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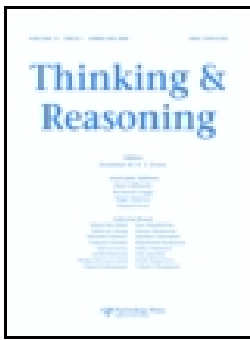**94** PUBLICATIONS   **2,728** CITATIONS

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# Actively open-minded thinking: development of a shortened scale and disentangling attitudes towards knowledge and people

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**ABSTRACT**
Actively open-minded thinking (AOT) is often used as a proxy for reflective thinking in research on reasoning and related fields. It is associated with less biased reasoning in many types of tasks. However, few studies have examined its psychometric properties and criterion validity. We developed a shortened, 17-item version of the AOT for quicker administration. AOT17 is highly correlated with the original 41-item scale and has highly similar relationships to other thinking dispositions, social competence and supernatural beliefs. Our analyses revealed that the AOT is not a unitary construct, but comprises four distinct dimensions, some of which concern attitudes towards knowledge, and others concern attitudes towards people. This factor structure was replicated in another data-set, and correlations with other measures in four data-sets (total $N$ = 3345) support the criterion validity of these dimensions. Different dimensions were responsible for the AOT's relationships with other thinking dispositions.

## Introduction

Actively open-minded thinking (AOT) is one of several thinking styles, or thinking dispositions, suggested to play an important role for how humans reason. According to Stanovich and West (2000), the long debate on whether humans are rational can be solved by responding that some people behave and think more rationally than others. Partly this is due to individual differences in cognitive ability, but Stanovich and colleagues have shown that independently of cognitive ability, thinking dispositions also play an important part in explaining the degree to which individuals tend to reason rationally (e.g., Stanovich, 2009). That is, those with a strong disposition to think

reflectively, to use all their cognitive skills to think things through, tend to display good reasoning, while those with a lower striving for good thinking tend to put less effort into their thinking, and therefore, to display poorer and less rational reasoning.

Among the thinking dispositions discussed in the reasoning literature, AOT describes a highly intellectual type of thinking. The concept is originally from Baron (1993), who wanted to define principles of good thinking that apply in any field. According to Baron, one central principle is avoiding myside bias (also known as confirmation bias), that is, looking at issues from a multitude of perspectives instead of only generating arguments in favour of one's own opinion, as people so often tend to do (Mercier & Sperber, 2011). To operationalise this tendency, Stanovich and colleagues have put together a scale that has come to be used in much research on reasoning. In Stanovich's refinement, the AOT (Sá, West, & Stanovich, 1999; Stanovich & West, 1997) intends to assess high-level epistemic goals, decontextualised reasoning and the tendency to reflect on the rules of inference. As such, the AOT has been used to illustrate humans' ability for the highest level of reflective thinking, which is decoupled from immediate experience (Stanovich, 2009).

Empirical studies have confirmed that the AOT succeeds in measuring the absence of myside bias. For example, AOT predicts the ability to evaluate argument quality objectively (Stanovich & West, 1997) and it is negatively related to the tendency to rate arguments that are in favour of one's own viewpoint as being better than counterarguments (Stanovich & West, 2008). AOT has also been found related to less use of heuristics and to being less influenced by prior beliefs (i.e., having less belief bias) on several types of reasoning tasks (Campitelli & Gerrans, 2014; Heijltjes, van Gog, Leppink, & Paas, 2015; Macpherson & Stanovich, 2007; West, Toplak, & Stanovich, 2008). Higher AOT has also been linked with providing more evidence for one's views (Sá, Kelley, Ho, & Stanovich, 2005). Furthermore, people high in AOT are better than those with low AOT at assessing their own level of knowledge and at assessing how many people agree with them, that is, at avoiding the curse of knowledge bias and the false consensus bias (Sá & Stanovich, 2001). Moreover, the AOT has been found to predict higher acceptance of counterintuitive ideas such as evolution (Sinatra, Southerland, McConaughy, & Demastes, 2003).

Despite its merits, the AOT measure in its current form could be improved in several ways. First of all, the measure is long — 41 items. For easier administration, a shorter measure is called for. Second, and more importantly, the dimensionality and other psychometric properties of the AOT have never been thoroughly reported. The items in the scale were originally drawn from a multitude of sources. Stanovich and West (1997) report that when choosing the items, "Within the larger domain of thinking dispositions, we examined those that we viewed as most relevant to rational thought" (p. 345), and "with

potential epistemic significance" (p. 345). Items were drawn from existing scales (and some newly devised scales) on flexible thinking, openness-ideas, openness-values, absolutism, dogmatism, categorical thinking, belief identification and counterfactual thinking. Summing these measures into one composite score was justified by a principal components analysis, which showed that one component accounted for most measures, while a second one captured the measure of counterfactual thinking. The resulting composite score is described as assessing cognitive flexibility, willingness to perspective-switch, willingness to decontextualise, the opposite of cognitive rigidity, epistemological absolutism and resistance to belief change.

Recently, Haran, Ritov, and Mellers (2013) presented a welcome, much shortened version of the AOT consisting of seven items that the authors deemed most closely corresponded to Baron's description of AOT and most relevant for a general population. Preliminary findings indicate that this short scale is related to unbiased reasoning on syllogistic reasoning tasks and has correlations with other thinking dispositions and abilities comparable to those that are typically found for the 41-item version of the AOT (Szaszi, Szollosi, Palfi, & Aczel, 2017). However, no studies to date have reported empirical evidence of how this short scale relates to the original, and thus, more research is needed to establish what aspects of the AOT construct it measures.

