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Development of short forms of the Empathy Quotient (EQ-Short) and the Systemizing Quotient (SQ-Short)

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Abstract

The empathizing–systemizing (E–S) theory has been tested using the Empathy Quotient (EQ) and the Systemizing Quotient (SQ). The present study tested $n = 1761$ students with these instruments, to determine if short versions of these scales could be constructed. This would be desirable both for faster assessment and to establish which are the key items on each scale. Principal component analysis and factor analysis suggested that a 22-item version of the EQ (EQ-Short) and a 25-item version of the SQ (SQ-Short) were highly correlated with the full scale versions. The reliability of each short scale was reasonable. Results showed that females scored significantly higher than males on the EQ-Short, whilst males scored higher than females on the SQ-Short. Additionally, scores were analyzed according to the degree the student was studying. On the EQ-Short, students studying humanities scored higher than students studying sciences, whereas on the SQ-Short, the results were the opposite. Finally, distributions of the population who showed 'brain types' based on the scores on two scales were examined. The pattern of distribution of the brain types was

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consistent with the E–S theory. These results suggest that the EQ-Short and SQ-Short are useful instruments for measuring fundamental cognitive styles.

Keywords: Empathizing; Systemizing; E–S theory; EQ-Short; SQ-Short; Cognitive style

1. Introduction

1.1. The empathizing–systemizing theory

Understanding (*intentional*) agency and non-agentive (*causal*) events are two fundamental aspects of human cognition (Baron-Cohen, 1997; Leslie, 1994; Premack, 1995; Tomasello, 1999). Baron-Cohen's (2002) Empathizing–Systemizing (E–S) theory consists of two psychological dimensions. This theory was developed from the folk psychology–folk physics model. The concept of empathizing extends the scope of folk-psychology, or theory of mind, by including an emotional response dimension. Similarly, the concept of systemizing includes a wider range of systems, such as *mechanical* (e.g., machines), *abstract* (e.g., mathematics), and *organizable* (e.g., taxonomy). Empathizing is used for making sense of an agent's behaviour, and systemizing is mostly used for predicting the behaviour of non-agentive events or objects. Empathizing is defined as the drive to identify emotions and thoughts in others and to respond to these with an appropriate emotion. Systemizing refers to the drive to construct systems, to predict the behaviour of a system, and to control it. According to the E–S theory, there are individual differences in both empathizing and systemizing. For example, sex differences are found in empathizing (stronger in females) and systemizing (stronger in males). A growing body of evidence suggests males spontaneously systemize to a greater degree than do females, whilst females spontaneously empathize to greater degree than do males (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003; Lawson, Baron-Cohen, & Wheelwright, 2004).

1.2. The Empathy Quotient (EQ) and the Systemizing Quotient (SQ)

The Empathy Quotient (EQ) and the Systemizing Quotient (SQ) were constructed as instruments to test the E–S theory (Baron-Cohen et al., 2003; Baron-Cohen & Wheelwright, 2004). The EQ was developed as a new measure of empathy because previous instruments that purport to measure empathy only tap part of empathy. Empathy has an affective component (feeling an appropriate emotion triggered by another's emotion), a cognitive component (understanding and/or predicting what someone else might think, feel, or do), and a mixed component (cognitive and affective). The SQ was constructed by using examples from everyday life in which systemizing is involved. The assumption was that a high systemizer would be drawn to use their systemizing skills across the range of domains more often than a low systemizer. Systemizing involves analysing the rules of a system and monitoring input–operation–output relations (e.g., If I do A, X occurs).

The E–S theory plots empathizing and systemizing as two-dimensional coordinates. Baron-Cohen et al. (2003) used the terms "brain types" to describe the three basic cognitive types generated from this. Individuals in whom empathizing is at a higher level than their systemizing

are referred to as having a brain of type E (the Empathizing brain type: E > S). Individuals in whom systemizing is at a higher level than their empathizing are said to have a brain of type S (the Systemizing brain type: S > E). Individuals in whom empathizing and systemizing are equally balanced are said to be type B (the Balanced brain type: E = S). These brain types are cognitive styles. On average, more males than females have a brain of type S, and more females than males have a brain of type E (Goldenfeld, Baron-Cohen, & Wheelwright, in press). Evidence supporting these sex differences in the E–S theory includes the findings that mathematics, physics and engineering (which all require a high degree of systemizing) are largely male in sex ratio (Benbow, 1988; Geary, 1996), and that women are better at decoding non-verbal communication, picking up subtle nuances from tone of voice or facial expression, or judging a person's character (Hall, 1978). However, a fundamental problem is that, it is not clear whether all items in each scale are needed to measure the hypothesized two constructs.

