



Born in Korea-adopted apart: Behavioral development of monozygotic twins raised in the United States and France



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ABSTRACT

Monozygotic (MZ) twins raised in different countries and cultures are rare. This report examines behavioral and physical similarities and differences of MZ female twins from South Korea, but raised separately in the United States and France. Analyses of the twins' intelligence, special cognitive abilities, personality traits, self-esteem, job satisfaction and health histories are considered with reference to their genetic relatedness and rearing conditions. Both striking similarities and intriguing differences were noted.

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1. Introduction

Monozygotic twins raised apart (MZA) in different countries are rare. Three reared-apart twin studies in the United States (Newman, Freeman, & Holzinger, 1937), England (Shields, 1962) and Denmark (Juel-Nielsen, 1965) included only 2/75 pairs in which co-twins had been raised in different countries. The more recent Minnesota Study of Twins Reared Apart (MISTRA; 1979–1999) included 12/137 sets raised in different countries (Segal, 2012). The only prospective study of adopted apart Chinese twin children includes only 2/15 sets raised in different countries and continents (Segal, Stohs, & Evans, 2011). The higher proportion of such pairs in the latter two studies probably reflects their more varied recruitment methods, including the Internet.

Unfortunately, data gathered from MZA co-twins reared in different countries have been “hidden” within larger samples. Such presentation forfeits opportunities to explore ways that cultural/experiential features of the twins' rearing environments may be linked to current behavioral and physical differences between them.

Critics have objected to genetic interpretations of MZA twins' similarities, asserting that twins' similar circumstances largely explain their observed similarities (Palmer, 2011). Such criticisms persist even though genetic contributions to individual differences in behavior have been well-established (Plomin, DeFries, Knopik, & Neiderhiser, 2012). Nevertheless, the challenge to study MZA twins from different countries lingers, not just among critics, but also twin researchers.

1.1. Present study

To meet the foregoing challenge, two case reports of MZA twins raised in South Korea and the United States have been completed (Segal & Hur, 2008; Segal, Hur, & Graham, under review). Here, a third case of MZA female twins from South Korea, but raised in the United States and France, is presented. A unique feature of this pair is that both twins were raised outside their birth nation and held minority status in their rearing environments.

2. Methods

2.1. Twin participants

The twenty-five-year-old twins came to attention in 2013 via a colleague. The twins were trying to raise money for a life history

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documentary (Futerman, 2013). One twin (US), an actress in Los Angeles, had posted a video on YouTube that was viewed by her twin's (FR) friends in France; their striking physical resemblance was noted. FR discovered that they were born on November 19, 1987 and adopted through different agencies. Suspecting they were twins, FR contacted US via Facebook on February 21, 2013 and received a response three days later. After exchanging information, the possibility of twinship appeared likely. DNA analysis showed concordance across fifteen short tandem repeat markers, indicating monozygosity with greater than 99% probability.

2.2. Protocols

The twins completed a life history interview, IQ test, special cognitive ability tests, personality inventories, self-esteem scale, job satisfaction questionnaire, medical life history and videotaped interview. Various components of the battery were completed when the twins were together (CSUF, June 2013) and apart (Internet; fall 2013). Their mean scores and profile concordance on some measures were compared in several ways (see Furr (2010)). FR was also fluent in English, but completed inventories translated into French whenever possible.

2.2.1. Life history

A modified version of the Life History Interview completed by MISTRA participants was administered to each twin (Segal, 2012). Items concerned age at adoption, rearing family circumstances and educational background.

2.2.2. Cognitive measures

The Wechsler Adult Intelligence Scale-IV (WAIS-IV) was administered to each twin, approximately one week apart, in September 2013 (US in Los Angeles and FR in France) by separate examiners. The WAIS-IV yields scores across ten core subtests and five supplemental subtests, organized into verbal comprehension, perceptual reasoning, working memory and processing speed scales, and an IQ score (Pearson, 2008). FR's scores were calculated using French norms; converting FR's raw scores to United States norms yielded negligible differences.

A special mental ability (SMA) battery was administered at CSUF in June 2013. They completed these tests at the same time in separate areas of the laboratory. The SMA included selections from the Cognitive Ability Battery (Hakstian & Cattell, 1975–77), and Hawaii Ability Battery (DeFries et al., 1974). Test selection was limited to spatial, visual, perceptual and memory skills because of the twins' language difference.

