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Systems Intelligence Inventory

Thesis submitted in partial fulfillment of the requirements for the degree programme of Master of Science in Technology in the Degree Programme in Engineering Physics and Mathematics.

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Instructor: Professor Raimo P. Hämäläinen

Aalto University School of Science	ABSTRACT OF THE MASTER'S THESIS

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Title: Systems Intelligence Inventory

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Abstract:

Systems Intelligence is intelligent behaviour in the context of complex systems involving interaction and feedback. The concept has been introduced in 2002 in Helsinki University of Technology and explored in a series of essay collections. In this study, the concept is expanded by introducing and developing a quantitative measurement tool of trait Systems Intelligence in the form of a self-report questionnaire. The items and factors in this questionnaire form the trait-SI inventory.

The development process in this study produces two inventories for trait-SI by applying both exploratory and confirmatory factor analysis methods. The full inventory consists of 50 items and eight factors. The short-form version of the same inventory consists of 32 items. Both are based on a simple factor structure, where each item loads to a single factor with a unit weight loading. The reliability and validity of the inventories are assessed to the extent allowed by the current data and are found to be decent. Further studies will focus on improving the factorial validity of the inventory and in relating the inventory to other similar already existing concepts.

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Tiivistelmä:

Systeemiäly (SI) on älykästä toimintaa, joka hahmottaa vuorovaikutuksellisia takaisinkytkentöjä sisältäviä kokonaisuuksia tarkoituksenmukaisesti ja luovasti. Käsite on esitelty vuonna 2002 Teknillisessä korkeakoulussa ja sitä on tutkittu ja käsitelty esseekokoelmien julkaisusarjalla. Tässä tutkimuksessa käsitettä laajennetaan kehittämällä kvantitatiivinen työkalu systeemiälyn piirteiden mittaamiseen itsearviointilomakkeella. Tätä mittaustyökalua kutsutaan systeemiälykyselyksi.

Tutkimuksessa kuvailtu kehitysprosessi soveltaa eksploratorista ja konfirmatorista faktorianalyysiä tuottaakseen kaksi systeemiälykyselyä. Täysi kysely sisältää 50 kysymystä ja kahdeksan faktoria. Lyhyt versio kyselystä sisältää 32 kysymystä. Kummatkin perustuvat yksinkertaiseen faktorirakenteeseen, missä jokainen kysymys katsotaan kuuluvaksi vain yhteen faktoriin yksikköpainolla. Kyselyiden luotettavuutta ja validiteettiä arvioidaan nykyisen aineiston sallimissa rajoissa ja ne havaitaan kohtalaisiksi. Jatkotutkimukset keskittyvät kyselyiden faktorivaliditeetin parantamiseen ja kyselyiden vertailuun jo olemassa olevien samankaltaisten käsitteiden kanssa.

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Avainsanat: systeemiäly, älykkyys, persoonallisuus, eksploratorinen faktorianalyysi, konfirmatorinen faktorianalyysi, rakenneyhtälömallinnus, psykometria, tilastotiede, kysely

Contents

1 Introduction

Systems Intelligence (SI) is defined as intelligent behaviour in the context of complex systems involving interaction and feedback (Saarinen and Hämäläinen 2007). It is a concept introduced in 2002 by professor Raimo P. Hämäläinen and professor Esa Saarinen and further explored in a series of essay collections. For an introduction, see Hämäläinen and Saarinen (2007). SI is suggested to be a useful concept in various fields and practices, including management practices, learning organizations, education and human relationships (SI Research Group 2011).

SI research has, for now, focused on qualitative description of the concept. There is little experimental data on how SI relates to actual work conditions and performance. Developing a quantitative measurement tool for SI would be of great use for gathering such data and for validating SI as an important personal asset worth to be explored and trained. Having a measurement tool would also enable us to directly relate SI to other similar and perhaps overlapping concepts such as Emotional and Social Intelligence (e.g. Bar-On 2006).

Rauthmann (2010b) describes three different ways to conseptualize SI for quantitative analysis:

- as a trait, a stable, consistent and enduring charasteristic,
- as a style, a manner of mental processes or behaviour, or
- as an ability, a form of performance.

The measurement of these different forms of SI requires different instruments. For example, measuring a person's 'ability-SI' requires developing a test where the person can demonstrate his or her actual SI performance, and where that performance can be graded reliably. An easier starting point for a quantitative SI instrument is trait Systems Intelligence (trait-SI). A trait-SI measurement tool is more akin to a personality test, and can be used to assess the perceived SI strengths and weaknesses of the respondent.

Trait-SI can be measured with a self-report questionnaire with an **inventory** of items that captures different facets of SI. An inventory is a measurement instrument whose responses are neither evaluated nor scored as right-wrong or pass-fail (Urbina 2004, p. 3). Closely related to an inventory is the **model** it is based on. In this study, the word 'model' refers to a system of structural equations in the context of structural equation modeling (SEM) (Bollen 1989,

pp. 10-11). A model defines how the items of the inventory relate to each other and to the latent factors which are thought to explain the item responses.

The quality of the inventory and the related model are assessed with two concepts: reliability and validity. The scores of an instrument are considered reliable if they are sufficiently consistent and free from measurement error to be useful (Urbina 2004, p. 117). The validity of the instrument depends on the amount of evidence that supports making inferences based on the instrument results (Urbina 2004, p. 151). An instrument needs to be both reliable and valid for it to be usable.

Developing an inventory from bottom up is a multi-phased and statistically demanding process. There are two prevalent approaches for developing and validating a model, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). (Hurley et al. 1997). In EFA, the underlying factors are 'extracted' statistically by fitting a more parsimonious model to data (Fabrigar et al. 1999; Costello and Osborne 2005). In CFA, the model is specified a priori based on an already existing theory and may possibly be modified based on results obtained when fitting the model to the data (Segars and Grover 1993). Often only either EFA or CFA is used when applying factor analysis (Hurley et al. 1997). In this study, we apply both EFA and CFA by using two separate samples of test participants. The first sample is used with EFA to find a rough factor structure underlying the given set of inventory items and for creating structural equation models based on the output. The second sample is used for evaluating these structural equation models and their reliability and the validity to choose the best available model.

Preliminary structures of SI, such as the five levels of SI described by Hämäläinen and Saarinen (2007), already exist. Thus, trait-SI can be thought to already have a rough theory underlying it. The exact factor structure of trait-SI is still unclear, especially in the context of a self-report questionnaire. Therefore, this study aims to both develop the factor structure of trait-SI and formulate a reliable and valid inventory based on the structure. An attempt is also made to consider the importance and usefulness of each procedure presented, and to consider the type of data and nature of this study in relation to the methods.

2 Background: Theoretical model of SI competence

The project of developing a quantitative model of trait-SI was begun by John Rauthmann in the University of Innsbruck (Rauthmann 2010a). In his study, he evaluated a 30-item trait-SI scale. The items in his scale were based on concepts discussed in SI publications. The scale was administered to 408 students of psychology in the University of Innsbruck in German language. Rauthmann analyzed his results with EFA using principal axis factoring and oblimin rotation to produce a four-factor model of trait-SI. He labeled these traits "Effective systems handling", "Systemic reflection", "Holistic systems perception", and "Systemic flexibility".

A team from the SI Research Group lead by professor Raimo P. Hämäläinen and professor Esa Saarinen (SI Research Group 2011) took this preliminary scale and its results as a basis for developing a complete SI inventory in cooperation with Rauthmann. The goal of the project was to receive more information about the potential factor structure of SI in addition to developing a measurement tool. The initial work was done by developing Rauthmann's items and expanding the inventory to include as many aspects of SI as possible. After the item list was expanded enough, the process shifted to formulating a factor structure to which the items would fit, and attempting to make each factor have an equal amount of items in it.

The original assumption for the inventory was that its structure would resemble the five levels of SI, as described by Hämäläinen and Saarinen (2007) and shown in Table 1. Table 2 shows an early model of SI from September 2010. Its seven factors are organized into four larger domains, which loosely follow the five level structure. This entire inventory version is shown in Appendix C.

The development was done by revising and adding items while doing test studies with 15 to 50 participants to see how the answers to the items were distributed. This method enabled us to drop difficult or oddly distributed items from the inventory at an early phase. The first larger scale study was administered online in November 2010, with participants gathered with e-mail and Facebook. The inventory used in this study is also shown in Appendix C. The items were then revised once more, and the inventory was translated into Finnish to improve the understandability and readability of the items

The exploratory factor analyses done on the November 2010 data showed a slightly different factorial structure from the one expected. The four domains shown in Table 2 were not present at all. Instead, factors from different do-

Table 1: The five levels of Systems Intelligence as described by Hämäläinen and Saarinen (2007)

	Factor	Description
1	Seeing oneself in the System	Ability to see oneself and one's roles and behaviour in the system. Also through the eyes of other people and with different framings of the system. Systems thinking awareness.
2	Thinking about SI	Ability to envision and identify productive ways of behaviour for oneself in the system and cognitively understanding systemic possibilities emerging from one's choices.
3	Managing SI	Ability to personally exercise productive ways of behaviour in the system.
4	Sustaining SI	Ability to continue and foster systems intelligent behaviour in the long run.
5	Leadership with SI	Ability to initiate and create systems intelligent organizations

mains, such as Attunement and Systemic Agency with People, were very close, as were also Reflection and Systems Agency with Oneself. We considered this an effect of the self evaluation questionnaire; thinking (e.g. self reflection) and acting (e.g. self growth) were hard to separate when answering, and may not be able to form statistically valid separate factors.

The complete Finnish language inventory was finished during January and February of 2011. The nine factors already present were readjusted and reordered. Based on the results, a tenth factor was added to the structure to measure attitude to new things and changes. The complete set of items used in the study is shown in Appendix A.1 with the original Finnish and the translated English items.

Table 2: The initial theoretically assumed factors in the trait-SI inventory (September 2010)

Factor	Description: The person...
Systemic Perception	
1. Systemic Perception	Comprehends/recognizes various types of systems. Senses different scales, scopes and dynamic elements. Has situational awareness.
Systemic Feeling	
2. Positivity	Is positive. Cultivates and fosters positivity. Respects others and the betterment of life.
3. Attunement	Engages intersubjectively and with invisible factors. Is present, mindful, situationally sensitive and open.
Systemic Thinking	
4. Reflection	Consciously addresses the complexities of cause and effect and feedback phenomena in personal encounters. Reflects upon one's thinking and actions. Appreciates the broaden and build effect of positive emotions.
5. Perspective Taking	Reframes phenomena from different perspectives. Generates new interpretations. Plays with ideas and possibilities. Exercises long-term thinking.
Systemic Action	
6. Personal Growth	Is self-committed to personal growth and development. Takes systemic leverage points and means successfully into action in personal growth.
7. Systems Agency with People	Has effective social style. Takes systemic leverage points and means successfully into action with people.
8. Systems Agency with General Contexts	Is able to find leverage points and successfully engage with and live in systems. Is able to effectively manage systems. Takes systemic leverage points and means successfully into action with the environment.

3 Methods

3.1 Participants

The data used in this study was collected in Finland over the internet with with five questionnaires. The participants belong to these five groups:

- students of three Aalto University courses: Probability, Statistics, and Optimization,
- students and other participants in a public Aalto University course on Philosophy and Systems Thinking,
- daycare personnel in the city of Vantaa,
- daycare managers in the city of Vantaa, and
- employees in the international company Outotec.

Table 3 shows totals for the groups and also aggregated totals for the Aalto University, daycare, and Outotec participants. In total, the data set consists of 1600 persons, of which 1137 (71%) are female and 440 (28%) male. In some groups the participant's age was also asked. This data is shown when available. The study was conducted in Finnish.

Table 3: Number of participants in test groups

Group	N	female	male	age ≤ 30	age > 30
Philosophy and Systems Thinking	284	127	149	186	95
Probability	48	15	31	44	4
Statistics	76	24	50	66	10
Optimization	51	16	33	48	3
AALTO TOTAL	459	182	263	344	112
Daycare Personnel	770	745	25		
Daycare Management	78	75	3		
DAYCARE TOTAL	848	820	28		
Outotec Company	293	135	149	46	239
OUTOTEC TOTAL	293	135	149	46	239
TOTAL	1600	1137	440	390	351

The five online questionnaires were administered in slightly different contexts. The daycare personnel responded to a questionnaire that also included sections of questions related to daycare bullying and daycare working conditions. The daycare managers answered a shorter version of the same daycare questionnaire. The questionnaire for the Outotec employees and the Philosophy and Systems Thinking course participants was presented as assessing their "ways of thinking and acting in wholes". The other Aalto University students were asked to complete a "Systems Intelligence Test".

The Philosophy and Systems Thinking course participants and the other Aalto University students are collectively referred to as the 'Aalto' group when appropriate. Incomplete answers were allowed. Six participants left at least 25% of the items unanswered. These participants were excluded from the data set.

The participants did not get any compensation for completing the questionnaire. Our computerized data collection system was designed so that after answering, the participants saw a result page with a short summary of their strengths and weaknesses and relative scoring against the data collected by that point in time.

3.2 Materials and item scales

The set of items used in this study is composed of 76 items in a 7-point Likert scale with labels "never", "very seldom", "seldom", "sometimes", "often", "very often" and "always". The answers are converted to integer values for the analysis, respectively from 0 to 6. A sample questionnaire, translated into English, is shown in Appendix E.

The answers are assumed to have an interval scale. Thus, in the statistical analyses used, either 0 or 6 evaluates to being the best score possible with respect to systems intelligence and the other end evaluates to be the worst score possible. Items whose 'best' answer is "always" are called positively phrased items, and items whose 'best' answer is "never" are called negatively phrased items.

The items of the questionnaire were developed as a collective effort by the SI Research Group (2010). The set of items was chosen with an assumption that SI consists of ten traits. The items, their a priori assumed factorings, and whether the item was meant to be phrased positively or negatively are shown in Appendix A.1.

3.3 Data analysis methods

Many statistical methods are used in developing a reliable and valid inventory from the data. To make the process easier to follow, the analysis is structured into three parts:

1. Data description: Evaluating the quality of the data and splitting the data into the analysis and validation sets.
2. Latent factor discovery: Extracting a factor structure from the data statistically
3. Model construction and comparison: Fitting simpler structural equation models to the extracted factors and estimating their quality. Estimating the validity and reliability of the models and choosing the best model.

