

Twins Reared Together and Apart: The Science Behind the Fascination¹

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The reasons behind the widespread interest in twins are fascinating to consider. There is no question that people are intrigued by twins—wherever I go I am asked about my work by both professionals and non-professionals. I often ask them, “Why do you care about this topic?” Most of them reply, “Well, it is just so interesting,” but no one can provide a more substantive answer. I have thought a great deal about this question. I believe that twins are fascinating because we expect and anticipate individual differences in behavior and appearance. Therefore, when we encounter two people who look so much alike and act so much alike, it becomes intriguing because it challenges our beliefs in the way the world works. For some people, this may be disturbing, but for many, it is quite compelling.

There are also many misunderstandings surrounding the origins of twinning and twin development. I address some of them in this paper and many others in my new book *Twin Mythconceptions* (Segal, 2017).

TWO TWIN TYPES

The study of twins rests on the availability of two types of twins. Identical, or monozygotic (MZ), twins share all of their genes in common, having split from a single fertilized egg between the first and fourteenth post-conceptual day (Segal, 2000). Fraternal, or dizygotic (DZ), twins result from the fertilization of two separate eggs by two separate sperm and share 50% of their genes, on average, by descent, just like full siblings. Fraternal twins come in two varieties, same-sex and opposite-sex pairs. These twins are quite intriguing, even though they lack the visual interest of identical twins, because the different pairs lie on a spectrum of genetic relatedness. That is to say, some pairs share higher proportions of genes related to certain traits than others. Note that the same-sex twins

1 Read 29 April 2016.

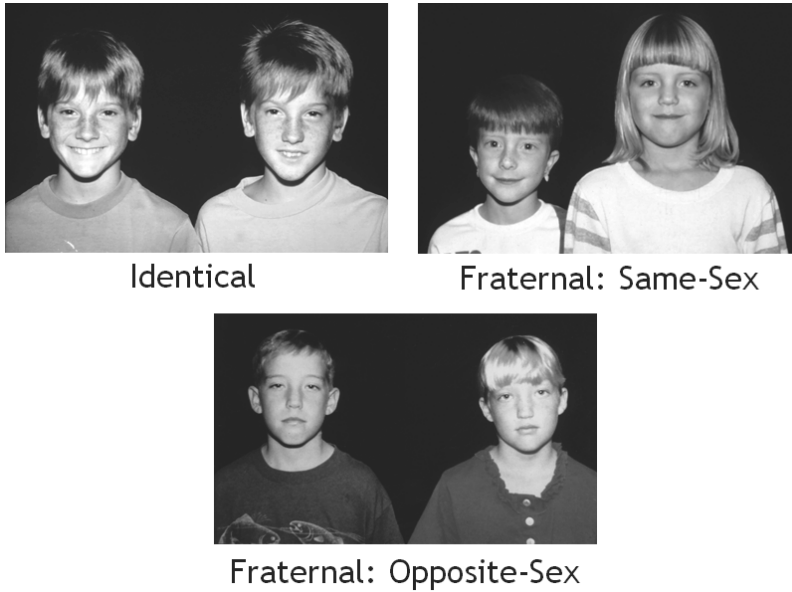


FIGURE 1. The study of twins. Photo credit: Nancy Segal.

in Figure 1 look quite different, whereas those who are opposite-sex look quite alike.

The logic of the twin design is simple and elegant. One simply compares the degree of similarity between identical twins with the degree of similarity between fraternal twins with respect to a given trait, such as height (Segal, 2012). For most measured characteristics, we find that identical twins are more alike than fraternal twins. This finding provides evidence of a genetic component underlying the trait under study. Height is a trait that is strongly influenced by genetic factors (correlations are 0.86 for reared-apart MZ twins and 0.93 for reared-together MZ twins; Bouchard et al., 1990). This finding is exemplified by two young women who the *Guinness World Records* 2007 has acknowledged as the tallest identical female twins in the world, at 6'8". The twins were volleyball players during their college days in Florida, and I appeared with them on the set of ABC's *Good Morning America*.