2.2.3. Personality and self-esteem

The first personality questionnaire was the *PfPI Questionnaire de Personnalite au Travail (Personality for Professionals Inventory)* (Rolland & de Fruyt, 2009). It includes 200 items organized into 21 personality dimensions and the Big Five personality traits of Openness, Conscientiousness, Extraversion, Agreeableness and Stability (reverse of Neuroticism). Correlations between the PfPI's five factor model scores and the corresponding NEO-PI-R domains range between .82 and .92. Both English and French versions are available.¹

The second personality inventory was the *Adjective Checklist (ACL)* (Gough & Heilbrun, 1983). It includes 300 adjectives respondents endorse if the term is self-descriptive. ACL items are organized into four task approach scales, fifteen needs scales, nine topical scales, five transactional scales, four orience–intellectence

scales and five other scales. Consistency in sex difference desirability is high across the American, French and Italian versions of the ACL (.89 to .98), although specific items may differ in translational comparisons (Fioravanti, Gough, & Frere, 1981).

The third personality questionnaire was the 60-item NEO-PI-R (McCrae & Costa, 2004). This inventory also yields scores on the Big Five personality traits. Factor analyses have demonstrated the universality of the American derived five-factor model across fifty cultures, including France (McCrae & Terracciano, 2005; Rolland, Parker, & Stumpf, 1998). Different versions of the NEO were completed by US (NEO-FFI-3) and FR (NEO-FFI), because the latter was available in French. Over 75% of the items overlap and different items are equally distributed among the five scales. Reliabilities for the five personality factors, based on the NEO-PI, NEO-PI-R and NEO-FFI, range between .75 and .88 (Caruso, 2000). Comparable personality data from three sources enabled constructive replication within the study.

The Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1989) includes five positively and five negatively worded items rated on a 0 (strongly agree) to 3 (strongly disagree) scale. This form is available in French. Cross-cultural comparison of the RSES, translated into twenty-eight languages and administered in fifty-three countries, supports an invariant factor structure (Schmitt & Allik, 2005).

2.2.4. Job satisfaction

The short form of the Minnesota Job Satisfaction Questionnaire (Weiss, Dawis, England, & Lofquist, 1967) was administered. It yields Extrinsic, Intrinsic and Overall Job Satisfaction scales. Respondents use a 1 (very dissatisfied) to 5 (very satisfied) scale to indicate their satisfaction with twenty job-related items. A single overall job satisfaction item was included.

Medical Life History. The twins completed a medical life history covering illnesses, injuries and hospitalizations. Handedness was assessed by self-report and observation by IQ examiners. The twins' heights and weights were recorded by research staff at CSUF.

Videotaped Interview. A joint videotaped interview at CSUF recorded reunion events, self-reported behavioral similarities and differences and twins' expectations for their relationship.

3. Results

3.1. Life history

The twins were born in Busan, South Korea. US's records show that their biological mother was twenty-four years old at their birth and had delivered a non-twin daughter two years earlier. The twins' single mother was financially unable to care for three children so relinquished the twins to insure a better future for them. Their mother had been binding her stomach to hide the pregnancy to continue working. It is suspected that the binding explains why FR was "tiny" at birth, weighing 4.85 lb; US was also small at birth. FR's records do not mention an older child and the maternal age differs by several years. Inaccuracy in adoptees' records is not uncommon (Adoptiontalk, 2011).

US was placed in foster care when two weeks old by the Spence-Chapin Adoption Services. Four months later, she was adopted by a New Jersey couple. US's adoptive father, a certified public accountant, was forty-three. Her adoptive mother, a preschool teacher with an M.A., was thirty-six. The couple had two older biological sons. US's community had few Koreans, but she never felt out of place. This may be explained by the fact that her adoptive parents had wanted a female child and were warm and supportive. The family was upper middle class, residing in a home that was "average" in the neighborhood.

¹ The English version included seven fewer items so appropriate adjustments were made in scoring.

FR was placed in foster care as a newborn through the Holt International Children's Services. Reasons why the twins' situations were managed by different adoption agencies are unclear. FR was adopted at three months by a French couple unable to have children. Her adoptive parents were thirty-seven years of age at the time. FR grew up in an affluent, Parisian suburb. Her family was upper middle class and her home was comparable to others nearby. FR was an only child, spending some childhood years in Belgium. FR's adoptive father is CEO of a company manufacturing watchband leather and her mother assists. FR's parents were loving and provided her with many material advantages.