The original, 41-item AOT scale tends to have an internal reliability coefficient of .70–.88 (e.g., Deniz, Donnelly, & Yilmaz, 2008; Heijltjes et al., 2015; Newstead, Handley, Harley, Wright, & Farrelly, 2004), indicating that the various items share a moderate amount of variance. Because all the original scales correlate with each other, most researchers no longer calculate subscales but treat the AOT as a single scale. However, it is currently not known whether AOT is a unitary phenomenon or whether it is multidimensional, an option that is certainly feasible given the various origins of the items. As Stanovich and West's (1997) principal components analysis was run on sum variables of the included scales, any possible dimensionality within the original scales was not examined. For example, the scale on flexible thinking included items on both reflexivity, willingness to consider alternative opinions and a willingness to postpone closure. In the few studies that report the internal consistencies of these original subscales, the consistencies tend to be low, with Cronbach's $\alpha$s in the range of .44–.78 (Newstead et al., 2004; Stanovich & West, 1997). This leaves open the possibility that the different aspects of the subscales are differently related to each other.

Possible dimensions in the AOT might also help clarify its relationship to other thinking dispositions. In research on both reasoning and in applied fields, many different measures of reflective, Type 2, or analytical thinking are in use, often without explanation of why a certain measure was chosen for a particular study. The most often used reflective thinking disposition measure is the Need for Cognition scale (NFC; Cacioppo, Petty, & Kao, 1984). In

addition, many studies include the Cognitive Reflection Test (CRT; Frederick, 2005), which partly measures numerical and reflective reasoning skill and partly disposition (for discussion of the CRT, see e.g., Campitelli & Gerrans, 2014; Szaszi et al., 2017; Toplak, West, & Stanovich, 2011). Even though the AOT typically correlates with both of these measures only around $r = .20$ (Campitelli & Gerrans, 2014; Kokis, Macpherson, Toplak, West, & Stanovich, 2002; Toplak et al., 2011; Toplak, West, & Stanovich, 2014), items from these different instruments are sometimes even mixed together. For example, to operationalise reflective processing, Klaczynski (2014) summed items from NFC, AOT and other scales into one composite variable. This type of praxis makes it difficult to know what proportions of variance the different scales accounted for.

To gain more insight into the similarities and differences between these different types of analytical or reflective thinking dispositions and skills, we will examine the relationships between NFC, CRT and the possible dimensions found in the AOT. For comparison, we will also look at how the AOT relates to the counterpart of reflective thinking, namely the disposition for intuitive thinking. Further, as AOT has been found related to the propensity to rate arguments without being biased by one's own opinions (Stanovich & West, 1997), we are also going to look at which of its subdimensions are responsible for this relationship.

Moreover, as some of the items on the AOT particularly concern how one relates to other people, it seems likely that these items might be related to measures of social competence. For example, the AOT items "I consider myself broad-minded and tolerant of other people's lifestyles" and "There are a number of people I have come to hate because of the things they stand for" explicitly concern attitudes towards others and they sound quite different from more impersonal items such as "Beliefs should always be revised in response to new information or evidence", which are more straightforwardly concerned with one's general epistemological stance. Thus, we can expect the former type of items to be related to interpersonal variables while the latter are probably not related to them.

Finally, one type of measure that is likely to bring out differences between the potential dimensions within the AOT is supernatural beliefs. Studies have found people with higher AOT to hold weaker supernatural beliefs (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2013). As these beliefs are independent of empathic ability (Lindeman, Svedholm-Häkkinen, & Lipsanen, 2015), they seem unlikely to be related to the interpersonal aspects of the AOT and their relationship to the AOT is more likely driven by its more epistemological aspects.

In sum, to find out whether a smaller number of items may be enough to assess the AOT concept and to get to the bottom of its possible dimensions, we will run factor analysis on the individual items in the AOT. In Study 1, we

will first use exploratory analysis to preliminarily identify the main dimensions in the AOT and to identify the items that most clearly tap into one of these main dimensions. Then, for a more rigorous test of the factor structure, we will use confirmatory factor analysis (CFA). The aim is to shorten the AOT scale and to form meaningful subfactors. By correlating these subfactors with external variables of other thinking dispositions, social competence and various forms of supernatural beliefs, we will explore their construct validity. Study 2 aims to replicate the factor structure using CFA on a different data-set, and Studies 2–4 will further explore the correlations of the subfactors with outside criterion variables. In addition, we will analyse the 7-item version of the AOT (Haran et al., 2013) to test what its relationship to the original scale is, how well it fits the data and what aspects of the AOT it measures.

## Study 1

### Method

*Participants and procedure.* The participants were 2735 Finnish volunteers (65% females). The mean age was 28 years ($SD = 8.87$, range 15–69). Of the participants, 27% were working, 64% were students and 9% were otherwise occupied. Of the students, most were university students (85%). Originally, 3086 people took part in the study, but 2 were excluded because their comments about the study revealed that they had not completed the questionnaire seriously. Because the questionnaire was long, many participants skipped one or more measures. Full data on the AOT was available for 2735 people. The participants were recruited to the online study via several open internet discussion forums, several student mailing lists and from a participant pool comprising individuals who had expressed an interest to participate in our studies. No exclusion criteria for participation were applied. The participants were told that the study concerned thinking and personality, and confidentiality and voluntary participation were emphasised. The respondents were given three weeks to participate in the study. As compensation, all participants received a thinking style profile based on the AOT.