The aims of the present study are: (1) To examine the psychometric properties of the EQ and SQ as instruments. (2) To produce Short versions of the EQ and SQ to improve their reliability, based on item analyses, and to compare the Short versions with the original scales. (3) To test if the EQ-Short is independent of the SQ-Short. (4) To examine sex differences and the differences between students in the humanities and sciences on the E–S theory. (5) To test hypotheses about the postulated types of brain, using the Short versions of the scales.

2. Method

2.1. Participants

Participants consisted of 1761 students of Cambridge University, comprising 723 males and 1038 females. Their mean age was 21.0 years (SD = 2.58, range = 18.2–26.3). They were recruited via several routes including e-mail, post, newspaper adverts and notices around the university. An incentive to participate was offered, in that everyone who completed all questionnaires was entered into a draw to win a prize. Only participants who replied to all items were included in the final analysis. Participants indicated their undergraduate degree subject and these were classified as sciences and humanities.

2.2. Procedure

All participants completed the EQ and SQ online, using a custom-designed website. After registering on the website and providing basic information, such as sex, age and their degree/area of study, participants were invited to fill in the two questionnaires. For each questionnaire, participants were instructed to read each statement carefully and judge how strongly they agreed or disagreed by selecting the appropriate option of each item.

2.3. Instruments

The EQ and SQ have a forced-choice format, and are self-administered. Both the EQ and SQ comprise 60 questions, 40 assessing empathizing or systemizing respectively, and 20 filler items.

Approximately, half the items are worded to produce a "disagree" response, and half an "agree" response, and items are randomized to avoid a response bias. An individual scores two points if they strongly display a systemizing/empathizing response, and one point if they slightly display a systemizing/empathizing response (i.e., each item being scored 2, 1, 0, 0) (Baron-Cohen et al., 2003; Baron-Cohen & Wheelwright, 2004).

3. Results

3.1. Psychometric properties of the original 40-item EQ and SQ

The *mean* EQ scores and *mean* SQ scores and their SDs of the participants are shown in Table 1. The *skewnesses* and *kurtosis* were calculated. On the EQ, *skewness* = −0.149 and *kurtosis* = −0.284. On the SQ, *skewness* = 0.426 and *kurtosis* = −0.081. Pearson's product moment correlation coefficients between EQ score and SQ score was $r = -0.17$ ($p < 0.01$). To examine the internal consistency of the EQ and SQ, Cronbach's alphas were calculated, these being 0.884 for the EQ and 0.881 for the SQ.

3.2. Constructing the short versions of the EQ and SQ

It is unclear whether all items in each scale are needed to measure the hypothesized two constructs. No statistical item analyses for each scale were reported in the earlier studies using the EQ and SQ, so the two scales might contain some unnecessary items. Therefore, we carried out multivariate analyses on the two scales to confirm their factorial consistency, and to construct short versions of the EQ and SQ to measure each cognitive style.

First, we applied a principal component analysis to both scales, because the EQ and SQ were originally conceptualized as being independent of each other. For the EQ the scree plot suggested that the EQ scale consisted of one-component (Eigenvalues were 8.46, 3.01, and 1.96) but the first principal component showed that 22 of 40 items loaded above 0.40. In the SQ, the scree plot also suggested one-component (Eigenvalues were 7.92, 2.54, and 1.82), and the first component showed that 25 of 40 items loaded above 0.40 (see Table 2). The internal consistencies (Cronbach's alpha) of these high loaded items were 0.90 in the EQ (22 items) and 0.89 in the SQ (25 items).

In order to confirm the validities of these high loaded items as the Short versions of the EQ and SQ, the correlations between original 40-item versions of the EQ/SQ and the EQ-Short/SQ-Short were calculated. The correlations between scores on the 40-item EQ and the 22-item EQ-Short was $r = 0.93$ ($r = 0.93$ in males, and $r = 0.93$ in females). The correlation between scores in the 40-item SQ and the 25-item SQ-Short was $r = 0.95$ ($r = 0.94$ in males, and $r = 0.95$ in females).

