# Personality traits, mental abilities and other individual differences: Monozygotic female twins raised apart in South Korea and the United States

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## ARTICLE INFO

## ABSTRACT

Twins reared apart are rare, especially twins raised in different countries and cultures. This report documents the behavioral, physical, and medical similarities and differences of monozygotic female cotwins, raised separately by an adoptive family in the United States and the biological family in South Korea. Similarities were evident in personality, self-esteem, mental health, job satisfaction and medical life history, consistent with genetic influence found by the Minnesota Study of Twins Reared Apart and related studies. An overall twin correlation across thirty-eight measures was $r = 0.95$, $p < .001$. In contrast with previous research, the twins' general intelligence and non-verbal reasoning scores showed some marked differences. Adding these cases to the psychological literature enhances understanding of genetic, cultural, and environmental influences on human development.

## 1. Introduction

Twins reared apart from birth are rare. Cotwins raised by families in separate countries are less common, enhancing their value for individual differences research on psychological traits and health. These pairs are generally included in other reared-apart twin samples, obscuring the cultural/familial effects that may underlie their phenotypic differences. Building an expanding series of cases can yield a sample of such pairs, enabling a search for meaningful trends (Segal, Niculae, Becker, & Shih, 2021).

### 1.1. Present study

This study of monozygotic (MZ) cotwins–one raised by her birth family in South Korea, the other raised by her adoptive family in the United States–adds to the limited literature on twins raised in different countries. The South Korean twin (SK) and the American twin (US) first met in South Korea in September 2021.

### 1.2. Twins' separation and discovery

SK and US were separated due to unusual circumstances. They were born in 1974 in Seoul, South Korea. At age two, their maternal grandmother took them to a market where US was lost. US was later seen wandering alone before being taken to a hospital where she was diagnosed with the measles; the hospital was approximately 100 miles from her family's residence. US then entered a home of a loving foster mother, then transferred to the then Kyong Dong Baby Home in Suwon City. Her case was eventually managed by South Korea's Holt International Adoption Agency whose staff arranged for her adoption by a United States couple. She has no recollection of having been lost. The twins' biological parents circulated flyers in the hope of finding her and appeared on a television program for missing persons.

US submitted a DNA sample in 2018 as part of South Korea's program for reuniting family members. In March 2020, she received a telephone call informing her of a genetic match–her biological mother had been identified in South Korea. During an online meeting in October 2020, US learned that she had not been born on April 25, but on October 8. She also learned that she has a twin, a biological brother four years older and a biological sister two years older.

## 2. Methods

The two investigators from the United States and South Korea, each administered interviews, tests, and questionnaires to the cotwin in her respective county. An exception was the Wechsler Adult Intelligence

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Scale-IV (WAIS-IV), administered to each twin by examiners in the two countries. All standardized scores (T; *M* = 50, *SD* = 10), except for the WAIS-IV, relied on U.S. norms. To estimate cotwin similarity, we computed double-entry intraclass correlations (ICC; Furr, 2010) for all psychological scales except the NEO Five-Factor Inventory-3 (NEO-FFI-3; Costa & McCrae, 2010) that has only five scales. The twins had not met prior to data collection.

### 2.1. Background measures

#### 2.1.1. Zygosity diagnosis
The twins were diagnosed as MZ, given their identity across fifteen DNA markers, analyzed by the HP Bio Company, Seoul, South Korea.

#### 2.1.2. Life history interview
The life history interview administered to Minnesota Study of Twins Reared Apart (MISTRA) participants was completed by US and SK, with modifications. Subjects included separation, adoption, home, residences, education, occupation, marital status, and twin relationship.

### 2.2. Family environment

The twins completed the Family Environment Scale (FES, Moos & Moos, 1986). The FES is a self-report instrument consisting of 90 true-false items describing the individual's perception of family social environments. It includes 10 scales (Cohesion, Expressiveness, Conflict, Independence, Achievement Orientation, Intellectual/Cultural Orientation, Activity/Recreation, Moral/Religious emphasis, Organization, and Control). The internal consistency reliabilities of the 10 scales range from .61–0.78 (Moos & Moos, 1986).

### 2.3. General intelligence/reasoning ability

#### 2.3.1. General Intelligence
The WAIS-IV (Wechsler, 2008) is a widely used general intelligence test that yields scores in Verbal Comprehension (VC), Perceptual Reasoning (PR), Working Memory (WM), Processing Speed (PS), and Full Scale IQ. The WAIS-full scale IQ has a reliability of 0.98 and a test-retest value of 0.96 (Wechsler, 2008). It is available in English and Korean.

#### 2.3.2. Nonverbal reasoning ability
The twins completed a nonverbal reasoning ability test, the Standard Progressive Matrices Plus (SPM; Raven, 2008). The SPM has five sections that become progressively more difficult; each section has 12 matrix items consisting of nonverbal stimuli (visual patterns and shapes). A time limit was not given. The twins' score was based on their number of correct answers with no deduction for incorrect responses. The SPM has been used in diverse populations and shows strong correlations with various intelligence measures (Raven, 2008). The split-half reliability was reported to be 0.94 (Raven, 2008).

