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| Author           | 敷島, 千鶴(Shikishima, Chizuru)<br>山形, 伸二(Yamagata, Shinji)<br>平石, 界(Hiraishi, Kai)<br>安藤, 寿康(Ando, Juko)   |
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# 17 Development of a Simple Test of Syllogism Solving

*Chizuru Shikishima<sup>1</sup>, Shinji Yamagata<sup>2,3</sup>,  
Kai Hiraishi<sup>4</sup>, and Juko Ando<sup>3</sup>*

<sup>1</sup> Keio Advanced Research Centers, Keio University

<sup>2</sup> Japan Society for the Promotion of Science

<sup>3</sup> Faculty of Letters, Keio University

<sup>4</sup> Kokoro Research Center, Kyoto University

## I. Introduction

Syllogisms are a form of logical deductive argument relating three terms in two premises and a conclusion. The syllogism was first described by Aristotle in 350 B.C. in his *Prior Analytics* (Bochenski, 1970). An example of a classic syllogism given by Aristotle is the following.

*If all humans are mortal,  
and all Greeks are humans,  
then all Greeks are mortal.*

Here, the three terms are “humans”, “mortal”, and “Greeks”. Two premises are “*All humans are mortal*” and “*All Greeks are humans*”; the conclusion is “*All Greeks are mortal.*”

Since the time of Aristotle, speaking and thinking in a logical fashion have been considered evidence of intelligence. Particularly in the fields of logic and philosophy, the deductive reasoning ability expressed in syllogisms has been regarded as a fundamental form of human thinking. Therefore, the comprehension and use of syllogisms are widely regarded as symbolic of human intelligence.

Consequently, in an effort to measure syllogistic reasoning ability as a psychometric tool, we have been developing an original measure, designated as the

*BAROCO* series. Repeated revisions of the *BAROCO* test, with administration to more than 1000 adults, eventually produced *BAROCO* II.3, which consists of 100 problems with various levels of difficulty in syllogistic deductive reasoning. Details of the developmental process of the *BAROCO* series are explained elsewhere (Ando, Shikishima, Hiraishi, Takemura, Sugimoto, & Okada, 2007).

We earlier reported administration of the *BAROCO* II.3 and a full-scale intelligence test in a group test design to 220 pairs of Japanese young adult twins (age 17–36). Results showed that logical deductive reasoning ability—as measured by syllogism solving—indicated human general intelligence ( $g$ ), with verbal and spatial abilities as measured using the intelligence test (Shikishima, Hiraishi, Yamagata, Sugimoto, Takemura, Ozaki, Okada, Toda, & Ando, 2009). Results clearly demonstrated that syllogism solving is an excellent index of  $g$ .

Unfortunately, the inconvenience of administering and solving 100 syllogism problems in a group test design might render the index inaccessible for many investigations. Considering the background explained thus far, this study is designed to develop a greatly shortened version of a syllogism-solving test, namely *BAROCO short*, and to examine its reliability and validity as a simple predictor of  $g$ .

If *BAROCO short* accurately assesses  $g$ , then the following would be true.

- i) The mean score changes according to age.

Results of previous studies have shown that the peak of the fluid ability,  $G_f$ , is reached in a person's twenties, although the crystallized ability,  $G_c$ , continues to develop (Horn and Hofer, 1992). In either case, as long as *BAROCO short* measures  $g$ , the curve representing the mean level change with age is expected to appear.

- ii) The genetic effect increases, although the shared environmental effect decreases during progress from adolescence to adulthood.

This is a robust finding from many previous studies in the West that have been reported in the literature (e.g. McGue, Bouchard, Iacono, & Lykken, 1993).

The validity of the shortened version of syllogism test, *BAROCO short*, was examined by testing these hypotheses.

## II. Method

### 1. Materials

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We have strived to develop the *BAROCO short*, which measures human intelligence effectively, and which can be conducted readily and simply at home.

One advantage of syllogism tests is that the correct answer of syllogism problems cannot easily be referred. In other words, respondents cannot cheat on them as easily as they might on verbal or numerical tests, for which correct answers are easily accessible at home without supervision.

We selected five syllogism problems that best predicted full IQ scores from the *BAROCO* II.3, and used the total scores of 0–5. The correlation between the factor score of 100 problems of the *BAROCO* II.3 and the five problems of the *BAROCO short* was .84.

*Some parrots are Babaros.*

*No Babaros are birds.*

Following the two premises above, respondents were required to choose the most appropriate answer from the five alternatives presented below.

1. Some parrots are birds.
2. All parrots are birds.
3. Some parrots are not birds.
4. No parrots are birds.
5. No valid conclusion.

This is the syllogism problem that explained the full IQ score best (correlation with IQ:  $r = .41$ ). The top five problems explained 33% of full IQ scores.