Table 1
Mean scores (and SDs) of the EQ and SQ in original items

	N	EQ	SQ
All participants	1761	44.3 (12.23)	27.5 (12.43)
Males	723	39.0 (11.56)	33.1 (11.78)
Females	1038	48.0 (11.28)	23.7 (11.37)

Table 2
Loadings of PCA of the EQ and SQ

EQ-item	Loadings	SQ-item	Loadings
34	*0.751*	*8*	*0.736*
14	*0.711*	*10*	*0.642*
22	*0.702*	*22*	*0.623*
28	*0.642*	*12*	*0.602*
36	*0.634*	*3*	*0.599*
15	*0.633*	*39*	*0.588*
35	*0.613*	*5*	*0.584*
13	*0.605*	*14*	*0.580*
26	*0.582*	*35*	*0.568*
12	*0.579*	*34*	*0.558*
29	*0.566*	*25*	*0.554*
1	*0.557*	*6*	*0.530*
11	*0.552*	*27*	*0.523*
38	*0.534*	*23*	*0.508*
31	*0.517*	*28*	*0.504*
4	*0.505*	*30*	*0.490*
8	*0.505*	*21*	*0.483*
9	*0.460*	*32*	*0.480*
3	*0.449*	*9*	*0.479*
18	*0.448*	*16*	*0.443*
21	*0.427*	*20*	*0.434*
39	*0.419*	*37*	*0.416*
7	0.377	*33*	*0.412*
20	0.364	*7*	*0.410*
27	0.359	*24*	*0.410*
19	0.329	25	0.340
33	0.327	15	0.328
32	0.312	38	0.317
40	0.306	36	0.309
16	0.296	13	0.277
30	0.269	11	0.260
2	0.264	1	0.254
5	0.253	2	0.232
24	0.249	29	0.215
23	0.226	40	0.191
17	0.166	4	0.145
10	0.156	26	0.128
37	0.137	12	0.102
25	0.112	17	0.100
6	0.042	31	0.051

The items of the EQ-Short and SQ-Short were shown in italics.

We administered a factor analysis by combining the original EQ and SQ (80 items) to confirm the validity and the independence of the two scales. A principal factor analysis was carried out on the inter item correlation matrix obtained from 1761 students' responses to the 80 items. The result of the initial factor analysis revealed that three factors had Eigenvalues greater than one.

However, the scree plot showed that the two factor solution was adequate (Eigenvalues: Factor I was 7.88, Factor II was 5.65, and Factor III was 1.31). The result of the Varimax rotated two-factor solution showed that the highly loaded items of each factor were identical with the items of each short version. These items are shown in Table 3.

The *mean* EQ-Short scores and *mean* SQ-Short scores and their SDs of the participants are shown in Table 4. The *skewnesses* and *kurtosis* of them were calculated. On the EQ-Short, *skewness* = −0.110 and *kurtosis* = −0.448. On the SQ-Short, *skewness* = 0.364 and *kurtosis* = −0.536. These results suggest the score distributions of the two scales are not skewed, and the kurtoses show that the distributions are slightly platykurtic but not problematic. Pearson's product moment correlation coefficients between EQ-Short and SQ-Short was $r = -0.15$ ($p < 0.01$) ($r = 0.03$, $p =$ n.s. in males and $r = -0.07$, $p < 0.05$ in females).

3.3. Investigating the E–S theory using the EQ-Short and SQ-Short

The results obtained in multivariate analyses and internal consistencies suggest that the EQ-Short and the SQ-Short are reliable and adequate to measure individual differences in empathizing and systemizing.

