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# Reared apart Korean female twins: Genetic and cultural influences on life histories, physical and health-related measures, and behavioral traits

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This paper reports physical and behavioral similarities and differences in a pair of 18-year-old monozygotic (MZA) female twins, raised apart from birth in dramatically different cultures: South Korea and the United States. The main outcome measures included life history characteristics (e.g., age at separation, age at reunion), physical and health-related traits (e.g., height, weight, body mass index, age at menarche, illnesses), and behavioral traits (e.g., IQ, special mental abilities, personality traits, dietary preferences). Similarities in some physical characteristics, as well as differences, were noted. High levels of concordance were obtained for IQ and for two special mental ability measures. Selected personality traits presented a mixed picture with respect to concordance and discordance, and dietary preferences showed some unexpected similarities. The findings are discussed with reference to genetic and cultural influences on development.

Keywords: adoption; genetics; Korean; twins

## Introduction

Monozygotic (MZA) twins separated at birth present a rare natural experiment. MZA twins provide direct estimates of genetic influence on health, intelligence, personality, and other measures, as well as associations between behavioral traits and environmental effects (Bouchard, Lykken, McGue, Segal, & Tellegen, 1990; Ripatti, Gatz, Pedersen, & Palmgren, 2003). Previous reared apart twin studies (Newman, Freeman, & Holzinger, 1937; Shields, 1962; Juel-Nielsen, 1965; Bouchard et al., 1990; Kervinen, Kaprio, Koskenvuo, Juntunen, & Kesaniemi, 1998; Kendler, Thornton, & Pedersen, 2000; Hayakawa, Shimizu, Kato, Onoi, & Kobayashi, 2002) generally included co-twins raised in the same culture, although exceptional cases have been identified (Segal, 2000, 2007). Unfortunately, data on these particular pairs are presented as part of the group findings, obscuring relationships between cultural influences and developmental outcomes. Critics of reared apart twin studies have claimed that similar features of the twins' rearing environments, not their similar genetic backgrounds, explain their observed physical and behavioral similarities. These charges persist even though careful evaluation has found them lacking in merit (Bouchard, 1996). An effective way to address these concerns is by studying twins raised in markedly different environments, such as those in the present report.

The twins (US and SK), now 18 years of age, were born in Seoul, South Korea, on 16 May 1987, to a 28-year-old mother and 31-year-old father. The couple already had a 4-year, 10-month-old son (BSK) at the time. The family could afford to raise only one of the infants, so decided to place the second-born twin (US) in foster care on the day of birth. (US was born 3 minutes later than her twin.) US was healthy at birth, while

her twin sister had hydrocephalus (accumulation of fluid in the brain), a condition corrected by means of a shunt to drain the excess fluid.

US remained in foster care until the age of 2 months and 28 days, when she was flown to the United States for adoption by a 34-year-old Caucasian mother and 38-year-old Caucasian father. She has an adopted sister from China who is eight years younger. Over the years, the two families maintained contact through letters, facilitated by social workers in South Korea. Thus, US and SK always knew that they had a twin sister. The twins began direct contact with one another at approximately age 12 years.

US, a freshman college student, contacted the senior author in the fall 2005 to request psychological literature on twins reared apart. She indicated that she had met her sister on only one occasion (at age 17 years), when she and her mother traveled to South Korea. The twins and their families spent 10–12 days together touring the country. Subsequent to that visit, the twins' contact included telephone calls (approximately one per month, with the assistance of translators), letters and cards (approximately two to three per year), e-mail correspondence (approximately once per week) and gifts (on birthdays and holidays). The twins are shown in Figure 1 at the time of their first reunion.

In March 2006, US and her adoptive mother visited the Twin Studies Center at California State University, Fullerton for several days of comprehensive psychological and physical assessment. US's twin sister, SK, completed a similar test battery at the Medical Research Center of Seoul National University in South Korea, at approximately the same time. US's mother and SK's mother and brother completed selected inventories and tests for comparative purposes with their adopted/adopted away and biological daughters and sisters.

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**Figure 1.** Twins, US and SK, at age 17, at their first reunion.

This report focuses on the twins, although comparative data are referenced where appropriate.

## Methods and materials

Prior to assessment, the twins' monozygosity was confirmed with greater than 99% probability by comparative examination of 13 short tandem repeat (STR) DNA markers. DNA, extracted from buccal swabs, was analyzed by Affiliated Genetics in Salt Lake City, Utah.

The assessment protocols, representing a variety of physical and psychological domains, are listed below. The methods and materials used to assess life history characteristics, physical/health measures, and behavioral traits are also described.

### *Life history*

Both twins completed a slightly modified version of the life history questionnaire administered to participants in the Minnesota Study of Twins Reared Apart (MSTRA) (Bouchard et al., 1990; Segal, 2000). This form requests information about adoption circumstances, rearing situation, family structure, family income, educational background, work history, and religious activities. Documents regarding the twins' separation and US's adoption were made available by the twins' families.