Despite the growing Korean community in France, FR was a minority in her neighborhood and occasionally experienced thoughtless comments from others. The first Koreans she met were classmates, also adoptees. She did not meet native Koreans until age eleven in England. At age eighteen, FR met a Korean friend raised in France, "but I felt quite different and similar at the same time as she had a mix of both cultures." FR felt some loneliness linked to these experiences of which her adoptive parents were unaware. She believed her adoptive parents truly wanted her, but she also knew she was adopted because they could not conceive.

US attended New York's Professional Performing Arts School, then received a B.F.A. in theater arts from Boston University. US currently lives in Los Angeles, working as an actress and part-time waitress. FR earned a B.A. in textiles from ENSAAMA Olivier de Serres, in Paris. She received a graduate degree in fashion design from London's Central Saint Martins College of Arts & Design.

Neither twin is affiliated with a formal religion. Until completing high school, US engaged in religious activities several times per year. Her adoptive father is Jewish and her adoptive mother is Catholic. US attended a Jewish pre-school, but was eventually christened and took communion; however, the family never attended church. US still celebrates most Jewish holidays for familial/cultural reasons only. FR participated in religious activities more than once a week during elementary school, more than once a month during high school, several times a year after high school, but not presently. Neither twin has married, although both have had relationships.

Contact. Following the twin's first Facebook contact, they communicated via Skype five days later. They continued contact "daily" through Skype and Whatsapp. Their first in-person meeting

occurred on May 14, 2013 in London, lasting ten days. During this time they stayed in separate residences, meeting with family and friends. A Skype interview with NS confirmed their monozygosity.

The twins' second meeting occurred in June when FR visited Los Angeles for two weeks. In July, both twins traveled to South Korea for ten days to attend a meeting of the *International Korean Adoptee Associations (IKAA)*. The twins met again in November 2013, when US visited Paris (6 days) and FR and her family visited New Jersey (4 days). Their total in-person contact time come to 44 days, although all cognitive tests were completed after 19 contact days and all personality questionnaires were completed after 34 contact days. Reared-apart twin research shows that length of contact prior to assessment is unrelated to behavioral resemblance (Segal, 2012).

3.2. General intelligence

US obtained an IQ score of 129, while FR obtained a score of 112. The twins' 17-point difference slightly exceeds the test's standard deviation of 15. This difference also exceeds the average 6-point difference of MZ twins reared together (MZT) (Plomin & DeFries, 1980) and the average differences of 7.07–14.00 reported by the four reared-apart twin studies (Segal, 2012). However, the magnitude of the within-pair difference varies considerably across previous MZA twin pairs, from 0 to 29 points (Segal, 2012).

A double entry intraclass correlation (ICC) was computed to compare the twins' profiles across the fifteen WAIS-IV subtests, shown in Fig. 1A. The ICC of .993, $p < .001$ indicated high similarity. The profile shape showed significant, albeit modest similarity ($r = .53$, $p < .05$), and a variance difference was noted (US: 9.70; FR: 3.60). More informative, perhaps, is the second graph in Fig. 1B showing the twins' five major scale scores which have greater reliability, given their derivation from multiple subtests. (An ICC was not computed due to the small number of scales.)

3.3. Special mental abilities

The twins' profiles across the thirteen special mental ability tests, organized by skill domain, are displayed in Fig. 2. Consistent with previous reared-apart twin research (Johnson et al., 2007), the twins showed less resemblance on most Memory tasks than in the