### 2.4. Big Five Personality, individualism-collectivism cultural value, and self-esteem

The NEO-FFI-3 was used to assess twins' personality. It consists of 60 items measuring Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, rated on a 5-point Likert scale (Costa & McCrae, 2010). The three-month test-retest reliabilities across the five factors ranged from 0.79–0.83 (Costa & McCrae, 2010).

Twins' individualism-collectivism (IC) cultural values were assessed using the Individualism-Collectivism Scale (Triandis & Gelfland, 1998), shown to have good construct validities (Triandis & Gelfland, 1998). The IC includes 16 items organized into four scales: Vertical Individualism (VI), Horizontal Individualism (HI), Vertical Collectivism (VC), and Horizontal Collectivism (HC). High scorers on VI see the self as fully

autonomous, but accept hierarchy among individuals; high scorers on HI see the self as fully autonomous, and believe that equality between individuals is the ideal; high scorers on VC see the self as a part of a collective and accept hierarchy and inequality within that collective; and high scorers on HC see the self as part of a collective, but perceive that members of that collective are equal. Items are answered on a 9-point Likert scale.

Self-esteem was assessed with the Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1989), that includes 10 items measuring global self-worth. It is used extensively in cross-cultural studies (Schmitt & Allik, 2005). Two-week test-retest reliability ranged from 0.85–0.88 (Rosenberg, 1989). Twins rated items on a 4-point Likert scale.

### 2.5. Mental health

The 11 clinical scales of the Personality Assessment Inventory (PAI; Morey, 2007) were used to assess the twins' adult mental health. The 11 clinical scales are Somatic Complaints, Anxiety, Anxiety-Related Disorders, Depression, Mania, Paranoia, Schizophrenia, Borderline Features, Antisocial Features, Alcohol Problems, and Drug Problems. Twenty-four day test-retest reliabilities ranged from 0.85–0.94 across the 11 scales (Morey, 2007). Twins rated items on a 4-point Likert scale (Morey, 2007).

### 2.6. Job satisfaction

The twins completed the short form of the Minnesota Job Satisfaction Questionnaire (Weiss, Dawis, England, & Lofquist, 1967). The questionnaire includes an "intrinsic" scale measuring personal values and interests affecting job satisfaction, and an "extrinsic" scale measuring external working situations and standards that may affect job satisfaction. An overall satisfaction item asks, "How satisfied are (were) you with this job overall?"

### 2.7. Medical life history

The twins completed a comprehensive medical life history inventory. Categories included past/present hospitalizations, diseases, system reviews, allergies, reproductive history, activity, smoking and medications.

## 3. Results

### 3.1. Life history

#### 3.1.1. US's adoptive family
US was received by her adoptive parents on December 23, 1976, at age two and a half years. Her mother was thirty years old, and her father, was thirty-five. Both parents are Caucasian and had adopted a Caucasian daughter three and a half years older than US. US's mother left school at age sixteen to marry, but completed a General Educational Development degree while US was a child. Her adoptive mother held various jobs during US's childhood, including nursing home staff member, substitute teacher and school cafeteria worker. She most enjoyed working in the school cafeteria given the stability of that position. She was Catholic but became a Baptist due to her husband's religion and raised US in that faith. Religion was of great importance to US's adoptive mother; US attended bible school until middle childhood and attended church more than once each week during elementary school and high school.

US's adoptive father earned a high school diploma before entering the work force. Religion was of great importance to him, and the family regularly attended church services. US's father worked for thirty-three years as a machine operator for the General Electric Company. US's adoptive sister joined the family at age six weeks. She completed one year of college and earned a certificate in administrative secretarial work. She is currently unemployed, but occasionally cleans homes. She

was previously married and delivered four sons, but is now divorced. US's adoptive family members were unavailable.

US is currently single, but in a significant relationship; she married in 2002 and divorced in 2014. She has no children due to fertility issues. US believes she ranked in the top 30% of her high school class. She earned an Associate of Arts degree in paralegal studies, with a grade point average of 3.4, earning summa cum laude. Her favorite school subject was English literature and her least favorite subject was "anything math." She now attends church approximately once per month, preferring non-denominational services.

US had considered attending law school, but her parents could not afford the tuition; however, she attended junior college after winning a scholarship. She has completed programs in computer programming and notary preparation, and volunteers for community-based activities. Since 2010, US has worked as a state government administrator in the division of licensing/protection. Prior to that, she worked as a cashier, front desk attendant and law firm assistant.

### 3.1.2. SK's biological family

SK was raised by her biological parents in a poor urban area. Her father finished high school. Her mother finished elementary school, but in her late sixties attended a school for older adults and earned her middle school degree. Her father managed a store at a Seoul market where her mother sold drinks.

Following high school graduation, SK enjoyed sports activities, and was often selected as a school athlete. She finished a two-year vocational college course in three years where she majored in the Japanese language; she required an extra year to complete the program because of daytime employment. SK considered herself a hard worker during school years, obtaining grades that usually placed her within the top 10% of her classmates. Her favorite subject was Japanese; she did not enjoy mathematics or science.