I now want to turn attention to the famous identical McKusick twins, Victor and Vincent, who were born on a farm in Parkman, Maine, on October 21, 1921 (Segal, 2016). The McKusicks are emblematic of twins who are both distinguished and illustrious—both of them were members of the American Philosophical Society. Before providing an overview of their lives, I would like to acknowledge the generosity of the twins' families—when I first told them about this talk, Vincent's daughter Kay Ralston sent me several photographs of the twins at



FIGURE 2. The McKusick twins about age 8. Photo courtesy of Kay Ralston.

different ages. Examining their pictures across different ages is an informative exercise because it shows that physical development is largely under genetic control across the lifespan.

In Figure 2, the twins are shown at about age 8 and appear identical in height. We see them again at about age 10 in Figure 3. A great deal of physical development takes place between the ages of 8 and 10, yet the twins are virtually indistinguishable at that age. Finally, let's fast forward to the age of 80—even after 70 years of development it is clear that these twins are still virtually indistinguishable (Figure 4).

The remarkable thing about twins is that they tell us so much about human behavioral and physical development just by being themselves. We can see that in Figure 5, the McKusick twins are seated alike, with their feet slightly apart and their hands folded in the same way with their thumbs resting on top. These behaviors can be amusing, but they also qualify as scientific data. When we see physical traits matched in identical twins and less so in fraternal twins, it tells us that the way we sit, stand, move, and gesture are not just a function of imitating the



FIGURE 3. The McKusick twins about age 10. Photo courtesy of Kay Ralston.

people around us, but rather reflect genetic underpinnings to these physical characteristics. All of us have preferred ways of sitting and standing—as I look around the audience, I see people sitting and holding their hands in different ways because everyone’s body is different, so everyone feels more comfortable in certain positions. If everyone here had an identical twin, it is likely they would be seated the same way.

I think of each pair of twins as a unique take on human development, and the McKusick twins are as well. Their individual accomplishments are extremely impressive, but the critical point is that both of these twins have achieved extraordinary levels of expertise and recognition in their particular fields. Here is a brief listing for each twin:

**Victor McKusick, M.D.
Father of Medical Genetics**

- Johns Hopkins University Medical School
- Lasker Award for Special Achievement in Medical Science (1997)
- National Medal of Science (2002)
- Japan Prize in Medical Genomics and Genetics (2008)
- *Mendelian Inheritance in Man* (1966–present)

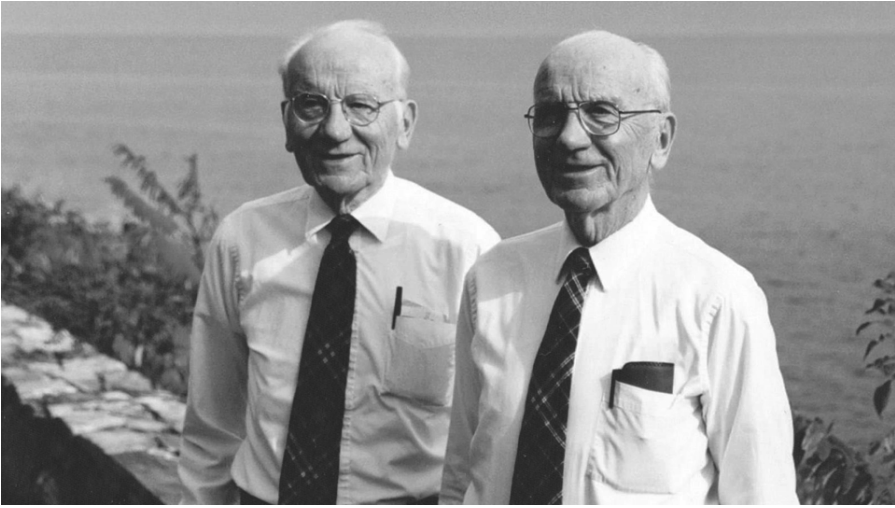


FIGURE 4. Victor and Vincent McKusick, in their later years. Photo courtesy of Kay Ralston.