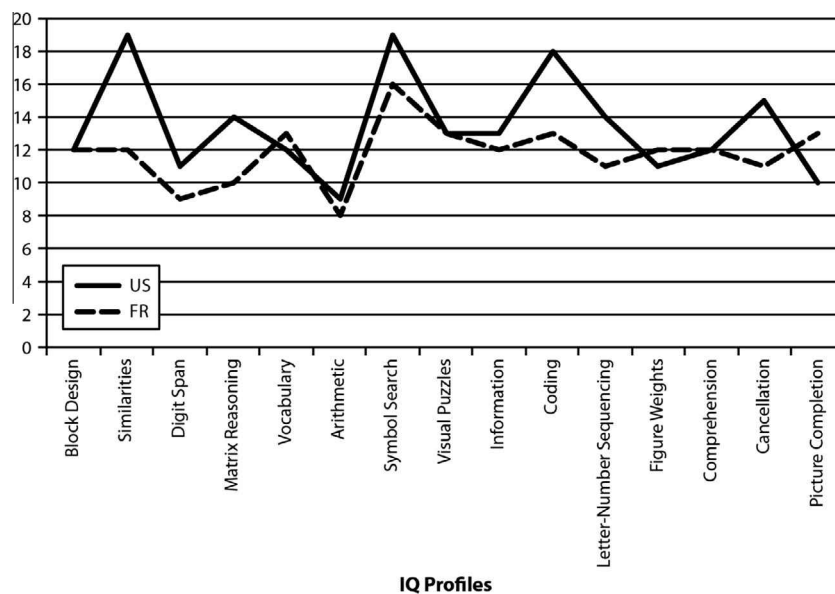


Fig. 1A. IQ profiles.

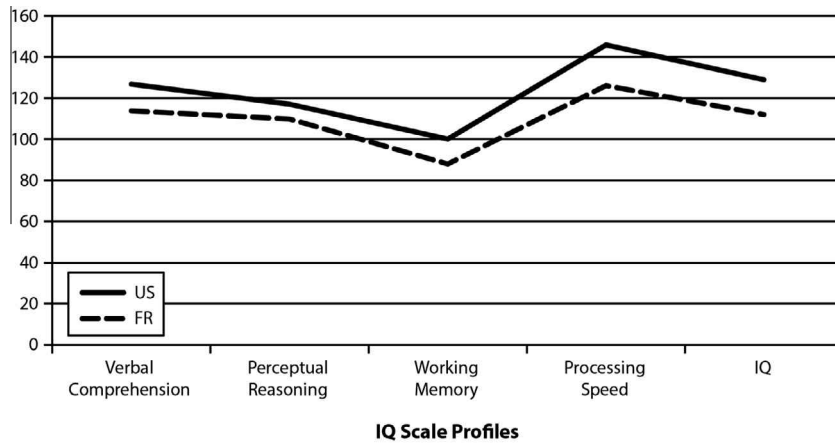


Fig. 1B. IQ scale profiles.

other three areas. Considerable congruence in the level and contour of their profiles is indicated by an ICC of .919, $p < .001$. The profile shape similarity was also high ($r = .91$, $p < .001$). The only marked score differences were for Picture-Number and Card Rotations on which US scored higher. These differences may explain the marked variance difference (US: 1,928.10; FR: 1,004.10).

3.4. Personality and self-esteem

The twins showed considerable congruence in their PffPI profiles. The ICC, based on the 21 dimensional scales only, was .886, $p < .001$. (Including the Big Five personality traits elevated the correlation to .983, $p < .001$). A Pearson correlation reflecting profile shape similarity was .83, $p < .001$. These findings compare favorably with results from MZA and MZT twin studies showing substantial genetic influence on these traits (Bouchard, 1993). It is also consistent with a lack of personality similarity in unrelated look-alikes who completed the PffPI (Segal, Graham, & Ettinger, 2013). However, a sizeable variance difference between the twins was noted, largely due to US's higher scores on frustration tolerance and enthusiasm. A graph comparing the twins' profiles across

the 21 dimensional scales, as well as the Big Five Personality traits, is shown in Fig. 3.

The twins' also showed considerable resemblance in their patterning of 39 ACL scales; the ICC for this measure was .836, $p < .001$; testsum, ACLcount and gender were eliminated. (Including these three scales did not alter the ICC.) There was also significant similarity in the shape of the profile ($r = .64$, $p < .001$). There was, however, considerable difference in the number of items checked, with US endorsing 133 adjectives and FR endorsing 72; this difference most likely contributed to a marked variance difference between the twins (US: 131.68, FR: 37.57). A graph depicting all 42 scales is shown in Fig. 4.

It was surprising to detect some substantial differences in the twins' Big Five personality trait profiles from the NEO. An ICC was not computed given the availability of just five scales, but graphs depicting their scores are presented in Fig. 5. The largest co-twin differences occurred for Neuroticism and Extraversion, with FR scoring higher on the former and US scoring higher on the latter. In contrast, the twins' scores were nearly identical for Conscientiousness and Agreeableness. Reasons for these findings are considered below.