SK married in 1999 and has two daughters who attend junior and senior high school, respectively. SK's husband finished a two-year vocational college program in engineering. Before marriage, SK helped her parents sell goods in the market, and worked for several shops, but the job was not stable. After marrying, SK earned certificates in cooking, maternity health care and pen handwriting to obtain stable employment. SK also volunteered for community-based activities. Currently, SK is a cook in a childcare center and assists with her husband's business at night. After marriage, SK's husband worked for a company for several

years, then began his own business. Facing bankruptcy, he returned to the company for a while. Currently, he manages a successful restaurant.

The twins' older brother and sister were raised with SK. Their brother finished a four-year college program, earning a pharmacist license. He currently runs a non-pharmacy shop and is married with two children. The twins' sister completed a two-year vocational college program. She is married and a housewife with two children. The twins' biological family members were unavailable.

SK is a Baptist who acquired her faith as an adult; religion is very important to her. She performs many volunteer activities at her church. Neither of SK's parents were religious while she was young, but her mother became a Baptist later in life and accompanies SK to church.

### 3.2. Family environment

SK and US were raised in quite different family environments, indicated by an ICC of 0.05 for the FES scales (Fig. 1). SK's home was rated higher than US's home on all scales except Conflict, Moral-Religious Emphasis, Control and Organization; thus, SK was raised in a more supportive and cohesive family atmosphere where personal growth was encouraged. In contrast, US was raised in a stricter, more religiously-oriented environment with higher levels of family conflict.

### 3.3. General intelligence

The twins differed in IQ by 16 points (US: 84, SK: 100), ten points higher than the mean difference of 6 points reported for MZ twins reared together (Plomin & DeFries, 1980). US and SK's profiles across raw and scaled WAIS-IV IQ subtests and composite scores are displayed (Fig. 2A-2D).

The composite score profiles (Fig. 2D) show that SK was somewhat higher than US in PR and PS. However, their VC and WM sum of scaled scores and composite scores were nearly identical. The ICC across the ten raw subtest scores shows substantial similarity [ICC = 0.76, $p < .001$. 95% CI = 0.41–0.90]. In contrast, the ICC across the scaled subtest scores was considerably less [ICC = 0.13, 95% CI = -1.15–0.65, *ns*], reflecting different norms and reduced variances in scaled scores.

### 3.4. Nonverbal reasoning ability

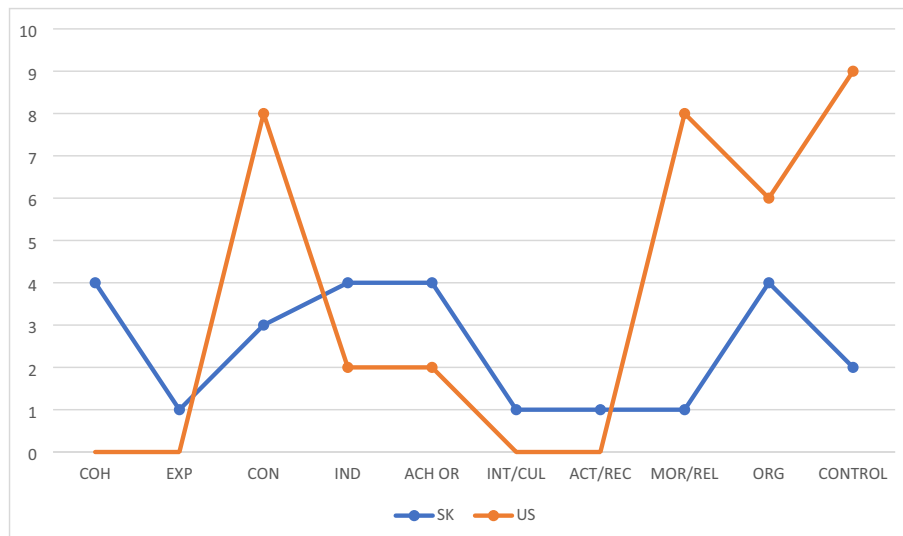US obtained a score of 31 on the SPM. US's testing time was 105 min,