*Measures.* We administered the 41-item AOT scale ($\alpha = .83$) (Sá et al., 1999; Stanovich & West, 1997). Other thinking dispositions were assessed with the 10-item Intuition subscale ($\alpha = .79$) and the 12-item Rational subscale ($\alpha = .86$; corresponding to the NFC subscale of the REI) of the rational/experiential multimodal inventory (REIm; Epstein, 2010). The CRT (Frederick, 2005), which consists of three items, was used to assess the disposition and skills necessary to inhibit heuristically compelling but incorrect responses and to calculate the correct response. To assess social competence, we included the Empathy Quotient (EQ-short, 15 items, $\alpha = .81$; Muncer & Ling, 2006), the Pictorial Empathy Test (PET, 7 items; $\alpha = .90$; Lindeman, Koirikivi, & Lipsanen, 2016),

the Tromsø Social Intelligence scale (21 items, $\alpha$ = .90, Silvera, Martinussen, & Dahl, 2001) and the Friendship Scale (6 items, $\alpha$ = .82, Hawthorne, 2006). Finally, to assess supernatural beliefs, we used 15 items ($\alpha$ = .94) on paranormal beliefs from the Revised Paranormal Beliefs Scale (RPBS; Tobacyk, 2004) and 8 items ($\alpha$ = .94) on religious beliefs (Jong, Bluemke, & Halberstadt, 2013).

## Results and discussion

In order to shorten the AOT, we first ran an exploratory factor analysis on the entire scale. Extraction was done using the maximum likelihood method and direct oblimin rotation. Inspection of the scree plot indicated that the scale contained five factors. Four-factor and six-factor solutions were also tested but setting the number of factors at five resulted in a solution with the clearest factor structure. There were 19 items with loadings >.40 on one of the five factors, and no crossloadings >.30.

Next, these 19 items were used in CFA. Preliminary analyses indicated that a factor consisting of the two items on counterfactual thinking (items 25 and 28) had only weak correlations with the other items, and thus, we left them outside further analyses. We tested four different models, summarised in Table 1. Model 1 tested whether AOT can be modelled as a unitary phenomenon, Model 2 tested the assumption that the AOT contains four distinct dimensions that are part of a larger underlying AOT factor and Model 3 tested four independent but intercorrelated factors. By adding crossloadings suggested by modification indices to Model 3, we arrived at Model 4 which showed good fit to the data. Table 2 shows the factor loadings in this model and Table 3 shows the correlations between its latent factors. The maximal weighted reliabilities (Raykov's $\rho$) of the four latent factors (crossloadings not included) were as follows: .73, .68, .45 and .63. In subsequent analyses, we used this 17-item version, which was highly correlated with the 41-item original ($r$ = .91). Tested using Feldt's (1980) method, the internal consistency of

**Table 1.** Summary of tested models with fit indices in Studies 1 and 2.

| Model nr | Model description | $X^2$ | df | NFI | CFI | RMSEA, 90% CI |
|---|---|---|---|---|---|---|
| Study 1 | | | | | | |
| 1 | 1 latent factor | 2812.987 | 119 | .644 | .654 | .091 [.088, .094] |
| 2 | 4 latent factors + 1 higher-order factor | 1588.191 | 115 | .799 | .811 | .068 [.065, .071] |
| 3 | 4 latent factors, no crossloadings | 1439.919 | 113 | .818 | .829 | .066 [.063, .069] |
| 4 | 4 latent factors, with crossloadings | 795.531 | 106 | .899 | .911 | .049 [.046, .052] |
| 5 | AOT7: 1 latent factor | 383.020 | 14 | .811 | .816 | .098 [.090, .197] |
| Study 2 | | | | | | |
| 6 | 1 latent factor | 613.011 | 119 | .612 | .658 | .098 [.090, .105] |
| 7 | 4 latent factors + 1 higher-order factor | 613.011 | 119 | .612 | .658 | .098 [.090, .105] |
| 8 | 4 latent factors, no crossloadings | 362.223 | 113 | .771 | .827 | .071 [.063, .079] |
| 9 | 4 latent factors, with crossloadings | 212.677 | 103 | .865 | .924 | .050 [.040, .059] |
| 10 | AOT7: 1 latent factor | 62.305 | 14 | .855 | .881 | .088 [.066, .110] |

Note: All $X^2$s significant at $p$ <.00001.