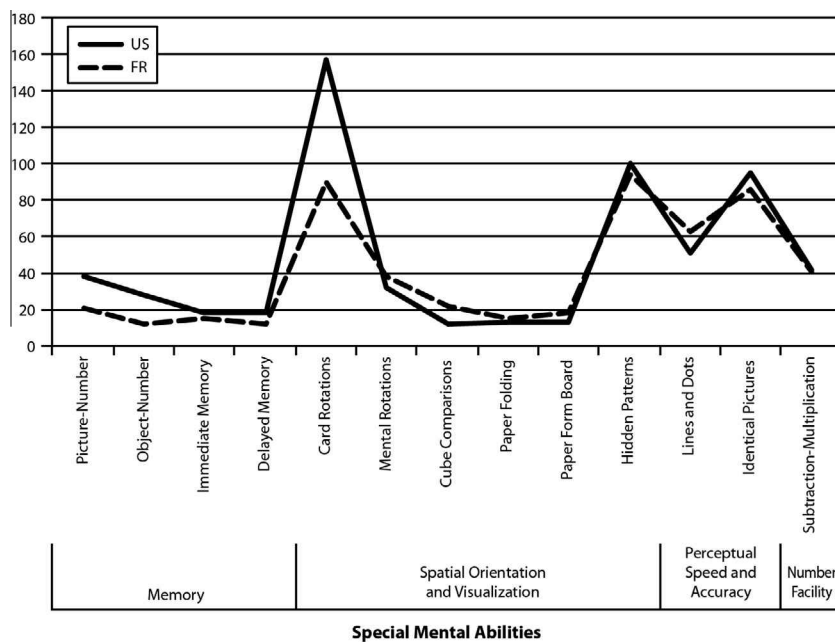


Fig. 2. Special mental abilities.

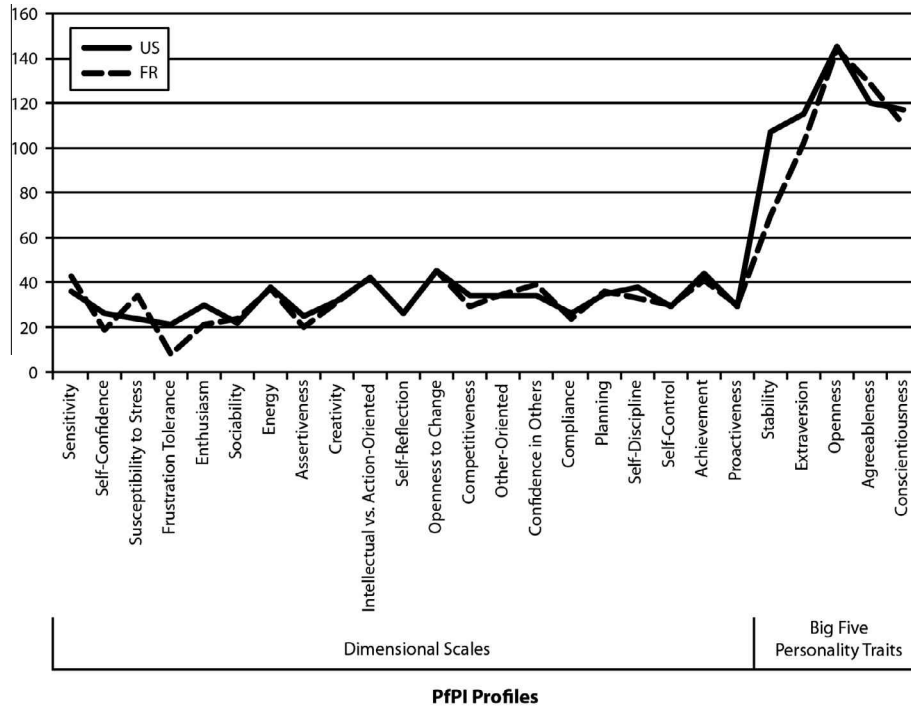


Fig. 3. PFI profiles.

US obtained a score of 24 and FR obtained a score of 15 on the RSES. Both twins' scores indicated good self-esteem (15–25), although their scores were at the upper and lower ends of this range, respectively. This finding is another interesting departure from their general resemblance.

3.5. Job satisfaction

The twins' scores on the MSQ compare favorably with those of the normative sample. They showed very similar profile patterns

on the three job satisfaction scales (intrinsic, extrinsic and general) and an overall job satisfaction item. Fig. 6 presents a graph depicting the twins' job satisfaction scores. FR's scores were slightly, but consistently higher than her sister's.