The analysis aims to producing a valid and reliable trait-SI inventory. The quality of the inventory is assessed descriptively by taking into account the various statistical tests used in the analysis and evaluating how well the inventory fits the SI theory. When making statistical tests for each of the 76 items separately, significance levels 0.01 and 0.001 are used for rejecting the null hypotheses of the tests.

3.3.1 Data description

Scales of measure and distributions. The methods used in this study treat the data as having a continuous interval scale. In addition, the CFA methods assume the data to be multivariate normal and identically distributed (Bentler and Chou 1987). EFA, when using principal factors methods, is also able to deal with nonnormal data (Fabrigar et al. 1999). These requirements are taken into consideration when studying the descriptive statistics and histograms of the answers.

Missing data. As missing answers were allowed, the possible problems missing data may cause need to be assessed. Data should be missing at random, as described by Schafer and Graham (2002). Otherwise, a missing answer will hold some information value in itself and should be taken into consideration. The nature of missing data is evaluated by comparing the distributions of missing answers per item and per participant to a theoretical binomial distribution, which should match if data is missing at random.

Test group differences. The item distributions in test groups are compared with the Mann-Whitney U test (Mann and Whitney 1947), also known as the Wilcoxon rank sum test, to give insight on how the groups differ from each other. The comparisons are done pairwise with the three main test groups: Aalto, Daycare, and Outotec. In addition, Philosophy and Systems Thinking course participants are compared to the other Aalto students within the Aalto group, and daycare managers and daycare personnel are compared with each other.

Test sets. The data is split into two sets, an analysis set and a validation set. The former set is used for developing and fitting the models, and the latter set is reserved for model validation. The size of each set is chosen so that the statistical methods applied to them have enough data to be reliable.

3.3.2 Latent factor discovery

The factors are discovered with EFA methods using data from the analysis set. In EFA, a smaller set of latent factors is calculated to approximate the original items. How this approximation is found depends on the method used, and how many factors are retained in the model needs to be chosen based on the data.

In this study, the number of factors retained is estimated with Horn's Parallel Analysis (Horn 1965) and Velicer's Minimum Average Partial method (MAP) (Velicer 1976). Both are common methods which produce somewhat different estimates. Parallel analysis tends to slightly overestimate the number of factors retained, while MAP tends underestimate them (Hayton et al. 2004).

The models are fitted with the principal factors method, which is known to be robust and does not require multinormal data (Fabrigar et al. 1999). The resulting factor loading matrix is rotated to achieve a simple factor structure. An oblique rotation method, oblimin, is used, as the factors are allowed to correlate with each other.

The item fit to the emerging factor structure is assessed with item communality scores. These scores reflect the amount of item variance explained by the unrotated EFA solution. If the communality score is low, the variance of the item is mostly extraneous to the model structure and the item can be considered not to fit the model. This can be caused e.g. by the item loading to a non-SI trait, or by a large amount of the item variance being error variance. The former implies that the item should not belong to a trait-SI inventory, while the latter means that the item is unreliable. Costello and Osborne (2005)

recommend considering dropping items whose communality scores are less than .40. In this study, items are dropped starting from the lowest communality score and redoing the EFA with the same number of factors after each rejection, until the lowest scored item has an acceptable communality score and good face validity.

The number of factors retained is recalculated with MAP and Parallel Analysis after communality rejections. As the methods tend to produce differing estimations, several alternative EFA models with different numbers of factors can be considered equally acceptable and can all be taken into account in the succeeding section. These models correspond to structural equation models where each item is allowed to load onto all of the latent factors.

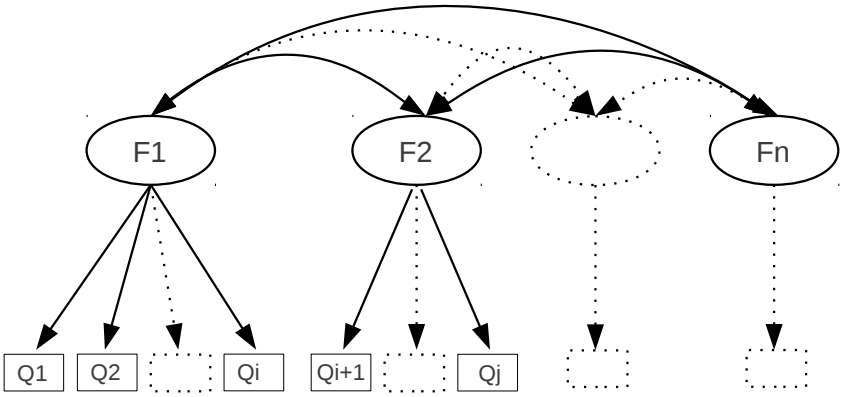
3.3.3 Model construction and comparison

The factor structures discovered with EFA are used to further develop models where each item only loads onto one latent factor. This kind of a model is called to have a 'simple structure'. There are several alternative ways to achieve a simple structure — items can either be forced to only load to one factor, or they can be dropped from the model if they would have significant loadings in several factors. Choosing what items to retain and what to drop results in alternative models of trait-SI. The model with the best validity is chosen as the trait-SI model.

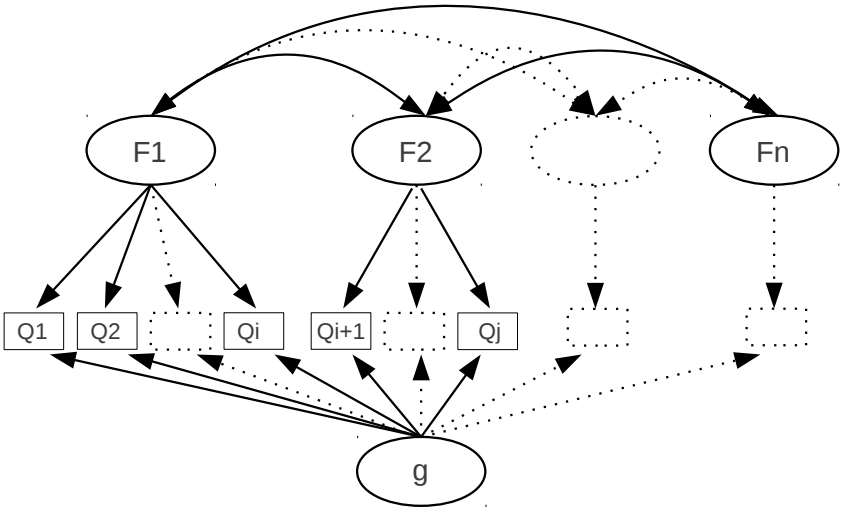
The models are implemented as structural equation models in AMOS 19 (Arbuckle 2010; Byrne 2001) and estimated with the validation set data. In the models, each item loads onto only one factor, and the factors are allowed to covary with each other. This kind of SEM structure is illustrated in Figure 1a.

Comparison of alternative trait-SI models. Choosing which model to use from the alternatives presents its own challenges. The fit of a model to the observed covariance matrix can be evaluated with the χ^2 test statistic (Schermelleh-Engel et al. 2003, p.31). However, as Schermelleh-Engel notes, the statistic improves with each parameter added to the model. It is therefore not a practical way to choose the best alternative simple structure model. Instead, we use two other descriptive fit statistics from the ones described by Schermelleh-Engel et al. (2003).

The Root Mean Square Error of Approximation (RMSEA) measures a null hypothesis of a "close fit" in the population (Schermelleh-Engel et al. 2003, p.36). RMSEA is usually considered good if the index is below 0.05, and adequate if it is between 0.05 and 0.08. The Comparative Fit Index (CFI)



(a) Simple structure CFA model



(b) CFA model with a general factor

Figure 1: Factor model diagrams. Dotted lines represent any number of items at the same level. Loadings are shown with straight lines and covariances with curved lines.

measures the relative fit of the model compared to the independence model, where all variables would be assumed uncorrelated. CFI is considered to have an acceptable fit when its value is above 0.95 (Schermelleh-Engel et al. 2003, p.41). Model validity is also assessed on theoretical grounds. If two models are indicator-wise nearly equal, but the other fits the theory clearly better, it is chosen to be the better one.

Comparison of nested models. The trait-SI model chosen to be the best is also compared to alternative formulations of the same item and factor structure. This way, it is possible to see if a simple model with the loadings and covariances set as free parameters is truly the best possible formulation of the given structure. If a model can be derived from another by fixing some of its parameters or imposing other additional constraints, the model is said to be nested within the other. Nested models can be compared with the χ^2 difference test to see whether their difference in χ^2 scores is statistically significant (Schermelleh-Engel et al. 2003, p.33). The nested models used in comparisons in this study are:

- **the single factor model**: items load to only one factor instead of several factors,
- **the unit weight model**: loadings are set to unit weight (+1 or -1, depending on the item phrasing),
- **the free weight model**: the model chosen previously, and
- **the general factor model**: all items also load to a common factor, as described in Figure 1b.

Out of these, the unit weight model is the easiest to use in practice. When using a model with unit weights, the test administrator only needs to sum answers together to get the test score, and the test can thus be completed without computer assistance if necessary. Using a model with fixed loadings would also give more credence to subsequent analysis. If the optimal loadings given by the CFA are used, all parameters are fitted to the data, and the resulting factor scores are likely to be over fitted. Mulaik and Millsap (2000), for example, recommend specifying values for all parameters of the structural equation model in advance.

A short form inventory is constructed based on the factor scores calculated from the chosen trait-SI model. In the short form questionnaire, each original factor is approximated by a smaller factor with N items. These smaller factors are chosen by evaluating the correlations between the original factor scores and the scores of each N-combination of the factor's items with the analysis

data set. The combination with the best correlation is chosen as each factor's short form version, and the result is validated with the validation data set.

Reliability and validity. The procedures for assessing the validity and reliability of a trait-SI model are very similar to the ones used in Emotional Intelligence literature. Thus, guidelines given by Gignac (2009) for emotional intelligence reseach are followed for validity and reliability analysis.

Reliability is usually assessed with the test-retest reliability and internal consistency reliability. The test-restest reliability assessment requires that the same participants fill the SI questionnaire twice at different points in time. Such data is not currently available, so the assessment is not done. The internal consistency reliability is assessed with Cronbach's Alpha and MacDonald's Omega for each of the SI factors. As a general guideline, Gignac (2009) recommends at least a reliability score of 0.70 when doing exploratory research.

Validity is assessed descriptively with face validity and content validity. In the former, factor items are evaluated regards to how well they fit their factor. The latter is used to measure how well the items are able to capture the entire factor. In addition, the factorial validity is assessed with the output from the stuctural equation models, such as the RMSEA and CFI fit statistics described in the previous section.

Predictive validity, concurrent validity and discriminant validity relate the test scores to other measures. As comparable measures are yet to be linked to the SI questionnaire results, assessing these forms of validity is left for further studies.

4 Results

4.1 Test sets

The data is split into two parts, the **analysis set** and the **validation set**. The size of the sets is chosen so that both the EFA methods used on the analysis set and the CFA methods used on the validation set have enough samples to be reliable.

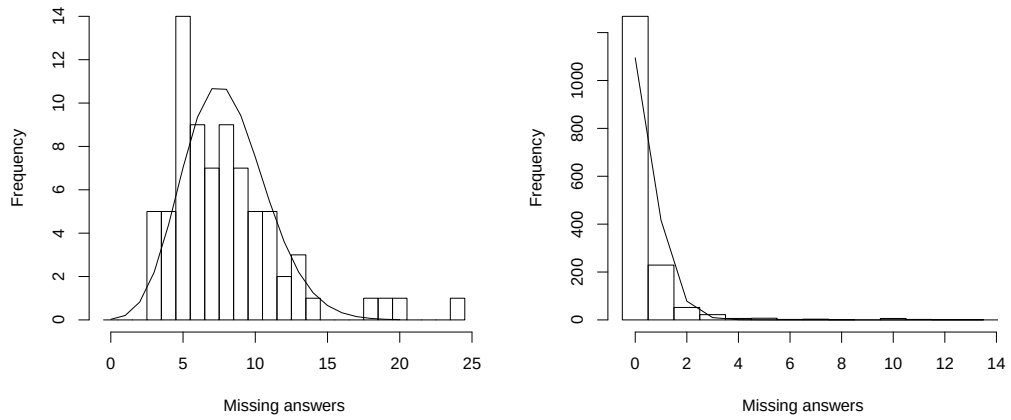
The daycare personnel are significantly over-represented within the female participant set. In the full data set, 820 (72%) of the 1137 female participants are daycare workers or managers. Therefore, any comparison between male and female participants is as likely to be a comparison between daycare workers and other participants. This problem is mitigated by downsampling the number of daycare participants closer to the Aalto and Outotec sample sizes.

Downsampling the daycare personnel data can only be done to a point where both the analysis set and the validation set have enough data to produce reliable results. For EFA, Fabrigar et al. (1999) recommend having at least 200, but with poor conditions 400–800 samples. In this study, 150 female and 150 male participants are sampled for the analysis set. For CFA, Bentler and Chou (1987) recommend that the sample size should be at least five times the amount of free parameters. We expect the final model to have at most 65 item loadings, 65 error variances, and 45 item covariances. Thus, the model is expected to have at most 165 parameters, which implies requiring a sample size of at least 875.

Table 4: Participants in the analysis and validation sets

set	N	female	male	age ≤ 30	age > 30	students
analysis	300	150	150	110	99	87
validation	915	616	276	280	252	221

set	Aalto	Outotec	daycare personnel	daycare mgmt
analysis	126	83	74	17
validation	333	210	311	61



(a) Missing answers by item

(b) Missing answers by participant

Figure 2: Histograms of missing answers and the corresponding binomial probability distributions as lines

The total amount of required participants is thus estimated to be 300 for the analysis set and 875 for the validation set, 1175 in total. To retain roughly this amount of samples, the the daycare personnel group is sampled down to 50% of its original size, which results in total 1215 samples. Descriptive statistics for the resulting data sets are shown in Table 4.