**Table 2.** Factor loadings in CFA Model 4 Study 1.

| Item | F1 | F2 | F3 | F4 | Source |
|------|----|----|----|----|--------|
| *Factor 1: Dogmatism* | | | | | |
| 23. I believe that loyalty to one's ideals and principles is more important than "open-mindedness". (R) | **.64** | | | | O-v |
| 32. I believe that the "new morality" of permissiveness is no morality at all. (R) | **.59** | | | | O-v |
| 24. Of all the different philosophies which exist in the world there is probably only one which is correct. (R) | **.52** | | | | Dogm |
| 8. I think there are many wrong ways, but only one right way, to almost anything. (R) | **.89** | −.49 | | | Cat |
| 39. I believe letting students hear controversial speakers can only confuse and mislead them. (R) | **.45** | | | | O-v |
| 7. I believe we should look to our religious authorities for decisions on moral issues. (R) | .20 | .29 | | | O-v |
| *Factor 2: Fact resistance* | | | | | |
| 33. One should disregard evidence that conflicts with your established beliefs. (R) | | **.64** | | | Bel |
| 15. It is important to persevere in your beliefs even when evidence is brought to bear against them. (R) | | **.61** | | | Bel |
| 19. Certain beliefs are just too important to abandon no matter how good a case can be made against them. (R) | | **.68** | −.22 | | Bel |
| 37. Beliefs should always be revised in response to new information or evidence. | −.68 | **.90** | | | Bel |
| 41. People should always take into consideration evidence that goes against their beliefs. | −1.14 | 1.28 | .48 | | Flex |
| *Factor 3: Liberalism* | | | | | |
| 18. I consider myself broad-minded and tolerant of other people's lifestyles. | | | **.58** | | O-v |
| 4. A person should always consider new possibilities. | | | **.40** | | Flex |
| 27. I believe that the different ideas of right and wrong that people in other societies have may be valid for them. | | | **.42** | | O-v |
| *Factor 4: Belief personification* | | | | | |
| 11. There are a number of people I have come to hate because of the things they stand for. (R) | | | | **.73** | Dogm |
| 3. I tend to classify people as either for me or against me. (R) | .27 | | | **.40** | Cat |
| 31. My blood boils over whenever a person stubbornly refuses to admit he's wrong. (R) | | | | **.44** | Dogm |

Note: Loadings in boldface are included in the sum variables used in subsequent analyses.
   R = reflected item, O-v = openness-values, dogm = dogmatism, cat = categorical thinking,
   bel = belief identification and flex = flexible thinking.

the shortened scale (Cronbach's $\alpha$ = .75) was lower than of the 41-item origi-nal, $t(2733)$ = 24.47, $p < .001$, but still acceptable.

Next, we compared the AOT17 to the 7-item version of AOT (AOT7). In the 7-item version used by Haran et al. (2013), 3 items were slightly reworded but

**Table 3.** Correlations between the latent factors in CFA Model 4, Study 1.

| | F1 | F2 | F3 |
|----|----|----|----|
| F2 | .85 | | |
| F3 | .60 | .39 | |
| F4 | .32 | .08 | .41 |

in the present analyses, we used the original wordings of the items as they were included in our data-set. Inspecting the AOT7 shows that four of its items overlapped with the newly found fact resistance subscale of the AOT17, while the remaining three items on the AOT7 did not make their way into the AOT17. To test the fit of AOT7 to the data, we tested a model in which its 7 items loaded onto one latent factor. As Table 1 shows, the AOT7 fit the data less well than the final version of AOT17 (Model 4), although the maximum weighted reliability of the latent AOT7 factor ($\rho = .68$) was comparable to the reliabilities of the latent subfactors in Model 4. However, the alpha reliability of these 7 items ($\alpha = .61$) was significantly lower than of AOT17, $t(2731) = 14.94$, $p < .001$. Likewise, the correlation of AOT7 with AOT41 ($r = .60$) was lower than of AOT17, $z = 27.03$, $p < .001$, two-tailed. The significance of the difference of the correlations was tested using the COCOR calculator (Diedenhofen & Musch, 2015), available at http://comparingcorrelations.org. These results indicate that as a shortened measure of the overall AOT construct, AOT7 was less reliable and less valid than AOT17.

Based on the results of the CFA, we then calculated simple sum variables representing the four factors of the AOT17. For clarity, we excluded items that loaded equally strongly on more than one factor. Items marked in boldface in Table 2 were included in the sum variables. Thus, subscale 1 (dogmatism) contained five items ($\alpha = .67$) expressing dogmatic thinking, subscale 2 (fact resistance) contained three items ($\alpha = .67$) expressing a resistance to change one's mind in the face of facts, subscale 3 (liberalism) contained three items ($\alpha = .43$) expressing liberal and tolerant attitudes towards people and subscale 4 (belief personification) contained three items ($\alpha = .56$) expressing the personification of opinions. Note that all subscales are coded in the direction that higher scores indicate greater open-mindedness. Table 2 also shows the source of the items, that is, the instruments from which Stanovich and West (1997) and Sá et al. (1999) originally drew the items. As the table shows, items from the original sources were distributed across the new factors/subscales.

To investigate the criterion validity of this four-dimensional structure, we turned to correlations with external variables, presented in Table 4. For comparison, Table 4 also presents correlations with AOT7. As EQ, PET, Social Intelligence and the Friendship Scale showed highly similar patterns of correlations with the new AOT subscales, we combined their standardised scores into a social competence composite variable to ease interpretation of the results. Likewise, the items on paranormal beliefs and religious beliefs (which were highly correlated with each other, $r = .68$) were combined into a supernatural beliefs composite variable.

As Table 4 shows, AOT17 showed highly similar correlations to all the studied variables as the original AOT41. Inspection of the correlations between AOT subscales and other variables reveals a pattern in which the fact resistance subscale dominated the associations between AOT and the criterion

**Table 4.** Correlations between the new AOT17 subscales, AOT7 and criterion variables, Study 1.

| | AOT41 | AOT17 | AOT7 | Dogma | Facts | Liberal | Person |
|---|---|---|---|---|---|---|---|
| AOT41 | – | – | – | .76** | .63** | .49** | .53** |
| AOT17 | .91** | – | – | .80** | .70** | .54** | .55** |
| AOT7 | .60** | .62** | – | .33** | .70** | .19** | .04* |
| FI | −.15** | −.12** | −.38** | .04 | −.26** | .12** | −.02 |
| NFC | .23** | .24** | .33** | .06** | .24** | .18** | .09** |
| CRT | .13** | .12** | .22** | <.01 | .15** | .06** | .05* |
| Social competence | .21** | .19** | −.10** | .22** | −.04* | .29** | .26** |
| Supernatural beliefs | −.31** | −.32** | −.43** | −.18** | −.44** | .04 | −.02 |