In addition to testing for sex differences, we analyzed the results according to degree/area of study to compare students studying humanities vs. sciences, using definitions from earlier studies (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Wakabayashi, Baron-Cohen, Wheelwright, & Tojo, in press) in order to examine the validity of the E–S theory.[1]

Mean EQ-Short and SQ-Short scores for each degree type are also shown in Table 4. Comparing groups using an ANOVA on the EQ-Short score by Sex and Degree, there was a main effect of Sex ($F(1,1757) = 177.623$, $p < 0.001$), females scoring higher than males. There was also a main effect of Degree ($F(1,1757) = 53.669$, $p < 0.001$), the students studying humanities scoring higher than the students studying sciences. There was no Degree by Sex interaction. Similarly, comparing groups using an ANOVA on the SQ-Short by Sex and Degree, there was a main effect of Sex ($F(1,1757) = 472.649$, $p < 0.001$), males scoring higher than females. There was again a main effect of Degree ($F(1,1757) = 388.156$, $p < 0.001$), the sciences students scoring higher than the humanities students. There was no interaction of Sex by Degree on the SQ-Short.

3.4. Brain types

Finally, we examined the differences of numbers in each 'brain type' in terms of males and females, and humanities vs. science students. We transformed the raw EQ-Short and SQ-Short scores from each participant into standard (T) scores. Then we subtracted the standard EQ-Short (T) score from the standard SQ-Short (T) score for each participant. We call this difference score

[1] Sciences included Physical Sciences (mathematics, physics, chemistry, computer science, engineering, etc.) and Biological Sciences (biology, neuroscience, physiology, medicine, genetics, pharmacology, etc.). Humanities included Humanities (classics, languages, education, law, history, philosophy, etc.) and Social Sciences (economics, commerce, social and political sciences, archaeology, etc.). We acknowledge that some Humanities (such as law or linguistics) or Social Sciences (such as economics) involve more systemizing than others, but these ways of dividing degree subjects may still capture some important differences between the highly lawful physical sciences and less lawful domains.

Table 3
Rotated factor loadings of the items in the EQ-Short and SQ-Short

Item	Factor I	Factor II
EQ 1	**0.564**	0.082
EQ 3	**0.441**	−0.097
EQ 4	**0.509**	0.030
EQ 8	**0.499**	−0.028
EQ 9	**0.459**	−0.003
EQ11	**0.567**	0.104
EQ12	**0.566**	−0.150
EQ13	**0.603**	−0.028
EQ14	**0.711**	−0.022
EQ15	**0.639**	0.036
EQ18	**0.434**	−0.082
EQ21	**0.429**	0.040
EQ22	**0.705**	−0.014
EQ26	**0.594**	0.118
EQ28	**0.641**	−0.043
EQ29	**0.576**	0.077
EQ31	**0.499**	−0.115
EQ34	**0.754**	0.006
EQ35	**0.617**	0.005
EQ36	**0.644**	0.042
EQ38	**0.541**	0.121
EQ39	**0.406**	−0.167
SQ 3	−0.027	**0.601**
SQ 5	−0.161	**0.567**
SQ 6	−0.142	**0.507**
SQ 7	−0.091	**0.406**
SQ 8	−0.224	**0.702**
SQ 9	−0.159	**0.451**
SQ10	−0.060	**0.634**
SQ12	−0.122	**0.587**
SQ14	−0.091	**0.570**
SQ16	0.007	**0.446**
SQ20	0.057	**0.448**
SQ21	−0.074	**0.463**
SQ22	−0.062	**0.615**
SQ23	−0.145	**0.491**
SQ24	0.107	**0.420**
SQ25	−0.080	**0.544**
SQ27	−0.045	**0.524**
SQ28	−0.109	**0.492**
SQ30	0.011	**0.492**
SQ32	0.001	**0.477**
SQ33	−0.026	**0.404**
SQ34	−0.063	**0.556**
SQ35	−0.117	**0.548**
SQ37	−0.019	**0.407**
SQ39	−0.140	**0.564**
Cont.	8.747	8.213

Table 4
Mean scores (and SDs) of the EQ-Short and SQ-Short

Group	*N*	EQ-Short	SQ-Short
All participants	1761	23.8 (8.75)	19.0 (10.05)
Males	723	20.7 (8.46)	24.1 (9.55)
Females	1038	26.0 (8.27)	15.4 (8.77)
Humanities	867	25.3 (8.32)	15.0 (8.84)
Sciences	894	22.4 (8.92)	22.8 (9.68)

Males: 304 Humanities and 419 Sciences; Females: 563 Humanities and 475 Sciences.