3.6. Medical health

The twins were very similar in height and weight. US was 58.75 inches and weighed 110 lb, while FR was 59.50 inches and weighed 109 lb. The twins' height difference of 0.75 inches slightly

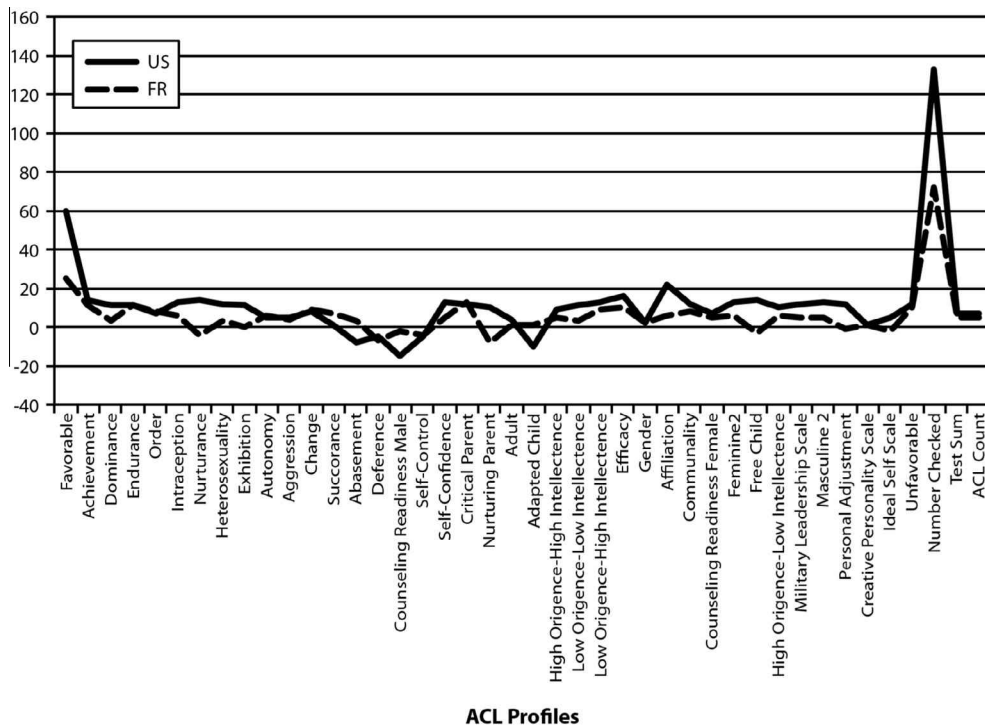


Fig. 4. ACL profiles.

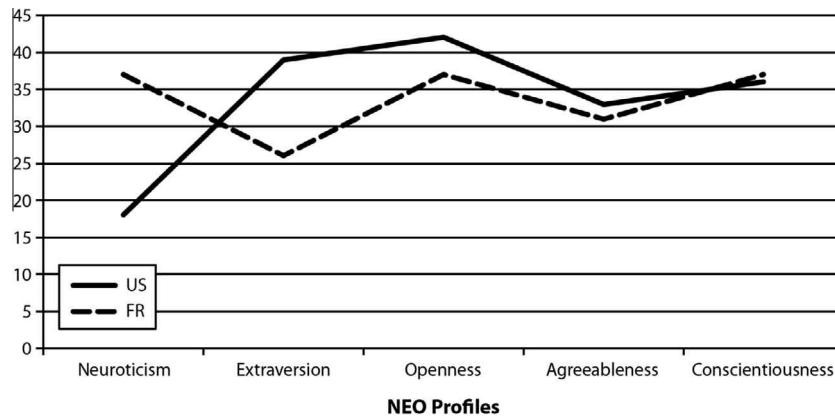


Fig. 5. NEO profiles.

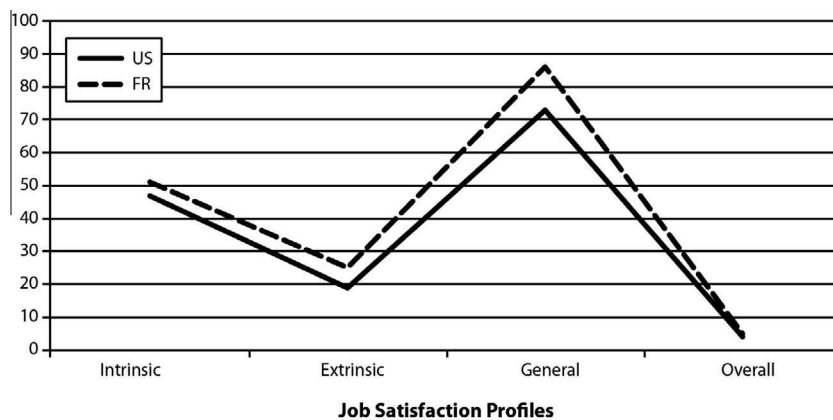


Fig. 6. Job satisfaction profiles.