Note: Dogma = dogmatism, facts = fact resistance, liberal = liberalism and person = belief personification.
**$p < .01$.
*$p < .05$.

variables. The associations with other thinking dispositions as well as with supernatural beliefs were largely driven by this subscale. However, the association between AOT and social competence, in turn, was driven by all other subscales but not the fact resistance subscale. These results indicate a dissociation between elements of the AOT that concern attitudes towards knowledge, and other elements that concern attitudes towards people. Besides this pattern of associations, slightly stronger correlations were also found between NFC and liberalism, and between supernatural beliefs and dogmatism. The AOT7, in turn, showed a similar pattern of correlations with the criterion variables as the fact resistance subscale, which was not surprising given its overlap with this subscale.

In sum, the present results indicate that it was possible to shorten the AOT to a 17-item version without compromising criterion validity, although reliability did suffer somewhat. The 17-item version showed better fit to the data than the 7-item version. Further, the results suggest that the AOT consists of four distinct dimensions with different patterns of association with external measures of other thinking dispositions, social competence and supernatural beliefs. Next, we conducted Study 2 to examine whether this same factor structure could be replicated in another data-set, and whether correlations with further criterion variables support the conclusions drawn from Study 1.

## Study 2

### Method

*Participants and procedure.* We reanalysed the data used in Svedholm and Lindeman (2013b, Study 2). The participants were 458 Finnish volunteers (77% females; mean age 27, $SD = 7.9$ years, range 18–65) who were recruited through student mailing lists and several online discussion fora. Of the sample, 76.6% were students, and 17.2% were working.

*Measures*. AOT was assessed as in Study 1. The reliability of the 41-item scale was $\alpha$ = .83. Faith in Intuition (FI) and NFC were assessed using the 20-item versions of the scales developed by Pacini and Epstein (1999). Supernatural Beliefs were assessed using 23 items ($\alpha$ = .94) from the RPBS (Tobacyk, 2004), with modifications described in Svedholm and Lindeman (2013b).

## Results and discussion

As in Study 1, we tested models expressing AOT17 as a unitary phenomenon, as four distinct dimensions that are part of a larger underlying AOT factor, and as four independent but intercorrelated factors. These models (6–8) were equivalent to Models 1–3 from Study 1. By adding crossloadings to Model 8, we arrived at Model 9, which was equivalent to Model 4 of Study 1 and which fit the data excellently. In addition, we tested AOT7, which again fit the data less well. The maximum weighted reliabilities (Raykov's $\rho$) for the four latent factors of AOT17 were .76, .73, .48 and .56, and the $\rho$ for the latent AOT7 factor was .72. Table 5 shows the factor loadings in the AOT17 and Table 6 shows their intercorrelations.

As in Study 1, we calculated sum variables for the four AOT subscales using the items that had strong loadings (the same items had strong loadings in both studies). We calculated the new subscales of dogmatism ($\alpha$ = .70), fact resistance ($\alpha$ = .65), liberalism ($\alpha$ = .46) and belief personification ($\alpha$ = .52). Table 7 shows their correlations with external criterion variables. As the table shows, AOT17 ($\alpha$ = .76) was again highly correlated with the original 41-item scale and it had highly similar correlations with all studied variables. However, its reliability was again lower than that of the original scale, $t(456) = 8.49$, $p <. 001$, although still on an acceptable level. Breaking down the correlations between AOT subscales and other variables reveals that as in Study 1, the fact resistance subscale had the strongest correlations with FI and with supernatural beliefs. However, NFC was almost equally related to all AOT subscales. As in Study 1, AOT7 had significantly weaker reliability ($\alpha$ = .66) than AOT17, $t(456) = 4.92$, $p < .001$. Moreover, AOT7 was less strongly related to AOT41 than was AOT17, $z = 10.15$, $p < .001$. Its pattern of correlations with the criterion variables was again similar to that of the fact resistance subscale of AOT17.

In sum, the results of Study 2 supported the validity of the shortened, 17-item version of AOT. The results also showed that the factor structure with four distinct factors on dogmatism, fact resistance, liberalism, and belief personification could be replicated in another data-set. Further, these results replicated the finding that many of the associations between AOT and knowledge-related variables were strongest for the AOT fact resistance subscale.

**Table 5.** Factor loadings in CFA Model 9 Study 2.

| Item | F1 | F2 | F3 | F4 |
|---|---|---|---|---|
| *Factor 1: Dogmatism* | | | | |
| 23. I believe that loyalty to one's ideals and principles is more important than "open-mindedness". (R) | **.67** | | | |
| 32. I believe that the "new morality" of permissiveness is no morality at all. (R) | **.63** | | | |
| 24. Of all the different philosophies which exist in the world there is probably only one which is correct. (R) | **1.13** | −.69 | | −.24 |
| 8. I think there are many wrong ways, but only one right way, to almost anything. (R) | **1.03** | −.59 | | |
| 39. I believe letting students hear controversial speakers can only confuse and mislead them. (R) | **.57** | | | |
| 7. I believe we should look to our religious authorities for decisions on moral issues. (R) | .35 | .28 | | |
| *Factor 2: Fact resistance* | | | | |
| 33. One should disregard evidence that conflicts with your established beliefs. (R) | | **.65** | | .23 |
| 15. It is important to persevere in your beliefs even when evidence is brought to bear against them. (R) | | **.66** | | |
| 19. Certain beliefs are just too important to abandon no matter how good a case can be made against them. (R) | | **.58** | | |
| 37. Beliefs should always be revised in response to new information or evidence. | −1.46 | 1.47 | .79 | |
| 41. People should always take into consideration evidence that goes against their beliefs. | −1.54 | 1.53 | .92 | |
| *Factor 3: Liberalism* | | | | |
| 18. I consider myself broad-minded and tolerant of other people's lifestyles. | | | **.55** | |
| 4. A person should always consider new possibilities. | | | **.43** | |
| 27. I believe that the different ideas of right and wrong that people in other societies have may be valid for them. | | | **.49** | |
| *Factor 4: Belief personification* | | | | |
| 11. There are a number of people I have come to hate because of the things they stand for. (R) | | | | **.73** |
| 3. I tend to classify people as either for me or against me. (R) | .25 | | | **.45** |
| 31. My blood boils over whenever a person stubbornly refuses to admit he's wrong. (R) | | | | **.32** |

