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Refinement of the Analysis-Holism Scale: A cross-cultural adaptation and validation of two shortened measures of analytic versus holistic thinking in Spain and the United States☆

Manuel Martín-Fernández [a], Blanca Requero [b], Xiaozhou Zhou (Zoe)[c], Dilney Gonçalves [c], David Santos [d,*]

[a] Department of Social Psychology and Methodology, Autonomous University of Madrid, Spain
[b] Department of Psychology, Villanueva University, Spain
[c] IE Business School, IE University, Spain
[d] IE School of Human Sciences and Technology, IE University, Spain

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ABSTRACT

Holistic-analytic thinking styles are tools that allow us to process information in different ways as well as serving as strategies that help us navigate the world in the various domains of life, such as making causal attributions or categorizing. The Analysis-Holism Scale (AHS) is a 24-item scale that was developed to examine systematic cognitive differences regarding holistic-analytic thinking style. However, its length could be a potential problem for studies where space and time are limited. The aim of the present research is to assess the psychometric properties of the AHS items in order to assemble two shortened versions. To this end, we considered the assessment of item content conducted by a panel of experts and also the conceptual model and the latent structure of the original measure, preserving its psychometric properties. Across five independent samples (N = 2,254), the full-length scale was shortened to assemble one brief version with 12 items (AHS-12) and another one with only 4 items (AHS-4). Their latent structures were examined conducting a series of confirmatory factor analyses, the measurement invariance of these instruments was assessed across two different cultures (America and Spanish) and validity was examined based on its relationship with other constructs and experimental tasks. The results showed that the latent structures of both shortened versions were stable in different samples, that were invariant across two different cultures, and presented adequate evidence of validity. Hence, the AHS-12 and the AHS-4 can allow researchers a brief and precise evaluation of cognitive styles in contexts where time is limited, with the AHS-12 being a better candidate for the short version of AHS compared to the AHS-4.

1. Thinking styles: scope and measurement

Thinking styles are tools that allow us to process information in different ways as well as serving as strategies that help us navigate the world in the various domains of life. Literature gathers several models of thinking styles such as the Threefold Model of Intellectual Styles (Zhang & Sternberg, 2005) or the holistic-analytic cognitive style approach (Nisbett et al., 2001). Regarding the latter, Nisbett et al. (2001) provided their theoretical model by conducting extensive research to examine significant psychological differences between East Asians and Westerners in many areas, such as attention (Kitayama et al., 2003), perception (Miyamoto et al., 2011), or categorization processes (Norenzayan et al., 2002). Previous literature has shown that such differences in attention, perception, and categorization can affect memory performance (Schwartz et al., 2014). These basic processes are the preliminary steps in cognitive processing, which influence higher levels of cognition. For example, thinking styles lead to differences in causal judgments and how people understand and explain social events (Choi et al., 2003), including the prediction of outcomes and the expectation of change (Ji et al., 2001). Furthermore, thinking styles influence the decision-making process by governing how and what information we attend, process and evaluate (Li et al., 2015). Therefore, thinking styles

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* Corresponding author at: IE School of Human Sciences and Technology, IE University, Castellón de la Plana, 8, Madrid 28006, Spain.
E-mail address: david.santos@ie.edu (D. Santos).

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shape how people attend to the environment, perceive others, memorize and learn information, and make judgments and decisions.

According to this theoretical model, holistic thinking is characterized by the belief that everything in the universe is related to everything. Thus, this view of the world as interconnected and intertwined leads to focus on the context to understand the relationships between a focal object and the field in which the object is embedded (Yama & Zakaria, 2019). That is, holistic thinkers typically focus on the "whole picture" instead of the individual parts. Furthermore, people with this style of thinking tend to perceive phenomena in constant change because of the complex pattern of interactions among the context elements (Koo & Choi, 2005; Li et al., 2018), and consider that contradictions can be reconciled, and even accepted, by seeking a middle way between opposing propositions (Spencer-Rodgers et al., 2010).

In contrast, analytic thinkers tend to view the universe as composed of independent objects and are prone to focusing more exclusively on the object (detaching it from its context), searching for those attributes of the object that would help explain and control its behavior (Yama & Zakaria, 2019). In the same line, people with this cognitive style perceive most objects as independent, and that their essence remains static over time. Consequently, analytic thinkers maintain a linear perspective, and therefore, expect greater predictability and control over change, or stability, of objects' patterns (Koo & Choi, 2005; Li et al., 2018). As people with this cognitive style often rely on formal logic reasoning, contradictions are resolved by choosing one of the two opposite propositions since it is considered that two opposite sides cannot coexist (Spencer-Rodgers et al., 2010).

The holistic-analytic thinking literature has focused largely on cross-cultural differences, especially between East Asians and Westerners (see Nisbett, 2003; Spencer-Rodgers & Peng, 2018, for extensive reviews) aiming to make a comprehensive list of *between-culture* differences in several cognitive domains such as attention, perception, categorization, or causal attribution. In this sense, East Asian cognition (e.g., Koreans, Chinese, Japanese, etc.) has been considered relatively "holistic," whereas Westerns cognition (e.g., Canadians, Americans, etc.) has been considered more "analytic" (Ji & Yap, 2016; Spencer-Rodgers et al., 2009. Just as there are some cultural differences in the extent to which cultures are typically more holistic or analytic than others, there are also some individual differences within each culture regarding cognitive styles. In this regard, previous research has focused on examining the differences regarding cognitive style within the same social group. For example, Choi et al. (2007) developed an instrument to examine systematic cognitive differences between individuals or subgroups *within* the same culture. This self-report measure is called the Analysis-Holism Scale (AHS) and consists of 24 Likert-type scale items that reflect the previously mentioned characteristics of these two styles of thinking, organized in four dimensions.

The first dimension is *causality*, which reflects the extent to which the elements of the universe are perceived as interconnected and interrelated (vs. the universe consists of atoms that are independent of each other, Li et al., 2018). The second one is *attitude towards contradiction*, which assesses the preference for resolving the contradiction through a reconciliation strategy, seeking the "middle way" (vs. formal logic strategy, Yama & Zakaria, 2019). The third, *perception of change*, refers to the tendency to perceive the elements as being in constant change and unpredictable (vs. linear changes and predictable, Ji, 2008). The last dimension is *locus of attention*, which places the focus on "the big picture," considering the elements of the stimulus as a whole (rather than decomposing the stimulus in their parts, Miyamoto et al., 2006).

This scale has been widely used to show the impact of holistic-analytic thinking on a wide range of domains like self-identity (Martin & Shao, 2016), well-being and satisfaction (Chen & Murphy, 2019; Ng et al., 2021), emotion experience (Larsen et al., 2017; Santos et al., 2021), consumer behavior (Allman et al., 2019), donation behavior (Zhou et al., 2021), environmental concern (Ito & Li, 2019; Sacchi et al., 2016), or performance creativity (Chen, 2020), just to mention a few examples. Furthermore, the role of the AHS varies as a function of the context, and can serve as predictor, outcome, mediator, or moderator of other variables of interest (see Koo et al., 2018, for a review). Therefore, the AHS can be utilized for various research purposes and this can be a useful tool to make theoretical contributions in many different fields. Furthermore, it is a convenient and practical tool that allows researchers to capture variations in perceptual and cognitive processes at the individual level as well as at the cultural level.

Although the AHS has been extensively used to assess differences on cognitive style (Slabu et al., 2014; Spina et al., 2010), its length could be a potential problem for large scale studies, where space and time are often limited (Rammstedt & Beierlein, 2014; Stanton et al., 2002). Given the relevance of holistic-analytic thinking for cross-cultural research and individual differences, there is thus a need for a reliable and valid short version of the AHS, suitable for these types of studies.

The shortening of composite measures entails, however, some methodological issues. As Marsh et al. (2010) underlined, "the fundamental problem in short-form development is to assume that psychometric properties for the short form based on the original sample used to select the items will generalize to a new cross-validation sample" (p. 439). Hence, retesting the psychometric properties of shortened measures in independent samples is crucial to avoid capitalization on chance and to ensure that the construct is properly assessed. It is also important to preserve the conceptual model of the original measure—including enough items of each dimension—, and to examine carefully the latent structure, internal consistency, and validity of shortened measures (Goetz et al., 2013; Marsh et al., 2005; Smith et al., 2000). Another methodological issue is the plethora of strategies and procedures used to identify and select the best items for shortened measures, something that can even result in different short versions of the same instrument (Kruyen et al., 2013; Stanton et al., 2002). Although there is still a lack of consensus on how to assemble shortened measures, a majority of researchers tend to use a combination of *content approaches*, preserving content validity (e.g., expert analysis), and *statistical approaches*, maintaining adequate psychometric properties of shortened versions.

1.1. The present study

The purpose of the current study is to empirically validate a short version of the AHS (Choi et al., 2007). To this end, we sought to assemble a 12-item version, the AHS-12, maintaining the original four-factor conceptual model by selecting three items of each dimension while reducing the length in half. To identify the best items for the AHS-12, we combined the statistical approach proposed by Marsh et al. (2005), with the assessment of item content conducted by a panel of experts. The psychometric properties of the resulting shortened measure (i.e., latent structure, internal consistency, and validity) were tested in five independent samples. In addition, an even shorter version of 4 items, the AHS-4, was assembled using one item of each dimension for those research settings where space and time are really limited.