**Fig. 1.** Score profiles of SK and US on the ten Family Environment Scales (FES). COH = Cohesion, EXP = Expressiveness, CON = Conflict, IND = Independence, ACH OR = Achievement Orientation, INT/CUL = Intellectual/Cultural Orientation, ACT/REC = Activity/Recreation, MOR/REL = Moral/Religious emphasis, CONTROL = Organization and Control.
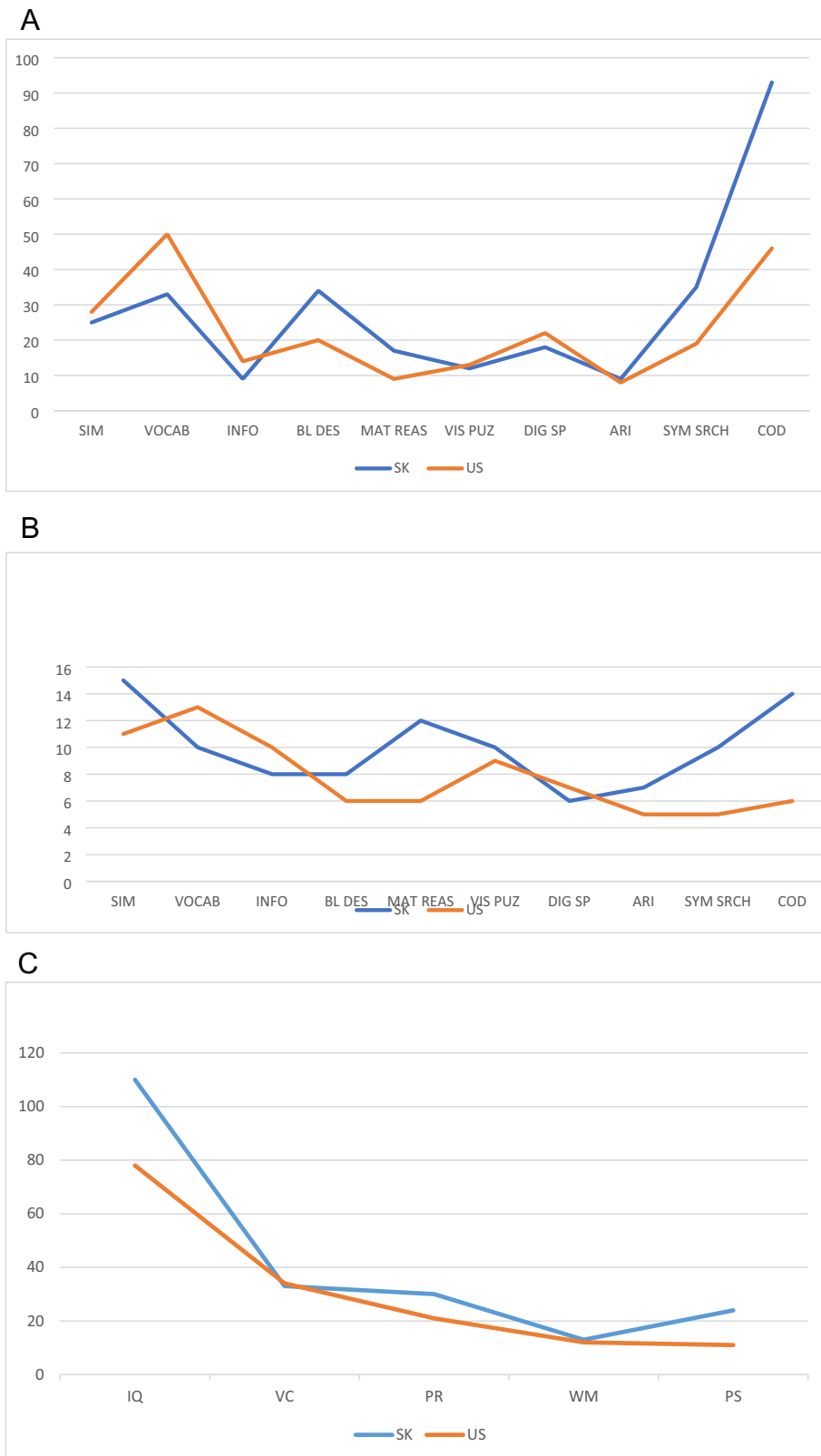
**Fig. 2.** A. Raw subtest scores; B. Scaled subtest scores; C. Sum of scaled scores: D. Composite scores. Profiles of SK and US on the subtest and composite scores of the Wechsler Adult Intelligence Scale-IV (WAIS-IV). SIM = Similarities, VOC = Vocabulary, INFO = Information, BL DES = Block Design, MAT REAS = Matrix Reasoning, VIS PUZ = Visual Puzzles, DIG SP = Digit Span, ARI = Arithmetic, SYM SRCH = Symbol Search, COD = Coding, VC = Verbal Comprehension, PR = Perceptual Reasoning, WM = Working Memory, PS = Processing Speed.
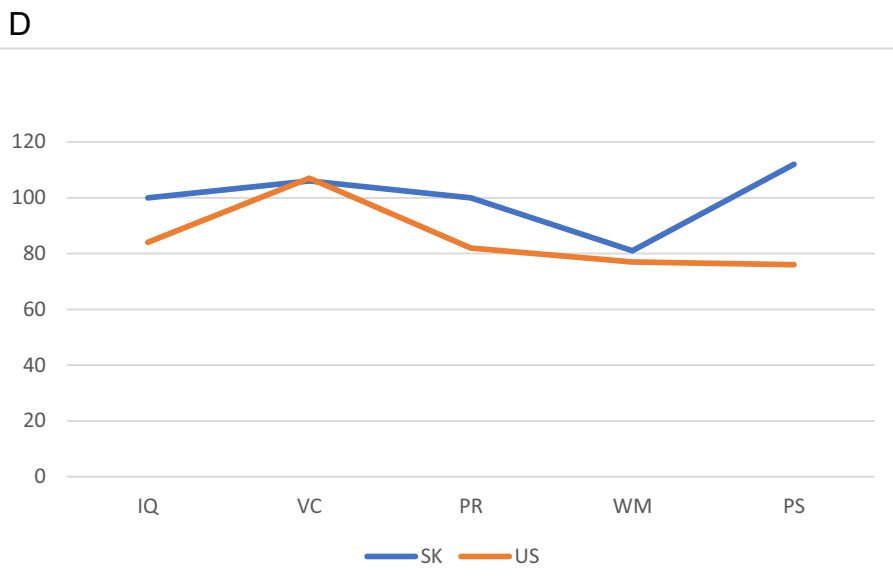
D