exceeded the mean differences reported for female MZT (0.62 inches) and MZA pairs (0.58 inches). Their weight difference (1.00 lb) was considerably below the mean differences reported for female MZT (11.53 lb) and MZA pairs (11.60 lb). US and FR's body mass indices (BMIs) of 22.48 and 21.28, respectively, were close and consistent with genetic effects on body size (Herrera & Lindgren, 2010).

Both twins were below the average height of 62.04 inches ($SD = 2.01$) reported for South Korean women of age 38.40 years ($SD = 8.60$). Their body weights were also below the average weight of 128.09 lb ($SD = 18.74$) reported for that group (Cui et al., 2007). The twins' biological mother's height of 62.20 inches was slightly above the average for South Korean females.

Both twins were right-handed, although FR uses both hands. She had broken her right arm at age fifteen, and used her left during recovery.

Menarche occurred at age eleven years for both twins, below the current mean (12.70 years) and median ages (12.43 years) of girls in the United States (Diaz, Laufer, & Breed, 2006). It is also below the mean (12.80) and median ages (12.80 years) for girls in France (Gaudineau et al., 2010). However, the twins' greatest contrast is with South Korean girls who experience menarche at an average age of 15.8 years ($SD = 8.4$); see Cui et al. (2007). Despite their different rearing situations (that included exercise differences), the twins did not differ in age at menarche, consistent with genetic effects. The average intra-pair interval for MZA and DZA female twins is 1.07 years ($SD = 1.04$), although the maximum within-pair MZA difference is four years (Segal & Stohs, 2007). Both twins described their periods as "very irregular; variation greater than 10 days."

The twins' were generally healthy, but showed similarities across various symptoms and complaints, mostly gastrointestinal. Both are lactose intolerant, but crave cheese and eat it despite their condition. They both experience indigestion and abdominal pain. Both twins indicated headaches, but US controls them with over-the-counter medications, while FR uses prescribed medicines. FR's headache medications are also used to treat her heart problems. US's headaches are "bothersome," whereas FR's headaches may require bed rest or "stopping normal activities."

Both twins have had hives, skin rashes and allergies. Both frequently experience thirst and dry mouth, bruise easily, wear contact lenses and take oral contraceptives. In 2012, FR experienced neuralgia in her left shoulder, a symptom US experienced on her right leg and foot.

The twins also indicated some different health-related problems. US has had sinus trouble and is allergic to antibiotics. She was hospitalized for removal of her wisdom teeth. FR is allergic to insects, seafood and aspirin. She has experienced low blood pressure, heart palpitations and joint pain. FR's hospitalizations include treatment for a broken arm, appendicitis and an organic cyst, and she has had episodes of bruxism. FR has scoliosis and while US does not, she received weekly care from a chiropractor from ages two to sixteen.

US engaged in sports "regularly, at least weekly" at ages thirteen, seventeen and twenty-five. In contrast, FR's activity level declined from "regular sport participation" (thirteen) to "occasional mild activity" (seventeen), before increasing to "occasional active sports" (twenty-five).

Both twins currently smoke an occasional cigarette, although their smoking histories differ. US had her first cigarette at age

eleven, but has never smoked daily over the course of one month. FR had her first cigarette at age nineteen and has smoked daily for a month or more, beginning at age twenty-two. The most she has smoked was less than one-half pack per day.

3.7. Videotaped interview

The twins used this opportunity to retrace events surrounding their reunion. They also emphasized their choice of artistic fields that do not require regular hours. They were surprised by these similarities, expecting reared-apart twins' life styles to differ. US felt more "feminine" with her twin sister, relative to how she felt with her brothers. The twins are comfortable with one another and look forward to additional shared time.

4. Discussion

Evidence of life history and cultural effects on behavioral and physical development highlights the ways that genetic expression can be modified by experience and background. US and FR were typical of MZA twins in displaying similarities across many domains. Their generally concordant IQ, SMAs, personality and job satisfaction profiles were striking. Their health histories showed remarkable resemblances, especially in body size, age at menarche and headache predisposition. Their earlier age at menarche, relative to Korean women, may reflect the more abundant diets in the United States and France.