4.2 Descriptive statistics

Descriptive statistics, including the mean, standard deviation, kurtosis, skewness, median and range of all items in the entire 1600 participant data are shown in Appendix A.2. When scoring the answers to integer values 0–6, the mean answer is 3.94 and the standard deviation is 1.33. The median answer is 4 (“often”). The actual item histograms are shown in Appendix A.3. Most of the item distributions are roughly bell curve shaped, but significantly skewed, with one tail of the distribution being longer than the other. Two items lack the other tail completely, and have their peaks at their maximum values: Q28, “I am very trustworthy”, and Q65, “I have dreams”. As the distributions of these items differ considerably from the rest, these two items are dropped from the analysis from this point onwards.

Table 5: Number of items with statistically significant differences in item distributions (out of 76 in total)

	$p < 0.01$	$p < 0.001$
Group comparisons		
Daycare - Aalto	68	63
Outotec - Aalto	34	25
Outotec - Daycare	60	52
Subgroup comparisons		
philosophy - math students	4	1
daycare managers - personnel	36	21

p values calculated with the two-sided Mann-Whitney U test

Missing data. Appendix A.2 also shows the number of missing answers for each item. The maximum amount of missing answers (24, 1.5%) is for Q43, "I strive to live by my standards and values". In total, there are 606 missing answers (0.50%). 20.75% of participants left at least one question unanswered.

If the answers are missing at random, the number of missing answers should follow a binomial distribution with a probability of $606/(1600 * 76) \approx 0.005$. When studying missing answers per participant, the number of samples for the distribution is 76, while for missing answers per item, the number of samples is 1600. Histograms of the missing answers from the data are shown in Figure 2 with the corresponding binomial distributions laid on top.

The distribution of missing answers per item follows the theoretical distribution well, with only four items (Q5, Q7, Q10, Q43) having highly unlikely values ($p < 0.001$ for each). The distribution of missing answers per participant has more kurtosis than the binomial distribution: many participants have zero missing answers and some have more answers missing than is to be expected. 103 participants (6%) have values with corresponding binomial distribution p less than 0.05, while 51 participants (3%) have values with p less than 0.001.

Test group differences. The differences between test groups are assessed with the two-sided Mann-Whitney U test with R 2.13.1 (R Development Core Team 2011). The numbers of statistically significant differences are shown in Table 5. Comparisons are shown between daycare, Outotec and Aalto University participants. In addition, the Aalto subgroups of Philosophy and Systems Thinking students and the other students are compared with each other, as well as the daycare subgroups of managers and personnel.

The daycare participant answers differ significantly in nearly all items from the answers of the Aalto and the Outotec participants. Outotec employees

Table 6: Items dropped based on the communality scores with nine factors

item	communality	content
Q49	0.24	I tend to feel mistreated
Q38	0.25	I keep in mind that my understanding of the situation can be insufficient
Q64	0.28	I'm satisfied with quick fixes when in a hurry
Q15	0.29	I'm able to keep distracting thoughts out of my mind
Q29	0.29	When people hurt me, I hurt them back in turn
Q36	0.29	I pay attention to how my presence affects a situation
Q44	0.32	My actions follow my principles
Q74	0.33	When I believe in a case, I pursue it
Q69	0.34	I prepare myself for situations to make things work
Q58	0.33	I'm concerned about things not working out

Horizontal lines are drawn where communality values have a significant step.

and Aalto participants also differ notably, with half of the items having a statistically significant difference between the two groups. The Philosophy and Systems Thinking student and other student answers differ significantly in 4 items (5%). The only difference with $p < 0.001$ is in item Q43, "I strive to live by my standards and values", what Philosophy and Systems Thinking students tend to claim to do more often.

4.3 Exploratory factor analyses

EFA is used to discover a set of latent factors which explain the answer data in the analysis set (N=300, 74 items) well. EFA is also useful for evaluating the fit of each item to the entire structure and for estimating which items might not fit into a trait-SI inventory. The models are fitted with the principal factors method and the resulting latent factor matrix is rotated with the oblimin rotation method to arrive to a simple structure, where each item loads only to few factors. The methods implemented in Amos 19 are used for the analysis.

Communality score analysis. The initial EFA is done with 74 items, after items Q28 and Q65 were dropped in the preceding section. Horn's parallel analysis recommends having nine factors in the model, and Velicer's MAP recommends seven factors. For analysis of communality scores, the higher of these numbers is chosen.

Badly scoring items are dropped from the model one by one. Table 6 shows the process, with the lowest communality items removed one at a time and the

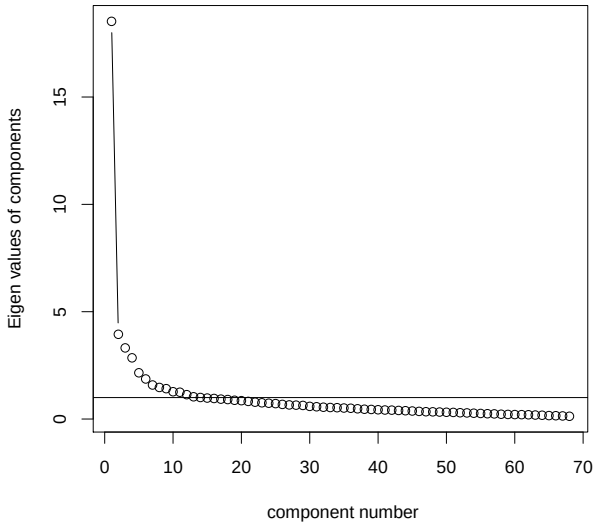


Figure 3: Scree plot for 68-item EFA

factor analysis then rerun with the same amount of factors. The two horizontal lines denote large steps in the communality scores and thus likely points where the process can be stopped. Based on the item content, the first two sets in the table have items that can be dropped based on them being too difficult to answer or by them possibly loading to traits that do not belong in trait-SI. The third group is retained, as its items are already content-wise very relevant to SI. It should be noted that the accepted communality scores of 0.32–0.34 are quite low. These numbers imply that over 65% of item variance is extraneous to the model and will be modeled in SEM as error variance.

Number of factors retained. After rejecting the six items from the model, Horn's parallel analysis still recommends having nine factors and Velicer's MAP seven factors. The scree plot for the EFA output with 68 items is shown in Figure 3. The first factor is very strong and contains a large portion of the model's variance. The three following factors are also clearly separate from the others. After the first four factors, the eigenvalues of the rest of the components decrease in a steady manner, implying that there are no other obvious cutoff points for the amount of factors to retain. Using only four factors would require loading most items to several factors, so the recommendations made by Velicer's MAP and parallel analysis are used to do the final EFA run.

EFA output. Loadings for each item for both seven-factor and nine-factor solutions are shown in Appendix D. The results are quite similar to the previously assumed ten-factor model described in Appendix A.1. Some of the items have shifted to a different factor, and the assumed factors F2 and F6 don't appear in the statistical analysis. In addition, in the nine-factor solution, factor F7 has split into two factors, one containing positively and the other negatively phrased items. In the seven-factor solution, F7 is intact and factors F3 and F4 have merged.

The split of F7 in the nine factor solution is undesirable from a content validity perspective, as it seems to be caused by item phrasing instead of item content. However, the split of F3 and F4 may be a good addition to a valid model. Thus, valid models can be constructed either based directly on the seven-factor solution, or by combining the best features of the seven-factor solution and the nine-factor solution to an eight-factor solution.

4.4 Structural equation models

Forming the simple structure models. The EFA results are used to build simple structure models where each item loads to only one factor. The basic assumption is that an item belongs to the factor it has the highest loading to in the EFA output shown in Appendix D. However, an item may also be dropped from the model entirely if it has several high loadings or no high loadings at all. The former case implies that the item does not fit a *simple* structure — it would need to load to several factors. The latter case implies that the item does not fit well to the factor structure in general. Additionally, based on its content, an item can be forced to belong to another factor than where the EFA output implies.

Based on the available EFA outputs and the decision rules described in the previous paragraph, six alternative trait-SI models are created for comparison:

- **7b:** 'Basic' seven-factor structure. All items are included in the model, and each item loads to the factor it has the highest loading to in the EFA output.
- **7r:** 'Reduced' seven-factor structure. As 7b, but items with several high loadings or no high loadings at all are dropped from the model.
- **7t:** 'Theory-adjusted' seven-factor structure. Factors have been been adjusted to make them more face and content valid.

Table 7: Number of items in each factor for the alternative structural equation models

		7 factors			8 factors		
code	factor	7b	7r	7t	8r	8r2	8t
act	Active Responsiveness	9	6	6	5	6	6
ref	Reflection	15	10	9	9	10	9
soc	Social System Skills	16	11	12			
eng	Positive Engagement				5	4	7
attu	Attunement				6	7	7
per	Systemic Perception	7	6	6	6	6	6
wis	Wise Action	4	4	6	5	4	6
dis	Spirited Discovery	5	4	6	5	4	6
atd	Attitude	12	7	7	9	7	8
	TOTAL	68	48	52	50	48	55

- **8r:** 'Reduced' eight-factor structure based on the nine-factor structure. Created from the nine-factor EFA output by dropping items with several high loadings or no high loadings at all. The 'Attitude' factor has been merged from the two factors containing positively and negatively phrased items.
- **8r2:** 'Reduced' eight-factor structure based on the seven-factor structure. As 7r, but the 'Social System Skills' factor has been split based on the nine-factor EFA output.
- **8t:** 'Theory-adjusted' eight-factor structure. Factors have been been adjusted from the **8r** and **8r2** models to make the factors more face and content valid.

These six models are shown in Appendix D next to the factor loadings. The amount of items in each factor is shown in Table 7.

SEM comparison for alternative models. In SEM, these models are fitted to approximate the observed data covariance matrix as well as possible. SEM methods attempt to find values for the factor loadings and error variances for each item, and for the covariances and variances of the factors to find an optimal solution. As a part of the data is missing, Amos 19 also needs to estimate the means and intercepts for each item, increasing both the amount of free parameters and the degrees of freedom. The observed covariance matrix formed by the remaining 68 items contains 68 variances and 2278 covariances. 1606 (71%) of the corresponding correlation coefficients for the covariances are statistically significant at significance level 0.001.

Table 8: Alternative models, their χ^2 values and fit statistics

model	items	parameters	df	χ^2	CFI	RMSEA
7b	68	225	2189	9402	0.768	0.060
7r	48	165	1059	4494	0.830	0.060
7t	52	177	1253	5424	0.814	0.060
8r	50	178	1147	4858	0.825	**0.059**
8r2	48	172	1052	**4370**	**0.835**	**0.059**
8t	55	193	1402	5838	0.815	**0.059**

Best values emphasized with bold text.
All χ^2 values are statistically significant at significance level $p < 0.001$.

Table 9: Nested models, their χ^2 values and fit statistics

model	parameters	df	χ^2	CFI	RMSEA
unit weight	136	1189	5277	0.808	0.061
single factor	150	1175	8213	0.669	0.081
free weight (8r)	178	1147	4858	0.825	0.059
general factor	228	1097	3975	**0.865**	**0.054**

Best values emphasized with bold text.
All χ^2 values are statistically significant at significance level $p < 0.001$.

The models are built as simple structure CFA models where each item loads to only one factor. Figure 1a in Section 3.3.3 illustrates the structure of these models. Amos 19 output for the models, evaluated with the maximum likelihood method, is shown in Table 8. The differences between the models are small with RMSEA scores varying between 0.059 and 0.060 and CFI scores between 0.768 and 0.835. Based on the fit statistics, model **8r2** has the best fit. However, model **8r** evaluates nearly as well. The latter model also has an advantage from a content validity perspective, as all its factors contain at least five items. Due to this, model **8r** is chosen to be the best alternative model and will be used for further development of the trait-SI inventory.

SEM comparison for nested models. Table 9 compares the chosen model **8r** with the other formulations of the same factor and item structure described in Section 3.3.3. Most of these models are nested with each other, i.e. they can be formed by placing additional restrictions on the more general models. An exception is the relationship betweeen the unit weight and the single factor model, which are not nested within each other. The statistical difference between the nested models can be evaluated with a χ^2 difference test, where the test parameters are the difference between the degrees of freedom and the difference between the χ^2 values of the nested models (Schermelleh-Engel et al. 2003, pp.33-34). Based on these tests, each of the more general models is

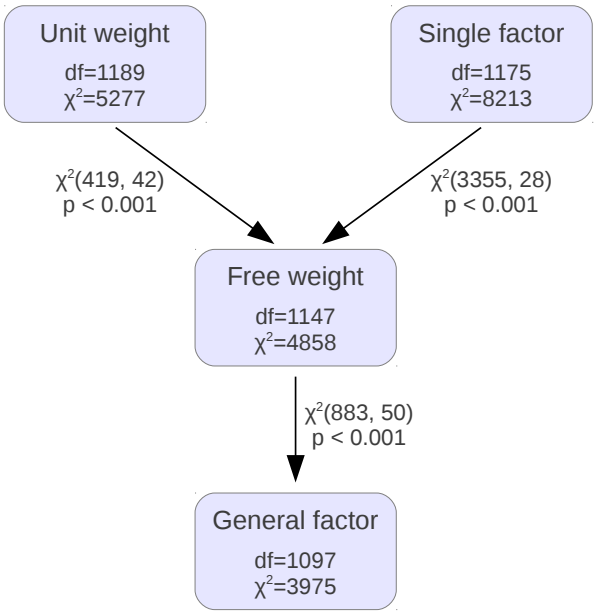


Figure 4: Nested CFA models and their χ^2 difference tests

statistically signicantly superior to the more restricted model with significance level 0.001. The nested models and the χ^2 difference test results are illustrated in Figure 4.

The model fit statistics and the nested χ^2 tests indicate that the general factor model is superior to all the other models, and that the free weight model is superior to the unit weight model and the single factor model. The single factor model, where a general trait-SI score attempts to explain all the answers, has significantly worse fit statistics than the multi-factor models. When comparing the single factor model to the unit weight model, the unit weight model is superior in all indicators; it has better fit statistics, more degrees of freedom, less parameters, and a lower χ^2 score.