**Fig. 2.** (*continued*).

but she stopped at D7 (42 items) from frustration with difficult items. SK completed all 60 items in 54 min with a score of 43.

### 3.5. Personality, self-esteem, individualism-collectivism scale

SK exceeded US in Neuroticism and Extraversion, whereas US exceeded SK in Openness, Agreeableness, and Conscientiousness (Fig. 3). However, on all five factors, SK and US are in immediately adjacent T-score categories, and T-score differences were less than 7 points on three factors, suggesting that overall, US and SK have similar personality profiles. SK is average to high across all five factors, whereas US is average to high in Extraversion, Openness, and Agreeableness, low in Neuroticism and very high in Conscientiousness.

US and SK obtained identical scores of 24 on the RSES, indicating favorable levels of self-regard, which ranges from 15 to 25.

On the Individualism-Collectivism Scale, US's score was considerably higher than SK's score on HI and HC, although both had similar scores on

VI (Fig. 4). Thus, US perceives the self as autonomous and believes that all members of a collective are of equal status, suggesting she has adapted well to American culture. Although the difference was relatively small, SK was higher than US on VC, suggesting that SK perceives the self as a part of a collective, and accepts hierarchy and inequality within that collective, in accordance with the South Korean culture of her age.

### 3.6. Mental health

The T-scores of US and SK across the PAI's 11 clinical scales were in the normal range or slightly below average (Fig. 5), suggesting that both twins are mentally healthy. SK and US had nearly identical scores (≤3 points differences) on 5 (Somatic Complaints, Anxiety, Anxiety-related disorders, Depression, and Antisocial Features) of 11 scales. SK scored lower than US in Mania and Schizophrenia, while the reverse occurred for Paranoia, Borderline Features, Alcohol Problems, and Drug
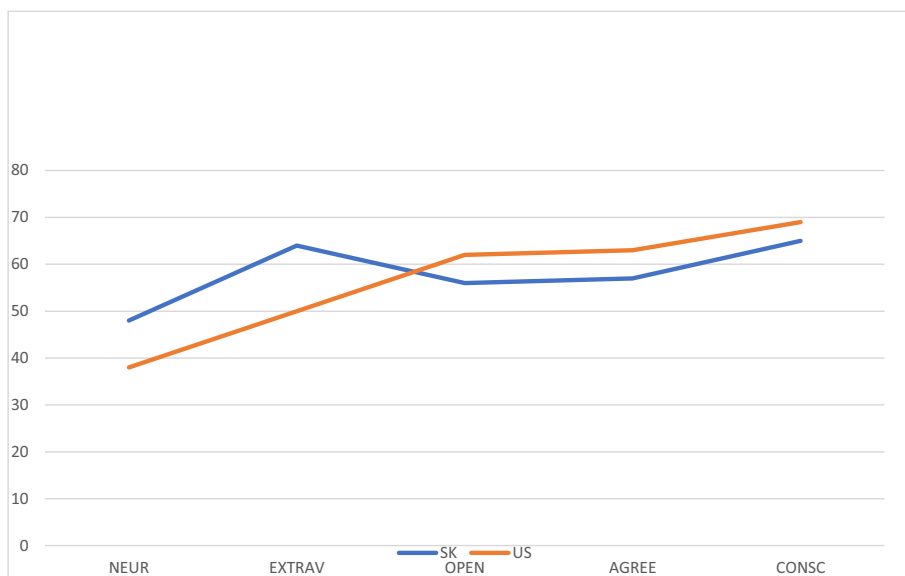