We also assessed the measurement invariance of the AHS-12 and AHS-4 across two different cultures. Despite the importance of holistic and analytic thinking styles in cross-cultural research, there is still a lack of evidence about the comparability of the AHS across different cultures. Measurement invariance is a crucial prerequisite to make meaningful comparisons across countries, as it allows researchers to test a potential cultural bias in participants' responses (Davidov et al., 2014; Milfont & Fischer, 2010). However, to the best of our knowledge, only one study has addressed this issue with the AHS across American and Mexican cultures (Lechuga et al., 2011). To address this gap in the literature we examined measurement invariance between American and Spanish cultures' holistic-analytic thinking. Spaniards are typically described as being a collectivistic culture, whereas Americans are described as being a more individualistic culture comparatively (e.g., Choi et al., 1999; López-Pérez et al., 2015; Triandis, 1995), and individualism-collectivism construct typically aligns with analytic-holistic thinking

styles at the cultural level (Lim et al., 2011; Menon et al., 1999). Hence, one critical goal of the present research is to test the measurement invariance of the instrument between these cultures, one more typically analytic and the other one tending to be less analytic.

For validity purposes, we examined the relation of the AHS-12 and AHS-4 to dialectical thinking, a construct usually related to the holistic-analytic thinking style (Spencer-Rodgers et al., 2018). We also tested its predictive validity by examining associations of the short versions of the AHS with performance on two cognitive tasks: A procedure to examine how individuals deal with the contradiction (Peng & Nisbett, 1999), and a categorization task (Norenzayan et al., 2002).

2. Method

2.1. Participants

Five samples were recruited for this study. The first, second, third and fifth samples were collected through Amazon Mechanical Turk (MTurk, a crowdsourcing website) in exchange for monetary compensation ($0.40). The first sample consisted of 595 American participants (54.8% female), aged from 19 to 67 ($M = 34.63$, $SD = 11.17$), and was used to shorten the original, full-length AHS. The second and third samples were composed of 349 American participants (39.0% female), aged from 19 to 67 ($M = 34.63$, $SD = 11.17$), and 606 American participants (38.11% female), aged from 18 to 77 ($M = 42.07$, $SD = 13.59$), respectively. These two samples were used to examine the psychometric properties of the shortened versions. The fourth sample was a convenience sample of 295 Spanish college students (79.6% female), aged from 18 to 29 ($M = 19.15$, $SD = 1.40$), and was used to assess the measurement invariance of the shortened versions across cultures (i.e., American and Spanish). The fifth and last sample was used to conduct the validity analyses, and was composed of 409 American participants (34.5% female), aged from 20 to 71 ($M = 36.86$, $SD = 11.44$). In addition, a panel of experts was contacted to assess item content validity. The panel consisted of 8 experts (62.5% female), aged from 29 to 57 ($M = 37.00$, $SD = 11.49$) with more than 3 years of experience in cross-cultural research. All data can be accessed from a public repository at https://osf.io/qsrbf/?view_only=437682a1cdcf4a21a95cf8712ef67e06.

2.2. Instruments

2.2.1. Analysis-Holism Scale

Participants thinking style was measured using the 24-item Analysis-Holism Scale (AHS, Choi et al., 2007). The scale is based on four six-item subscales: Causality (e.g., "Everything in the universe is somehow related to each other"), attitude towards contradiction (e.g., "It is more desirable to take the middle ground than go to extremes"), perception of change (e.g., "Every phenomenon in the world moves in predictable directions"), and locus of attention (e.g., "The whole, rather than its parts, should be considered in order to understand a phenomenon"). Participants indicated how much they agreed with items on a 7-point Likert-type scale anchored at 1 ("*strongly disagree*") to 7 ("*strongly agree*"). Higher scores indicate greater holistic cognitive style and lower scores indicate greater analytic cognitive style. For the Spanish sample, we used the items of the Spanish version of Lechuga et al. (2011), and adapted the item statements to Spanish socio-cultural context following a 2-step back translation. To this end, two Castilian-Spanish researchers reviewed the item statements and discuss its content until they reached an agreement to write the Castilian-Spanish version of the items. The statements were thereafter sent to another expert in cross-cultural research in Mexico and translated back to its Mexican-Spanish form. There was some disagreement in the wording of 2 items (item 9 and 19), which was addressed by a focus group composed by all experts until there was an agreement in the wording for all items.

2.2.2. Dialectical Self Scale

The Dialectical Self Scale (DSS; Spencer-Rodgers et al., 2015) is a direct individual difference 32-item measure of dialectical thinking in the domain of the self. The DSS assesses the tendency to view oneself as contradictory (internally inconsistent) and malleable across time and contexts. The scale consists of three factors, including: 1) Contradiction (e.g., "When I hear two sides of an argument, I often agree with both"), 2) cognitive change (e.g., "I often find that my beliefs and attitude will change under different contexts"), and 3) behavioral change (e.g., "I often change the way I am, depending on who I am with"). Each item was rated on a scale ranging from 1 to 7 (1 = "*strongly disagree*", 7 = "*strongly agree*"). A higher score indicates a higher level of dialecticism. This scale is conceptually related to the AHS (Spencer-Rodgers et al., 2018) and presents good internal consistency in our sample (Cronbach's $\alpha = 0.85$, 0.82, and 0.78 for contradiction, cognitive change, and behavioral change, respectively).

2.2.3. Plausibility in contradictory statements

In order to examine how individuals deal with contradiction, two statements were presented as brief descriptions of the findings from a scientific study (adapted from Peng & Nisbett, 1999, Study 5). The two opposing statements were seemingly incompatible. Specifically, the statements were "A health magazine survey found that people who live a long life eat some sorts of white meat, e.g., fish or chicken" and "A study by a health organization suggests that it is much healthier to be a strict vegetarian who does not eat meat at all." All participants were instructed to indicate how much they believed each of the statements to be true on two 7-point Likert type scale from 1 ("*strongly disbelieve*") to 7 ("*strongly believe*"). Scores on each measure were added to create one overall index, such that higher scores indicate that the two statements are perceived as highly plausible and lower scores indicate that at least one of the statements is perceived as implausible (note that there is no inconsistency in disagreeing with both statements). Individuals with greater capacity to deal with contradictory information are expected to be more likely to consider both statements plausible.

2.2.4. Categorization task

A series of drawings was presented to participants. Each series consisted of a target object and two groups of four similar objects. The participant's task was to judge to which group the target object was most similar. The objects were carefully constructed and categorized into one of two groups. The objects in a "family resemblance group" looked similar to each other and to the target object, and those in a "rule" group did not closely resemble each other but shared a certain characteristic with all members in the group and the target object (Choi et al., 2007). Norenzayan et al. (2002), using the same procedure, demonstrated that holistic thinkers base their similarity judgments on relationships among objects or relationships between objects and the field, whereas analytic thinkers evaluate the similarity based on internal properties of the objects.

2.3. Procedure

All samples were collected using the Qualtrics platform, from which a reusable link was generated for each study and distributed via MTurk (American samples), or by using a students' pool at a large university in exchange for course credit (Spanish sample). In the MTurk samples, all participants currently reside in the United States as we only allowed those whose location was within the U.S. to take part in our studies. The Spanish student sample consists of Spanish nationals only who took the study in a laboratory with computers. The data collection was approved by the Institutional Review Board (IRB) of IE University (IERC/39-2019-2020). An email invitation to participate was sent out to 14 experts with at least 3 years of experience in cross-cultural research, of which 8 experts responded (response rate 57.14%) and agreed to partake in the item content assessment of the original, full-length AHS.

2.4. Data analysis

The aim of this study was to assess the psychometric properties of the original AHS in order to refine it and develop the AHS-12 and the AHS-4, two shortened versions of this measure. To this end, we followed the guidelines proposed by Goetz et al. (2013), which stressed the relevance of taking into account the conceptual model and the latent structure of the original measure, preserving its psychometric properties (i.e., internal consistency, item content, and validity evidence), and making explicit the set of criteria used to reduce the original, full-length measure.

To select the items of the AHS-12 and the AHS-4 we used a combination of qualitative and quantitative criteria. We asked first a panel of experts in cross-cultural research to assess the representativeness and clarity of the items of the original AHS, and computed the Osterlind index for each item. This index ranges from −1 to +1, and was computed averaging the responses of the experts in a 5-point Likert type scale (−1 = "*not representative/clear*", +1 = "*very representative/clear*"). Values of this index above 0.5 are usually considered to indicate that the items are representatively and clearly evaluating the construct (Sanduvete-Chaves et al., 2013). A descriptive analysis of the items was also conducted, obtaining the mean, standard deviation, skewness, and kurtosis statistics, and the corrected item-total correlations between each item and its subscale. The items rated by the experts as not representative or not clear, and the items whose corrected item-total correlations were close to zero were dropped for the following analyses.