### *Physical and health-related measures*

The twins completed comprehensive medical and dental life history questionnaires covering illnesses, injuries, hospitalizations, and various other conditions and symptoms. Their heights and weights were measured by each investigator, and hand preference was assessed by the Crovitz-Zener Self-Report Handedness Inventory (Crovitz & Zener, 1962).

### *Behavioral traits*

*Mental abilities.* Both twins completed the Wechsler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981). An

independent examiner administered the test to US and to her mother; the second author (YMH) administered the test to SK and to her brother 1.5 months later. Both sets of tests were scored immediately upon completion. The twins also completed the Picture-Number (MA-1) and Object-Number (MA-2) associative memory tests from the Educational Testing Service (ETS) cognitive test battery (Ekstrom, French, Harman, & Dermen, 1976). These measures assess ability to recall one part of a previously learned but otherwise unrelated pair of items when the other part is presented.

*Personality, habits and interest inventories.* The twins completed the Eysenck Personality Questionnaire (EPQ) (Eysenck & Eysenck, 1991), the Rosenberg Test of Self-Esteem (Rosenberg, 1965) and a Morningness-Eveningness questionnaire (Smith, Reilly, & Midkiff, 1989). The twins also completed smoking and drinking questionnaires, as well as a dietary preference questionnaire.

## Results

### *Life history and background*

In addition to adoption circumstances (reported above), a number of family characteristics were compared between the twins. US was raised in a suburban area of the United States in a home described as "among the best in the community." She had attended five schools, beginning at age 3 years (preschool) and described all but one as "above average in quality." At the time of the study, US was attending a small suburban college with plans to become a medical assistant. She had held several part-time jobs over the last few years, including office assistant and violin mentor. Her extracurricular activities included gymnastics (age 11 years), soccer (ages 8 to 16 years) and music (ages 8 to 16 years).

US's mother had obtained an MA degree in speech pathology and worked part-time as a speech pathologist. Her father had obtained a BS degree in systems analysis and worked as a database administrator for a large corporation. The family income was \$76,000–100,000. The family was Methodist; at the time of the study US attended church activities several times each year, although she had attended services somewhat more frequently as a young child. She felt a strong sense of belonging to her family. However, US admitted that she had felt "somewhat sensitive and self-conscious" as a Korean girl being raised in a predominantly Caucasian community. According to her mother, US wished that the Asian populations at her various schools and college had been larger. These feelings have grown less intense over the years as US has accepted them as part of everyday life.

SK was raised in a large urban area in a home described as "average" compared with others in the community. At the time of the study she was preparing for competitive college entrance examinations. (She had been admitted to college the previous year, but not to the school of her choice.) Her mother and father had each completed 12 years of schooling. SK's father owned a butcher shop and her mother assisted her husband in running this business, which the couple had done together throughout their marriage. The shop was modest in size, but the couple worked hard to maintain it. (SK's parents did not wish to disclose the family income.) SK's mother had attended a Buddhist temple on several occasions as an adult, but neither

she nor her husband felt serious about religion. SK had attended church infrequently as a child. SK also felt a strong sense of belonging to her family.

### Physical and health-related measures

*Height, weight and handedness.* The twins closely resembled one another in height: US was 154.94 cm, while SK was 156.85 cm. However, the twins showed an appreciable weight difference: US weighed 60.78 kg, while SK weighed 55.40 kg, a difference of 5.38 kg. The twins' body mass indexes (BMIs) were 25.3 (US) and 23.1 (SK). Both twins were right-handed, although SK scored slightly higher (27) than her twin sister (23), indicating that she was less strongly right-handed. Their handedness scores place them both within the range including 98% of right-handers (14–30). These data and others results are summarized in Table 1.

*Pubertal development.* The twins' age at menarche occurred 11 months (0.92 years) apart, at 9.75 years for US and at 10.67 years for SK. Both the twins' biological mother and US's adoptive mother experienced menarche much later than their daughters (at ages 17 years and 13 years, respectively). US reported some menstrual irregularity, with periods lasting from

four to ten days across cycles, while SK reported general menstrual regularity, with periods lasting the same length per cycle. US, but not SK, experienced symptoms of dysmenorrhea (pain and discomfort), although medication allows her to resume normal activities. Neither US nor SK have been married or pregnant.

*Physical complaints.* Both twins reported taking aspirin for headaches, although their symptom severity differed. SK experiences symptoms two to three times per month. Her headaches are variously treatable with aspirins and prescribed medication. Headache treatment might also require bed rest and/or cessation of normal activities. US is affected with migraine headaches approximately once each month, usually severe enough to curtail her normal activities and to require bed rest. When US was younger she experienced migraine headaches as often as once per week, causing school absence. Both the twins' biological mother and US's adoptive mother complain of migraine headaches.