FIGURE 5. Victor and Vincent McKusick. Note the similar seating positions and hand postures. Photo courtesy of Kay Ralston.

The twelfth edition of Dr. McKusick's volume *Mendelian Inheritance in Man* (1966) was published in 1998. It is currently updated online on a continual basis as new genetic discoveries are made; it is available at OMIM.org (*Online Mendelian Inheritance in Man*).

Vincent McKusick, M.A., J.D.
Chief Justice, Maine Supreme Court

- MIT, Electrical Engineering (1947)
- Harvard Law School President (1950)
- President of the *Harvard Law Review*
- Clerked: Felix Frankfurter and Learned Hand (1950–1952)
- Possible Candidate: Supreme Court Justice
- *Maine Civil Practice* (1959)

Chief Justice Vincent McKusick was called “a brilliant mind” by the Maine judicial branch. His book *Maine Civil Practice* (McKusick, 1959) is still used today and has undergone reprintings.

The question becomes: Is it just an accident that these identical twin brothers are so illustrious, or are there deeper explanations for their matched accomplishments? To answer that question, I will refer to scientific, systematically based studies, particularly the Minnesota Study of Twins Reared Apart (MISTRA), a project with which I was involved for 9 years, between 1982 and 1991, first as a post-doctoral fellow and later as a research associate (Segal, 2012). However, the project actually began in 1979 and lasted for 20 years, ending in 1999. The study was launched by Professor of Psychology Thomas J. Bouchard, Jr. at the University of Minnesota in Minneapolis.

The MISTRA included 137 reared-apart twin pairs, 81 of whom were identical (monozygotic twins reared apart [MZA]) and 56 of whom were fraternal (dizygotic twins reared apart [DZA]). The main focus was on learning how differences in the twins' life histories were associated with current differences in their abilities, personalities, interests, and health. Before presenting our findings, I will share some of the life stories of selected reared-apart twin pairs, beginning with the “Fireman Twins,” Jerry and Mark, who grew up in different cities in the state of New Jersey. Both twins were volunteer firefighters but also pursued similar day jobs—one twin installed chemical fire suppression systems in hotels, and the other installed burglar alarm systems. Their signature quirks were their love for Budweiser beer and their holding of the beer can with the little finger underneath (Segal, 2005).

The twins' style of holding the can is a good example of what I mentioned before regarding body position. Observing this physical

trait repeated in MZA twins gives us a new domain for explaining personal habits and other idiosyncratic behaviors. In the case of the fireman twins, perhaps they fear spilling the precious liquid, or perhaps it is just a matter of comfort. Regardless, seeing these unusual behaviors duplicated more often in MZA twins than in DZA twins offers a fresh perspective on the origins of such habits, based partly on their matched genetic backgrounds. Certainly, the explanation cannot be imitation since these brothers did not grow up together. In fact, on the first day of our assessment, we took unposed photographs of all of the twins. Invariably, the MZA twins assumed similar stances, whereas the DZA twins did not.

Jack and Oskar, also identical twins raised apart (MZA), had among the most dramatic of differences in their rearing backgrounds of any of the twin pairs we studied (Segal, 2005). They were born in Trinidad in 1933 to a Romanian Jewish father and a Catholic German mother. Their parents' relationship dissolved when the twins were 6 months old. Jack remained with his father in Trinidad and was raised in the Jewish faith, whereas Oskar was brought to Nazi Germany by his mother, was raised Catholic, and participated in the Hitler youth. Oskar, while very pro-German, was not a Nazi; when World War II ended, he was only 12 years old. It is fascinating that the twins handled their fears in the same way; only the content differed. Oskar was concerned that someone would discover his Jewish roots, so he became very pro-German. In contrast, Jack, who was living in British-controlled Trinidad, was afraid that someone would discover his German roots, so he became very pro-British.

When the twins met at age 20 in Oskar's home in Germany, it was a very cool and distant reunion. Not surprisingly, the twins embraced different political and historical understandings and parted with the idea of never seeing each other again. Jack moved to southern California to establish a business, and Oskar remained in Germany to work in the mines. However, their wives stayed in touch, and when the twins turned 40, Jack's wife learned about the MISTRA. Oskar agreed to participate, and Professor Bouchard was interested in them as well.