Afterwards, we conducted a confirmatory factor analysis (CFA) with the first sample, replicating the four-factor model of the original measure (Choi et al., 2007). The model was estimated using robust maximum likelihood (MLR) as estimation method, since this procedure has demonstrated to perform well with non-normally distributed indicators (Li, 2016). Goodness of fit was assessed by a combination of fit indices: With CFI and TLI values above 0.95, RMSEA values below 0.06, and SRMR values below 0.08 indicating good fit to the data; CFI and TLI values above 0.90, and RMSEA values below 0.08 indicating a fair fit (Brown, 2015; Hu & Bentler, 1999; MacCallum et al., 1996).

We followed Marsh et al. (2005, 2010) procedure for selecting the items of the original measure that best assessed the construct. Our aim was to (a) assemble a 12-item and a 4-item shortened versions of the AHS scale (i.e., AHS-12, and AHS-4, respectively), (b) preserve its 4-factor latent structure including three items of each factor for the AHS-12, and one item per factor for the AHS-4, and (c) maintain a reasonable internal consistency, with Cronbach's α and McDonald's ω above 0.70.

To select the items of the AHS-12 and AHS-4, we examined the CFA solution and its modification indices and decided to keep:

(1) Items with high standardized factor loadings in their factor.
(2) Items with minimal cross-loadings. That is, if the fit of the model would be improved by allowing an item to load in more than one factor, then that item was removed from both shortened versions of the AHS.
(3) Items with minimal correlated residuals. That is, if allowing the residuals of two items from the same factor to be related would result in an improvement of the model goodness of fit, then one of those items should be removed from the shortened versions.

Once the items of the AHS-12 and AHS-4 were selected and in order to avoid capitalization on chance, we carried out a new CFA to test their latent structure in two additional independent samples (i.e., second and third samples). We then calculated Cronbach's α and McDonald's ω statistics to examine the scales' internal consistency, and computed the correlations between the original, full-length measure and both shortened versions.

Next, we assessed the measurement invariance of the AHS-12 and AHS-4 across American and Spanish cultures. A multi-group CFA was carried out testing configural, metric, and scalar invariance levels, using MLR as estimation method (Milfont & Fischer, 2010). The configural invariance level evaluates whether the construct is conceptualized in the same way in different groups, estimating hence the same factorial model across countries and keeping the rest of parameters free. The metric invariance level tests whether the same item loadings could be estimated for each group, and thus if the items are interpreted in a similar manner across countries. The scalar invariance level constrains the item intercepts to the same value across groups, evaluating whether the same pattern of responses yields the exact same factor score in both countries. These invariance levels are nested models—being the scalar invariance level the most restrictive—and hence we compared the goodness of fit of each invariance level obtaining the change in the CFI (ΔCFI) and RMSEA (ΔRMSEA): ΔCFI below 0.010, and ΔRMSEA below 0.015 indicate that the model fit does not change substantially and thus the most restrictive model could be held (Chen, 2007; Cheung & Rensvold, 2002). If the scalar invariance level is achieved, then the scores of the AHS-12 and AHS-4 could be compared between American and Spanish respondents.

Finally, criterion-related validity was tested by relating the factor scores of the AHS-12 and AHS-4 to dialectical thinking (i.e., contradiction, cognitive change, and behavioral change, Spencer-Rodgers et al., 2015) in a fifth independent sample. In addition, we conducted a linear regression using the factor scores of each shortened version as predictors of the perceived plausibility of contradictory statements, and a ROC curve to test whether the AHS-12 and AHS-4 were able to discriminate between those participants who selected the holistic option in all trials of the categorization experimental task and the rest.

All analyses were conducted with the statistical package R (R Core Team, 2019), using the *psych*, *lavaan*, and *pROC* libraries (Revelle, 2018; Robin et al., 2011; Rossell, 2012).

3. Results

3.1. Expert and descriptive analyses

A panel of 8 experts in cross-cultural research assessed the item content of the original AHS. They rated the items using a 5-point Likert type scale assessing their representativeness (e.g., 1 = "*not representative at all*", 5 = "*very representative*"), and clarity (e.g., 1 = "*not clear at all*", 5 = "*very clear*"). Expert ratings were rescaled between −1 and +1 and were averaged to compute the Osterlind index. Those items with values below 0.5—the point where the "*somewhat representative/clear*" category begins—, were dropped from the scale (i.e., items 8, 10, 11, 15, and 16; see Table 1).

The descriptive analysis was carried out with the first sample and showed that item means were around 4.70, with standard deviations around 1.40 for most of the items (Table 1). All items were slightly skewed to the right, and the kurtosis statistics indicated a slight leptokurtic distribution for most of the items. Taken together, descriptive statistics pointed out that respondents tended to choose the agreement categories of the items. The corrected item-total correlations between each item and its subscale of the AHS were overall high, except for items 11 and 17, which were close to zero. For this reason, we decided to also drop item 17 for the subsequent analysis.

3.2. Confirmatory factor analysis and scale reduction

We next conducted a CFA with the remaining 18 items using the four-factor model of the original measure. The model's goodness of fit was fair ($\chi_{SB}^2[df]$ = 404.20 [129], CFI = 0.91, TLI = 0.89, RMSEA [95% CI] = 0.069 [0.061; 0.077], SRMR = 0.067), indicating that the conceptual model proposed by Choi et al. (2007) could be maintained. All standardized item loadings were above 0.50, with the exception of item 24, which was 0.34 (Table 2). Afterwards we inspected the modification indices of the model to identify which items could present potential cross-loadings or correlated residuals.

To assemble the AHS-12 we selected items 1, 4, and 5 for the factor

Table 1
Descriptive statistics of the original, full-length AHS.

	Descriptive analysis					Expert analysis	
	M	SD	Skew	Kurtosis	$r_{item\text{-}test}$	Repr.	Clarity
ahs1	5.28	1.42	−0.74 (0.06)	0.22 (0.06)	0.74	0.88	0.75
ahs2	4.63	1.79	−0.43 (0.07)	−0.75 (0.07)	0.53	0.63	0.63
ahs3	4.98	1.44	−0.50 (0.06)	−0.15 (0.06)	0.72	0.56	0.50
ahs4	5.16	1.41	−0.53 (0.06)	−0.17 (0.06)	0.72	0.50	0.81
ahs5	5.27	1.36	−0.61 (0.06)	0.16 (0.06)	0.66	0.63	0.88
ahs6	5.27	1.31	−0.52 (0.05)	−0.03 (0.05)	0.63	0.69	0.88
ahs7	4.73	1.43	−0.29 (0.06)	−0.32 (0.06)	0.48	0.50	0.94
ahs8	5.29	1.36	−0.72 (0.06)	0.17 (0.06)	0.66	0.19	0.88
ahs9	5.13	1.46	−0.70 (0.06)	0.10 (0.06)	0.64	0.56	0.88
ahs10	5.27	1.41	−0.66 (0.06)	−0.01 (0.06)	0.63	0.13	0.63
ahs11	4.52	1.77	−0.27 (0.07)	−0.89 (0.07)	0.05	0.31	0.81
ahs12	4.83	1.56	−0.47 (0.06)	−0.42 (0.06)	0.41	0.50	0.50
ahs13	4.15	1.68	−0.10 (0.07)	−0.91 (0.07)	0.59	0.56	0.50
ahs14	4.05	1.65	0.03 (0.07)	−0.76 (0.07)	0.72	0.63	0.94
ahs15	3.65	1.61	0.29 (0.07)	−0.58 (0.07)	0.66	0.31	0.94
ahs16	3.74	1.48	0.20 (0.06)	−0.30 (0.06)	0.72	0.44	0.75
ahs17	5.80	1.16	−0.93 (0.05)	0.68 (0.05)	0.07	0.56	0.81
ahs18	3.78	1.53	0.19 (0.06)	−0.57 (0.06)	0.57	0.56	0.75
ahs19	4.87	1.42	−0.46 (0.06)	−0.08 (0.06)	0.68	0.94	0.94
ahs20	4.38	1.44	−0.34 (0.06)	−0.10 (0.06)	0.65	0.88	0.88
ahs21	4.50	1.44	−0.42 (0.06)	−0.01 (0.06)	0.57	0.69	0.81
ahs22	4.59	1.51	−0.26 (0.06)	−0.37 (0.06)	0.64	0.94	0.94
ahs23	4.90	1.42	−0.46 (0.06)	−0.01 (0.06)	0.57	1.00	0.88
ahs24	5.60	1.13	−0.54 (0.05)	−0.19 (0.05)	0.31	0.50	0.81

Note: ahs = analysis-holism scale item, M = mean, SD = standard deviation, ritem-test = corrected item test correlation, Repr = representativeness. In brackets: Standard error of the skew and kurtosis statistics.

"causality", and items 19, 20, and 22 for the factor "locus of attention", as all these items had high standardized factor loadings, and did not show potential cross-loadings or correlated residuals between them. For the factor "attitude towards contradiction" we kept items 7, 9, and 12, and items 13, 14, and 18 for the factor "perception of change", so the AHS-12 could retain the conceptual model of the original, full-length measure with a minimum of three indicators per factor. For the AHS-4, we selected the items with the highest standardized items loadings per factor, namely items 1, 7, 18, and 22.