Choosing the model. The goal of this study is to develop a simple structure model of trait-SI. Therefore, the general factor model is excluded from the subsequent analysis. The two next best models are the free weight and the unit weight model. The free weight model is statistically significantly better based on the χ^2 difference test, but the differences between their model fit statistics are small — the difference in RMSEA scores is 0.002 and the difference in CFI scores 0.017. The unit weight model also has a distinct disadvantage in the sense that the free weight model is able to overfit its parameters to current data. Considering the small difference in model quality and this advantage,

Table 10: Pairwise factor correlations for the unit-weight model

	per	attu	eng	ref	atd	dis	wis
Systemic Perception							
Attunement	0.487						
Positive Engagement	0.574	0.653					
Reflection	0.611	0.499	0.519				
Attitude	0.541	0.535	0.532	0.388			
Spirited Discovery	0.627	0.466	0.577	0.577	0.524		
Wise Action	0.601	0.570	0.447	0.558	0.580	0.507	
Active Responsiveness	0.644	0.477	0.498	0.439	0.561	0.529	0.522

All correlations statistically significant at significance level $p < 0.001$.

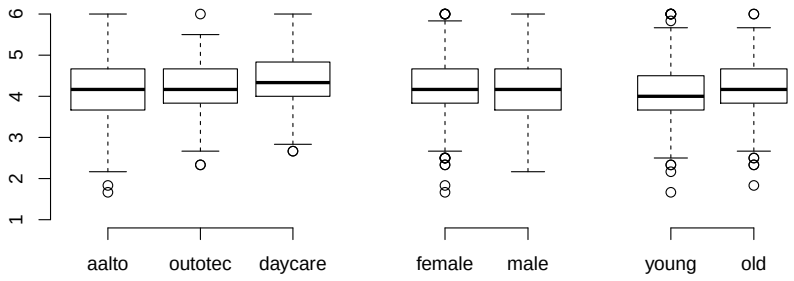
we consider the unit weight model to have roughly equal factorial validity as the free weight model and choose it as the trait-SI model due to its simplicity and ease of use.

4.5 Factor scores

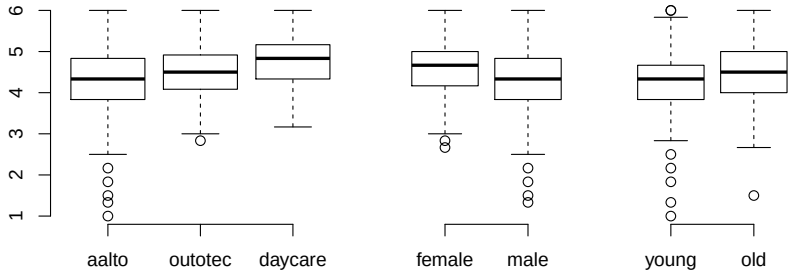
To study the features of the unit weight model, we calculate values for the eight latent variables in the structural equation model for each participant. The values are scaled to the original answer range 0–6 to make comparing the factors easier. These scaled values are called the **factor scores** of the participant. The factor scores can be equivalently calculated by converting negatively phrased items to positive (setting value 0 to "always" and 6 to "never") and calculating the arithmetic mean of all the item answers in the factor.

The analysis set and the validation set are combined to a single data set (N=1215) for the analysis of the factor scores. Table 10 shows the pairwise Pearson correlations for the scores. All factor correlations are statistically significant and range from 0.388 (Reflection – Attitude) to 0.653 (Positive Engagement – Attunement). When the factor scores of the unit weight model are compared to the latent variable scores of the free weight structural equation model from the previous section, correlations for each factor pair are over 0.99. The unit weight model can therefore be considered a very reliable alternative to the free weight model.

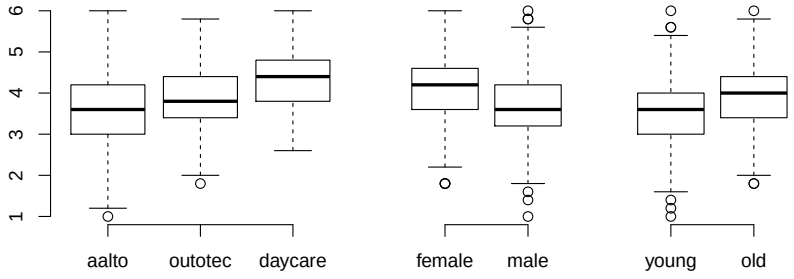
Figure 5 shows box-and-whisker plots for the unit weight scores for each factor, grouped by test group, gender, and age category (where 'young' is 30 years old or younger and 'old' over 30 years of age). The overall trend in the factor scores



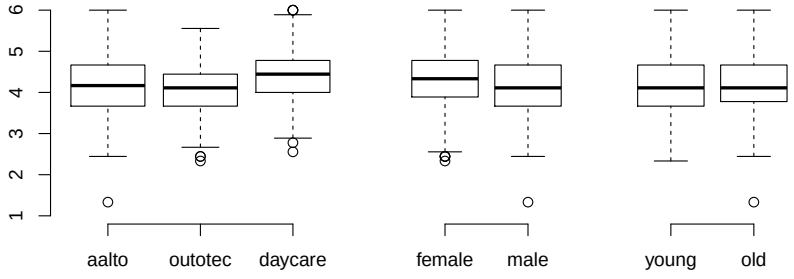
(a) Systemic Perception



(b) Attunement

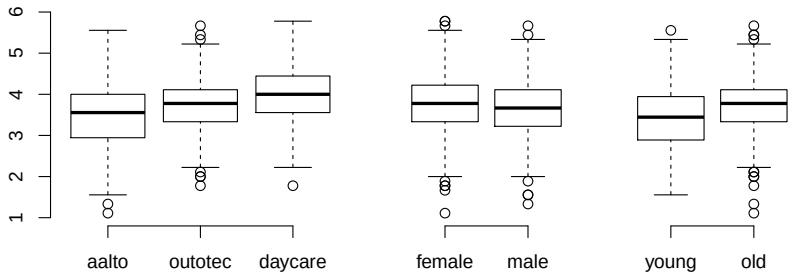


(c) Positive Engagement

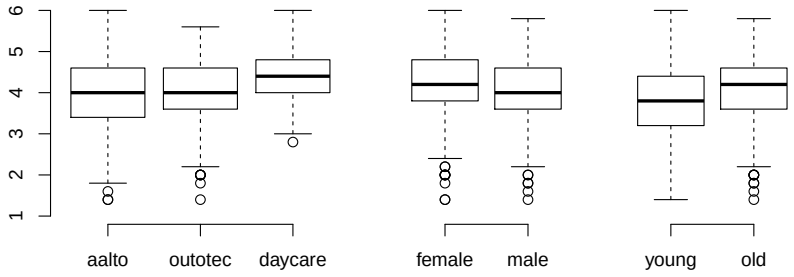


(d) Reflection

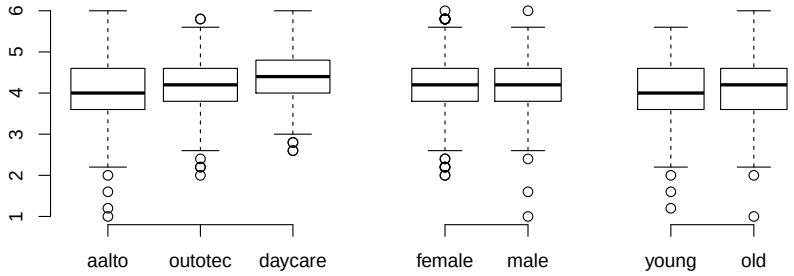
Figure 5: Box-and-whisker plots for unit-weight model factor scores. The factor scores are scaled to the range 0–6 for each factor.



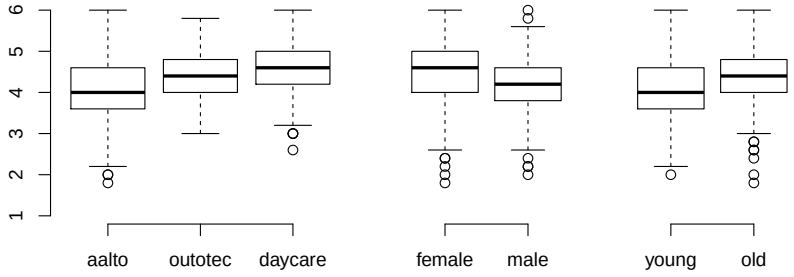
(e) Attitude



(f) Spirited Discovery



(g) Wise Action



(h) Active Responsiveness

Figure 5: Box-and-whisker plots for unit-weight factor scores (continued)

Table 11: Correlations and coefficients of determination between unit-weight model and short form model for each factor calculated from the validation data set

factor	original items	correlation	R^2
Systemic Perception	6	0.975	95%
Attunement	6	0.965	93%
Positive Engagement	5	0.986	97%
Reflection	9	0.918	84%
Attitude	9	0.931	87%
Spirited Discovery	5	0.981	96%
Wise Action	5	0.973	95%
Active Responsiveness	5	0.981	96%

is that old people tend to have higher scores than young people, females tend to have higher scores than males, and daycare employees tend to have higher scores than Outotec employees, who tend to have higher scores than Aalto University participants. There are, however, differences between the factors. In Systemic Perception, the scores of all groups are distributed roughly equally. In Reflection, the Aalto university participants tend to score somewhat higher than Outotec employees. An interesting detail is that in the factor labeled Wise Action, young and old participants are roughly equal, but in Spirited Discovery, older participants score higher.

4.6 Short form inventory

We build a short form version of the trait-SI inventory by finding the four-item subset of each factor that correlates best with the unit weight factor score. The subsets are chosen with the analysis data set. After selection, they are validated with the validation data set.

The resulting four-item factors are shown in Appendix B. Table 11 shows the resulting correlations between the short-form factor scores and the original unit weight model factor scores. The table also lists their R^2 coefficients of determinations (squares of correlations), which estimate the amount of variance accounted for by the short form inventory factors. For most factors, R^2 is well over 90%, with the two largest factors, Reflection and Attitude, having R^2 around 85%. The values are high enough that the short form questionnaire can be considered a reliable approximation of the full form inventory.

Table 12: Cronbach's α scores for the model and for each factor

factor	full model	short form
Systemic Perception	0.88	0.81
Attunement	0.83	0.75
Positive Engagement	0.83	0.78
Reflection	0.84	0.71
Attitude	0.83	0.71
Spirited Discovery	0.82	0.78
Wise Action	0.72	0.61
Active Responsiveness	0.77	0.70
full model	0.95	0.93

When the short form inventory is implemented as a structural equation model, the resulting fit statistics are $\chi^2 = 2379$ with 460 degrees of freedom ($p < 0.001$), CFI 0.834, and RMSEA 0.068. The short form model thus has a better CFI score than the unit-weight and free-weight models, but a worse RMSEA score. The entire short form model AMOS 19 output is shown in Figure 6.

4.7 Reliability and validity

Internal Consistency Reliability. Cronbach's α for each factor and for the entire model are shown in Table 12. The values are calculated both for the full unit weight model and for the short form version. For the full model, Wise Action and Active Responsiveness coefficients are between 0.70 and 0.80, while the rest are over 0.80. The full model α reliability score is a very high 0.95. Short form reliability scores are smaller, with Wise Action score going below 0.61 and being thus rather unreliable. Estimates by R's 'psych' package (Revelle 2011) for McDonald's ω scores for the full model are 0.75 for the hierarchical omega and 0.97 for the total omega. For the short form version, hierarchical omega is 0.74 and total omega 0.95.

Test-Retest Reliability. The first Test-Retest reliability studies of the SI inventory are currently underway. A large-scale study of reliability is to be done at a further date.

Face Validity. The item loadings are, in general, very well in line with the item content and the factors are easy to understand and describe. In further studies, most consideration should be given to developing the Attitude factor.

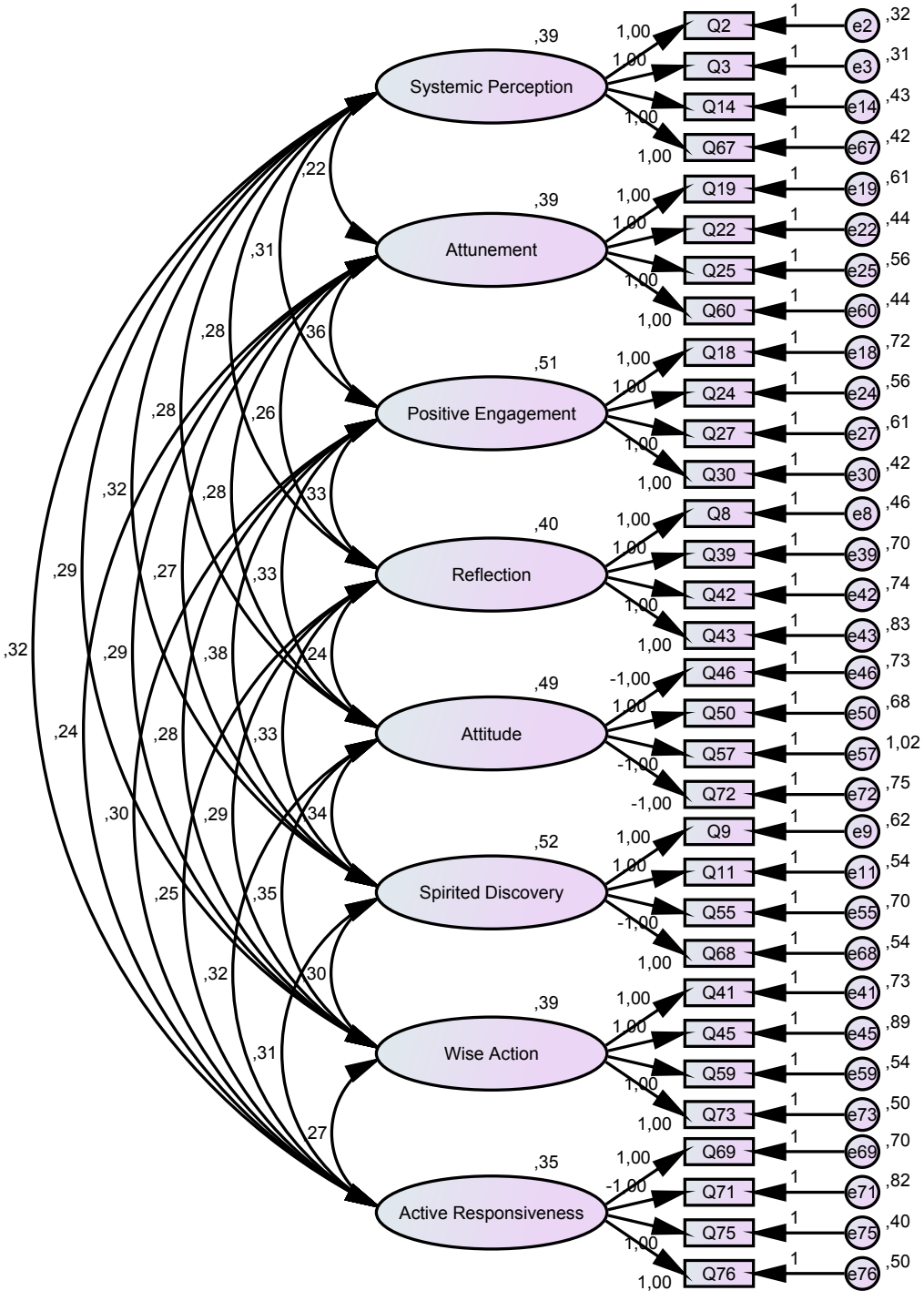


Figure 6: Amos 19 graph for the short form unit weight model

Most of the negatively phrased items in this study load to Attitude, and in some cases the loading may have more to do with item phrasing than item content. For example, Q58, "I'm concerned about things not working out", would likely fit better to some other factor.