*Dental history.* US's dental history was unremarkable, other than the fact that she had had orthodonture when she was in middle school, and had never had cavities. At the time of the study US brushed her teeth twice daily, flossed and used an

**Table 1**

*A summary of test results*

Measure	Twins		Biological family			Adoptive family			
	SK	US	Brother	Mom	Dad	Mom	Dad		
Physical/health	Height (cm)	156.85	154.94	175.40	158.00		161.93	167.64	
	Weight (kg)	55.40	60.78	87.00	64.00		59.42	74.84	
	BMI	23.10	25.30	28.30	25.60		22.68	26.64	
	Hand preference	Right – 27	Right – 23		Right	Right	Right – 14	Right	
	Migraine	Yes	Yes		Yes	No	Yes		
	Dental	Normal	Normal		Normal	Normal	Normal		
	Age at menarche (years)	10.67	9.75		17.00		13.00		
	Smoking/drinking	Never/ infrequent	Never/ infrequent		Never	Smoker	Never	Never/ occasionally	
	Diet								
	Meals (days/week)	6.3	6.3				6.7		
Snacks (days/week)	3.3	2.3				2.0			
Psychological	WAIS IQ	107	107	117			113		
	WAIS subtests:								
	Verbal IQ	101	113	120			112		
	Performance IQ	115	97	108			114		
	Special mental skills								
	Picture-number	40	40				20		
	Object-number	30	27				7		
	Personality (EPQ)								
	Extraversion	14	8				10		
	Neuroticism	17	9				17		
	Psychoticism	3	0				0		
Lie	12	14				14			
Morning–evening	23	21				48			
Self-esteem	23	24				19			

Notes. SK = MZ twin raised in South Korea; US = MZ twin raised in the United States.

oral rinse. In contrast, SK had developed several cavities as a child. At the time of the study she brushed her teeth three times daily, but did not floss or use an oral rinse.

*Activity level.* SK described her general activity level as “sedentary – didn’t like sports” at both ages 13 and 17 years. In contrast, US regularly participated in sports “at least weekly” at age 13 years, and “occasionally” at age 17 years. SK had had several minor injuries (e.g., falling down stairs; having bike accidents) requiring stitches. US did not indicate any injuries.

### Behavioral traits

*Mental abilities.* US and SK both obtained IQ scores of 107, placing them within the average range (90–109) for general intelligence. (Both tests were scored with American norms.) However, their Verbal and Performance IQ scores and subtest scores showed marked differences, as displayed in Figure 2. US’s Verbal IQ score was 16 points higher than her Performance IQ score (113 and 97, respectively), while her twin sister showed the reverse pattern (101 and 115, respectively); a Verbal IQ–Performance IQ difference of 10 is considered statistically significant at the 5% level. The twins’ Verbal IQ and Performance IQ within-pair differences were 12 and 18 points, respectively.

BSK, the twins’ older brother, obtained an overall IQ score of 117, placing him within the high average range (110–119). Thus, his overall score exceeded the twins’ by two-thirds of a standard deviation. He obtained a Verbal IQ score of 120 and a Performance IQ score of 108. The direction of the difference between his Verbal and Performance IQ scores (12 points) was the same as US’s, rather than SK’s. However, his subtest profile differed considerably from those of both of his sisters. US’s adoptive mother scored slightly above both twins with an IQ

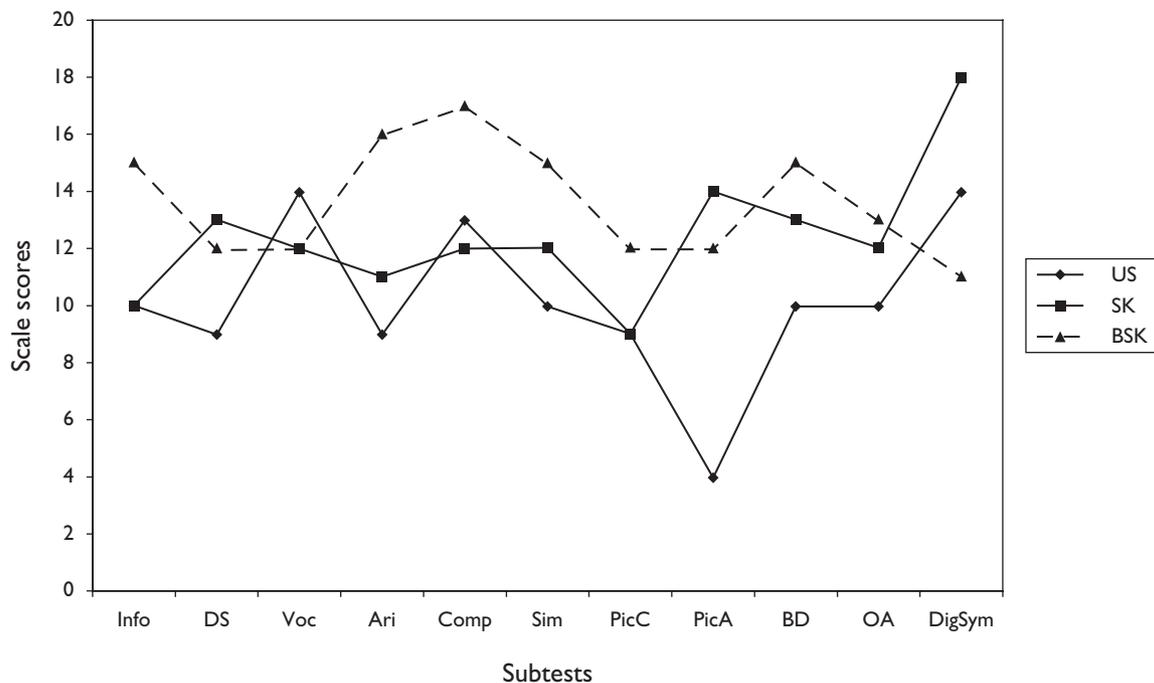
of 113. Her Verbal (112) and Performance IQ scores (114) did not show the marked discrepancies that characterized the scores of both twins.