The internal consistency was good for the AHS-12 ($\omega_{total} = 0.89$), and adequate for each factor (i.e., causality: $\alpha = 0.81$ and $\omega_{total} = 0.80$, attitude towards contradiction: $\alpha = 0.69$ and $\omega_{total} = 0.73$, perception of change $\alpha = 0.76$ and $\omega_{total} = 0.76$, and locus of attention $\alpha = 0.81$ and $\omega_{total} = 0.81$). The correlations between each factor of the AHS-12 and the complete, full-length AHS were very strong (i.e., $r = 0.94$ for causality, $r = 0.91$ for attitude towards contradiction, $r = 0.93$ for perception of change, and $r = 0.92$ for locus of attention), pointing out that the AHS-12 sorted the participants very similarly as the full-length AHS. Given the 4-factor structure of the original scale, the internal consistency of the AHS-4 was poor ($\alpha = 0.57$ and $\omega_{total} = 0.58$), although there was a close correlation between this short version and the complete, full-length AHS (i.e., $r = 0.60$ for causality, $r = 0.63$ for attitude towards contradiction, $r = 0.67$ for perception of change, and $r = 0.69$ for locus of attention). Despite this initial lack of internal consistency of the AHS-4, we decided to further examine its psychometric properties in the other samples.

3.3. Psychometric properties of the AHS-12 and AHS-4

A new CFA was carried out for both shortened versions in two new independent samples (i.e., second and third samples), in order to test the stability of the factorial model. A four-factor model was estimated for the AHS-12, whereas a single "holism" factor was estimated for the AHS-4 since this version does not include enough items to capture the different factors. The four-factor model of the AHS-12 fitted the data well in the second sample ($\chi_{SB}^2[df] = 83.46$ [48], CFI = 0.97, TLI = 0.95, RMSEA [95% CI] = 0.053 [0.033; 0.072], SRMR = 0.053), and showed standardized factor loadings above 0.60 for most of the items, except for items 5 and 12, that were 0.58 and 0.59, respectively (Fig. 1). All factors were strongly related.

The model also showed an excellent goodness of fit in the third sample ($\chi_{SB}^2[df] = 86.72$ [48], CFI = 0.97, TLI = 0.96, RMSEA [95% CI] = 0.036 [0.026; 0.047], SRMR = 0.042), with factor loadings also above 0.60 for all items, with the exception of items 9 and 14, which was 0.57 and 0.56 (Fig. 1). In this sample the relationship between all factors were more moderate.

The overall internal consistency was adequate in the second and third samples (ω_{total} = 0.89 and 0.86, respectively). Regarding the subscales, the internal consistency was good for the factors of causality (α = 0.77 and 0.78, ω_{total} = 0.74 and 0.78), perception of change (α = 0.80 and 0.73, ω_{total} = 0.80 and 0.74), and locus of attention (α = 0.82 and 0.82, ω_{total} = 0.83 and 0.82). Regarding the factor attitude towards contradiction, the internal consistency was mediocre (α = 0.67 and 0.67, ω_{total} = 0.69 and 0.67). All factors of the AHS-12 showed again a strong relation to the complete, full-length AHS (i.e., r = 0.93 and 0.95 for causality, r = 0.89 and 0.93 for attitude towards contradiction, r = 0.95 and 0.91 for perception of change, and r = 0.92 and 0.92 for locus of attention).

The AHS-4 showed an excellent fit to the data in the second sample ($\chi_{SB}^2[df] = 3.58$ [2], CFI = 0.98, TLI = 0.94, RMSEA [95% CI] = 0.048 [0.001; 0.107], SRMR = 0.033), with standardized factor loadings above 0.30 for all items (Fig. 2). In the third sample, the goodness of fit of the model was fair according to most of the fit indices ($\chi_{SB}^2[df] = 8.18$ [2], CFI = 0.90, TLI = 0.71, RMSEA [95% CI] = 0.071 [0.026; 0.125], SRMR = 0.031), and the standardized factor loadings were also above 0.30 for all items. Again, the internal consistency of the AHS-4 was poor, especially in the third sample (α = 0.58 and 0.40, ω_{total} = 0.60 and 0.40), albeit its relation to the complete, full-length AHS was high (i.e., r = 0.58 and 0.52 for causality, r = 0.69 and 0.55 for attitude towards contradiction, r = 0.72 and 0.57 for perception of change, and r = 0.70 and 0.63 for locus of attention).

3.4. Measurement invariance

Measurement invariance across cultures (i.e., American and Spanish) was examined conducting a multi-group CFA using the second and fourth samples. Configural, metric, and scalar invariance levels were supported for the AHS-12, as the change in the fit indices were below ΔCFI = 0.010 and ΔRMSEA = 0.015, indicating that there were no substantive changes in the model's goodness of fit. This result supported that the same factor model could be applied across groups, and that the same item parameters (i.e., factor loadings and intercepts) could be

Table 2
CFA loadings of the AHS and modification indices.

	Causality	Attitude towards contradiction	Perception of change	Locus of attention	Crossloadings	Correlated residuals
ahs1	0.82 (0.04)					ahs3, ahs6
ahs2	0.57 (0.04)					
ahs3	0.80 (0.04)					ahs1, ahs6
ahs4	0.79 (0.04)					
ahs5	0.71 (0.04)					ahs6
ahs6	0.67 (0.05)					ahs1, ahs3, ahs5
ahs7		0.76 (0.05)				
ahs9		0.56 (0.05)				
ahs12		0.65 (0.05)				
ahs13			0.71 (0.04)			
ahs14			0.71 (0.04)			
ahs18			0.72 (0.04)			
ahs19				0.77 (0.04)		
ahs20				0.76 (0.04)		ahs21, ahs24
ahs21				0.62 (0.05)		ahs20
ahs22				0.75 (0.04)		
ahs23				0.61 (0.05)		ahs24
ahs24				0.34 (0.06)	Causality, contradiction	ahs20, ahs23

Note: in brackets: loading standard error of estimate.

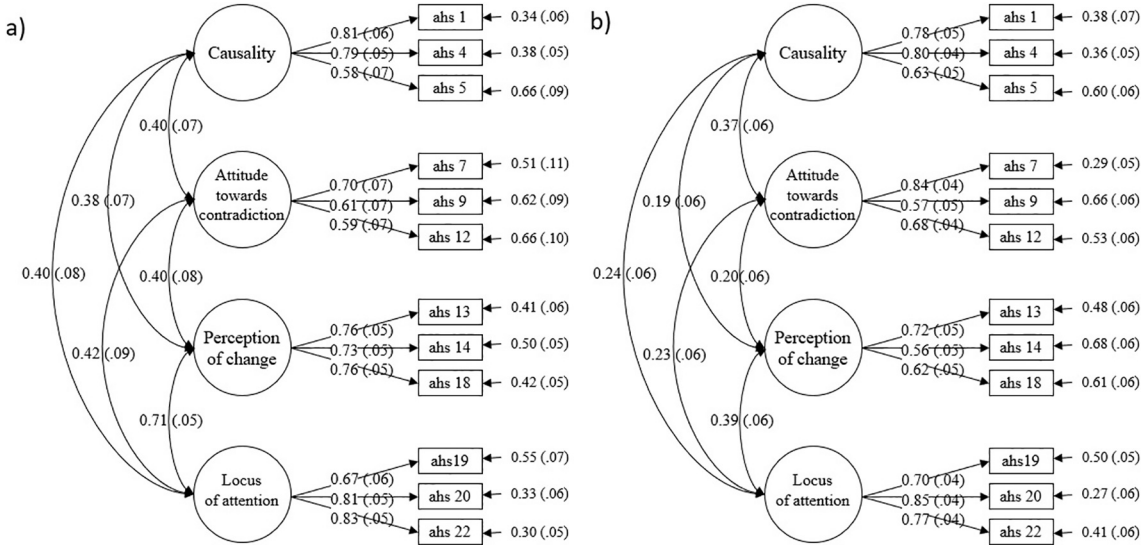

Fig. 1. Four-factor CFA models of the AHS-12.

constrained to the same value between American and Spanish respondents (Table 3). As scalar invariance was established, we compared the latent means of both groups in each factor. The resulting model fitted the data well ($\chi_{SB}^2[df] = 203.20$ [112], CFI = 0.95, TLI = 0.94, RMSEA [95% CI] = 0.050 [0.039; 0.061]), and we found that Spanish respondents presented higher levels of perception of change ($Z = 0.72$, $p <$ .001), and lower levels of locus of attention ($Z = -1.19$, p < .001). No differences were found in causality ($Z = -0.00$, $p = .975$), and attitude towards contradiction ($Z = -0.06$, $p = .559$).

In the case of the AHS-4, only configural invariance was supported, with mediocre goodness of fit (Table 3), which in turn indicated that although American and Spanish respondents conceptualize the construct in the same manner, no comparisons could be made across groups.