Table 5
The distribution of the five cognitive styles (brain types) (%)

	Extreme Type E	Type E	Type B	Type S	Extreme Type S
Males	1.4	5.8	45.9	24.1	22.8
Females	15.4	25.9	46.6	8.5	3.6
Humanities	14.8	22.8	49.7	9.5	3.2
Sciences	4.7	12.6	43.1	20.1	19.5

'*D*'. A high *D* score can be attained either by a high SQ-Short score with a low EQ-Short score, or vice versa. A low *D* score means the difference between scores in the EQ-Short and SQ-Short is small. The greater the *D* score in a positive direction, the stronger is one's systemizing, and the greater the *D* score in a negative direction, the stronger one's empathizing.

A *D* score falling below ± 10 ($-10 < D < 10$: within ± 1 SD) is termed a brain of type B (Balanced brain), from 10 to below 20 ($10 < D < 20$) is type S, and 20 and over ($D > 20$) is the *extreme* type S. A *D* score falling from -10 to above -20 ($-10 > D > -20$) is a brain of type E, and -20 and below ($D < -20$) is an *extreme* type E. The percentages of participants fitting each brain type are shown in Table 5.

The distribution of *extreme* type E and type E was greater in females than in males, whilst the proportion of *extreme* type S and type S was greater in males than in females. The proportion of *extreme* type E and type E were greater in students studying humanities than among students studying science, whilst the proportion of *extreme* type S and type S were greater in sciences students than those studying humanities. These results were confirmed by a chi-square by sex ($\chi^2 = 46.131$, df = 4, $p < 0.001$), and by degree ($\chi^2 = 24.203$, df = 4, $p < 0.001$).

4. Discussion

In this study, we examined the psychometric properties of the EQ and SQ, and shortened the scales in order to reduce them to their essential items. Then, we tested the E–S theory of sex differences (Baron-Cohen, 2002) using the Short EQ (EQ-Short) and SQ (SQ-Short). Results of principal component analyses suggested that about half the items were sufficient to measure empathizing and systemizing. The EQ-Short and SQ-Short were therefore constructed from 22 items

and 25 items, respectively. The internal consistency of each scale rose compared with their original 40-item scales, suggesting that the original scales contained some unnecessary items. The result of factor analysis by combining the EQ-Short and SQ-Short revealed that two factors corresponding to the empathizing and systemizing, and confirmed their independence.

As predicted by the E–S theory, females scored significantly higher than males on the EQ-Short, and males scored significantly higher than females on the SQ-Short. This replicates other studies using the EQ and SQ (Baron-Cohen et al., 2003; Lawson et al., 2004). Regarding area of study, students in the humanities scored higher than students in the sciences on the EQ-Short, and reverse was shown on the SQ-Short. Although the EQ-Short and SQ-Short were inversely correlated ($r = -0.15$), the size of the correlation coefficient was very low, suggesting the two scales are almost independent of each other. In support of this view, the correlations between the two scales calculated in males and females separately were close to zero ($r = 0.03$ in males, and $r = -0.07$ in females). However, there may be some trade-off between these two cognitive styles. This is suggested from the results comparing the degrees of the students. Students in the humanities scored significantly higher on the EQ-Short, and significantly lower on the SQ-Short, compared with the students in the sciences.

There were also clear sex differences, and effects of degree type, on the 5 brain types. 41% of females showed type E or *extreme* type E and 12% of females showed type S or *extreme* type S. In contrast, 47% of males showed types S or *extreme* type S whilst about 7% of males showed types E or extreme type E. 38% of humanities students showed types E or *extreme* type E and 13% of them showed types S or *extreme* type S. In contrast, 17% of science students studying sciences showed types E or *extreme* type E, and 40% of them showed types S or *extreme* type S. These patterns of distribution are very similar to those found in the original EQ and SQ (Goldenfeld et al., in press).

It might be suggested that empathizing overlaps with "emotional intelligence" and shares large parts of variance with this concept, and systemizing relates to the mental capacity of reasoning as measured by many intelligence tests. However, the SQ is uncorrelated with the Raven's Matrices as an index of IQ (Billington, Wheelwright, Baron-Cohen, Parekh, & Hoxley, submitted for publication). We plan to test the relationship between the EQ and emotional intelligence measures in future studies.