Both twins obtained scores of 40 on the Picture-Number task, and scores of 27 (US) and 30 (SK) on the Object-Number test. US’s adoptive mother scored considerably below the twins on both tests (20 and 7, respectively).

*Personality, habits and interests.* The twins showed little resemblance in two EPQ personality scales (Extraversion and Neuroticism) known to have genetic effects, although they scored similarly on the Psychoticism and Lie scales. In contrast, their scores on the Rosenberg Test of Self-Esteem were nearly identical. US scored 24 out of 30, while SK scored 23, indicating high self-esteem. US’s adoptive mother scored below both twins (19), indicative of less favorable self worth. Both twins’ scores on the Morningness–Eveningness scale indicated tendencies toward eveningness (US: 21, SK: 23), although SK’s score placed her on the borderline for the Intermediate Type. US’s mother scored 48 on this questionnaire, placing her well within the Morning Type category. The three classification categories are: Evening Type (22 and less), Intermediate Type (23 to 43) and Morning Type (44 and above).

Neither twin smoked, or had ever smoked, at the time of the study. US’s adoptive parents and the twins’ biological mother were non-smokers. In contrast, the twins’ biological father had smoked throughout adulthood, although he smokes less than one pack per day. US indicated having been intoxicated on six occasions, all within the last year; however, US was not a heavy drinker. SK was not a heavy drinker either, but she reported being drunk several times after finishing high school. US’s adoptive father consumed alcohol occasionally, while the other three parents did so rarely or infrequently.

The twins consumed meals with exactly the same frequency (6.3 times per week), although SK consumed snacks somewhat



**Figure 2.** IQ subtest profiles for twins and biological brother.

*Notes.* US: MZ twin raised in the United States; SK: MZ twin raised in South Korea; BSK: Twins’ biological brother, raised with SK; Info: Information; DS: Digit Span; Voc: Vocabulary; Ari: Arithmetic; Comp: Comprehension; PicC: Picture Completion; PicA: Picture Arrangement; BD: Block Design; OA: Object Assembly; DigSym: Digit Symbol.

more frequently than her sister (3.3 and 2.3 times per week, respectively). US's mother consumed meals slightly more often (6.7 times per week) and snacks slightly less often (2.0 times per week) than her adopted daughter. Both twins indicated that they never ate fish, while US's mother ate it infrequently. US consumed coffee three to six times each week and rarely drank tea, while her twin sister rarely consumed coffee, but drank green tea once or twice daily.

Both twins are musically talented. SK plays the piano, while US plays the violin. The twins participated in duets during their single visit together.

## Discussion

### *Physical development*

The twins were approximately one standard deviation below the mean height of South Korean girls ( $M = 161.75\text{cm}$ ,  $SD = 5.13$ ) born between 1980 and 1986 (Hwang, Shin, Frongillo, & Shin, 2003). Their closely matched heights are consistent with previous reared apart and reared together twin studies, showing high heritability for such a stable, reliably measured trait (see Bouchard et al., 1990). Their 1.91cm difference is generally consistent with values reported for MZ twins reared apart (1.27–1.52cm) and together (1.52 to 2.03cm), and specifically for MZ female twins reared apart (1.47cm) (Farber, 1981).

In contrast with height, the twins' 5.38kg weight difference exceeds the average 2.46kg difference reported for reared together MZ female twins from Sweden (Fischbein & Skarind, personal communication, 1999). This difference is, however, more consistent with differences reported for MZ twins reared apart (5.26kg; see Farber, 1981). (Unfortunately, most twin studies of body size measures do not report within-pair differences.) It is possible that despite US's greater activity, her larger body size reflected subtle prenatal influences, e.g., greater nutrition (Machin & Keith, 1999). US's larger body size might also reflect the higher concentration of fat and sugar characteristic of American diets, relative to South Korean diets.