3.5. Criterion-related validity

Criterion-related validity was assessed relating the factor scores of both shortened versions to the Dialectical Self Scale, to the plausibility of contradictory statements and to the categorization tasks in a fifth independent sample. We found a positive correlation between all factors of the AHS-12 and the subscales contradiction and behavioral change of the Dialectical Self Scale, pointing out that participants with higher levels in the AHS-12 factors also tend to present higher levels of dialectical thinking (Table 4). Regarding the AHS-4, the holism factor was positively related to the three factors of the DSS: Contradiction, cognitive change, and behavioral change.

We carried out a linear regression using the AHS-12 and AHS-4 as predictors of the perception of plausibility of contradictory information. Results indicated a significant effect of the AHS-12 on the score in this task ($F[404] = 44.24$, $p < .001$, adjusted $R^2 = 0.298$). In particular, the causality and perception of change factors had a positive effect ($\beta = 0.36$, $t = 3.91$, $p < .001$, and $\beta = 0.50$, $t = -4.67$, $p < .001$, respectively), indicating that for each standard deviation in these factors, participants tended to show higher perceived plausibility of the contradictory statements. No significant effect was found for the attitude towards contradiction and locus of attention factors ($\beta = -0.13$, $t = -0.99$, $p =$ .323, and $\beta = -0.03$, $t = 0.32$, $p = .746$, respectively). We also found a significant effect of the AHS-4 ($F[407] = 126.9$, $p < .001$, adjusted $R^2 = 0.236$), indicating that those participants with higher levels of holism showed higher perceptions of plausibility of the contradictory statements ($\beta = 0.60$, $t = 11.26$, $p < .001$).

Finally, we conducted a ROC curve in order to test whether the AHS-12 and AHS-4 could discriminate between the participants that selected

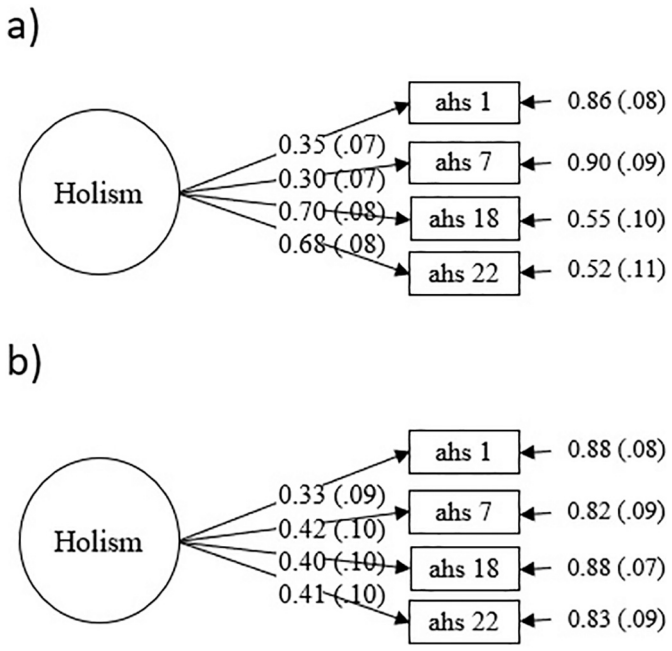

Fig. 2. One-factor CFA models of the AHS-4.

Table 3
Measurement invariance goodness of fit.

	χ^2	*df*	CFI	RMSEA (95% CI)
AHS-12				
Configural	154.08	96	0.964	0.043 (0.032; 0.055)
Metric	169.23	104	0.960	0.044 (0.033; 0.055)
Scalar	172.61	116	0.965	0.039 (0.028; 0.050)
AHS-4				
Configural	14.219	4	0.901	0.089 (0.042; 0.141)
Metric	9.785	7	0.973	0.035 (0.001; 0.082)
Scalar	158.907	11	0.010	0.204 (0.177; 0.233)

Table 4
Correlations between the shortened versions and the Dialectical Self Scale.

	Contradiction	Cognitive change	Behavioral change
AHS-12			
Causality	0.22**	−0.03	0.13*
Attitude towards contradiction	0.23**	0.06	0.23**
Perception of change	0.20**	0.17*	0.39**
Locus of attention	0.21**	0.13*	0.29**
AHS-4			
Holism	0.18**	0.12*	0.29**

* $p < .01$.
** $p < .001$.

the holistic option in all trials of the categorization experimental task. Regarding the AHS-12 (Fig. 3), we found that the area under the curve was good for perception of change (AUC = 0.708), fair for attitude towards contradiction (AUC = 0.642) and locus of attention (AUC = 0.692), and not adequate for causality (AUC = 0.576). This result pointed out that with the exception of causality, AHS-12 factors could discriminate well between participants with the most holistic performance in the categorization experimental task and the rest. For the AHS-4 (Fig. 4), we found that the area under the curve was also fair (AUC = 0.672).

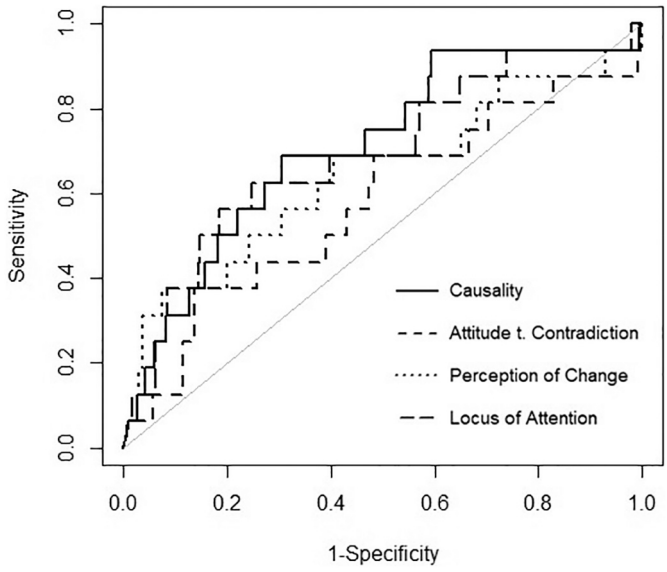

Fig. 3. AHS-12 ROC curve.

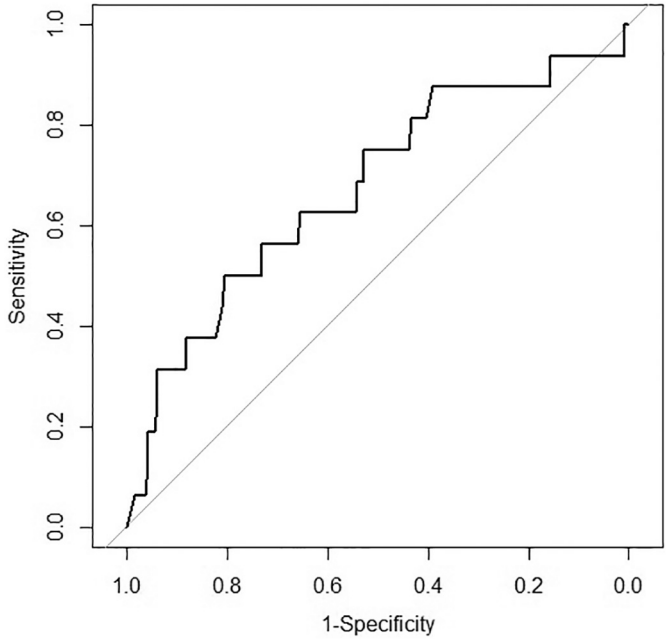

Fig. 4. AHS-4 ROC curve.

4. Discussion

The current study explored the reliability, validity and measurement invariance of two shortened versions of the Analysis-Holism Scale (AHS), namely AHS-12 and AHS-4. Across five independent samples, the original, full-length scale was reduced to assemble one shortened version with 12 items and another one with only 4 items, their latent structure was confirmed in different samples, the measurement invariance of these instruments was assessed across two different cultures, and their validity was examined based on their relationships with other constructs and experimental tasks.

One of the main goals of the present study was to preserve the conceptual model proposed by Choi et al. (2007), that is, a latent structure comprised of four differentiated factors: Causality, attitude towards contradiction, perception of change, and locus of attention. The AHS-12 fitted well to a four-factor structure, and the items of the AHS-4 yielded a

single factor of holism. Specifically, three CFAs were conducted on three independent samples providing good fit indices both for AHS-12 and AHS-4. It is important to note that, to the best of our knowledge, this is the first time that the internal structure of the AHS is studied to this level of detail. On the one hand, the original study of Choi et al. (2007) did not report any error of measurement index (e.g., RMSEA). On the other hand, the study conducted by Lechuga et al. (2011) reported adequate fit indices for the four-factor latent structure, albeit this could only be achieved after adding new parameters to the original model (i.e., item residual correlations). Nonetheless, our work provides convergent evidence regarding the structure and measurement invariance of the AHS. Congruently with Choi et al. (2007), the relationships among the four factors are in the same directions. Also, congruently with Lechuga et al. (2011), the shortened versions of the AHS are comparable among cultures.

