climate change.	.685	.02	.528	.03
8. I believe more people are willing to take actions to help solve problems caused by climate change.	.626	.02	.543	.03
3. Even when some people give up, I know there will be others who will continue to try to solve problems caused by climate change.	.512	.03	.532	.03
5. Every day, more people begin to care about problems caused by climate change.	.476	.03		
4. Because people can learn from their mistakes, they will eventually mitigate and adapt to climate change.	.308	.03		
Factor 3: Lack of will and way (LW)				
13. Climate change is beyond my control, so I won't even bother trying to solve problems caused by climate change.[a]	.861	.01	.895	.02
15. The actions I can take are too small to help solve problems caused by climate change.[a]	.708	.02	.731	.02
14. Climate change is so complex we will not be able to solve problems that it causes.[a]	.724	.02	.723	.02
12. I can't think of what I can do to help solve problems caused by climate change.[a]	.605	.03		

Note. CFA = confirmatory factor analysis; CCHS = Climate Change Hope Scale.
[a]These items are reversely coded in data analysis.

The omega coefficient was between .75 and .83 for each of three dimensions. The Cronbach's alpha was between .681 and .797 for each of three dimensions. Hence, the internal consistencies of the overall scale as well as for its three dimensions are acceptable (Nunnally, 1978).

Table 7. Correlations Among CCHS, Trust, and Self-Efficacy.

Instruments	CCHS	CW	PW	LW	Trust	Self-efficacy
CCHS	1					
CW	.819 (906)	1				
PW	.811 (906)	.539 (910)	1			
LW	.794 (906)	.410 (910)	.504 (917)	1		
Trust	.541 (878)	.431 (888)	.454 (892)	.431 (892)	1	
Self-efficacy	.630 (897)	.410 (906)	.648 (912)	.504 (912)	.544 (894)	1

Note. All correlations are significant at the $p < .05$ level. CCHS = Climate Change Hope Scale; CW = collective-sphere willpower and waypower; PW = personal-sphere willpower and waypower; LW = lack of willpower and waypower.

Convergent validity was evaluated by comparing the scores of the final CCHS with the trust and the self-efficacy scales. Pearson's correlations between the three instruments indicated a significant positive correlation between hope and trust and between hope and self-efficacy, supporting the convergent validity of CCHS (Table 7). Hope, trust, and self-efficacy are positively related. Together with a low number of missing responses to the questionnaire, confirming its feasibility, these results indicate that the CCHS with 11 items is applicable for measuring hope concerning climate change among high school students who believe the climate is changing.

High school students ($N = 978$) from the study tend to be slightly hopeful that society, as a whole, is able to and will solve problems caused by climate change ($M = 26.78/35.00$; $SD = 4.47$). They tend to slightly agree that they can think of ways to and can help solve problems caused by climate change ($M = 14.98/21.00$; $SD = 3.40$). In terms of lack of willpower and waypower, it shows that they slightly disagree that climate change is so complex that we will not be able to solve problems that it causes ($M = 6.74/21.00$; $SD = 4.27$).

Discussion

The development and validation process of the CCHS among more than 1,900 U.S. adolescents involved testing 42 different items, revising language, and identifying a three-factor structure of CCHS in the CFA. The three factors, collective-sphere willpower and waypower, personal willpower and waypower, and lack of willpower and waypower, were confirmed through EFA and CFA. The factor structure of CCHS is consistent with previous studies (Ojala, 2012, 2015) that suggest hope of climate change among adolescent comes from three sources—trust from themselves, trust from others, and positive reappraisal. Although researchers can examine the willpower and

waypower scores independently, our factor-based analysis did not separate them. Willpower and waypower thinking do not appear to vary differently in the context of solving problems of climate change. This, perhaps, indicates that if people can think of routes to solve problems caused by climate change (waypower), they also believe that society and they have the requisite motivation to actually use such routes (willpower). They tend to vary together. This finding suggests that high school students who have high levels of willpower will tend to have high levels of waypower scores. However, an interesting finding of this research is that students who hold high levels of personal-sphere willpower and waypower do not always hold high levels of collective-sphere willpower and waypower. The separation of the personal and collective level implies that, perhaps, young adults have less knowledge on a global scale. For example, students have not had enough experiences to know that Melbourne Australia has an emergency climate change report (Wales, Khanjanasthiti, Savage, & Earl, 2012) or that Miami is rebuilding the storm sewers to cope with sea level rise (Miami-Dade County, 2010). Thus, they have less information and imagery about the solutions that are already being created. A good environmental education program might increase students' collective-sphere willpower and waypower for solving problems caused by climate change if the programs (a) provide knowledge of solutions at their community level and (b) build students' experience through school and community partnerships (Uzzell, 1999). Perhaps, providing students authentic experience at a community level might lead to the development of action competence (Jensen & Schnack, 1997).