**Fig. 3.** T-score profiles of SK and US on the NEO Five-Factor Inventory-3 (NEO-FFI-3). NEUR = Neuroticism, EXTRAV = Extraversion, OPEN = Openness, AGREE = Agreeableness, CONSC = Conscientiousness.
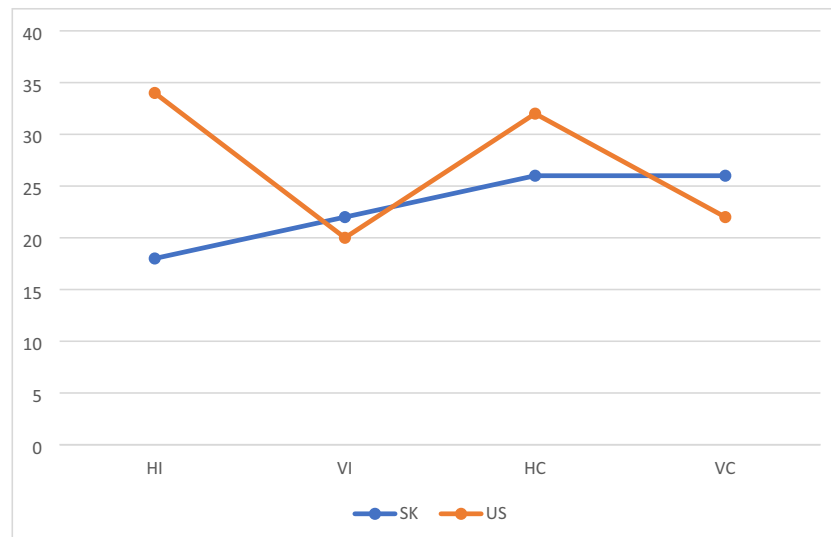
**Fig. 4.** Score profiles of SK and US on the four Individualism-Collectivism scales. HI = Horizontal Individualism, VI = Vertical Individualism, HC = Horizontal Collectivism, VC = Vertical Collectivism.
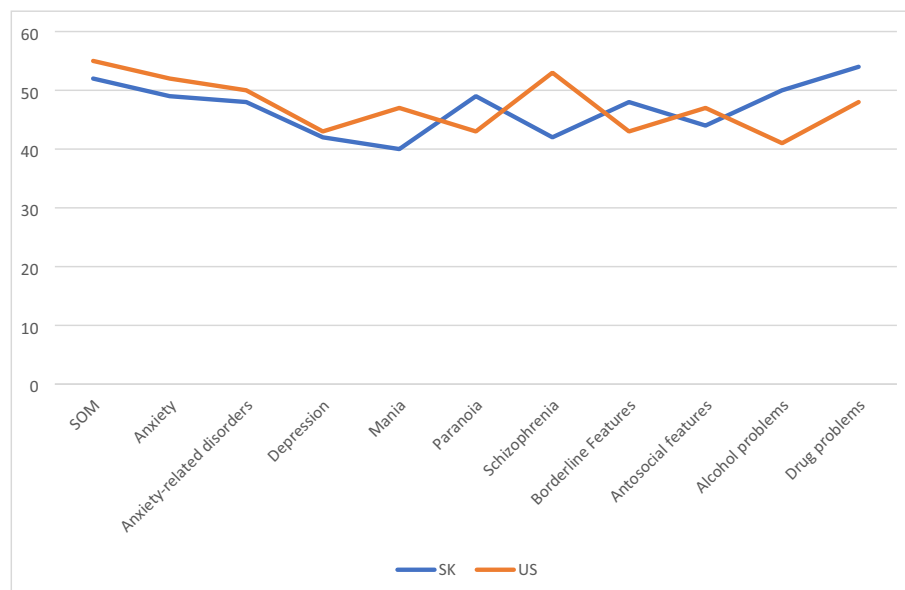


**Fig. 5.** T-score profiles of SK and US on the 11 clinical scales of the Personality Assessment Inventory (PAI). SOM = Somatic Complaints.

Problems. However, these score differences were mostly less than 10, indicating that the twins' clinical symptom profiles are quite similar.

ICC was substantial for the raw scores across 11 scales (ICC = 0.81, 95% CI = 0.60–0.92, $p < .001$) but was not significant for T-scores (ICC = 0.21). Lower ICC for T-scores may be due to reduced variances of the T-scores.

### 3.7. Job satisfaction

US expressed a high degree of job satisfaction with her current job as government administrator (Fig. 6). SK also expressed a high degree of job satisfaction with her current job as cook. On both intrinsic and extrinsic satisfaction scales, US scored slightly but consistently higher than SK (intrinsic satisfaction = 4.42 vs. 4.17; extrinsic satisfaction = 4.13 vs. 3.63). Interestingly, at the overall job satisfaction scale, SK's rating was higher than US's (5.00 vs. 4.00), although the difference was only 1 point. Overall, SK and US appear satisfied with their jobs, albeit to

slightly different degrees.

### 3.8. Medical life history

US was slightly shorter and heavier than SK (4 ft, 8.0 in. vs. 4 ft, 9.6 in.; 111 pounds vs. 101.41 pounds). Interestingly, neither twin reveals her height to other people. US experienced menarche at age 10, with cycles as "somewhat irregular–variation of 4–10 days." Her menstrual cycle ceased at age 36. SK experienced menarche at age fourteen-fifteen, describing her cycles as "very irregular." SK has not undergone menopause.