With respect to the internal consistency, the AHS-12 has been shown to be a reliable scale to measure cognitive styles across all the samples, with an overall internal consistency of $\omega = 0.89$ for the AHS-12, ranging from 0.73 to 0.81 for the four factors. Regarding the AHS-4, albeit the data fitted well, its internal consistency was poor ($\omega = 0.40$–0.60). The lower reliability shown by the AHS-4 can be explained by two reasons: (1) Each item pertains to a different factor and, (2) there is always a tradeoff between the internal consistency and the length of a scale, as scales with fewer items tend to yield lower values of internal consistency (Smith et al., 2000). Thus, the AHS-12 can be regarded as a reliable measure while precautions should be taken for AHS-4 as a whole in terms of its reliability.

One of the main strengths of the present study is that samples from the United States and Spain were used to test the equivalence of AHS-12 and AHS-4, representing two cultures that differ in their levels of holistic-analytic style as well as their level of individualism-collectivism (López-Pérez et al., 2015; Triandis, 1995). A second strength is that the measurement invariance tested in the present study provided evidence for using the AHS-12 to compare thinking styles scores across countries, an idea that had only been previously addressed with this construct in a single study between American and Mexican samples (Lechuga et al., 2011). Consistent with the conceptual model, the results showed that Spaniards presented higher levels of perception of change as compared to Americans. Moreover, Spaniards presented lower levels of locus of attention as compared to Americans (for an example of research showing that Spaniards are more analytic attention-wise compared to other cultures, see San Martin et al., 2019). No differences were found between Spaniards and Americans regarding causality, and attitude towards contradiction. Considering the results on these two factors, future studies should test the AHS-12 in prototypical holistic cultures such as the Koreans or the Japanese to examine the differences in cognitive styles across the four factors.

Validity evidence based on the relationships between the AHS-12 and AHS-4 to other constructs were assessed using not only other self-report measure, but also experimental decision tasks. All factors of the AHS-12 were positively related to the contradiction and behavioral change subscales of the Dialectical Self Scale. The subscale cognitive change of this measure was also positively related to perception of change and locus of attention, but not to causality and attitude towards contradiction. Furthermore, AHS-12 and AHS-4 scores were able to predict higher perceived plausibility in contradictions. Specifically, participants with higher scores (representing a more holistic cognitive style) showed greater perceptions of plausibility of contradictions than participants with lower scores (representing a more analytic cognitive style). These results are congruent with previous research showing that holistic cultures tend to deal with contradictions using a compromise strategy, finding truth in both sides, compared to analytic cultures (Peng & Nisbett, 1999). In addition to the statements task, the scores in the AHS-12 (with the exception of the causality factor) and the AHS-4 were able to discriminate fairly between participants who responded in a holistic manner to all the trials of the categorization task and participants who responded in an analytic manner. This result is also in line with previous research showing that holistic individuals tend to use an overall resemblance strategy, evaluating the similarity based on relationships among objects or relationships between objects and the field, whereas analytic individuals tend to use a rule-based strategy for determining the similarity based on internal properties of the objects (Norenzayan et al., 2002; see also Choi et al., 2007). Another strength of this study is the combination of qualitative (i.e., expert-analysis) and quantitative criteria (psychometric analysis) to shortening the original, full-length AHS. Although currently there is no unified approach for the shortening of composite measures, we followed the recommendations of Goetz et al. (2013), prioritizing item content and preserving the conceptual model of the original measure in order to identify and select the best items for the AHS-12 and AHS-4, aiming also to maintain an adequate internal consistency and validity evidence (Marsh et al., 2010; Smith et al., 2000; Stanton et al., 2002). Therefore, in light of these results, the AHS-12 can be regarded as a more robust and refined measure of thinking style compared to the AHS-4. Great caution should be exerted when using the AHS-4, and we recommend its use only for cases where an extreme limited time is allowed.

The present study is not without limitations and future research is needed to continue testing the properties of these two short versions, especially regarding the AHS-4. First, the study is conducted mostly on Mturkers except for one sample that uses a conventional student sample in a laboratory setting. Although they have been shown to be a good representation in terms of sociodemographic and other background variables of the U.S. population (Behrend et al., 2011), future studies should employ other populations and other platforms to collect the data such as laboratory settings with more control over the participants. Second, although we used two well-established tasks to study the validity of the AHS-12 and AHS-4 scores, more research is needed to examine the relationship between these measures with other tasks used to explore cognitive styles, such as the inclusion task (Choi et al., 2003), the proverb task (Peng & Nisbett, 1999), the change task (Ji et al., 2001), the causal attribution task (Kitayama & Ishii, 2002), the outside-in task (Cohen & Gunz, 2002), the framed line test (Kitayama et al., 2003), or the change blindness task (Masuda & Nisbett, 2006). Third, because of the cross-sectional nature of the data, we were not able to assess whether the analytic and holistic cognitive styles change at individual level over time. Future studies should apply a longitudinal approach, allowing to test changes over time as well as the causal role of the cognitive styles in the experimental tasks.

Finally, although we obtained the measurement invariance of the AHS-12 between two cultures (American and Spaniards), we were unable to establish the scalar invariance level for the AHS-4, which in turn indicates that no comparisons could be made across American and Spanish cultures with this very brief version. In addition, future research should use other cultures more representative of holistic thinking style such as Korean (Choi et al., 2007), Japanese (Na et al., 2020) or Chinese (Chiu, 1972) cultures, since measurement invariance is yet to be established across these cultures. Moreover, other cultures than Americans can be used as a representative culture of analytic thinking style such as Canadians (Spina et al., 2010) or Norwegians (Singh, 2006).

To summarize, the AHS-12 and AHS-4 have shown to have adequate reliability and validity evidence of thinking styles, shortening the time of application by two or six times compared to the original scale of 24 items. Moreover, the AHS-12 has shown measurement invariance across American and Spanish cultures. This short version can hence be used in these countries to assess thinking styles because the difference between scores in the two countries might be attributable to actual differences in cognitive styles rather than other characteristics of the scale (e.g., item comprehension or familiarity with item response formats). Therefore, the AHS-12 and the AHS-4, applied from within the framework of psychology, allow for a brief and precise evaluation of thinking styles in contexts where time is a limited resource. However, it is worth highlighting the AHS-12 as a better candidate when using a shortened

version of the AHS (Choi et al., 2007), and that the use of the AHS-4 should be considered only in cases of extremely limited time, assuming the limitations of this short measure. Thus, we recommend the use of the AHS-12 as a short measure of holistic-analytic thinking styles.

CRediT authorship contribution statement

Manuel Martín-Fernández: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Methodology. **Blanca Requero:** Conceptualization, Writing – original draft, Writing – review & editing, Methodology. **Xiaozhou Zhou:** Writing – review & editing, Methodology. **Dilney Gonçalves:** Funding acquisition, Resources, Writing – review & editing. **David Santos:** Conceptualization, Project administration, Methodology, Writing – original draft, Writing – review & editing, Supervision.

Appendix A

The 12-item Analysis-Holism Scale (AHS-12).

Factor 1: causality
(1) 1. Everything in the universe is somehow related to each other.*
(4) 2. Even a small change in any element of the universe can lead to significant alterations in other elements.
(5) 3. Any phenomenon has numerous numbers of causes, although some of the causes are not known.

Factor 2: attitude towards contradictions
(7) 4. It is more desirable to take the middle ground than go to extremes.*
(9) 5. It is more important to find a point of compromise than to debate who is right/wrong, when one's opinions conflict with other's opinions.
(12) 6. We should avoid going to extremes.

Factor 3: perception of change
(13) 7. Every phenomenon in the world moves in predictable directions.R
(14) 8. A person who is currently living a successful life will continue to stay successful.R
(18) 9. Future events are predictable based on present situations.R,*

Factor 4: locus of attention
(19) 10. The whole, rather than its parts, should be considered in order to understand a phenomenon.
(20) 11. It is more important to pay attention to the whole than its parts.
(22) 12. It is more important to pay attention to the whole context rather than the details.*

Note: In brackets the item number of the AHS-24.
R = Reverse-coded items. The scores of the reverse items were reversed for factor analysis.
* = AHS-4 items.

Appendix B

The 12-item Spanish Analysis-Holism Scale (adapted from Lechuga et al., 2011).

Factor 1: causality
Todo el universo está relacionado de alguna manera entre sí.*
Incluso un cambio pequeño en cualquier elemento del universo puede causar una alteración significativa en otros elementos.
Cualquier fenómeno tiene numerosas causas, aunque algunas de las causas pueden no ser conocidas.

Factor 2: attitude towards contradictions
Es más conveniente adoptar un término medio que ir a los extremos.*
Cuando la opinión de uno está en conflicto con la opinión de otro, es más importante encontrar un punto común que debatir quien está equivocado o quien tiene la razón.
Debemos evitar ir a los extremos.

Factor 3: perception of change
Todo fenómeno en el mundo se mueve en direcciones predecibles.
Una persona que actualmente está viviendo una vida exitosa seguirá siendo exitosa.
Los eventos futuros son predecibles si se basan en eventos presentes. *

Factor 4: locus of attention
Se debe considerar “el todo”, en vez de sus partes individuales, para entender un fenómeno.
Es más importante prestar atención “al todo” que a sus partes individuales.
Es más importante prestar atención a todo el contexto que a los detalles individuales. *

* = AHS-4 items.