Our research showed that these twins were similar in their abilities and personalities despite the extreme differences in their rearing circumstances. In addition to their different cultures, Jack was raised by a father, whereas Oskar was raised by a grandmother while his mother worked as a nursemaid in Italy. In addition, Jack was an only child, whereas Oskar had an older sister.

I believe that the most intriguing aspect of Jack and Oskar emerged from a conversation they had regarding their growing up years. Each twin realized that had their positions been reversed, each would have

grown up embracing the thoughts and perspectives that he currently loathed. This realization recalls the work of philosopher Dale Wright who wrote, “the self-understanding that grounds our identity is subject to contingencies that are context-dependent” (Wright, p. 229). I believe Wright’s words perfectly capture the developmental processes that affected Jack and Oskar.

PERSONALITY AND INTELLIGENCE

Numerous papers across many disciplines have been published by researchers associated with the MISTRA. Some data are still being analyzed, and some papers are still being written, given the treasure trove of information collected during the course of this comprehensive study. I consider two papers, however, to be seminal, given the considerable impact they have had on thinking and research on human behavior. The first one, published in 1988, was the first four-group twin study of personality (Tellegen, 1988). It included both MZ and DZ twins reared together (MZT; DZT) and apart. This analysis was led by University of Minnesota Professor of Psychology Auke Tellegen. Professor Tellegen developed the *Multidimensional Personality Questionnaire*, an 11-scale form that the twins completed as part of the standard assessment battery. The median correlations for the different twin groups were: 0.49 (MZA), 0.51 (MZT), 0.21 (DZA), and 0.23 (DZT). It can be seen that the correlations for the MZA and MZT twin did not differ across the 11 personality scales, showing that shared environment does *not* predict shared personality. This finding also demonstrated that relatives living together may resemble one another in personality, but that is because of their shared genes, not their shared environments. That still leaves about 50% of the environmental variance to be explained; this 50% consists of the non-shared events people experience apart from their families, perhaps an exciting college class or an exotic international vacation. These concepts are mirrored in the two DZ twin groups who showed less similarity than the MZ twins, but the DZA and DZT twins did not differ in their overall degree of resemblance.

This personality study proved to be controversial. Some critics misunderstood the message—they thought the implication was that environments do not matter. However, this idea was never expressed in our publication. Instead, it appears that the environment works in ways that differ from what is generally expected. It makes intuitive sense to suppose that shared time leads to shared behavior, but the data indicate otherwise. It is also the case that parents can help a shy child better control his or her social fears or encourage an outspoken youngster to

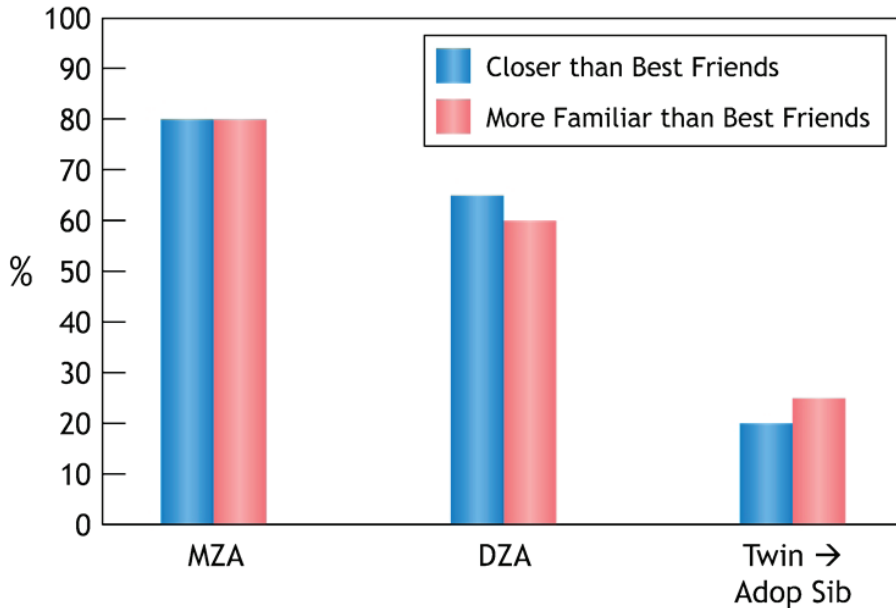


FIGURE 6. Twin and adoptive sibling relations—current (Segal et al., 2003).

show greater behavioral control. However, parents cannot transform the basic, genetically influenced personality make-up of their children.