However, the twins' differences offer opportunities to explore cultural and experiential explanations. Their IQ scores differed by over a full standard deviation (129 vs. 112), with US obtaining the higher score. Both the magnitude and direction of the difference were unanticipated because the twins were monozygotic and college graduates. Furthermore, FR had just completed her education, while US had completed her B.A. degree three years earlier and had been working in non-academic settings. Thus, FR was expected to obtain the higher IQ score. However, both acting and waitressing require good memory, social comprehension and problem-solving skills, and waitressing requires good numerical facility. It is likely that FR, who worked in fashion design, exercised various visual-spatial skills as she imagined the look and movement of sizes and shapes. Nevertheless, US may have been better positioned to practice more diverse abilities due to her different pursuits; this may also explain the greater variance in her subtest scores. Other than low birth weight, possible prenatal and postnatal events underlying the twins' IQ difference are unknown.

The twins' performance across the thirteen SMAs showed similarities and differences. US more frequently obtained the higher score. Reasons suggested for the twins' IQ difference might also explain their SMA differences in scores and score variance. FR outperformed US on four of the five visual-spatial tests, consistent with the idea that fashion designers benefit from good visual skills. US's superior performance on the memory tasks is consistent with her memorization of theatrical dialog and food requests.

The twins showed considerable similarity across the PFI and ACL scales, with ICCs of .886 and .836, respectively. These findings concur with most Big Five personality studies using twins (Shane, Nicolaou, Cherkas, & Spector, 2010). The twins differed especially on the PFI dimensions of frustration tolerance and enthusiasm on which FR scored lower. This may partly reflect FR's subjection to prejudice and feelings of loneliness while growing up.

The twins' patterning across the Big Five scales of the NEO showed some marked differences. US scored higher in Extraversion and lower in Neuroticism than FR. The lack of parallel NEO profiles is partly explained by the fact that the NEO assesses Neuroticism, whereas the PFI assesses its opposite (Emotional Stability). Thus,

the findings appear generally consistent across inventories. The use of different forms of the NEO, and/or the shorter length of this personality inventory relative to the PFI and ACL may also have contributed to some variation across the personality protocols.

The twins' self-esteem scores differed, with US (25) scoring higher than FR (15). Schmitt and Allik (2005) reported somewhat higher United States than French means, although both countries are individualistic. Consistent with her lower self-esteem score, FR also scored lower in Stability (PFI), Dominance and Self-Confidence (ACL), and higher in Neuroticism (NEO-FFI). FR had recently completed a graduate program and taken a new job in France. Again, FR's relatively lower score may have reflected prejudiced encounters while growing up and/or her transition from school to the workplace. Regardless, both twins indicated similar satisfaction with their work, consistent with genetic influence on job satisfaction (Arvey, Bouchard, Segal, & Abraham, 1989).

The twins' heights, weights, BMIs and age at menarche were closely matched. FR experienced a higher frequency of physical problems including heart palpitations and appendicitis. Some of her complaints could be linked to prenatal factors, given that MZ twins experience the intrauterine environment differently (Martin, Boomsma, & Machin, 1997). Epigenetic processes, causing different patterns of genetic expression in MZ twins, may be involved (McGue & Gottesman, 2012).

US has generally maintained a higher activity level. This may be due to the greater emphasis on sports for women in the United States than in France, and US's interactions with two older brothers. US has smoked for a longer period, but FR has smoked with greater frequency and to a greater degree. This difference may reflect the greater cultural and societal constraints on smoking in the United States than in Europe.

5. Summary

US and FR are novel because these Korean twins were raised separately in the United States and France, with no knowledge of twinship until age twenty-five. The findings support prior reared-apart twin studies showing genetic influence across a range of measured traits. Identifying similarities in reared-apart twins becomes comprehensible with reference to active gene-environment correlation. It is likely that the twins sought similar opportunities in their respective environments that were compatible with their genetic predispositions. It is also likely that others reacted in kind to each twins' expressed behaviors, exemplifying reactive gene-environment correlation. However, the twins also differed in some special abilities, personality measures and self-esteem. Reasons for these differences were suggested, but remain speculative. The present study reminds us that case studies suggest novel hypotheses that can be further examined using informative participant samples.

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