The twins' body size difference is interesting, given that BMI shows substantial heritability in both American and South Korean populations (Maes, Neale, & Eaves, 1997; Hur, 2007a). Studies of Korean immigrants have shown that the mean BMI increases with the length of residence (Cho & Juon, 2006), supporting an environmental effect on body size. It is possible that genes underlying body size may be expressed differently, depending upon the nutritional composition of the diet and other relevant culture-specific factors.

US indicated somewhat higher levels of activity and sports involvement during all phases of development, relative to her sister. This may be explained by the fact that sports activities are encouraged to a greater degree for females in the United States than in South Korea. Genetic effects on sports participation in Western cultures show an increase with age, when individuals have greater freedom of choice (Stubbe, Boomsma, & De Geus, 2005). Given that US and SK had recently completed high school, it would be interesting to track the differences in their sports activities in early and later adulthood.

Treolar & Martin (1990) reported a .91 correlation for age at menarche, based on a small sample of twins who provided

this information on two occasions, three months apart. Treolar (personal communication, 2006) found a .82 correlation for over 3600 individual twins for information given 8 years apart. The twins' 0.92-year difference in age at menarche is within the mean interval reported for both MZ and DZ female twins raised together (0.08 to 1.25 years; from 0.56 to 1.43 years); see Segal & Stohs (2007). The only formal study of menarche in twins reared apart reported a within-pair difference of 1.07 years ( $SD = 1.04$ ) for MZA twins and 1.67 years ( $SD = 1.59$ ) for DZA twins (Segal & Stohs, 2007).

The twins' age at menarche was, however, considerably younger than the mean age reported for South Korean girls ( $M = 12.67$ ,  $SD = 1.17$ ) born between 1980 and 1986 (Hwang et al., 2003). They also fall into the "early maturing" group of Asian-American girls (menarche occurring at age 11 years or younger), who represented only 5.2% of 460 Asian participants (Filipino and Chinese) in a large national survey (Adair & Gordon-Larsen, 2001). SK's mother reached menarche much later than both twins, a finding possibly linked to the non-additive genetic component of that trait (Treolar & Martin, 1990) and/or cohort differences. Only one twin (US) reported menstrual irregularity and menstrual discomfort. Farber's (1981) review included five out of five sets concordant for irregular menstruation, and five out of six sets concordant for dysmenorrhea. More recently, Treolar, Heath & Martin (2002) reported genetic influence on premenstrual symptoms. Thus, US and SK are somewhat atypical of MZ twins in this respect, although the reasons are unclear.

Both twins complained of headaches, although US experienced them more severely than her twin. A previous twin study found that genetic effects explained approximately 50% of the variation, with the remainder explained by non-shared environment and measurement error (Ziegler, Hur, Bouchard, Hassanein, & Barter, 1998). The twins' mother may have transmitted this predisposition to her daughters, although US's adoptive mother had similar complaints.

US and SK were discordant for the occurrence of dental caries; US was cavity-free, while SK had developed cavities as a child. This finding is worth noting, given that previous studies have shown genetic contributions to this trait of up to 65% (Bretz et al., 2005, 2006). Sugar consumption is a well-known risk factor for dental caries (Karjalainen, 2007), yet the twin with better dental health (US) was raised in a culture in which sweet foods are more plentiful. It is possible that US's more diligent dental care contributed to her lack of dental caries.

### *Intelligence*

It is striking that US and SK obtained identical IQ scores despite their lifelong exposure to different educational and cultural systems. At the time of the study, US had completed a semester of college, while SK was preparing for college entrance examinations. The twins also obtained identical scores on one of the special ability tests (Picture-Number) and nearly identical scores on the other one (Object-Number). Their matched performances are consistent with previous IQ studies of reared apart twins that demonstrate genetic influence on mental abilities (Bouchard et al., 1990). The fact that the twins' brother was raised with one twin, yet scored 10 points higher than both twins, further supports a genetic explanation of individual differences in general mental skill.

It is possible to consider the scores of these genetically identical twins as repeat measures, with reference to published

findings on repeated testing. A sample of individuals ( $n = 71$ ) between the ages of 25 and 34 years completed the IQ test a second time, 2 to 7 weeks after the first (Wechsler, 1981). Mean differences were 3, 9, and 7 for the Verbal, Performance, and Full Scale IQ scores, respectively. The twins' overall scores did not differ, but their Verbal IQ and Performance IQ score within-pair differences (12 and 18 points, respectively) substantially exceeded the values reported for the reference sample at time 1 and time 2.