Appendix C

Scoring the items of the AHS-12 and AHS-4.

In order to preserve the latent structure of the AHS-12 and AHS-4, instead of using the direct scores of the items (i.e., the raw sum) to compute the scores of the short versions, we recommend obtaining the factor scores of the scale using the R script provided below:

```
##################################################.
#### Analysis-Holistim Scale - Short version ####.
##################################################.
library(lavaan).
#### Scoring AHS-12.
ahs12<−read.csv("insert data path here", header=T) # insert here where the data is located (e.g., "C:/Documents/AHS/my_ahs12_data.csv").
colnames(ahs12)<−paste("ahs", 1:12, sep="") #note that the data file in this example only has 12 variables, the 12 items of the AHS-12.
ahs12[,7:9]<−8-ahs12[,7:9] #recoding inverse items.
model4f<−"Causality =~ ahs1 + ahs2 + ahs3.
Att_Contradiction =~ ahs4 + ahs5 + ahs6.
Percep_Change =~ ahs7 + ahs8 + ah9.
Locus_Attention =~ ahs11 + ahs10 + ahs12".
fit4f<−cfa(model4f, ahs12, estimator = "MLR", std.ov = T, std.lv = T).
summary(fit4f, fit.measures=T).
ahs12_scores<−predict(fit4f).
write.csv(ahs12_scores, "ahs12_scores.csv",row.names = F) # returns a .csv file is saved with the AHS-12 factor scores.
#### Scoring AHS-4.
ahs4<−read.csv("insert data path here", header=T) # insert here where the data is located (e.g., "C:/Documents/AHS/my_ahs4_data.csv").
colnames(ahs4)<−paste("ahs", 1:4, sep="") #note that the data file in this example only has 4 variables, the 4 items of the AHS-4.
ahs4[,3]<−8-ahs4[,3] #recoding inverse items.
model1f<−"Holism =~ ahs1 + ahs2 + ahs3 + ahs4".
fit1f<−cfa(model1f, ahs4, estimator = "MLR", std.ov = T, std.lv = T).
summary(fit1f, fit.measures=T).
ahs4_scores<−predict(fit1f).
write.csv(ahs4_scores, "ahs4_scores.csv",row.names = F) # returns a .csv file is saved with the AHS-4 factor scores.
```

References

Allman, H. F., Hewett, K., & Kaur, M. (2019). Understanding cultural differences in consumers' reactions to foreign-market brand extensions: The role of thinking styles. *Journal of International Marketing, 27*(2), 1–21. https://doi.org/10.1177/1069031X19836780

Behrend, T. S., Sharek, D. J., Meade, A. W., & Wiebe, E. N. (2011). The viability of crowdsourcing for survey research. *Behavior Research Methods, 43*, 800. https://doi.org/10.3758/s13428-011-0081-0

Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2nd ed.). Guilford Publications.

Chen, B. (2020). Enhance creative performance via exposure to examples: The role of cognitive thinking style. *Personality and Individual Differences, 154*, Article 109663. https://doi.org/10.1016/j.paid.2019.109663

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling, 14*, 464–504. https://doi.org/10.1080/10705510701301834

Chen, S., & Murphy, D. (2019). The mediating role of authenticity on mindfulness and wellbeing: A cross cultural analysis. *Asia Pacific Journal of Counselling and Psychotherapy, 10*(1), 40–55. https://doi.org/10.1080/21507686.2018.1556171

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9*, 233–255. https://doi.org/10.1207/S15328007SEM0902_5

Chiu, L.-H. (1972). A cross-cultural comparison of cognitive styles in Chinese and American children. *International Journal of Psychology, 7*(235–242). https://doi.org/10.1080/00207597208246604

Choi, I., Dalal, R., Kim-Prieto, C., & Park, H. (2003). Culture and judgement of causal relevance. *Journal of Personality and Social Psychology, 84*, 46–59. https://doi.org/10.1037/0022-3514.84.1.46

Choi, I., Koo, M., & Choi, J. A. (2007). Individual differences in analytic versus holistic thinking. *Personality and Social Psychology Bulletin, 33*, 691–705. https://doi.org/10.1177/0146167206298568

Choi, I., Nisbett, R. E., & Norenzayan, A. (1999). Causal attribution across cultures: Variation and universality. *Psychological Bulletin, 125*, 47–63. https://doi.org/10.1037/0033-2909.125.1.47

Cohen, D., & Gunz, A. (2002). As seen by the other … perspectives on the self in the memories and emotional perceptions of Easterners and Westerners. *Psychological Science, 13*, 55–59. https://doi.org/10.1111/1467-9280.00409

Davidov, E., Meuleman, B., Cieciuch, J., Schmidt, P., & Billiet, J. (2014). Measurement equivalence in cross-national research. *Annual Review of Sociology, 40*, 55–75. https://doi.org/10.1146/annurev-soc-071913-043137

Goetz, C., Coste, J., Lemetayer, F., Rat, A. C., Montel, S., Recchia, S., … Guillemin, F. (2013). Item reduction based on rigorous methodological guidelines is necessary to maintain validity when shortening composite measurement scales. *Journal of Clinical Epidemiology, 66*, 710–718. https://doi.org/10.1016/j.jclinepi.2012.12.015

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55. https://doi.org/10.1080/10705519909540118

Ito, K., & Li, L. M. W. (2019). Holism and pro-environmental commitment: An examination on the mediating roles of affective and cognitive determinants. *Personality and Individual Differences, 149*, 160–166. https://doi.org/10.1016/j.paid.2019.05.055

Ji, L. J. (2008). The leopard cannot change his spots, or can he? Culture and the development of lay theories of change. *Personality and Social Psychology Bulletin, 34*, 613–622. https://doi.org/10.1177/0146167207313935

Ji, L. J., Nisbett, R. E., & Su, Y. (2001). Culture, change, and prediction. *Psychological Science, 12*, 450–456. https://doi.org/10.1111/1467-9280.00384

Ji, L. J., & Yap, S. (2016). Culture and cognition. *Current Opinion in Psychology, 8*, 105–111. https://doi.org/10.1016/j.copsyc.2015.10.004

Kitayama, S., Duffy, S., Kawamura, T., & Larsen, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at New Look. *Psychological Science, 14*, 201–206. https://doi.org/10.1111/1467-9280.02432

Kitayama, S., & Ishii, K. (2002). Word and voice: Spontaneous attention to emotional utterances in two languages. *Cognition & Emotion, 16*, 29–59. https://doi.org/10.1080/0269993943000121

Koo, M., & Choi, I. (2005). Becoming a holistic thinker: Training effect of Oriental medicine on reasoning. *Personality and Social Psychology Bulletin, 31*, 1264–1272. https://doi.org/10.1177/0146167205274692

Koo, M., Choi, J. A., & Choi, I. (2018). Analytic versus holistic cognition: Constructs and measurement. In J. Spencer-Rodgers, & K. Peng (Eds.), *The psychological and cultural foundations of east Asian cognition: Contradiction, change, and holism* (pp. 105–134). Oxford University Press. https://doi.org/10.1093/oso/9780199348541.003.0004.

Kruyen, P. M., Emons, W. H., & Sijtsma, K. (2013). On the shortcomings of shortened tests: A literature review. *International Journal of Testing, 13*, 223–248. https://doi.org/10.1080/15305058.2012.703734

Larsen, J. T., Hershfield, H., Stastny, B. J., & Hester, N. (2017). On the relationship between positive and negative affect: Their correlation and their co-occurrence. *Emotion, 17*(2), 323–336. https://doi.org/10.1037/emo0000231

Lechuga, J., Santos, B. M., Garza-Caballero, A. A., & Villarreal, R. (2011). Holistic reasoning on the other side of the world: Validation of the Analysis-Holism Scale in Mexicans. *Cultural Diversity and Ethnic Minority Psychology, 17*, 325–330. https://doi.org/10.1037/a0023881

Li, C. H. (2016). Confirmatory factor analysis with ordinal data: Comparing robust maximum likelihood and diagonally weighted least squares. *Behavior Research Methods, 48*, 936–949. https://doi.org/10.3758/s13428-015-0619-7

Li, L. M. W., Masuda, T., Hamamura, T., & Ishii, K. (2018). Culture and decision making: Influence of analytic versus holistic thinking style on resource allocation in a fort game. *Journal of Cross-Cultural Psychology, 49*, 1066–1080. https://doi.org/10.1177/0022022118778337

Li, L. M. W., Masuda, T., & Russell, M. J. (2015). Culture and decision-making: Investigating cultural variations in the East Asian and North American online decision-making processes. *Asian Journal of Social Psychology, 18*(3), 183–191. https://doi.org/10.1111/ajsp.12099

Lim, T. S., Kim, S. Y., & Kim, J. (2011). Holism: A missing link in individualism-collectivism research. *Journal of Intercultural Communication Research, 40*(1), 21–38. https://doi.org/10.1080/17475759.2011.558317

López-Pérez, B., Gummerum, M., Keller, M., Filippova, E., & Gordillo, M. V. (2015). Sociomoral reasoning in children and adolescents from two collectivistic cultures. *European Journal of Developmental Psychology, 12*, 204–219. https://doi.org/10.1080/17475759.2011.558317