US has suffered various health-related conditions, e.g., Maturity Onset Diabetes of the Young (MODY) Type 3. MODY is a rare condition linked to a genetic mutation, typically diagnosed before age 30. It is associated with high blood sugar, increased urination, increased thirst and weight loss (Diabetes UK, 2022). US was diagnosed with this condition at age 28. US also suffers from glaucoma related to MODY Type 3.
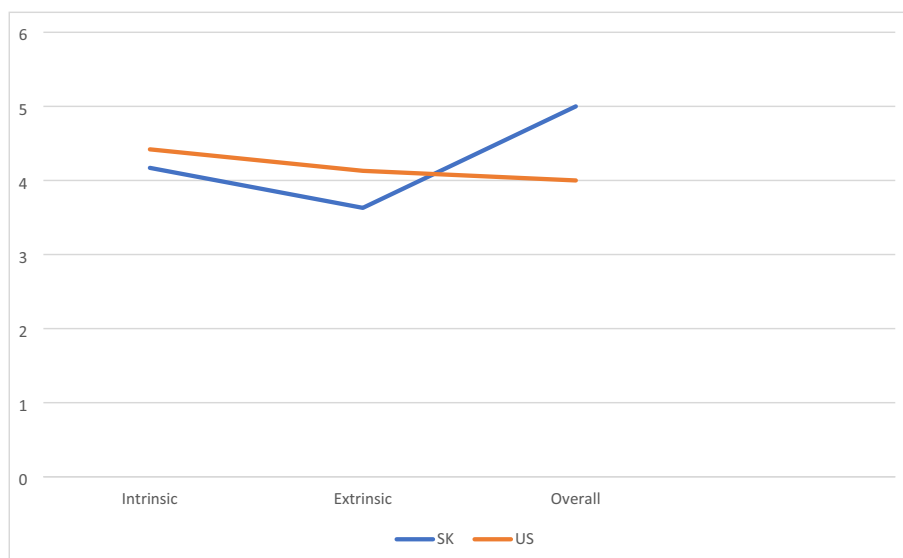
**Fig. 6.** Score profiles of SK and US on the three Job Satisfaction Scales.

SK was diagnosed with diabetes, but not until age 44. US takes medications to control her diabetes, whereas SK is attempting treatment with diet alone. The twins' biological mother and brother have been diagnosed with diabetes and take medicines to control the condition.

US experiences high cholesterol levels and seasonal affective disorder. SK's cholesterol levels are in the normal range, and she has never experienced affective disorders. SK feels that she is generally mentally healthy. At age 34 anemia was suspected, but was not confirmed. Both twins have undergone surgeries to remove large tumors on their ovaries. US's operations took place at ages 9 and 19, when her ovaries were removed (oophorectomy). SK's procedure occurred only at age 19, but surgeons saved her ovaries. SK underwent surgeries for a herniated disc at ages 44 and 45, whereas US has not experienced this condition.

US had three concussions as an adult, caused by car accidents and from falling on ice. The most recent and severe incident occurred in January 2018, resulting in classic symptoms of light sensitivity and concentration difficulty. US feels she is a "different person," with increased anger and anxiety. She requires additional time to process information in some problem-solving situations, although she has always seen herself as a poor test taker.

US is a non-smoker, a status she has maintained since age seventeen when she smoked occasionally. SK has never smoked. US's participation in sports and other physical activities has increased over the years. She considered herself "sedentary" at age 13; enjoyed occasional mild physical activities at ages 17–30; participated occasionally in active sports at age 35 and participated regularly in sports at ages 40 to the present. In contrast, SK regularly participated in sports activities throughout school. She believes she still has athletic ability and would enjoy sports, but does not currently participate because of her responsibilities.

### 3.9. Twin relationship

US and SK have been in daily contact with the assistance of translators and online translation programs. Using a 1 (less close/familiar than people I meet for the first time) to 7 (closer/more familiar than best friends) scale, US's first impression of their relationship was that they would become closer than best friends, and indicated that SK was "as familiar to her as a best friend." Currently, she indicated they are "closer than best friends," and that SK seems "more familiar than a best friend." In contrast, US feels that she and her adopted sister are "as close as casual friends," and that her adopted sister feels "less familiar than a best

friend, but more familiar than a casual friend."

SK's responses matched those of US with one slight exception–her first impression was that US seemed more familiar than a best friend. SK also provided current closeness and familiarity ratings for her two biological siblings. She indicated that she and her brother are "less close than best friends, but closer than casual friends." She feels that she and her nontwin sister are "closer than best friends and "more familiar than best friends."

## 4. Discussion

The twins were raised in very different environments, aside from their different countries and cultures. US endured a conflictual home atmosphere; SK enjoyed a more harmonious home setting. Prior studies show that genes moderately influence perception of childhood family environments through the mechanism of gene-environment correlation and/or genetic influences on subjective perception (Krueger, Markon, & Bouchard, 2003). However, US and SK showed little resemblance in rearing family environment ratings, indicated by near zero ICC for the FES scales.