Overall IQ may be largely influenced by genetic factors, yet genotype-interaction effects may affect the development of specific mental skills. US's higher Verbal IQ score may partly reflect the emphasis on language skills (both written and spoken) in American schools. It is also possible that US's mother, who was a speech pathologist, especially encouraged her daughter's verbal development. In contrast, SK's higher Performance IQ score may partly reflect the high value placed on mathematical achievement in East Asian nations (Chen & Stevenson, 1995; Geary, 1996). Of course, cultural emphases cannot fully explain the twins' Verbal and Performance IQ differences, given that their brother (BSK, who was raised in South Korea) scored considerably higher in Verbal IQ than in Performance IQ (12-point difference), like his adopted-away sister.

### *Personality, habits and interests*

The twins' dietary habits showed similarities and differences. Their meal and snack frequencies were well matched, a compelling finding in view of their different lifestyles. US's preference for coffee, and SK's preference for tea would seem to be directly tied to the habits of their respective cultures. However, neither twin liked fish, suggesting genetic effects because fish is eaten frequently in South Korea. Perhaps the smell and/or texture of fish is unappealing to these twins. Twin research has found moderate heritability for odor identification and perceived odor intensity, and non-significant heritability for odor detection and perceived odor pleasantness, based on a comprehensive smell survey (Finkel, Pedersen, & Larsson, 2001). More recent work has revealed moderate genetic influence on the perceived intensity and pleasantness of androstenone, a specific odorous compound (Knaapila et al., 2008).

SK's mother indicated that she had never been a heavy smoker or drinker. In spite of substantial cultural differences between the twins, neither US nor SK had been a smoker or engaged in heavy drinking. These findings are consistent with genetic influences on these behaviors.

Contrary to expectation, the personality findings showed little similarity. Given the well-documented genetic influences on personality traits in members of South Korean and Western populations (Plomin, DeFries, McClearn, & McGuffin, 2001; Hur, 2005, 2006, 2007b), further research is needed to determine whether the present findings are best explained by sampling error, or reflect the importance of culture in personality development. It seems reasonable that the twins' differential exposure to the values of their culture partly explains their lack of resemblance in measured personality traits. However, such an explanation requires careful consideration, as well as reference to specific events in each twin's life.

East–West differences in self-concept (i.e., knowledge and understanding of self) and self-esteem measures (i.e., appraisal of the self) have been demonstrated (Markus & Kitayama, 1991; Hur, 2005). Asians typically show lower levels

of subjective well-being than Americans, a finding associated with dialectical cognitive tendencies (e.g., acknowledging and accepting opposing appraisals of the self; Spencer-Rodgers, Peing, Wang, & Hou, 2004). SK outscored US on neuroticism (a trait encompassing anxiety, depression and moodiness), consistent with expectations based on the cross-cultural literature. However, another explanation might reside in the fact that SK was under considerable stress at the time of the study, given that she had been denied admission to the college of her choice and was facing competitive examinations for admission the following year. SK's higher score on extraversion (a trait encompassing sociability, expressivity and activity) seems surprising at first. However, US was a minority member of her community and was sensitive to the differences between herself and others. As such, she may have become less outgoing and assertive than her twin, who was a majority member of her community in Seoul. The social experiences and adjustment issues facing Korean adoptees in the United States are well described in a recent essay collection (Bishoff & Rankin, 1997).

Studies of self-evaluation tendencies show that European Americans tend toward self-enhancement, while East Asians tend toward self-criticism (Kitayama & Uchida, 2003; Spencer-Rodgers et al., 2004; Kim, Peng, & Chiu, 2008). However, the twins' self-esteem scores were very well matched. Previous twin and adoption studies in both cultures have indicated modest genetic influence on self-esteem and an absence of shared environmental effects (McGuire, Neiderhauser, Reiss, Hetherington, & Plomin, 1994; Neiderhauser & McGuire, 1994; Hur, 2005). Therefore, US and SK's similarity suggests at least a partial genetic origin of self-esteem.

The twins' morningness–eveningness scores were also well-matched, consistent with reported genetic effects. Genetic effects on morningness–eveningness are estimated to be 45–55%, comparable to those on most personality traits (Vink, Groot, Kerkhof, & Boomsma, 2001; Hur, 2007c).

### Closing comment

Case studies are rich sources of new ideas and directions for research with larger twin samples. Close attention to life history details that might be overlooked in formal studies can suggest new directions for future study and new explanations for extant findings. New directions suggested by the present outcomes include the possible effects of different educational systems on mental ability profiles and the possible effects of different activity levels on menstrual difficulties. New explanations of unanticipated findings include genetic effects on highly specific dietary preferences and genetic effects on self-esteem, despite differences in cultural and social factors.