Note: R = reflected item. Loadings in boldface are included in the sum variables used in subsequent analyses.

**Table 6.** Correlations between the latent factors in CFA Model 9, Study 2.

| | F1 | F2 | F3 |
|---|---|---|---|
| F2 | .82 | | |
| F3 | .65 | .21 | |
| F4 | .09 | −.12 | .35 |

## Study 3

### *Method*

*Participants and procedure.* For this study, we reanalysed the data gathered for Svedholm and Lindeman (2013a). The participants were 102 Finnish upper secondary school (grade 10–12) students (47% females, mean age 16 years,

Table 7 . Correlations between the new AOT17 subscales, AOT7 and criterion variables in Study 2.

| | AOT41 | AOT17 | AOT7 | Dogma | Facts | Liberal | Person |
|---|---|---|---|---|---|---|---|
| AOT41 | – | – | – | .71** | .67** | .50** | .45** |
| AOT17 | .90** | – | – | .78** | .73** | .55** | .46** |
| AOT7 | .64** | .65** | – | .33** | .74** | .16** | .04 |
| FI | −.18** | −.12* | −.44** | .01 | −.31** | .20** | .02 |
| NFC | .40** | .41** | .35** | .20** | .29** | .32** | .25** |
| Supernatural Beliefs | −.41** | −.40** | −.49** | −.26** | −.48** | −.04 | <−.01 |

Note: Dogma = dogmatism, facts = fact resistance, liberal = liberalism and person = belief personification.
**$p < .01$.
*$p < .05$.

age range 15–18). The participants were recruited with the help of teachers from the schools and the study was conducted in classrooms during school hours.

*Measures.* AOT was assessed as before. The reliability of the 41-item scale was $\alpha = .83$. Faith in intuition and NFC were assessed using the 5-item versions (FI: $\alpha = .60$; NFC: $\alpha = .75$) of Epstein, Pacini, Denes-Raj, and Heier (1996). Because trust in complementary and alternative medicine (CAM) is positively related to supernatural beliefs, intuitive thinking, openness and magical thinking (Honda & Jacobson, 2005; Saher & Lindeman, 2005), we included it in the present analyses. Trust in CAM was assessed using a list of 13 commercially available treatments such as homeopathy and oriental medicine ($\alpha = .92$); for details, see Svedholm and Lindeman (2013a).

## Results and discussion

Table 8 shows the correlations between the studied variables. Because this data-set was smaller, we did not run CFA. Instead, we calculated the new subscales of dogmatism ($\alpha = .58$), fact resistance ($\alpha = .60$), liberalism ($\alpha = .58$) and belief personification ($\alpha = .48$) using the same items as before, as well as the AOT7. As the table shows, AOT17 ($\alpha = .71$) was again highly correlated with

Table 8. Correlations between the new AOT17 subscales, AOT7 and criterion variables in Study 3.

| | AOT41 | AOT17 | AOT7 | Dogma | Facts | Liberal | Person |
|---|---|---|---|---|---|---|---|
| AOT41 | – | – | – | .80** | .62** | .53** | .42** |
| AOT17 | .89** | – | – | .76** | .69** | .57** | .55** |
| AOT7 | .62** | .58** | – | .36** | .64** | .23* | <−.01 |
| FI | −.39** | −.38** | −.29** | −.27** | −.38** | −.02 | −.27** |
| NFC | .15 | .25 | .08 | .10 | .08 | .13 | .35** |
| Trust in CAM | −.19 | −.18 | −.20 | −.14 | −.25* | .22* | −.08 |

Note: Dogma = dogmatism, facts = fact resistance, liberal = liberalism and person = belief personification.
**$p < .01$.
*$p < .05$.

AOT41, and had similar correlations to the other studied variables, although its reliability was lower than that of the original scale, $t(100) = 5.93$, $p < .001$. In line with the findings from Studies 1 and 2 on a negative association between fact resistance and supernatural beliefs, fact resistance was the subscale with the strongest relationship to trust in alternative medicine. Differing slightly from the results in Studies 1 and 2, the intuitive disposition was nearly as strongly associated with dogmatism and belief personification as it was with fact resistance. On NFC, the only subscale with a significant association was belief personification. These different emphases in the results may be due to the younger age of the participants: adolescents may not have fully established their thinking dispositions yet because of their limited life experience, which gives them little grounds to trust their intuition (Fletcher, Marks, & Hine, 2012). The AOT7 ($\alpha = .47$) showed the strongest correlation to the fact resistance subscale and its only significant correlation with the criterion variables was a fairly strong negative association with the intuitive disposition. Again, AOT7 had significantly lower reliability, $t(100) = 3.76$, $p < .001$ and a lower correlation with AOT41, $z = 4.65$, $p < .001$, than AOT17 did.