It is striking that the twins showed substantial differences in cognitive abilities (WAIS IV and SPM) that have been linked to strong genetic influence. In composite scores of the WAIS-IV, they were nearly identical in WM and VC, but US was considerably lower than SK in PR and PS, with an overall IQ difference of 16 points. The mean IQ difference for MZA twins in the MISTRA was 7.07 (*SD* = 5.83), with a range of 0–29 points. Larger IQ differences in some MZA pairs were variously associated with brain damage resulting from accidents (Segal, 2012). US's SPM score was also considerably lower than SK's score. Given that the SPM measures reasoning abilities to form perceptual relations and identify perceptual distractors, independent of language (Van der Ven & Ellis, 2000), and that US worked much longer than SK, it can be concluded that US is lower than SK in perceptual reasoning and processing speed. US's lower scores in these cognitive domains may reflect her history of concussions.

The overall configuration of the twins' personality was similar, consistent with literature on moderate genetic influences on personality in adulthood (Briley & Tucker-Drob, 2014). Notable is that both twins are distinctively high on Conscientiousness, indicating that both are purposeful, well-organized, dutiful, and achievement-striving. This personality facet is also reflected in their attitude toward their current job. US's low score in Neuroticism indicates she is emotionally stable and

relaxed. However, this finding is unexpected given her experience with seasonal affective disorder. Neuroticism has been shown to be a genetic risk factor for such disorders (Kendler, Neale, Kessler, Heath, & Eaves, 1993).

The twins' profiles on clinical scales were similar, confirming genetic influences on mental health in prior studies (Smoller et al., 2019). As indicated, US was raised in a family with high conflict and experienced divorce. However, US's scores were not elevated on any of the 11 clinical scales relative to the norm, indicating negligible influence of rearing family environment on adult mental health.

Culture influences self-esteem and individualism-collectivism (Markus & Kitayama, 1991; Triandis & Gelfland, 1998). Self-esteem is generally higher in Americans than East Asians (Markus & Kitayama, 1991). However, the twins had identical scores on the RSES, confirming genetic influences (Kendler, Gardner, & Prescott, 1998). Both twins showed favorable self-worth, which is somewhat surprising given US's conflictual home atmosphere and divorce. Perhaps US had a resiliency allowing her to withstand surrounding difficulties. The United States is a predominantly individualistic culture, whereas South Korea is a mainly collectivist culture. US's higher HI score and SK's higher VC score suggest the importance of culture on their respective value systems.

The twins' job satisfaction scores showed greater similarity on the intrinsic than the extrinsic scale, consistent with a modest heritability of 0.315 and lower heritability in extrinsic than intrinsic satisfaction (Arvey, Bouchard, Xx, & Abraham, 1989). The twins' jobs as government administrator (US) and cook (SK) pose very different working conditions, most likely explaining their different extrinsic satisfaction scores.

The twins' feelings of considerable closeness/familiarity toward their newly found twin agree with findings from previous reared-apart twin studies (Segal, 2012; Segal, 2021). It is striking that US's ratings for her twin exceeded those for the adoptive sibling with whom she was raised. It is also revealing that SK's ratings for her twin were as high as her ratings for her nontwin sister with whom she was raised. These findings may be understood at proximal and evolutionary levels. First, the twins' perceptions of their behavioral similarities may provide the "social glue" attracting each to the other and maintaining that relationship. The psychological literature reveals more positive assortment between spouses and friends for behavioral traits, such as attitudes and values, than physical traits (Rushton & Bons, 2005; Zietsch, Verweij, Heath, & Martin, 2011). An evolutionary view predicts greater cooperation/altruism between close genetic relatives than distant relatives as a way of transmitting common genes. Social attraction would facilitate these tendencies.

The twins' physical characteristics and medical life histories reveal marked similarities, but also differences in treatment. Their height difference (1.50 in.) exceeds the mean height differences of 0.58 in. and 0.62 in. reported for reared-apart and reared-together MZ female twins, respectively. Their weight difference (8.50 pounds) is less than the mean differences of 11.60 pounds and 11.53 pounds reported for reared-apart and reared-together MZ female twins, respectively (Farber, 1981).

Both twins developed tumors requiring surgical removal, although US had two operations. US experienced menarche four to five years earlier than her sister, a difference above the average difference of 1.07 years reported for MZA female twins (Segal & Stohs, 2007). Ovarian tumors in childhood/adolescence have been associated with abnormal menstrual activity (Heo et al., 2014). This cotwin difference may be tied to prenatal factors and/or differences in medical attention (Segal, 2017). Only US experienced high cholesterol levels and seasonal affective disorder; the causes of these contrasts are unknown. However, given her low scores on the PAI (Neuroticism, Depression and Anxiety), US's experience with seasonal affective disorder may be tied to her concussions, rather than genetic vulnerability. Both twins have diabetes, a condition with a genetic basis in their case. Their treatments differed, possibly due to differences in medical care and/or family practices.

## 5. Conclusions

US and SK offer a novel look at how many behavioral traits (conscientiousness, self-esteem) remain the same despite their very different rearing environments (overall $r = 0.95$). They also show that cultural climates can modify values. Given online adoption and DNA platforms, it is likely that other transnational reared-apart MZA twins will be identified. It is important to include these pairs in future studies.

## Credit authorship contribution statement

Nancy L. Segal identified the separated twins. Both authors gathered information, analyzed data and contributed to the introduction, methods, results, discussion, and conclusions.

## Acknowledgments

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