Content Validity can be considered adequate for the purposes of this inventory. Trait-SI is meant to capture a subset of the entire concept of Systems Intelligence. This trait-SI inventory can be seen as a very useful tool in helping to assess SI and the personal strengths and weaknesses of the participant.

Factorial Validity The fit statistics from the unit weight model indicate that further work may be required to improve the inventory. The RMSEA score of 0.061 is within acceptable bounds for an exploratory study, but the CFI score of 0.808 is far from the recommended value of 0.95. It is possible that the discrete scale and relative nonnormality of the data is causing the fit statistics to be distorted.

Convergent Validity and Discriminant Validity have not currently been measured. Measuring these forms of validity requires setting up a new large-scale study with various other measures also included. These tests are currently being planned.

5 Discussion

The simple structure trait-SI model. The factor analytic process in this study produced a trait-SI inventory which contains 50 items and eight factors, shown in Appendix B. Each item only belongs to one factor. The eight trait-SI factors have 5–9 items each and cover a wide array of systems intelligent traits from social traits to personal attitudes that enable and sustain SI.

The short form version of the inventory contains the same factors but only four items per factor, resulting in an inventory with 32 items. The short form inventory is a reliable approximation of the full inventory with correlations between the factor scores ranging from 0.918 to 0.986.

The statistical models for both inventories are based on structural equation models where item loadings are fixed to either +1 or -1. The factor scores of the models are direct sums of the answers, so the inventory can be used and its results interpreted very quickly. Using such a model is well justified, as the model performs nearly as well as a model where the loadings are left as free parameters. The factor scores also correlate very highly with the free parameter model factor scores, each correlation coefficient being greater than 0.99.

More complex models. The statistics used for assessing model validity, RMSEA and CFI, both improve as the model complexity is increased. An unexpected result is that including a general factor in addition to the separate trait-SI factors improves the model significantly. This general factor may be explained by the existence of a general component to trait-SI, or by the participants having systematic differences to how they answer self-report questionnaires — some participants may evaluate their answers in a more positive or negative light than the others.

The EFA methods used in the study were chosen to produce an inventory with a simple structure. When a general factor is introduced into the model at a later stage, fit statistics improve, but the face and content validity of the model suffer considerably and some item loadings become weak enough that the model can be considered to be badly specified. If a general factor is to be introduced to the trait-SI model, the EFA phase of this should be redone with methods that account for the existence of a general factor from the beginning.

The scree plot shown in Figure 3 implies that a four-factor model where each item could load to all the factors might also be a valid way to assess trait-SI. However, such a model would have many more free parameters and would be more difficult to use in practice than the current model or a model with a general factor. Such a model can therefore be rejected as impractical.

Data quality. The item answers are assumed to be measurable on an interval scale. This is an assumption in the statistical methods used. It is possible that this assumption is too strong. In addition, the data is discrete and non-normal, though the item distributions do have rough bell curve shapes. Due to these problems, the SEM procedures with their strong normality assumptions may be unreliable and the resulting fit statistics may be distorted. It's possible that the significant difference between the RMSEA and CFI scores — the former is nearly acceptable, while the latter is far from it — is caused by the coarseness of the data. A potential solution for this problem could be doing the analysis with polychoric correlations, which attempt to model the correlation between the underlying continuous indicators of the ordinal variables (Bollen 1989, pp. 441-445).

Missing data isn't a significant problem. The largest number of missing answers per item is only 1.6% of total answers. Only 51 (3%) of the total 1600 participants have so many answers missing that it cannot be explained by random variation from the underlying binomial distribution (with significance level $p < 0.001$).

Test group differences in factor scores. The box-and-whisker plots in Figure 5 illustrate the distribution of factor scores for each factor. When comparing the distributions between female and male participants, it should be noted that a large part of the female participants still come from the daycare manager and personnel data sets, which in general score higher than the other data sets. Thus, at least a part of the differences between genders is explained by the differences in the test groups.

The young and the old participants have almost similar distributions of scores in the Reflection and Wise Action factors. The content of these factors is strongly related with introspection and self-control. The older participants tend to have higher scores in other factors. All daycare participants seem to grade themselves quite highly, with factor scores below 3.0 being rare. In the Aalto participant group, lower scores are more common and the low end of the distribution in both Attunement and Positive Engagement is near 1.0.

Effect of inventory context. Whether the questionnaire is framed as a 'Systems Intelligence test' or an assessment of 'ways of thinking and acting in wholes' does not seem to have a strong effect on the results, based on the similarity of the answers of the Philosophy and Systems Thinking participant group when compared with the other Aalto University students. Thus, there likely isn't a need to avoid using the word 'Intelligence' in the questionnaire introduction. The context where the questionnaire was made seems to have a much larger effect, with the Outotec and Daycare participants scoring much higher than the Aalto participants. The former two groups can be considered to have answered the questionnaire in a work context, while the latter answered in a more personal context.

Further development. The test-retest reliability and the convergent and discriminant validity of the trait-SI inventory have not yet been assessed, but are important and required before the inventory can be considered both fully reliable and valid. In addition, the factor validity problem of unsuitable fit statistics needs to be resolved, either by showing that in this case, the nature of the data tends to produce CFI values in this range, or by improving the underlying statistical model of the inventory.

Convergent and discriminant validity will be assessed by connecting the trait-SI inventory with similar widely used inventories and personality tests. For example, the trait-SI inventory factors of Attunement and Positive Engagement may have much to do with the concepts of Emotional and Social Intelligence, and the Attitude factor may be closely tied to Positive Psychology research in positive and negative affect (Bar-On 2006; Fredrickson and Losada 2005). Finding how trait-SI relates to these already existing theories and constructs lets us relate SI with the discourse on personal and work-related well-being and effectiveness on a new level.

6 Conclusions

This study has produced two inventories for trait Systems Intelligence. The full inventory consists of 50 items and eight factors. The short-form version of the same inventory consists of 32 items. Both are based on a simple factor structure, where each item loads to a single factor with a unit weight loading. The reliability and validity of the inventories have been assessed to the extent allowed by the current data.

The full inventory and its factor structure is based on an exploratory analysis of the data, but the inventory also matches well with the original assumptions of our research group presented in Appendix A.1. Thus, the face and content validity of the inventory can be considered good. Structural equation model fit indices imply that the factorial validity of the inventory is currently lacking and further development needs to be done on the inventories and their underlying statistical models before they are ready for wide usage.

The reliability of the full inventory is good, with the Cronbach α reliability coefficients for the factors ranging from 0.77 to 0.88 and the α for the entire inventory being 0.95. The short-form inventory is a reliable approximation of the full inventory, with even the lowest factor score correlation between the inventories being 0.918.

This study still leaves open what the convergent and discriminant validity of the resulting trait-SI inventory are. It will be interesting to link trait-SI not only to social and emotional intelligence, but also to widely used instruments such as the Big Five model in subsequent studies.

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A Appendix: Item data

A.1 Items

Table 13: Items, their English and Finnish versions, original factor assumptions and positive/negative phrasing

item	English translation Finnish original	factor	phrasing
Q1	I form a rich overall picture of situations Muodostan monipuolisen kokonaiskuvan tilanteista	F1	+
Q2	I easily grasp what is going on Käsitän helposti, mitä on meneillään	F1	+
Q3	I quickly get a sense of what matters Saan nopeasti käsityksen siitä, millä on merkitystä	F1	+
Q4	I quickly get a sense of what is essential to a given situation Näen, mikä tilanteessa on olennaista	F1	+
Q5	I pay attention to what doesn't meet the eye Kiinnitän huomiota siihenkin, mikä ei suoraan nouse esille	F1	+
Q6	I find it important to understand how things relate to each other Koen tärkeäksi hahmottaa, miten asiat liittyvät toisiinsa	F1	+
Q7	I see connections between seemingly unrelated things Hahmotan yhteyksiä näennäisesti toisiinsa liittymättömien asioiden välillä	F1	+
Q8	I view things from many different perspectives Katson asioita monista eri näkökulmista	F2	+
Q9	I like to play with new ideas Leikin mielelläni uusilla ajatuksilla	F8	+
Q10	I look for new approaches Etsin uusia lähestymistapoja asioihin	F8	+
Q11	I like to try out new things Kokeilen mielelläni uusia asioita	F8	+
Q12	I have a narrow perspective on things Ajattelen asioista yksipuolisesti	F2	-
Q13	I consider the overall context when I act Toimin pitäen mielessäni kokonaiskuvan	F2	+
Q14	I keep both the details and the big picture in mind Pidän sekä yksityiskohdat että kokonaiskuvan mielessäni	F2	+
Q15	I'm able to keep distracting thoughts out of my mind Kykenen pitämään häiritsevät asiat pois mielestäni	F2	+
Q16	I read social situations well Tulkitsen sosiaalisia tilanteita hyvin	F3	+
Q17	I sense how other people feel Koen, miltä toisista ihmisistä tuntuu	F3	+
Q18	I contribute to the shared atmosphere in group situations Luon osaltani yhteistä tunnelmaa	F4	+

Table 13: Items (continued)

item	English translation Finnish original	factor	phrasing
Q19	I am considerate towards others Olen hienotunteinen ihmisiä kohtaan	F3	+
Q20	I feel enthusiastic about experiencing things together with others Jaetut kokemukset innostavat minua	F3	+
Q21	I easily find the same wavelength with people Löydän helposti "saman aallonpituuden" toisten kanssa	F4	+
Q22	I approach people with warmth and acceptance Lähestyn ihmisiä lämpimän hyväksyvästi	F3	+
Q23	I make people feel appreciated Saan ihmiset tuntemaan itsensä arvostetuiksi	F4	+
Q24	I praise people for their achievements Kehun ihmisiä heidän suorituksistaan	F4	+
Q25	I am easily approachable Minua on helppo lähestyä	F4	+
Q26	I take into account what others think of the situation Otan huomioon, miten muut kokevat tilanteen	F3	+
Q27	I'm good at alleviating tension in difficult situations Olen hyvä laukaisemaan jännittyneitä tilanteita	F4	+
Q28	I am very trustworthy Minuun voi ehdottomasti luottaa	F10	+
Q29	When people hurt me, I hurt them back in turn Kun minua loukataan, vastaan samalla mitalla	F4	-
Q30	I bring out the best in others Nostan ihmisten parhaat puolet esiin	F4	+
Q31	I help people even if they don't help me Autan ihmisiä, vaikka he eivät auttaisi minua	F4	+
Q32	I am fair and generous with people from all walks of life Olen reilu ja hyväntahtoinen kaikkia ihmisiä kohtaan	F4	+
Q33	I follow my values in my everyday life Noudatan elämänarvojani päivittäisessä toiminnassani	F6	+
Q34	I critically evaluate my ways of thinking Tarkkailen kriittisesti ajattelutapojani	F5	+
Q35	I pay close attention to my prejudices Kiinnitän toden teolla huomiota ennakkoluuloihini	F5	+
Q36	I pay attention to how my presence affects a situation Kiinnitän huomiota siihen, miten läsnäoloni vaikuttaa tilanteeseen	F5	+
Q37	I know what is truly important in my life Tiedän, mikä elämässäni on todella tärkeää	F7	+
Q38	I keep in mind that my understanding of the situation can be insufficient Pidän mielessä, että ymmärrykseni tilanteesta voi olla puutteellinen	F5	+

Table 13: Items (continued)

item	English translation Finnish original	factor	phrasing
Q39	I pay attention to what drives my behaviour Tarkkailen sitä, mikä ohjaa käytöstäni	F5	+
Q40	I try to improve my behaviours Pyrin parantamaan toimintatapojani	F6	+
Q41	I am able to control my emotional reactions Kykenen hallitsemaan tunnereaktioni	F9	+
Q42	I make strong efforts to grow as a person Ponnistelen aidosti kasvaakseni ihmisenä	F6	+
Q43	I strive to live by my standards and values Teen työtä elääkseni arvojeni mukaisesti	F6	+
Q44	My actions follow my principles Puheeni ja tekoni vastaavat toisiaan	F6	+
Q45	I am willing to take advice Otan mielelläni neuvoja vastaan	F6	+
Q46	I get frustrated when things don't go my way Turhaudun, kun asiat eivät mene haluamallani tavalla	F9	-
Q47	I explain away my mistakes Puolustelen virheitäni selityksillä	F6	-
Q48	I allow myself to act in ways I disapprove of in others Sallin itselleni tekoja, joita en hyväksyisi muiden tekevän	F6	-
Q49	I tend to feel mistreated Koen tulevani väärinkohdelluksi	F6	-
Q50	I have a positive outlook on the future Näen tulevaisuuden valoisana	F7	+
Q51	I am a very positive person Olen hyvin positiivinen	F7	+
Q52	When facing hard times, I remember the good things I have Kun minulla on vaikeaa, muistan myös hyvät asiat elämässäni	F7	+
Q53	I enjoy other people's success Iloitsen toisten ihmisten onnistumisesta	F7	+
Q54	I speak ill of others Puhun pahaa ihmisistä	F7	-
Q55	I tend to reject new things Sanon uusille asioille helposti "ei"	F8	-
Q56	I'm afraid of changes Pelkään muutoksia	F8	-
Q57	I easily complain about things Valitan helposti asioista	F7	-
Q58	I'm concerned about things not working out Olen huolissani, että asiat eivät tule sujumaan hyvin	F7	-
Q59	I take into account that achieving good results can take time Otan huomioon, että hyvien tulosten saavuttaminen voi viedä aikaa	F9	+
Q60	I let other people have a voice Annan tilaa muiden mielipiteille	F3	+