However, a single case cannot convey the “big picture” that is provided by systematically conducted studies. Specifically, a case study may not fully represent the kinship, group or population from which it was drawn. This raises the problem of misleading information. Some observations on US and SK affirm previous twin research findings (e.g., their matched height and musical talent), while others are inconsistent with what has been reported (e.g., their discrepant personality scale scores and dental histories). In particular, the fact that US and SK showed little resemblance on the EPQ personality measures is intriguing, given that genetic factors explain 50% of the variance on most personality traits. It is also difficult to ascribe their difference to cultural factors, because the

direction of their difference (in extraversion) does not conform to cultural expectations. In contrast, their self-esteem and morningness–eveningness scores were well-matched. These discrepancies in the different sets of findings may be resolved only by further tests using large samples of twins raised apart in different cultures.

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### References

- Adair, L.S., & Gordon-Larsen, P. (2001). Maturation timing and overweight prevalence in US adolescent girls. *American Journal of Public Health, 91*(4), 642–644.
- Bishoff, T., & Rankin, J. (Eds.) (1997). *Seeds from a silent tree: An anthology by Korean adoptees*. San Diego, CA: Pandal Press.
- Bouchard, T.J. Jr. (1996). Behaviour genetic studies of intelligence, yesterday and today: The long journey from plausibility to proof. *Journal of Biosocial Science, 28*, 527–555.
- Bouchard, T.J. Jr., Lykken, D.T., McGue, M., Segal, N.L., & Tellegen, A. (1990). Sources of human psychological differences: The Minnesota Study of Twins Reared Apart. *Science, 250*, 223–228.
- Bretz, W.A., Corby, P.M., Schork, N.J., Robinson, M.T., Coelho, M., Costa, S. et al. (2005). Longitudinal analysis of heritability for dental caries traits. *Journal of Dental Research, 84*, 1047–1051.
- Bretz, W.A., Corby, P.M., Coelho, M.O., Costa, S.M., Robinson, M., Schork, N.J. et al. (2006). Heritability estimates for dental caries and sucrose sweetness preference. *Archives of Oral Biology, 51*(12), 1156–1160.
- Chen, C., & Stevenson, H.C. (1995). Motivation and mathematics achievement: A comparative study of Asian-Americans, Caucasian-Americans and East Asian High School Students. *Child Development, 66*, 1215–1234.
- Cho, J., & Juon, H-S. (2006). Assessing overweight and obesity risk among Korean Americans in California using World Health Organization body mass index criteria for Asians. *Preventing Chronic Disease: Public Health Research, Practice and Policy, 3*(A79), 1–11.
- Crovitz, H.F., & Zener, K. (1962). A group test for assessing hand and eye dominance. *American Journal of Psychology, 75*(2), 271–276.
- Ekstrom, R.B., French, J.W., Harman, H.H., & Dermen, D. (1976). *Manual for kit of factor referred cognitive tests*. Princeton, NJ: Educational Testing Service.
- Eysenck, H.J., & Eysenck, S.B.G. (1991). *Manual for the EPQ-R*. Sevenoaks: Hodder and Stoughton.
- Farber, S.L. (1981). *Identical twins reared apart: A reanalysis*. New York: Basic Books, Inc.
- Finkel, D., Pedersen, N.L., & Larsson, M. (2001). Olfactory functioning and cognitive abilities. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences, 56*, 226–233.
- Geary, D.C. (1996). International differences in mathematics achievement: The nature, causes and consequences. *Current Directions in Psychological Science, 5*(5), 133–137.
- Hayakawa, K., Shimizu, T., Kato, K., Onoi, M., & Kobayashi, Y. (2002). A gerontological cohort study of aged twins: The Osaka University aged twin registry. *Twin Research, 5*(5), 387–388.
- Hur, Y.M. (2005). Genetic and environmental influences on self-concept in female preadolescent twins: Comparison of Minnesota and Seoul data. *Twin Research and Human Genetics, 8*(4), 291–299.
- Hur, Y.M. (2006). Nonadditive genetic effects on hostility in South Korean adolescent and young adult twins. *Twin Research and Human Genetics, 9*(5), 637–641.
- Hur, Y.M. (2007a). Gender difference in heritability of BMI in South Korean adolescent twins. *Obesity, 15*, 2908–2911.
- Hur, Y.M. (2007b). Evidence for nonadditive genetic effects on Eysenck Personality Scales in South Korean twins. *Twin Research and Human Genetics, 10*, 373–378.
- Hur, Y.M. (2007c). Stability of genetic influence on morningness–eveningness: A cross-sectional examination of South Korean twins from preadolescence to young adulthood. *Journal of Sleep Research, 16*, 17–23.