## 2. Participant

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We included these five syllogism problems in a questionnaire with an instruction of “Please answer each problem within 1 min.” The questionnaires were sent by post as part of a postal survey conducted by the Keio Twin Research Center (KoTreC). They were sent to a randomly selected 35% of all Japanese junior high or high school twin students living in the Tokyo area. Questionnaires for their parents were also included for every twin pair. The response rate in terms of family participation was 23.4%.

Data were collected from 487 pairs of twins (1021 individuals) who comprise 98 male and 151 female identical (MZ) pairs: 63 male, 67 female, and 108 male–female fraternal (DZ) pairs aged 13–18 ( $M=15.3$ ), and from 536 mothers (age 34–62:  $M=46.2$ ) and 431 fathers (age 36–68:  $M=48.7$ ). The participants were 1988 individuals.

III. Results

1. Internal Reliability

The internal reliability of the scale, Cronbach’s  $\alpha$ , was .64 for children, .61 for mothers, .58 for fathers, and .63 for all participants. In fact, we did not select the five problems out of 100 of the *BAROCO* full version for their internal consistency, but rather for their high correlation with IQ scores. It might be necessary to add another few problems to support the scale’s reliability.

However, principal component analysis for the five problems showed a clear one-component solution (Table 1).

Table 1. Principal Component Analysis

| Problem            | Component |
|--------------------|-----------|
|                    | 1         |
| 1                  | .62       |
| 2                  | .60       |
| 3                  | .75       |
| 4                  | .64       |
| 5                  | .58       |
| Eigenvalue         | 2.1       |
| Variance explained | 41%       |

2. Construct Validity

Figure 1 presents the mean level of the total score of the *BAROCO short* according to age. For age 13–18, which is the twin children’s age, the score increases gradually. After reaching one’s 30s, which is the parents’ age, the score increases gradually. It later decreases gradually after the late 50s.

If the score represents the fluid ability, then it should decrease after one’s 20s. Results of our previous study imply that syllogistic reasoning ability equivalently accounts for  $G_f$  and  $G_c$  (Shikishima, Ando, Grialou, Takemura, & Okada, 2005). This curve is plausible if such is the case.

Regarding the second hypothesis, first, the resemblance of identical (MZ) twins and fraternal (DZ) twins was compared by dividing the twins by age into three categories: 13–14 years old, 15–16 years old, and 17–18 years old.

Figure 2 shows that although DZ twins’ correlations are stable across ages, the MZ twins’ correlations increase as children grow up, which reflects the increasing

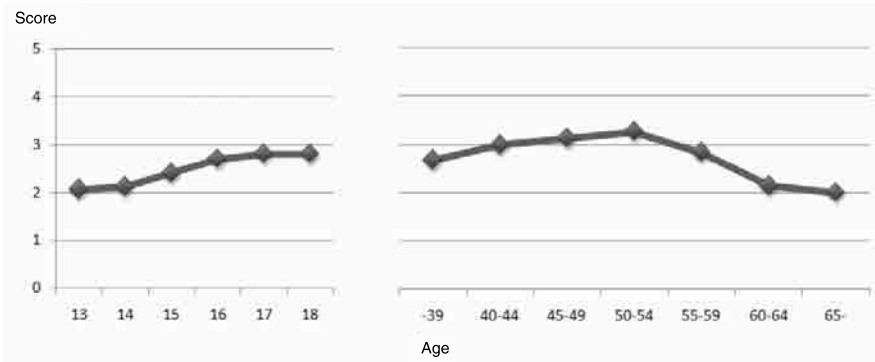


Figure 1. Mean score change according to age.

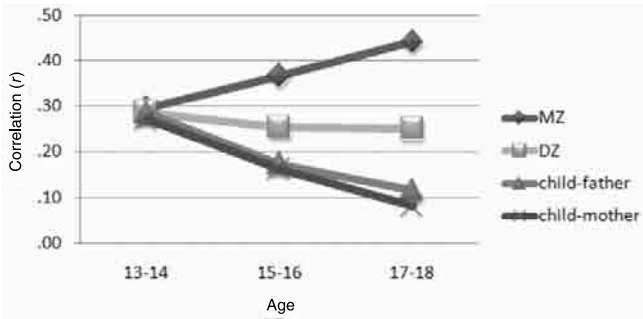


Figure 2. Intrafamily correlation

influence of genetics from early adolescence to late adolescence.

The respective correlations between children and fathers and between children and mothers also clearly indicated that at age 13–14, the family resemblance was equivalent, irrespective of the genetic relation. However, older children show less family resemblance, except for MZ children, which implies a substantial decrease in effects of the family environment, especially the environment shared by children and parents.

#### IV. Discussion

Although the findings of this study are preliminary, both hypotheses described earlier herein were supported, which provides some validity of the greatly shortened

version of syllogism test (*BAROCO short*) as a predictor of *g*. Further tests of external validity by analyzing scores with other measurements are necessary to confirm its validity.

It is intriguing that this simple measurement requiring only a simple task measures complex human abilities. At the same time, we might say that because *g* is so pervasive, and because it is observable stably and saliently anywhere, such a simple measurement as ours can assess human mental abilities reliably.

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