Table 13: Items (continued)

item	English translation Finnish original	factor	phrasing
Q61	I pay attention to how things have developed over time Kiinnitän huomiota siihen, miten asiat ovat kehittyneet ajan myötä	F9	+
Q62	I am wise in my judgements Osoitan viisautta harkinnassani	F9	+
Q63	I think about the consequences of my actions Ajattelen toimintani seurauksia	F9	+
Q64	I'm satisfied with quick fixes when in a hurry Tyydyn kiireessä hätäratkaisuihin	F9	-
Q65	I have dreams Minulla on unelmia	F9	+
Q66	Long-term goals steer my actions Pitkän aikavälin tavoitteet ohjaavat toimintaani	F9	+
Q67	I successfully manage problematic situations Hallitsen monimutkaiset ongelmatilanteet hyvin	F10	+
Q68	I act creatively Toimin luovasti	F10	+
Q69	I prepare myself for situations to make things work Valmistaudun tilanteisiin saadakseni asiat sujumaan	F10	+
Q70	I get things done Saan asiat hoidettua	F10	+
Q71	I easily give up when facing difficult problems Annan helposti periksi, kun kohtaan vaikeita ongelmia	F10	-
Q72	I let problems in my surroundings get me down Annan toimintaympäristöni ongelmien latistaa minua	F8	-
Q73	I keep my cool even when situations are not under control Säilytän mielenmalttini hallitsemattomissakin tilanteissa	F9	+
Q74	When I believe in a case, I pursue it Kun uskon asiaani, vien sitä määrätietoisesti eteenpäin	F10	+
Q75	I'm able to put the first things first Osaan pitää asiat tärkeysjärjestyksessä	F10	+
Q76	When things don't work, I take action to fix them Kun asiat eivät suju, tartun toimeen	F10	+

A.2 Aggregate values

Table 14: Item aggregates: mean, standard deviation, kurtosis, skewness, median, minimum, maximum, and number of missing answers (of 1600 in total)

item	mean	sd	kurt	skew	median	min	max	missing
Q1	4.20	0.84	0.78	-0.39	4	0	6	4
Q2	4.42	0.79	1.01	-0.60	4	0	6	9
Q3	4.35	0.78	0.74	-0.48	4	0	6	10
Q4	4.36	0.74	0.74	-0.35	4	0	6	6
Q5	3.96	0.99	-0.44	-0.01	4	1	6	20
Q6	4.60	0.86	0.17	-0.31	5	1	6	5
Q7	3.47	1.04	0.36	-0.17	3	0	6	18
Q8	4.56	0.88	0.35	-0.35	5	0	6	4
Q9	4.42	1.04	-0.11	-0.43	5	0	6	9
Q10	4.11	0.97	0.24	-0.26	4	0	6	19
Q11	4.42	1.03	0.07	-0.40	4	0	6	13
Q12	1.96	0.98	-0.32	0.14	2	0	5	10
Q13	4.31	0.82	0.63	-0.17	4	0	6	6
Q14	4.22	0.87	0.75	-0.34	4	0	6	6
Q15	3.59	1.02	0.39	-0.51	4	0	6	5
Q16	4.20	0.90	0.84	-0.56	4	0	6	6
Q17	4.31	0.92	0.74	-0.60	4	0	6	10
Q18	4.43	1.08	0.57	-0.64	5	0	6	5
Q19	4.68	0.92	0.84	-0.64	5	1	6	5
Q20	4.77	0.96	0.58	-0.66	5	0	6	9
Q21	4.28	0.85	1.54	-0.81	4	0	6	4
Q22	4.50	0.93	0.90	-0.57	5	0	6	8
Q23	3.94	0.88	0.53	-0.25	4	0	6	9
Q24	4.26	1.00	0.48	-0.46	4	0	6	11
Q25	4.61	0.98	1.12	-0.72	5	0	6	7
Q26	4.44	0.86	0.39	-0.31	4	0	6	5
Q27	3.73	1.06	-0.01	-0.29	4	0	6	5
Q28	5.26	0.80	1.07	-0.94	5	0	6	6
Q29	2.13	1.19	-0.01	0.31	2	0	6	7
Q30	3.79	0.95	0.30	-0.10	4	0	6	14
Q31	4.38	1.00	-0.02	-0.35	4	0	6	4
Q32	4.63	0.85	1.79	-0.61	5	0	6	8
Q33	4.71	0.90	1.25	-0.65	5	0	6	11
Q34	4.26	1.08	0.12	-0.38	4	0	6	10
Q35	3.94	1.10	0.06	-0.32	4	0	6	11
Q36	3.84	1.06	0.39	-0.40	4	0	6	5
Q37	4.94	0.98	1.42	-1.02	5	0	6	5
Q38	3.88	0.94	0.47	0.06	4	0	6	11
Q39	3.66	1.04	0.58	-0.34	4	0	6	13
Q40	4.44	0.92	0.33	-0.17	4	0	6	5
Q41	4.17	1.00	1.03	-0.80	4	0	6	10
Q42	4.37	1.09	-0.08	-0.38	4	0	6	9

Table 14: Item aggregates (continued)

item	mean	sd	kurt	skew	median	min	max	missing
Q43	4.48	1.10	0.60	-0.70	5	0	6	24
Q44	4.76	0.73	0.38	-0.32	5	2	6	3
Q45	4.37	1.07	0.39	-0.45	4	0	6	6
Q46	3.01	1.03	0.50	-0.02	3	0	6	9
Q47	2.41	1.11	-0.16	-0.06	3	0	6	7
Q48	1.70	1.21	0.05	0.50	2	0	6	5
Q49	1.89	1.05	-0.40	0.32	2	0	5	3
Q50	4.68	1.00	0.83	-0.76	5	1	6	6
Q51	4.29	1.06	0.74	-0.66	4	0	6	3
Q52	4.06	1.12	0.17	-0.33	4	0	6	6
Q53	4.84	0.98	0.34	-0.66	5	0	6	9
Q54	1.94	1.00	-0.49	0.23	2	0	6	3
Q55	1.97	1.11	-0.17	0.41	2	0	6	12
Q56	1.99	1.17	-0.18	0.31	2	0	6	8
Q57	2.44	1.16	-0.24	0.25	3	0	6	12
Q58	2.89	1.21	-0.14	0.03	3	0	6	8
Q59	4.42	0.92	0.59	-0.38	4	0	6	7
Q60	4.64	0.83	0.82	-0.35	5	0	6	8
Q61	4.24	0.90	0.35	-0.42	4	0	6	8
Q62	3.85	0.83	0.61	-0.15	4	0	6	5
Q63	4.55	0.84	0.64	-0.35	5	0	6	8
Q64	2.98	0.99	0.83	0.20	3	0	6	6
Q65	4.95	1.07	0.14	-0.84	5	0	6	3
Q66	4.08	0.99	0.49	-0.45	4	0	6	11
Q67	3.97	0.89	0.35	-0.34	4	0	6	7
Q68	4.02	0.98	0.09	-0.31	4	1	6	8
Q69	4.49	0.91	0.56	-0.52	5	0	6	7
Q70	4.70	0.77	1.81	-0.73	5	0	6	7
Q71	1.77	1.10	0.33	0.60	2	0	6	5
Q72	2.01	1.18	-0.22	0.27	2	0	6	13
Q73	4.33	0.95	1.32	-0.70	4	0	6	5
Q74	4.80	0.91	0.04	-0.50	5	0	6	4
Q75	4.29	0.81	0.80	-0.51	4	1	6	8
Q76	4.30	0.95	0.43	-0.42	4	0	6	5

A.3 Distributions

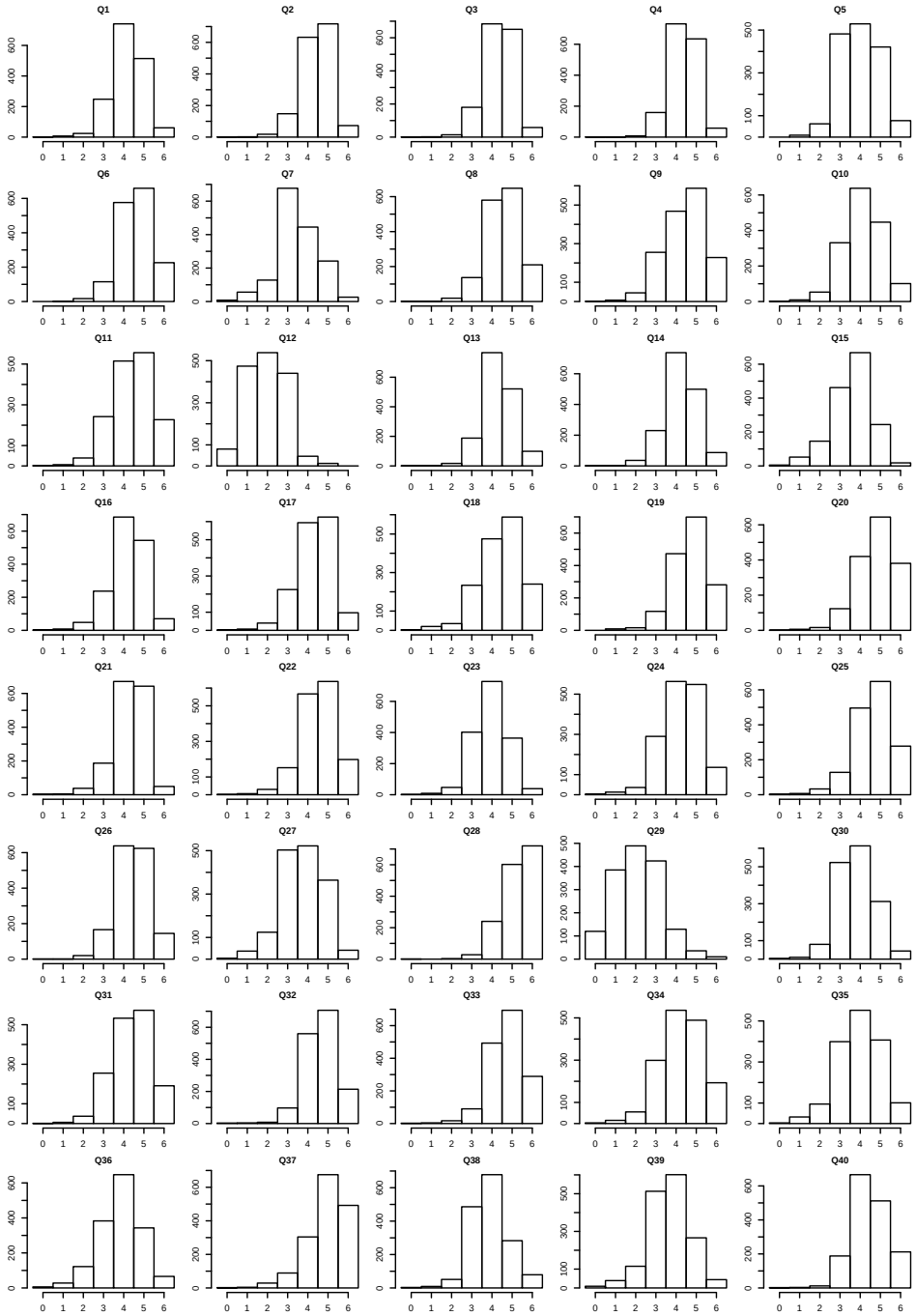

Figure 7: Histograms for items Q1-Q40

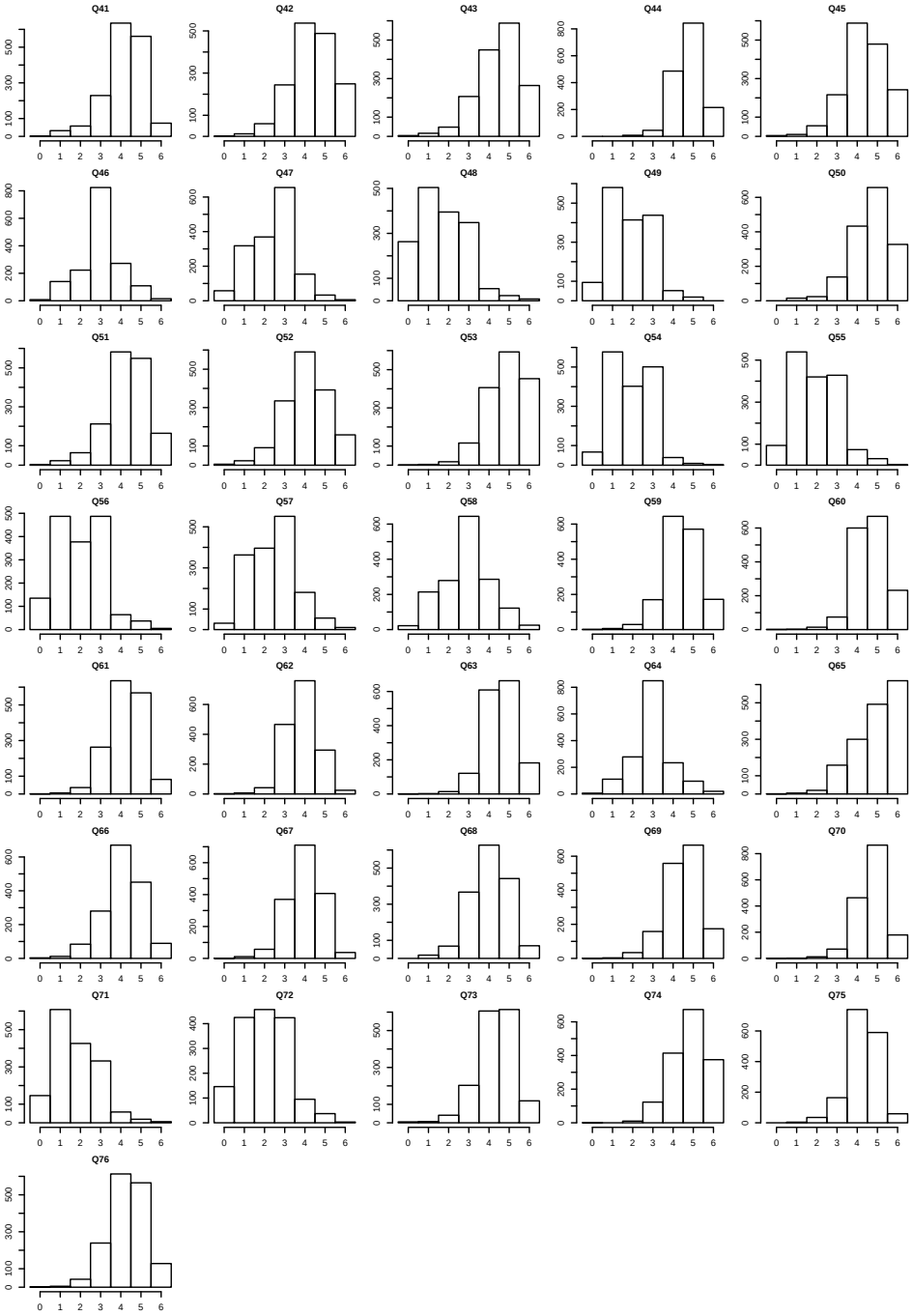

Figure 8: Histograms for items Q41-Q76

B Appendix: SI Inventory

The following pages contain the complete trait-SI inventory and its short form, developed as a result of this study.