- Hwang, J.Y., Shin, C., Frongillo, E.A., & Shin, K.R. (2003). Secular trend in age at menarche for South Korean women born between 1920 and 1986: The Ansan study. *Annals of Human Biology, 30*, 434–442.
- Juel-Nielsen, N. (1965). *Individual and environment: Monozygotic twins reared apart*. New York: International Universities Press.
- Karjalainen, S. (2007). Eating patterns, diet and dental caries. *Dental Update, 34*, 295–298.
- Kendler, K.S., Thornton, L.M., & Pedersen, N.L. (2000). Tobacco consumption in Swedish twins reared apart and reared together. *Archives of General Psychiatry, 57*, 886–892.
- Kervinen, K., Kaprio, J., Koskenvuo, M., Juntunen, J., & Kesaniemi, Y.A. (1998). Serum lipids and apolipoprotein E phenotypes in identical twins reared apart. *Clinical Genetics, 53*, 191–199.
- Kim, Y.-H., Peng, S., & Chiu, C.-Y. (2008). Explaining self-esteem differences between Chinese and North Americans: Dialectical self (vs. self-consistency) or lack of positive self-regard. *Self and Identity, 7*(2), 113–128.
- Kitayama, S., & Uchida, Y. (2003). Explicit self-criticism and implicit self-regard: Evaluating self and friend in two cultures. *Journal of Experimental Social Psychology, 39*, 476–482.
- Knaapila, A., Tuorila, H., Silventoinen, K., Wright, M.J., Kyvik, K.O., Keskitalo, K. et al. (2008). Genetic and environmental contributions to perceived intensity and pleasantness of androstenone odor: An international twin study. *Chemiosensory Perception, 1*(1), 35–42.
- Machin, G.A., & Keith, L.G. (1999). *An atlas of multiple pregnancy*. New York: Parthenon.
- Maes, H.M., Neale, M.C., & Eaves, L.J. (1997). Genetic and environmental factors in relative body weight and human adiposity. *Behavior Genetics, 27*, 325–351.
- Markus, H., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review, 98*, 224–253.
- McGuire, S., Neiderhauser, J.M., Reiss, D., Hetherington, E.M., & Plomin, R. (1994). Genetic and environmental influences on perceptions of self-worth and competence in adolescence: A twin study of twins, full siblings, and step-siblings. *Child Development, 65*, 785–799.
- Neiderhauser, J.M., & McGuire, S. (1994). Competence during middle childhood. In J.C. DeFries, R. Plomin, & D.W. Fulker (Eds.), *Nature and nurture during middle childhood* (pp. 141–151). Cambridge, MA: Blackwell.
- Newman, H.N., Freeman, F.N., & Holzinger, K.J. (1937). *Twins: A study of heredity and environment*. Chicago, IL: University of Chicago Press.
- Plomin, R., DeFries, J.C., McClearn, G.E., & McGuffin, P. (2001). *Behavioral genetics* (4th ed.). New York: Worth.
- Ripatti, S., Gatz, M., Pedersen, N.L., & Palmgren, J. (2003). Three-state frailty model for age at onset of dementia and death in Swedish twins. *Genetic Epidemiology, 24*, 139–149.
- Rosenberg, M. (1965). *Society and the adolescent self-image*. Princeton, NJ: Princeton University Press.
- Segal, N.L. (2000). *Entwined lives: Twins and what they tell us about human behavior*. New York: Plume.
- Segal, N.L. (2007). *Indivisible by two: Lives of extraordinary twins*. Cambridge, MA: Harvard University Press.
- Segal, N.L., & Stohs, J.H. (2007). Resemblance for age at menarche in female twins reared apart and together. *Human Biology, 79*(6), 623–635.
- Shields, J. (1962). *Monozygotic twins: Brought up apart and together*. London: Oxford University Press.
- Smith, C.S., Reilly, C., & Midkiff, K. (1989). Evaluation of three circadian rhythm questionnaires with suggestions for an improved measure of morningness. *Journal of Applied Psychology, 74*, 728–738.
- Spencer-Rodgers, J., Peing, K., Wang, L., & Hou, Y. (2004). Dialectical self-esteem and East–West differences in psychological well-being. *Personality and Social Psychology Bulletin, 30*, 1416–1432.
- Stubbe, J., Boomsma, D.I., & De Geus, E.J.C. (2005). Sports participation during adolescence: A shift from environmental to genetic factors. *Medicine and Science in Sports and Exercise, 37*, 563–570.
- Treolar, S.A., Heath, A.C., & Martin, N.G. (2002). Genetic and environmental influences on premenstrual symptoms in an Australian twin sample. *Psychological Medicine, 32*, 25–38.
- Treolar, S.A., & Martin, N.G. (1990). Age at menarche as a fitness trait: Non-additive genetic variance detected in a large twin sample. *American Journal of Human Genetics, 47*, 137–148.
- Vink, J.M., Groot, A.S., Kerkhof, G.A., & Boomsma, D.I. (2001). Genetic analysis of morningness and eveningness. *Chronobiology International, 18*(5), 809–822.
- Wechsler, D. (1981). *Wechsler adult intelligence scale-revised*. New York: Psychological Corporation.
- Ziegler, D.K., Hur, Y.M., Bouchard, T.J. Jr., Hassanein, R.S., & Barter, R. (1998). Migraine in twins raised together and apart. *Headache, 38*, 417–422.