## Study 4

### Method

*Participants and procedure.* For this study, we reanalysed the data gathered for Svedholm and Lindeman (2013b, Study 1). The participants were 50 Finnish volunteers (74% females, mean age 34 years, age range 19–62) recruited from student mailing lists, by snowball sampling and by inviting people who had expressed an interest in further studies. Of the sample, 38% were university students, 42% were working full time and 10% were otherwise occupied. The majority (62%) had completed a university degree.

Measures. AOT was assessed as before. The reliability of the 41-item scale was $\alpha = .84$. We calculated the new subscales of dogmatism ($\alpha = .49$), fact resistance ($\alpha = .64$), liberalism ($\alpha = .58$), and belief personification ($\alpha = .48$). FI was assessed using 19 items ($\alpha = .88$) from Pacini and Epstein (1999), and NFC using the 18-item ($\alpha = .81$) version of Cacioppo et al. (1984). The ability to rate argument quality independently of one's own opinion was assessed using the Argument Evaluation Test developed by Stanovich and West (1997; Finnish adaptation by Svedholm & Lindeman, 2013b). Supernatural Beliefs were assessed with 23 items ($\alpha = .95$) from the RPBS (Tobacyk, 2004).

### Results and discussion

Table 9 shows the associations between all the studied variables. AOT17 ($\alpha = .68$) was again highly correlated with AOT41, and had very similar correlations

**Table 9.** Correlations between the new AOT17 subscales, AOT7 and criterion variables, Study 4.

| | AOT41 | AOT17 | AOT7 | Dogma | Facts | Liberal | Person |
|---|---|---|---|---|---|---|---|
| AOT41 | – | – | – | .67** | .61** | .44** | .59** |
| AOT17 | .89** | – | – | .76** | .68** | .50** | .58** |
| AOT7 | .66** | .69** | – | .30* | .74** | .13 | .16 |
| FI | −.19 | −.21 | −.36** | −.13 | −.13 | .08 | −.03 |
| NFC | .21 | .18 | .23 | .06 | .03 | .29* | .03 |
| AET | .34* | .36** | .31* | .37** | .41** | .08 | .05 |
| Supernatural Beliefs | −.48** | −.43* | −.40** | −.25 | −.43* | −.03 | −.09 |

Note: Dogma = dogmatism, facts = fact resistance, liberal = liberalism and person = belief personification.
**$p < .01$.
*$p < .05$.

to the other studied variables, but lower reliability than the AOT41, $t(48) = 5.37$, $p < .001$. Due to the small sample size, few correlations reached significance. However, notable findings are that the AET, which can be thought of as a direct assessment of the absence of myside bias, was fairly strongly positively correlated with AOT's dogmatism and fact resistance subscales, but not with liberalism or belief personification. NFC had a positive association with liberalism but with none of the other subscales. In this data-set, the AOT7 ($\alpha = .59$) had stronger relationships to the other thinking dispositions than the fact resistance subscale did, but its correlations with AET and Supernatural Beliefs were of a similar magnitude as those of fact resistance. Even in this small data-set, the correlation with AOT41 was higher for AOT17 than for AOT7, $z = 3.17$, $p = .002$. However, the difference in reliability coefficients did not reach statistical significance, $t(48) = 1.19$, $p = .24$.

## General discussion

The aims of the present study were twofold: first, to develop a shorter version of the AOT assessment instrument and secondly, to explore its possible dimensions. Through exploratory and confirmatory analyses of four separate samples, including students as well as the general population and adolescents, we found that it was possible to shorten the AOT to less than half its original items without compromising criterion validity. In all samples, the 17-item version of the AOT had a high correlation with the original 41-item version, and highly similar correlations with external criterion variables assessing other thinking dispositions, social competence and supernatural beliefs. Moreover, even though the internal consistency of the AOT17 was lower than that of the AOT41, it was acceptable and on par with that typically reported for the AOT41 (Heijltjes et al., 2015; Newstead et al., 2004; West et al., 2008). The advantages of a shorter scale are multiple: since they require less time than longer scales, they are particularly suitable for use in longitudinal studies and large-scale studies, and they also lessen participant boredom and fatigue

(for discussion, see Donnellan, Oswald, Baird, & Lucas, 2006; Gosling, Rentfrow, & Swann, 2003). However, shortening the scale as drastically as to 7 items, like Haran et al. (2013) did, resulted in a larger loss of reliability and to an instrument that less strongly reflects the same construct as the original. Based on the present results, then, the 17-item version is preferable to the 7-item version if the aim is to assess overall AOT.

Regarding the dimensionality of the AOT, we found that AOT is unquestionably not a unitary phenomenon, as models testing this assumption showed very poor fit to the data. Nor could AOT be modelled as separate dimensions subsumed under one higher-order factor. Rather, the data pointed us to search for distinct but intercorrelated factors within the AOT. The model that fit the data the best, and which was replicated in another sample, revealed four AOT subfactors: dogmatism (a lack of dogmatic thinking), fact resistance (an openness to change one's mind in the face of facts), liberalism (liberal and tolerant attitudes towards other people) and belief personification (a refusal to judge people for their opinions).