Trait-SI Inventory

Factor	Item #	Item
Systemic Perception	1	I form a rich overall picture of situations
	2	I easily grasp what is going on
	3	I quickly get a sense of what matters
	4	I quickly get a sense of what is essential to a given situation
	5	I keep both the details and the big picture in mind
	6	I successfully manage problematic situations
Attunement	7	I am considerate towards others
	8	I approach people with warmth and acceptance
	9	I am easily approachable
	10	I take into account what others think of the situation
	11	I am fair and generous with people from all walks of life
	12	I let other people have a voice
Positive Engagement	13	I contribute to the shared atmosphere in group situations
	14	I make people feel appreciated
	15	I praise people for their achievements
	16	I'm good at alleviating tension in difficult situations
	17	I bring out the best in others
Reflection	18	I find it important to understand how things relate to each other
	19	I see connections between seemingly unrelated things
	20	I view things from many different perspectives
	21	I critically evaluate my ways of thinking
	22	I pay attention to what drives my behaviour
	23	I try to improve my behaviours
	24	I make strong efforts to grow as a person
	25	I strive to live by my standards and values
	26	I think about the consequences of my actions
Attitude	27	I get frustrated when things don't go my way (neg)
	28	I explain away my mistakes (neg)
	29	I have a positive outlook on the future
	30	I am a very positive person
	31	When facing hard times, I remember the good things I have
	32	I speak ill of others (neg)
	33	I easily complain about things (neg)
	34	I'm concerned about things not working out (neg)
	35	I let problems in my surroundings get me down (neg)
Spirited Discovery	36	I like to play with new ideas
	37	I look for new approaches
	38	I like to try out new things
	39	I tend to reject new things (neg)
	40	I act creatively
Wise Action	41	I am able to control my emotional reactions
	42	I am willing to take advice
	43	I take into account that achieving good results can take time
	44	I am wise in my judgements
	45	I keep my cool even when situations are not under control
Active Responsiveness	46	I prepare myself for situations to make things work
	47	I get things done
	48	I easily give up when facing difficult problems (neg)
	49	I'm able to put the first things first
	50	When things don't work, I take action to fix them

Trait-SI Inventory, short form

Factor	Item #	Item
Systemic Perception	1	I easily grasp what is going on
	2	I quickly get a sense of what matters
	3	I keep both the details and the big picture in mind
	6	I successfully manage problematic situations
Attunement	7	I am considerate towards others
	8	I approach people with warmth and acceptance
	9	I am easily approachable
	12	I let other people have a voice
Positive Engagement	13	I contribute to the shared atmosphere in group situations
	15	I praise people for their achievements
	16	I'm good at alleviating tension in difficult situations
	17	I bring out the best in others
Reflection	20	I view things from many different perspectives
	22	I pay attention to what drives my behaviour
	24	I make strong efforts to grow as a person
	25	I strive to live by my standards and values
Attitude	27	I get frustrated when things don't go my way (neg)
	29	I have a positive outlook on the future
	33	I easily complain about things (neg)
	35	I let problems in my surroundings get me down (neg)
Spirited Discovery	36	I like to play with new ideas
	38	I like to try out new things
	39	I tend to reject new things (neg)
	40	I act creatively
Wise Action	41	I am able to control my emotional reactions
	42	I am willing to take advice
	43	I take into account that achieving good results can take time
	45	I keep my cool even when situations are not under control
Active Responsiveness	46	I prepare myself for situations to make things work
	48	I easily give up when facing difficult problems (neg)
	49	I'm able to put the first things first
	50	When things don't work, I take action to fix them

C Appendix: Inventory development

The following pages contain snapshots of the development process of the SI inventory.

SI inventory version 7 - updated 10.9.2010

Domain	Factor	Item #	Item
Systemic Perception	1 Systemic Perception	1	I have a sense of belonging to a bigger whole
		2	I am aware of my surroundings and its influences on me.
		3	I sense the atmosphere and moods in social situations
		4	I try to grasp the big picture
		5	I have an intuitive feeling for unspoken things.
		6	I think that little pieces often create an important whole
Systemic Feeling	2 Positivity	1	I am eager to look for new opportunities
		2	I trust in a positive future
		3	I am a positive person
		4	I easily say no
		5	Most of the time I have positive feelings
		6	I feel that most people I meet like me
		7	I think many people find me a negative person (neg)
		8	It's hard for me to overcome bad experiences (neg)
		9	I seek harmony
		10	I love being generous
	3 Attunement	1	I use minor actions such as smile to connect with other people
		2	I trust in people.
		3	I enjoy seeing people flourish.
		4	I enjoy being in different social settings
		5	I am committed to my friends.
		6	I enjoy sharing uplifting experiences with other people
		7	I am supportive
		8	I sense other people's expectations
Systemic Thinking	4 Reflection	1	I often think about my thoughts, feelings, intentions, and actions.
		2	I look for the root causes of my actions
		3	I am not a very self-reflective person. (neg)
		4	I often think about my role in my surroundings.
		5	I take time out for myself and my thoughts.
		6	I often consider the effects of my actions on others
		7	I seek new thoughts to act better
		8	I seek to look beyond my blind spots
	5 Perspective Taking	1	I have difficulties seeing things from different perspectives.
		2	I often think what other people think, feel, and aim at
		3	I can see myself through the eyes of the other
		4	I can laugh at myself
		5	I play with ideas and possibilities
		6	I think of alternative solutions before acting.
		7	I accept that achieving good results often takes time.
		8	By acting wisely today I prevent problems tomorrow
		9	I do not let initial difficulties discourage me
		10	I always try to look beyond the obvious.
		11	When making everyday decisions, I reflect on their impact on my long term goals
Systemic Action	6 Personal Growth	1	I take hardships as lessons in life
		2	I often feel that people do not understand me (neg)
		3	I do not challenge my habits (neg)
		4	I am unforgiving (neg)
		5	I am judgemental about people (neg)
		6	I am humble
		7	I listen to other people
	7 Systems Agency with People	1	I try to show example with my actions
		2	I try to solve disagreements by understanding other people's perspectives
		3	I encourage people through positive feedback
		4	I try to change situations to help people
		5	I apologise when I have hurt another person
		6	I often act unselfishly to help others
		7	I take notice of the influence of my actions on other people
		8	I sometimes make cynical comments
		9	I appreciate receiving advice
		10	I don't blame other people when problems occur
		11	I find it useful to ask for the opinions of others
	8 Systems Agency with general contexts	1	I am not afraid of trying new solutions
		2	My gut feeling often points towards good solutions.
		3	I get things done.
		4	I manage my everyday activities successfully.
		5	I develop practices to make things work in the long run
		6	When confronted with problems, I do not give up until I have found a solution.
		7	When I see things going wrong, I take action
		8	I adapt to situations
		9	In difficult situations I focus more on actions than explanations
		10	I believe that my actions have a positive impact on my surroundings
		11	I believe that one person can make a difference

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Domain	Factor	Item #	Item
Systemic Perception	1 Systemic Perception	1	I sense how my surroundings have an influence on me
		2	I easily see a rich overall picture
		3	I easily grasp what is going on
		4	I pay attention to what doesn't meet the eye
		5	I sense myself as part of a whole
		6	I quickly get a sense of what matters
		7	I see connections between seemingly unrelated things
Systemic Attitude	2 Positivity	1	I find new opportunities in challenging situations
		2	I see the future positively
		3	I am very positive
		4	When facing hard times I remember the good things I have
		5	I easily complain about things
		6	I have concerns that things won't work out well
		7	I am fair and generous with people
	3 Attunement	1	I am reserved with people
		2	I sense how other people feel
		3	I enjoy other people's success
		4	I read people's intentions well
		5	I want good to other people
		6	I am easily approachable
		7	I read social situations well
Systemic Thinking	4 Self-reflection	1	I question whether I really live by my values
		2	I deeply reflect on my ways of thinking
		3	I am attentive to what drives my behaviour
		4	I consider how I might improve my behaviours
		5	I reflect on how to grow as a person
		6	I actively pay attention to my prejudices
		7	I think about things too narrowly
	5 Reflection and Perspective Taking	1	I think about the effect of my presence on what is happening
		2	I look at things from different perspectives
		3	I see myself through the eyes of others
		4	I like to play with new ideas
		5	I easily see things from the perspective of others
		6	I keep both the details and the big picture in mind
		7	I balance several perspectives in my choices
	6 Long term Systemic Orientation	1	I take into account that achieving good results can take time
		2	I am future-oriented
		3	I act to create trust
		4	I pay attention to where things will develop over time
		5	I think how to help others reach breakthroughs
		6	I think about the consequences of my actions
		7	Long-term goals steer my actions
Systemic Action	7 Systems Agency with Oneself	1	I easily give up when facing difficult problems
		2	I tolerate uncertainty well
		3	I let my emotional reactions take over
		4	I keenly work on my habits to improve them
		5	I make efforts for personal growth
		6	I develop my strengths
		7	I ask for advice to improve on my weaknesses
	8 Systems Agency With People	1	I succeed in resolving difficult situations with people
		2	I give positive feedback to people
		3	I make people feel appreciated
		4	I generate collaboration
		5	I bring out the best in others
		6	I am good to people who are not good to me
		7	I make room for other people's opinions
	9 Systems Agency with general contexts	1	I get things done
		2	I successfully manage problematic situations
		3	I act with the overall context in mind
		4	I find ways to improve the overall situation with small actions
		5	When I see things going wrong, I take action
		6	In difficult situations I provide solutions and not explanations
		7	I make improvements which have long-term impacts

D Appendix: Factor loadings

The following pages contain the full 7-factor and 9-factor exploratory factor analysis solutions and the alternative trait-SI models built from them. Loadings with absolute values less than 0.1 have been hidden.

The factors have been labeled with the following factor codes:

code	factor
act	Active Responsiveness
ref	Reflection
soc	Social System Skills
eng	Positive Engagement
attu	Attunement
per	Systemic Perception
wis	Wise Action
dis	Spirited Discovery
atd	Attitude