Our other seminal paper was a study of IQ similarity in the MZA twins (Bouchard, et al., 1990). Three previous studies and one subsequent study using reared-apart twins had also been conducted, giving us comparative findings. The first study was conducted in the United States (Newman, Freeman, and Holzinger, 1937), followed by a study in England (Shields, 1962) and a study in Denmark (Juel-Nielsen, 1965). A study that followed ours was conducted in Sweden (Pedersen et al., 1992). The results across the different studies are remarkably robust—despite differences in the countries, participants, investigators and protocols, the correlations between the MZA twins vary from 0.64 to 0.78, with an average of 0.73 (McGue et al., 1993). These results indicate that about 70–73% of the individual differences among us in general intelligence are genetically influenced. Updated analyses from the Minnesota study yielded a correlation for the *g* factor (the broad mental capacity shown to underlie performance across cognitive tests) of 0.77, confirming these earlier findings (Segal, 2012).

TWIN RELATIONSHIPS

When I left The University of Chicago in 1982 as a new Ph.D., I had just completed doctoral research on the nature of cooperation, competition,

and altruism within young twin pairs. I found that identical twins were more cooperative with their co-twin than were fraternal twins on a series of joint tasks (Segal, 1984). I was fascinated to discover if the reared-apart twins in Minnesota showed such differences when it came to their within-pair relationship. I, therefore, composed a Twin Relationship Survey that included some key questions. For example, I asked them to choose from the following alternatives:

When I met my twin for the first time, I felt that we would become:

1. *closer than best friends.*
2. *as close as best friends.*
3. *less close than best friends, closer than casual friends.*
4. *as close as casual friends.*
5. *as close as most people I meet for the first time.*
6. *less close than most people I meet for the first time.*

This question was repeated with respect to feelings of initial familiarity, current familiarity, and current closeness. I also had the twins rate their current feelings of familiarity and closeness toward the unrelated siblings they were raised with as children. The results, which are displayed in Figure 6, are quite striking (Segal, Hershberger, and Arad, 2003). Approximately 80% of the identical (MZA) twins currently (i.e., at the time I was studying them) felt closer or more familiar than best friends. That figure decreased to about 60% for the fraternal (DZA) twins. However, the really striking finding was that only 20% and 30% of the twins, respectively, felt closer or more familiar to the unrelated sibling with whom they had been raised and had known all their lives. This shows that one can feel closer to someone despite knowing the person for only a limited time, compared with someone known since childhood. I believe that the mechanism underlying this difference is that perceptions of behavioral similarity trigger and maintain the social attraction between identical twins, and that the perception of similarity and consequent attraction are greater for them than for fraternal twins.

YOUNG CHINESE TWINS REARED APART

Most people have never witnessed an actual reunion between reared-apart twins. I have a growing collection of such video clips that are extremely moving to see. One sequence shows a pair of 6-year-old twins raised separately in Sacramento, California, and Fresvik, Norway. I was contacted by one of the mothers for information about twins and

was able to arrange the twins' first reunion with the British Broadcasting Company (BBC). The twins are also participants in a study I am conducting on young Chinese twins adopted apart and together. The group of separated twins (nearly 20 pairs) is unique because I am able to track their development as it unfolds. In contrast, the previous studies of reared-apart twins used mostly adults, so their childhood data were gathered retroactively.