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods, 1*, 130–149. https://doi.org/10.1037/1082-989X.1.2.130

Marsh, H. W., Ellis, L. A., Parada, R. H., Richards, G., & Heubeck, B. G. (2005). A short version of the Self Description Questionnaire II: Operationalizing criteria for short-form evaluation with new applications of confirmatory factor analyses. *Psychological Assessment, 17*, 81–102. https://doi.org/10.1037/1040-3590.17.1.81

Marsh, H. W., Martin, A. J., & Jackson, S. (2010). Introducing a short version of the Physical Self Description Questionnaire: New strategies, short-form evaluative criteria, and applications of factor analyses. *Journal of Sport and Exercise Psychology, 32*, 438–482. https://doi.org/10.1123/jsep.32.4.438

Martin, L., & Shao, B. (2016). Early immersive culture mixing: The key to understanding cognitive and identity differences among multiculturals. *Journal of Cross-Cultural Psychology, 47*(10), 1409–1429. https://doi.org/10.1177/0022022116639391

Masuda, T., & Nisbett, R. E. (2006). Culture and change blindness. *Cognitive Science, 30*, 381–399. https://doi.org/10.1207/s15516709cog0000_63

Menon, T., Morris, M. W., Chiu, C. Y., & Hong, Y. Y. (1999). Culture and the construal of agency: Attribution to individual versus group dispositions. *Journal of Personality and Social Psychology, 76*, 701–717. https://doi.org/10.1037/0022-3514.76.5.701

Milfont, T. L., & Fischer, R. (2010). Testing measurement invariance across groups: Applications in cross-cultural research. *International Journal of Psychological Research, 3*, 111–130. https://doi.org/10.21500/20112084.857

Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and the physical environment: Holistic versus analytic perceptual affordances. *Psychological Science, 17*, 113–119. https://doi.org/10.1111/j.1467-9280.2006.01673.x

Miyamoto, Y., Yoshikawa, S., & Kitayama, S. (2011). Feature and configuration in face processing: Japanese are more configural than Americans. *Cognitive Science, 35*(3), 563–574. https://doi.org/10.1111/j.1551-6709.2010.01163.x

Na, J., Grossmann, I., Varnum, M. E., Karasawa, M., Cho, Y., Kitayama, S., & Nisbett, R. E. (2020). Culture and personality revisited: Behavioral profiles and within-person stability in interdependent (vs. independent) social orientation and holistic (vs. analytic) cognitive style. *Journal of Personality*. https://doi.org/10.31234/osf.io/7gzrd

Ng, H. K., Chen, S. X., Ng, J. C., & Ng, T. K. (2021). Does having multiple identities predict life satisfaction? Holistic thinking as a condition for achieving integrated self-concept. *Current Psychology, 1*, 1–11. https://doi.org/10.1007/s12144-021-01477-1

Nisbett, R. E. (2003). *The geography of thought: How Asians and westerners think differently … and why*. Free Press.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review, 108*, 291–310. https://doi.org/10.1037/0033-295X.108.2.291

Norenzayan, A., Smith, E. E., Kim, B. J., & Nisbett, R. E. (2002). Cultural preferences for formal versus intuitive reasoning. *Cognitive Science, 26*, 653–684. https://doi.org/10.1207/s15516709cog2605_4

Peng, K., & Nisbett, R. E. (1999). Culture, dialectics, and reasoning about contradiction. *American Psychologist, 54*, 741–754. https://doi.org/10.1037/0003-066X.54.9.741

R Core Team. (2019). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/.

Rammstedt, B., & Beierlein, C. (2014). Can't we make it any shorter? The limits of personality assessment and way to overcome them. *Journal of Individual Differences, 35*, 212–220. https://doi.org/10.1027/1614-0001/a000141

Revelle, W. (2018). *Psych: Procedures for personality and psychological research (version 1.8.10)*. Northwestern University. https://CRAN.R-project.org/package=psych.

Robin, X., Turck, N., Hainard, A., Tiberti, N., Lisacek, F., Sanchez, J. C., & Müller, M. (2011). pROC: An open-source package for R and S+ to analyze and compare ROC curves. *BMC Bioinformatics, 12*, 77. https://doi.org/10.1186/1471-2105-12-77

Rossell, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software, 48*, 1–36. https://doi.org/10.18637/jss.v048.i02

Sacchi, S., Riva, P., & Aceto, A. (2016). Myopic about climate change: Cognitive style, psychological distance, and environmentalism. *Journal of Experimental Social Psychology, 65*, 68–73. https://doi.org/10.1016/j.jesp.2016.03.006

San Martin, A., Schug, J., & Maddux, W. W. (2019). Relational mobility and cultural differences in analytic and holistic thinking. *Journal of Personality and Social Psychology, 116*, 495–518. https://doi.org/10.1037/pspa0000142

Sanduvete-Chaves, S., Chacón-Moscoso, S., Sánchez-Martín, M., & Pérez-Gil, J. A. (2013). The revised Osterlind index: A comparative analysis in content validity studies. *Acción Psicológica, 10*, 10–26. https://doi.org/10.5944/ap.10.2.11821

Santos, D., Requero, B., & Martín-Fernández, M. (2021). Individual differences in thinking style and dealing with contradiction: The mediating role of mixed emotions. *PLoS One, 16*(9), e0257864. https://doi.org/10.1371/journal.pone.0257864

Schwartz, A. J., Boduroglu, A., & Gutchess, A. H. (2014). Cross-cultural differences in categorical memory errors. *Cognitive Science, 38*(5), 997–1007. https://doi.org/10.1111/cogs.12109

Singh, S. (2006). Cultural differences in, and influences on, consumers' propensity to adopt innovations. *International Marketing Review, 23*, 173–191. https://doi.org/10.1108/02651330610660074

Slabu, L., Lenton, A. P., Sedikides, C., & Bruder, M. (2014). Trait and state authenticity across cultures. *Journal of Cross-Cultural Psychology, 45*, 1347–1373. https://doi.org/10.1177/0022022114543520

Smith, G. T., McCarthy, D. M., & Anderson, K. G. (2000). On the sins of short-form development. *Psychological Assessment, 12*, 102–111. https://doi.org/10.1037/1040-3590.12.1.102

Spencer-Rodgers, J., Anderson, E., Ma-Kellams, C., Wang, C., & Peng, K. (2018). What is dialectical thinking? Conceptualization and measurement. In J. Spencer-Rodgers, & K. Peng (Eds.), *The psychological and cultural foundations of east Asian cognition: Contradiction, change, and holism* (pp. 1–34). Oxford University Press. https://doi.org/10.1093/oso/9780199348541.003.0001.

Spencer-Rodgers, J., Boucher, H. C., Mori, S. C., Wang, L., & Peng, K. (2009). The dialectical self-concept: Contradiction, change, and holism in East Asian cultures. *Personality and Social Psychology Bulletin, 35*, 29–44. https://doi.org/10.1177/0146167208325772

Spencer-Rodgers, J., & Peng, K. (2018). *The psychological and cultural foundations of east Asian cognition: Contradiction, change, and holism*. Oxford University Press. https://doi.org/10.1093/oso/9780199348541.001.0001

Spencer-Rodgers, J., Srivastava, S., Boucher, H. C., English, T., Paletz, S. B., & Peng, K. (2015). *The Dialectical Self-Scale*. Unpublished manuscript. San Luis Obispo: California Polytechnic State University.

Spencer-Rodgers, J., Williams, M. J., & Peng, K. (2010). Cultural differences in expectations of change and tolerance for contradiction: A decade of empirical research. *Personality and Social Psychology Review, 14*, 296–312. https://doi.org/10.1177/1088868310362982

Spina, R. R., Ji, L. J., Guo, T., Zhang, Z., Li, Y., & Fabrigar, L. (2010). Cultural differences in the representativeness heuristic: Expecting a correspondence in magnitude between cause and effect. *Personality and Social Psychology Bulletin, 36*, 583–597. https://doi.org/10.1177/0146167210368278

Stanton, J. M., Sinar, E. F., Balzer, W. K., & Smith, P. C. (2002). Issues and strategies for reducing the length of self-report scales. *Personnel Psychology, 55*, 167–194. https://doi.org/10.1111/j.1744-6570.2002.tb00108.x

Triandis, H. C. (1995). *Individualism & collectivism*. Westview Press.

Yama, H., & Zakaria, N. (2019). Explanations for cultural differences in thinking: Easterners' dialectical thinking and Westerners' linear thinking. *Journal of Cognitive Psychology, 31*, 487–506. https://doi.org/10.1080/20445911.2019.1626862

Zhang, L. F., & Sternberg, R. J. (2005). A threefold model of intellectual styles. *Educational Psychology Review, 17*(1), 1–53. https://doi.org/10.1007/s10648-005-1635-4

Zhou, Z., Requero, B., Gonçalves, D., & Santos, D. (2021). Every penny counts: The effect of holistic-analytic thinking style on donation decisions in the times of Covid-19. *Personality and Individual Differences*. https://doi.org/10.1016/j.paid.2021.110713