Item	7 factor EFA							9 factor EFA									Models					
	per	ref	soc	wis	act	dis	atd	per	ref	attu	eng	wis	act	dis	neg	atd	**7b**	**7r**	**7t**	**8r**	**8r2**	**8t**
Q01	**.429**	.302			.126	-.163	-.136	**.430**	.237				.130	-.220	-.103		**per**	**per**	**per**	**per**	**per**	**per**
Q02	**.506**		.212		.299			**.509**			.142		.299				**per**	**per**	**per**	**per**	**per**	**per**
Q03	**.456**	.187		-.131	.157		-.101	**.440**	.124			-.161	.137			.133	**per**	**per**	**per**	**per**	**per**	**per**
Q04	**.521**	.165	.103	-.157	.299			**.509**	.116			-.183	.276				**per**	**per**	**per**	**per**	**per**	**per**
Q05	.179	**.403**				-.387		.158	.330	-.100	.175	-.109		**-.358**			**ref**					
Q06	.212	**.614**	-.110					.229	**.515**		-.193			-.216		.158	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Q07	.228	**.520**	-.127		-.159	-.238		.221	**.419**	-.129			-.145	-.308		.132	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Q08	.111	**.401**	.245	-.143	-.123	-.183		.153	**.398**	.134	.182		-.114	-.186			**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Q09		.374				**-.481**			.281	-.105		-.124		**-.497**			**dis**	**dis**	**dis**	**dis**	**dis**	**dis**
Q10	.167	.457				**-.450**		.144	.336	-.106				**-.506**		.153	**ref**	**dis**	**dis**	**dis**	**dis**	**dis**
Q11			.101			**-.693**					.170			**-.711**			**dis**	**dis**	**dis**	**dis**	**dis**	**dis**
Q12	-.212	-.112	-.192	.131			**.337**	-.267	-.136	-.167				.149	**.408**	.106	**atd**					
Q13	**.310**	.188			.297		-.141	**.322**	.168				.306		-.152		**per**					
Q14	**.392**	.260			.175		-.164	**.359**	.199			-.185	.135		-.124	.157	**per**	**per**	**per**	**per**	**per**	**per**
Q15																						
Q16	.379		**.490**					**.399**		.220	.341						**soc**					
Q17		.241	**.574**				.160	.123	.273	**.383**	.299				.101		**soc**	**soc**	**soc**		**attu**	**attu**
Q18			**.426**	.119		-.354			.101		**.560**			-.213	-.140		**soc**			**eng**		**eng**
Q19	-.110		**.535**	-.126		.163				**.497**	.138			.136			**soc**	**soc**	**soc**	**attu**	**attu**	**attu**
Q20			**.359**		.129	-.302				.263	.206		.161	**-.335**			**soc**					
Q21	.406	-.146	**.557**					**.405**	-.181	.345	.272					.158	**soc**					
Q22			**.636**	-.201				.122		**.628**	.121			-.106			**soc**	**soc**	**soc**	**attu**	**attu**	**attu**
Q23		.115	**.624**	.118		-.133			.113	.310	**.460**					.143	**soc**	**soc**	**soc**	**eng**	**eng**	**eng**
Q24			**.513**	.201		-.116				.165	**.493**					.166	**soc**	**soc**	**soc**	**eng**	**eng**	**eng**
Q25	.154	-.135	**.614**				-.123	.182	-.166	**.500**	.206			-.101		.155	**soc**	**soc**	**soc**	**attu**	**attu**	**attu**
Q26	.121	.231	**.573**			.126		.161	.248	**.402**	.265			.144			**soc**	**soc**	**soc**	**attu**	**attu**	**attu**
Q27	.220		.315	.166		**-.326**		.184			**.515**			-.156			**dis**			**eng**		**eng**
Q28																						
Q29																						
Q30		.125	**.488**			-.246			.127	.199	**.428**			-.161			**soc**	**soc**	**soc**	**eng**	**eng**	**eng**
Q31	-.216		**.477**		.104	-.203	-.106	-.207		.306	**.327**			-.143			**soc**	**soc**	**soc**		**eng**	**eng**
Q32			**.514**	-.329		.130	-.201			**.657**		-.226				.122	**soc**	**soc**	**soc**	**attu**	**attu**	**attu**
Q33	-.137	.289	.223		**.346**		-.245	-.105	.268	.261			**.337**		-.160	.160	**act**					
Q34		**.556**		-.181			.122		**.602**		.164	-.188				-.202	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Q35	-.108	**.357**	.158	-.175		-.320			**.340**		.173	-.161		-.303			**ref**					
Q36																						
Q37		.194	.237	.221	**.330**	.149	-.169		.138	.295		.217	.332			**.354**	**act**					
Q38																						
Q39		**.666**				.123	.134	.107	**.665**								**ref**	**ref**	**ref**	**ref**	**ref**	**ref**

Item	7 factor EFA							9 factor EFA									Models					
	per	ref	soc	wis	act	dis	atd	per	ref	attu	eng	wis	act	dis	neg	atd	**7b**	**7r**	**7t**	**8r**	**8r2**	**8t**
Q40		**.554**	.170						**.511**	.161				-.101			**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Q41	.142			**-.569**	.184							**-.685**					**wis**	**wis**	**wis**	**wis**	**wis**	**wis**
Q42		**.639**				-.131			**.552**					-.202		.185	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Q43	-.142	**.473**	.120	.208	.141		-.210	-.134	**.467**		.141	.110	.118	.102	-.179	.184	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Q44	-.128	-.137	.141	-.229	**.421**			-.133	-.107	.127		-.267	**.361**				**act**	**act**	**act**		**act**	**act**
Q45	-.118	.109	.147	**-.263**		-.127	-.162	-.158		.253		**-.319**		-.176		.236	**wis**	**wis**	**wis**	**wis**	**wis**	**wis**
Q46				.142			**.556**				-.159	.249			**.570**	-.120	**atd**	**atd**	**atd**	**atd**	**atd**	**atd**
Q47				.155	-.224		**.303**						-.246		**.400**	.150	**atd**			**atd**		
Q48	.247	-.145	-.151	.103		-.120	**.384**	.169	-.171	**-.409**	.233	-.108	-.160		.348		**atd**					
Q49																						
Q50	.142	.132			.159	-.110	**-.304**					-.129				**.648**	**atd**		**atd**	**atd**		**atd**
Q51	.258		.280			-.178	**-.400**	.174	-.151	.108	.198	-.116	-.112	-.105	-.164	**.578**	**atd**	**atd**	**atd**	**atd**	**atd**	**atd**
Q52	.107	**.346**	.137	.194	.198		-.221		.307	-.116	.276			.137	-.141	**.405**	**ref**			**atd**		**atd**
Q53	-.248		**.456**		.367	-.258		-.258		.224	**.409**		.311	-.152		.126	**soc**		**soc**			**eng**
Q54	.171			.271			**.483**	.143		-.216	.167	.173			**.428**		**atd**	**atd**	**atd**	**atd**	**atd**	**atd**
Q55	-.107					.348	**.409**	-.128			.121			**.494**	.351		**atd**		**dis**	**dis**		**dis**
Q56	-.209					.321	**.459**	-.182	.119					**.372**	.351	-.165	**atd**	**atd**	**dis**		**atd**	**dis**
Q57				.102			**.547**					.108			**.527**		**atd**	**atd**	**atd**	**atd**	**atd**	**atd**
Q58			.125	-.308	-.145		**.511**			.160		-.197	-.136		**.417**	-.278	**atd**	**atd**	**atd**	**atd**	**atd**	**atd**
Q59		.166		**-.283**	.236	-.115	-.196		.136			**-.394**	.155		-.174		**wis**	**wis**	**wis**	**wis**	**wis**	**wis**
Q60			**.486**	-.224			-.197			**.563**					-.142		**soc**	**soc**	**soc**	**attu**	**attu**	**attu**
Q61	.110	**.402**	.169		.157	-.146		.123	**.333**	.146			.147	-.207	.111	.115	**ref**	**ref**	**ref**		**ref**	**ref**
Q62	.202	**.282**		-.278	.194			.196	.246			**-.314**	.146				**ref**		**wis**	**wis**		**wis**
Q63		**.396**		-.299	.151			.110	**.399**	.174		-.233	.142		-.110		**ref**	**ref**	**wis**	**ref**	**ref**	**wis**
Q64																						
Q65																						
Q66	.113	.325	-.133		**.400**				.256	-.103		-.164	**.343**			.183	**act**					
Q67	**.553**			-.103		-.211	-.117	**.513**				-.161		-.211		.151	**per**	**per**	**per**	**per**	**per**	**per**
Q68		.188	.137	-.110		**-.423**			.145		.210	-.140		**-.390**			**dis**	**dis**	**dis**	**dis**	**dis**	**dis**
Q69		.124		-.164	**.501**	-.112			.107			-.256	**.430**				**act**	**act**	**act**	**act**	**act**	**act**
Q70	.145				**.650**			.152					**.628**				**act**	**act**	**act**	**act**	**act**	**act**
Q71	-.126				**-.466**		.243	-.124					**-.469**		.278		**act**	**act**	**act**	**act**	**act**	**act**
Q72	-.181	.189			-.207	.168	**.396**	-.152	.172	.118	-.202		-.190		**.436**		**atd**	**atd**	**atd**	**atd**	**atd**	**atd**
Q73	.218			**-.532**			-.156	.187		.108		**-.586**			-.113		**wis**	**wis**	**wis**	**wis**	**wis**	**wis**
Q74				.102	.357	**-.359**					.165		**.323**	-.313		.137	**dis**					
Q75					**.709**			.102			-.139		**.697**				**act**	**act**	**act**	**act**	**act**	**act**
Q76			.113	.105	**.577**	-.252					.225		**.546**	-.201			**act**	**act**	**act**	**act**	**act**	**act**

E Appendix: SI questionnaires

The following pages contain an English example of a SI questionnaire used. The test name, introduction paragraphs, and the personal information section at the end were adjusted to each questionnaire, but the questions were always presented in a similar fashion.

Aalto University
School of Science

Systems
Analysis Laboratory

Systems Intelligence Self Evaluation

The following phrases refer to characteristic **ways of thinking, feeling, and acting**. Please indicate as honestly and truthfully as possible how often you think, feel, and behave the ways described. Think of your current everyday life and then indicate the frequency which you think suits best. Please choose the response that feels most "natural" to you if you are uncertain as to what to answer.

The test has **76 questions**, and it will take about 10 minutes to complete. Please answer all the questions. At the end, you will see an estimate of how systems intelligent you are compared to other people, and a summary of your relative strengths and possibilities for growth.

	never	very seldom	seldom	some-times	often	very often	always
1. I contribute to the shared atmosphere in group situations	○	○	○	○	○	○	○
2. My actions follow my principles	○	○	○	○	○	○	○
3. When I believe in a case, I pursue it	○	○	○	○	○	○	○
4. I'm good at alleviating tension in difficult situations	○	○	○	○	○	○	○
5. I critically evaluate my ways of thinking	○	○	○	○	○	○	○
6. I help people even if they don't help me	○	○	○	○	○	○	○
7. I am very trustworthy	○	○	○	○	○	○	○
8. I strive to live by my standards and values	○	○	○	○	○	○	○
9. I easily give up when facing difficult problems	○	○	○	○	○	○	○
10. I am considerate towards others	○	○	○	○	○	○	○
11. I view things from many different perspectives	○	○	○	○	○	○	○
12. I feel enthusiastic about experiencing things together with others	○	○	○	○	○	○	○
13. I pay close attention to my prejudices	○	○	○	○	○	○	○
14. I like to try out new things	○	○	○	○	○	○	○
15. I prepare myself for situations to make things work	○	○	○	○	○	○	○
16. I enjoy other people's success	○	○	○	○	○	○	○
17. I like to play with new ideas	○	○	○	○	○	○	○
18. I pay attention to what is not immediately obvious	○	○	○	○	○	○	○
19. I easily complain about things	○	○	○	○	○	○	○
20. I speak ill of others	○	○	○	○	○	○	○
21. I'm able to put first things first	○	○	○	○	○	○	○
22. I tend to feel mistreated	○	○	○	○	○	○	○
23. I perceive connections between seemingly unrelated things	○	○	○	○	○	○	○
24. I am wise in my judgements	○	○	○	○	○	○	○

	never	very seldom	seldom	some-times	often	very often	always
25. I act creatively	○	○	○	○	○	○	○
26. When things don't work, I take action to fix them	○	○	○	○	○	○	○
27. I easily grasp what is going on	○	○	○	○	○	○	○
28. I get things done	○	○	○	○	○	○	○
29. I praise people for their achievements	○	○	○	○	○	○	○
30. I approach people with warmth and acceptance	○	○	○	○	○	○	○
31. I have aspirations for the future	○	○	○	○	○	○	○
32. I take into account what others think of the situation	○	○	○	○	○	○	○
33. I pay attention to how things have developed over time	○	○	○	○	○	○	○
34. I'm satisfied with quick fixes when in a hurry	○	○	○	○	○	○	○
35. When facing hard times, I remember the good things I have	○	○	○	○	○	○	○
36. I keep both the details and the big picture in mind	○	○	○	○	○	○	○
37. I make strong efforts to grow as a person	○	○	○	○	○	○	○
38. I am willing to take advice	○	○	○	○	○	○	○
39. I have a positive outlook on the future	○	○	○	○	○	○	○
40. I'm able to keep disturbing thoughts out of my mind	○	○	○	○	○	○	○
41. When people hurt me, I hurt them back in turn	○	○	○	○	○	○	○
42. I consider the overall context when I act	○	○	○	○	○	○	○
43. I sense how other people feel	○	○	○	○	○	○	○
44. I have a narrow perspective on things	○	○	○	○	○	○	○
45. I bring out the best in others	○	○	○	○	○	○	○
46. I let problems in my surroundings get me down	○	○	○	○	○	○	○
47. I explain away my mistakes	○	○	○	○	○	○	○
48. I pay attention to how my presence affects a situation	○	○	○	○	○	○	○
49. I tend to reject new things	○	○	○	○	○	○	○
50. I pay attention to what drives my behaviour	○	○	○	○	○	○	○
51. Long-term goals steer my actions	○	○	○	○	○	○	○
52. I am able to control my emotional reactions	○	○	○	○	○	○	○
53. I take into account that achieving good results can take time	○	○	○	○	○	○	○
54. I am easily approachable	○	○	○	○	○	○	○
55. I successfully manage problematic situations	○	○	○	○	○	○	○
56. I easily find the same wavelength with people	○	○	○	○	○	○	○

	never	very seldom	seldom	some-times	often	very often	always
57. I keep my cool even when situations are not under control	○	○	○	○	○	○	○
58. I quickly get a sense of what matters	○	○	○	○	○	○	○
59. I look for new approaches	○	○	○	○	○	○	○
60. I know what is truly important in my life	○	○	○	○	○	○	○
61. I get frustrated when things don't go my way	○	○	○	○	○	○	○
62. I am a very positive person	○	○	○	○	○	○	○
63. I form a rich overall picture of situations	○	○	○	○	○	○	○
64. I think about the consequences of my actions	○	○	○	○	○	○	○
65. I'm concerned about things not working out	○	○	○	○	○	○	○
66. I keep in mind that my understanding of the situation can be insufficient	○	○	○	○	○	○	○
67. I make people feel appreciated	○	○	○	○	○	○	○
68. I let other people have a voice	○	○	○	○	○	○	○
69. I follow my values in my everyday life	○	○	○	○	○	○	○
70. I find it important to understand how things relate to each other	○	○	○	○	○	○	○
71. I am fair and generous with people from all walks of life	○	○	○	○	○	○	○
72. I get a sense of what is essential in a given situation	○	○	○	○	○	○	○
73. I allow myself to act in ways I disapprove of in others	○	○	○	○	○	○	○
74. I read social situations well	○	○	○	○	○	○	○
75. I try to improve my behaviours	○	○	○	○	○	○	○
76. I'm afraid of changes	○	○	○	○	○	○	○

Personal information

These questions are optional and do not affect your results. This information is used in our research in developing this test further. All this data will remain anonymous.

Gender ○ Female ○ Male ○ No answer

Age ○ 15 or under ○ 16-20 ○ 21-25 ○ 26-30 ○ 31-35 ○ 36-45 ○ 46-55 ○ 56-65 ○ over 65

Position ○ Professional ○ Upper management ○ Middle management ○ Student ○ Other

By sending your answers you consent to letting us use them in our studies.