This study confirms there are important individual differences in cognitive style. Future studies will need to test the external validity of the EQ and SQ, such as the relation between the SQ and mathematical ability or mental rotation and between the EQ and theory of mind tasks. These studies are underway in our lab. We conclude that the EQ-Short and the SQ-Short are useful methods for testing such individual differences in cognitive styles.

Finally, some limitations remain. This study was conducted with university students, who may not be a representative sample. It will need further investigation in different populations. Against this, previous studies have found no significant difference between EQ and SQ among students and non-students (Baron-Cohen et al., 2003). A more significant limitation is that these measures are self-report, and it is not yet clear how self-report of empathizing or systemizing relate to actual performance. The fact that the SQ and SQ-Short correlates well with area of study (such as maths, physics and engineering students scoring higher on the SQ than is found among students in other subjects, and these three areas require high systemizing skill) suggests that SQ may be a good indicator of systemizing skill. But empathy is by definition a skill where an individual low empathy may

be unaware of their limitations, unless others give them feedback. Despite these concerns, the instruments may be useful as screening instruments for identifying individuals who lie at different points on the empathy and systemizing spectra, and for understanding underlying neural mechanisms.

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Appendix. List of items of EQ-Short and SQ-Short

Empathy Quotient

1. I can easily tell if someone else wants to enter a conversation.
3. I really enjoy caring for other people.
4. I find it hard to know what to do in a social situation.[a]
8. I often find it difficult to judge if something is rude or polite.[a]
9. In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking.[a]
11. I can pick up quickly if someone says one thing but means another.
12. It is hard for me to see why some things upset people so much.[a]
13. I find it easy to put myself in somebody else's shoes.
14. I am good at predicting how someone will feel.
15. I am quick to spot when someone in a group is feeling awkward or uncomfortable.
18. I can't always see why someone should have felt offended by a remark.[a]
21. I don't tend to find social situations confusing.
22. Other people tell me I am good at understanding how they are feeling and what they are thinking.
26. I can easily tell if someone else is interested or bored with what I am saying.
28. Friends usually talk to me about their problems as they say that I am very understanding.
29. I can sense if I am intruding, even if the other person doesn't tell me.
31. Other people often say that I am insensitive, though I don't always see why.[a]
34. I can tune into how someone else feels rapidly and intuitively.
35. I can easily work out what another person might want to talk about.
36. I can tell if someone is masking their true emotion.
38. I am good at predicting what someone will do.
39. I tend to get emotionally involved with a friend's problems.

Systemizing Quotient

3. If I were buying a car, I would want to obtain specific information about its engine capacity.
5. If there was a problem with the electrical wiring in my home, I'd be able to fix it myself.

Appendix (*continued*)

6. I rarely read articles or web pages about new technology.[a]
7. I do not enjoy games that involve a high degree of strategy.[a]
8. I am fascinated by how machines work.
9. In math, I am intrigued by the rules and patterns governing numbers.
10. I find it difficult to understand instruction manuals for putting appliances together.[a]
12. If I were buying a computer, I would want to know exact details about its hard disc drive capacity and processor speed.
14. I find it difficult to read and understand maps.[a]
16. When I look at a piece of furniture, I do not notice the details of how it was constructed.[a]
20. I find it difficult to learn my way around a new city.[a]
21. I do not tend to watch science documentaries on television or read articles about science and nature.[a]
22. If I were buying a stereo, I would want to know about its precise technical features.
23. I find it easy to grasp exactly how odds work in betting.
24. I am not very meticulous when I carry out D.I.Y.[a]
25. When I look at a building, I am curious about the precise way it was constructed.
27. I find it difficult to understand information the bank sends me on different investment and saving systems.[a]
28. When travelling by train, I often wonder exactly how the rail networks are coordinated.
30. If I were buying a camera, I would not look carefully into the quality of the lens.[a]
32. When I hear the weather forecast, I am not very interested in the meteorological patterns.[a]
33. When I look at a mountain, I think about how precisely it was formed.
34. I can easily visualize how the motorways in my region link up.
35. When I'm in a plane, I do not think about the aerodynamics.[a]
37. I am interested in knowing the path a river takes from its source to the sea.
39. I am not interested in understanding how wireless communication works.[a]

Nos. of items are in original versions.
[a] Reversal items.

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