There are two other implications from the reliability and validity study. First, the panel of experts confirmed the content validity. The response process was appropriate based on the focus group discussion. The omega coefficient verified the structure of dimensionality and the internal consistency of each dimension. Convergent validity was verified based on the significantly positive correlations between hope, trust, and self-efficacy and this is consistent with other relevant studies (Lane & Chapman, 2011; Magaletta & Oliver, 1999; Snyder et al., 2001). This indicates that the scale measures the hope concerning climate change in a consistent way. Second, people who have high levels of hope tend to have high levels of trust and self-efficacy in solving problems of climate change. The implication of this result could be that environmental education or social learning activities that result in an increased level of trust and social capital will likely cultivate hope as well.

The high completion rate for each item (range = 96.6%-100%) suggested this is a readable and easy-to-use scale. The eighth response on the scale "I do not think climate is changing" provided an option for climate change doubters. Most (60%) of these respondents ($N = 19$) did not complete the survey.

Some of them wrote comments in the survey, such as "I believe climate change is natural, out of control of humans" and "Climate change is not real." If climate change is not perceived to be a problem, there is no reason to solve it, and no goal is relevant (Snyder, 1994). So they cannot express hope, and these items would not be appropriate.

Different than Ojala's (2012) scale that measured 10 items on the three different sources of hope (trust other, trust self, and positive reappraisal), researchers can use the CCHS to understand respondents' baseline level of personal-sphere willpower and waypower, collective-sphere willpower and waypower, and lack of willpower and waypower. Our samples show that, on average, high school students score between *slightly agree* (5) to *agree* (6) on both personal and collective-sphere willpower and waypower and *slightly disagree* on lack of willpower and waypower. Researchers can use scores generated from the scale to compare mean differences across gender, socioeconomic status, or educational programs. Environmental educational researchers can administer the scale before and after climate change programs and determine whether the program influenced hope. The information collected by using CCHS, specifically, could offer insights on how to design effective programs or teaching strategies to increase personal and collective-sphere willpower and waypower, and decrease lack of willpower and waypower.

Limitations and Future Research

One limitation was associated with the statistical procedure for adjusting the model fit based on the MIs in the CFA approach (Marsh, Hau, & Wen, 2004). Because potential solutions could result in misspecified models that should have been considered acceptable, the decision for the changes was not clear-cut with regard to model-fit indices or their psychometric properties. As Hu and Bentler (1999) recommend, researchers should interpret the use of goodness of fit with caution. Further validation studies with random sampling using CCHS are needed to advance our preliminary results. If researchers plan to use CCHS to assess their audience, cross-validation of factor structure and items' factor loadings could verify the reliability and validity in different audience groups, such as adults and younger students (Stevenson & Peterson, 2016). The only specific "trust in others" source group that was designated in the scale was scientists. This is simply because the design of the survey was to measure the effectiveness of a secondary climate science curriculum (Monroe & Oxarart, 2015) in which the researchers were interested in knowing how students view the role of scientists to fight against climate change. A different purpose for the scale could lead to a modification by adding other stakeholders, such as community

leaders and environmentalists. Future study could also modify the scale from a one-tier scale to a multiple-tier scale. In a multiple-tier scale, the scale would use a general question in the beginning to ask about students' belief regarding climate change instead of asking deniers to rate each statement and mark the statement "I do not think climate is changing." Then, if students endorse a belief in climate change, they would continue with the survey; if not, they would skip the survey. This would remove the eighth response. Future research could also look at how the hope scale relates to climate change action competence (Jensen & Schnack, 1997) among young people to find out whether this hope scale is a motivational force.

Conclusion

The development and validation process of the CCHS provided empirical evidence of its reliability and validity. Three factors were tested and confirmed; these are collective-sphere willpower and waypower, personal willpower and waypower, and lack of willpower and waypower. We believe that CCHS can be used by educators, curriculum developers, and researchers in environmental psychology and environmental education who wish to use a quantitative approach to explore climate change hopefulness or test the effectiveness of the climate change education programs to increase learner efficacy. We believe that the CCHS is a reliable, valid, and feasible tool to measure climate change hope among U.S. high school students and can be adapted to students from different cultures and backgrounds.

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