The adoption of twins, both apart and together, came about indirectly because of a government regulation and a cultural view. China's One-Child policy, enacted in 1979, limits urban families to one child and rural families to two. This stipulation, in addition to the Chinese peoples' preference for male children, explains the abandonment of many thousands of baby girls since the policy limiting family size was put into place (Segal, 2005). Currently, I am tracking the reared-apart twins' intellectual progress, personality development, and behavioral adjustment, and comparing some of these measures with identical female twins adopted together from China (about 50 pairs).

Our recent study of developmental risk factors showed that (contrary to some previous findings), age at adoption was not a major predictor of behavioral problems in childhood. We also detected genetic influence on four early infant content areas associated with developmental risk (Developmental Delays at Adoption, Initial Adaptation to Adoption, Crying/Clinging, and Refusal/Avoidance), with shared environmental effects on Developmental Delays at Adoption and Crying/Clinging (Segal, Tan, and Graham, 2015). A study of the twins' first meeting showed that most twins (ages 18 months and older) were immediately attracted to one another, based on parental reports (Segal, Stohs, and Evans, 2011). As the participant pool expands, it will be possible to compare the nature of the evolving relationships between the MZ and DZ twins.

REARED-APART DZ TWINS: THE WORLD'S LONGEST SEPARATED TWIN PAIR

It is important to mention a pair of fraternal female twins who met for the first time at age 78. The twins were born in England, but one twin later moved to the United States with her biological mother who raised her. (The twins' mother was single and lacked the financial means to raise two children at the same time). I reunited these twins in May 2014 on my campus at California State University, Fullerton. They came to my attention when the son of the America-raised twin contacted me to say that his mother's twin sister had finally located her.

Meeting for the first time at age 78 secured these twins a place in the 2016 *Guinness World Records*.

The twins and their adult children participated in a two-day psychological assessment in my laboratory. Typical of DZA twins, they did not display the striking behavioral or physical similarities characteristic of MZA twins (Segal et al., 2015).

TWINS MARRIED TO TWINS

When identical twins marry unrelated spouses and have children, they create some unusual and informative twin research designs (Segal, 2000, 2005). The identical twins are not just the aunts and uncles of their co-twin's children but also the "genetic parents." In addition, their children are not just first cousins but also "genetic half-siblings" because they have a genetically identical parent. If two sets of identical twins married, all four twins would be the genetic parents of their nieces and nephews, and the children from the two families would be genetic full siblings. In contrast, when fraternal twins marry unrelated individuals, family members retain the ordinary family aunt-uncle/niece-nephew relationships.

Many comparisons are possible using these particular families (Segal, 2000). I have been conducting studies predicting greater social closeness between identical twin aunts-uncles toward their niece-nephews, relative to fraternal twin aunts-uncles toward their nieces-nephews. This hypothesis derives from evolutionary reasoning that posits greater cooperation and affiliation between people who share proportionally higher degrees of genetic relatedness than more distantly related individuals (Hamilton, 1964). Questions concern how much identical- and fraternal-twin aunts and uncles like taking care of their nieces and nephews, as well as perceptions of physical resemblance between them data have been analyzed three times with increasing sample sizes (Segal et al., 2007; Segal and Marelich, 2011; Segal et al., 2016). The two main findings from the most recent analysis are that (1) identical-twin aunts and uncles express greater social closeness than fraternal-twin aunts and uncles toward their nieces and nephews, and (2) twins with female co-twins express greater social closeness than twins with male co-twins toward their nieces and nephews. The second finding was expected and is consistent with the concept of paternity uncertainty; that is, males can never be certain that the children born to their partner are truly theirs due to hidden ovulation and internal fertilization (Buss, 2015). In contrast, females can be certain that the child that they delivered belongs to them.

Individuals can, therefore, be confident of their relatedness to their sister's children but not to their brother's children.

VIRTUAL TWINS: SAME-AGE UNRELATED SIBLINGS

There are several additional interesting kinships to discuss. The first is a sibling pair that I have labeled virtual twins (VTs). VTs are same-age unrelated siblings who have no genes in common but who enter their family at approximately the same point in time. They are an excellent comparison for identical twins raised apart because they are reared-apart identical twins in reverse. Identical reared-apart twins share 100% of their genes but not their environment; in contrast, VTs share their rearing environment but not their genes. This contrast reveals the effects of a shared environment versus shared genes on behavioral resemblance.