That AOT is not unitary is not a new idea and not surprising, given that the original scale is a composite of diverse measures. Rather, this result confirms what was already known in principle. However, the dimensions that we identified on statistical grounds turned out to be somewhat different from the factors that were originally included. For example, our analyses formed the dogmatism subscale from items that were originally from the openness-values, dogmatism and categorical thinking scales used by Stanovich and colleagues. Our fact resistance subscale mostly consists of items that were originally included in the Belief Identification scale, but our analyses show that one item on Flexible Thinking also loads strongly on this same factor. Moreover, we found that the subdimensions do not reflect a common higher-order factor, which indicates more conceptual independence of the different dimensions than has perhaps been previously thought.

The correlations of these subscales with outside variables are indicative of the different elements making up the AOT. Most strikingly, the present studies revealed that many of the relationships between AOT and other thinking dispositions and supernatural beliefs were mainly driven by one AOT subfactor, namely fact resistance. That is, the more open one was to change one's mind in light of new facts, the less one tended to trust one's intuition, the less one believed in phenomena such as clairvoyance, ghosts and alternative medicine, and the better one did on the trick questions in the CRT. Further, dogmatism and fact resistance were responsible for the AOT's association with the Argument Evaluation Test, while the other subfactors bore no relation to it. Taken together, these findings indicate that fact resistance and dogmatism measure the propensity to avoid myside bias and to evaluate information objectively, which is the hard core of what researchers have wanted to capture with the AOT (Stanovich & West, 1997). Based on item

overlap with fact resistance as well as correlations with criterion variables, AOT7 (Haran et al., 2013) also seems to mostly focus on this aspect of AOT.

However, the findings indicate that the longer versions of AOT also involve elements of a softer nature, which concern how one relates to other people. Our analyses showed that the AOT items concerned with interpersonal attitudes formed two distinct factors, liberalism and belief personification, which were separate from the factors concerned with knowledge. These two people-focused subscales (together with dogmatism) drove the association between AOT and our measure of social competence, which was comprised of measures of empathy, social intelligence and friendship quality. These results are understandable — it is not difficult to see why people who have an open and allowing attitude towards others, and who refrain from ad hominem-type thinking, are more likely to fare well in social situations.

Another consequence of knowing what dimensions the AOT contains is that it helps us clarify the relationships of the AOT with other thinking dispositions and abilities, particularly NFC and CRT. Across our four samples, NFC had variable associations with the different subscales of the AOT. These results may be explained in terms of the more general scope of NFC compared to AOT. That is, the NFC is a more general interest in understanding the surrounding world (a review: Petty, Briñol, Loersch, & McCaslin, 2009), explaining why it mostly tended to only be related to overall AOT. In von Stumm and Ackerman's (2013) terms, both of these thinking styles can be thought of as "investment traits" that determine how much effort the person invests in thinking. However, while the NFC is seen as a higher order factor, intellectual curiosity such as that assessed by AOT is a more specific concept as it focuses on avoiding bias. In contrast, the CRT was mainly related to the fact resistance subscale of the AOT, indicating that the CRT captures a more focused open-minded stance towards knowledge.

### Limitations and future directions

When assessing the findings of the present study, a few limitations should be taken into account. First, as the newly formed AOT subscales had low reliabilities (no better than the internal consistencies of the original subscales), the correlations between these subscales and other variables were likely deflated and any findings obtained using these subscales should be taken as preliminary. If in future studies one wishes to measure the different dimensions of AOT, it may be best to start by developing more statistically robust assessment instruments with more items per subscale.

Second, the findings of the present studies are necessarily limited by the choice of external variables that we used. To establish whether the dissociation between knowledge-related and people-related elements in the AOT can be replicated, future studies should test for associations between AOT and

more diverse measures of, on the one hand, social skills, and on the other hand, good reasoning. A particular variable related to good reasoning that deserves attention in this context is epistemic sophistication. In their description of how the AOT was developed, Stanovich and West (1997) noted that "Perhaps the strongest similarities are with the two dispositional factors that Schommer (1990, 1993) called 'belief in simple knowledge' and 'belief in certain knowledge'". However, we know of no research directly testing whether the AOT measure covaries with the epistemic factors of Schommer or with any other assessments of epistemological beliefs.

Third, the variable relationships of the NCF with different AOT subfactors need to be interpreted with caution. Partly, these variable results may stem from subtle differences between the different versions of the NFC that were in use in the different studies. In particular, the finding that NFC was only related to belief personification in Study 3 was obtained using a 5-item scale, which has not been validated for adolescents, who made up the sample for that study. Likewise, that NFC was only related to liberalism in the small sample in Study 4 is a deviating result that needs to be replicated before any conclusions can be drawn from it.

## Conclusions

The present studies confirmed that in line with its background as a collection of items from multiple sources, actively-open minded thinking is a multidimensional rather than a unitary thinking disposition. We developed a shortened, 17-item version, which was highly correlated with the original and showed comparable reliability and criterion validity. In studies in which the purpose is to assess overall AOT, we recommend using this AOT17 for quicker administration. Within the AOT, we found four distinct dimensions. Two of them concerned knowledge (a lack of dogmatism and an openness to facts even if they contradict one's previous views) and two concerned people (a liberal attitude towards people and a refusal to judge others for their opinions). The knowledge-related and the interpersonal dimensions showed different relationships to other thinking dispositions, to social competence and to supernatural beliefs. These results indicate a dissociation between elements of the AOT that concern attitudes towards knowledge, and other elements that concern attitudes towards people, and call for more research to develop statistically robust instruments to more reliably assess these different aspects of the actively open-minded disposition.

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