VTs come about in basically two ways. These pairs may consist of a biological child in the family and an adoptee, or two adoptees. I have now studied approximately 160 such pairs, although published findings are available for 142. The study is comprehensive, but I will focus on the IQ data here. What I found is a modest intraclass correlation ($r_i = 0.28$) for the VTs who have a mean age of about 8 years (Segal et al., 2012). This finding is consistent across studies. Most of my colleagues who study adopted children over time find that adopted siblings show a reduction in resemblance as they approach adolescence, declining from about 0.25 to near 0.0; I found a similar effect upon comparing a subset of VT children at ages 8 and 11 (Segal et al., 2007). The 0.25 correlation reflects the shared home environment of young children living at home. However, it is likely that as small genetic effects are expressed and children gain greater freedom over what they do in their environment, their intellectual resemblance decreases. If we contrast the VT correlation with that of reared-apart twin studies, we see much higher MZA correlations—on the order of 0.70, as I indicated earlier—showing that 70% of individual differences in general intelligence is explained by genetic differences among people.

The last kinship I will discuss concerns switched-at-birth twins (Segal, 2011). The most recent case concerns two identical male sets who are part of my Bogotá Twins Project, reviewed in a *New York Times Magazine* article (Dominus, 2015). The Bogotá Twins Project took place in Bogotá, Colombia the capital city. One pair of identical male twins was born in Bogotá about 27 years ago, and another identical male pair was born at about the same time in a tiny rural town about 150 miles away. One newborn twin in the small town was very sick and needed more sophisticated medical treatment than the local hospital could offer. His grandmother, therefore, brought him to the

larger hospital in Bogotá, where the other pair of twins had been born and were being cared for in the premature infant nursery. An aunt agreed to bring the child back home a week later, and she did—only she brought back the wrong baby.

This inadvertent switch created two sets of reared-apart twins, and two identical copies of an unrelated sibling (VT) pair. Each family assumed they were raising a pair of fraternal twins. The discovery came about after the small-town twins moved to Bogotá and somebody who knew a twin from the city-raised pair confused him for her friend.

I was alerted to this case by Yesika Montoya, Assistant Director of Social Work at Columbia University in New York (but also from Colombia). Montoya contacted me, knowing of my work with twins and switched-at-birth twins. We decided to collaborate and left several months later for Bogotá. The most informative and intriguing feature of these twins is that the two sets of reared-apart identical twins were raised in dramatically different environments, as were the unrelated VTs who believed that they were fraternal twins. As such, the four brothers offer us a multi-layered, fascinating case study. I completed a second visit to Bogotá for follow-up study in July 2016. I am currently working on a book in progress called *Accidental Brothers*, to be published in 2017 with Ms. Montoya.

A CLOSING THOUGHT

In closing, I will share a favorite quote from Professor Thomas J. Bouchard, Jr., the Director of the Minnesota Study of Twins Reared Apart. This comment, which appears at the end of my 2012 book, *Born Together-Reared Apart: The Landmark Minnesota Twin Study*, captures the nature of twin research in an insightful way. Bouchard said, “Twin studies refute both biological and environmental determinism. They do not negate the effect of the environment on behavior, nor do they over glorify the role of genes. They account for the uniqueness of each of us.”

Acknowledgments

I wish to thank Dr. Howard E. Gardner of Harvard University’s Graduate School of Education for the invitation to speak to the membership of the American Philosophical Society at their April 2016 meeting. I am grateful to the family of Vincent McKusick (wife Barbara, and children James, Kay, and Anne) and Victor McKusick (wife Anne, and children Carol, Kenneth, and Victor) for their generosity and support as I developed the conference presentation and prepared this article. Kay Ralston (Vincent McKusick’s daughter and family photo

archivist) provided photographs of her father (Vincent) and uncle (Victor). Kami Bedard of the Pierce Atwood Law Firm in Portland, Maine, was helpful in many ways regarding Vincent McKusick.

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