Twin Studies of Dietary Behaviors: Why We Eat When We Do

Nancy L. Segal
Department of Psychology, California State University, USA

In September, 2001, while reviewing e-mail messages, I came upon a piece entitled, "Dining habits governed by your genes" (Zandonella, 2001). This was a project to which I had contributed, not as an investigator, but as a participant. In July, 1990, my twin sister, Anne, and I were invited to enroll in Georgia State University's (GSU) *Twins Weight, Intake and Nutrition Study*. The project, directed by Dr. John M. de Castro from GSU's Neuropsychology and Behavioral Neuroscience Program, is a comprehensive investigation of factors affecting food intake (de Castro, 2000, 2001a; de Castro & Plunkett, 2001). I was familiar with this work, having visited GSU's Psychology Department several years earlier. Knowing the difficulties of attracting DZ twin volunteers, I offered the research services of my sister and myself in the event of future studies.

This would not be the first time that my participation in twin research produced dividends other than publications — as a visiting graduate student at Indiana University, I had taken part in the twin-family studies of fear (Rose & Ditto, 1983). Even though my name was not in the credits, the final paper felt like a contribution to the field, albeit different from the kind I was used to making. Participation also reminded me of the generous spirit twins bring to the challenging tasks we place before them. I, therefore, resolved to enroll in research again (as a twin) should the occasion arise. My sister did not share my level of enthusiasm (we are, after all, DZ!), but I was able to persuade her. Thus, we both completed the questionnaires and other materials sent by de Castro's laboratory.

DeCastro brings a multi-facted approach to the complex questions surrounding food intake in humans. I asked him how he became fascinated with dietary behaviors and how these interests led to twin-based research. He explained:

> I have been studying food intake regulation for many years as a model system for the investigation of the psychological, physiological and social processes involved in regulating behavior. My primary goal has been to understand how a behavior is controlled, given the vast array of variables that affect it in the natural environments of free-ranging individuals. What these studies have revealed is that there are potent variables in all spheres that can profoundly alter the behavior.
>
> I became interested in studying twins in order to investigate how inheritance might affect the control of food intake. Early on in the analysis, it was demonstrated that inheritance has major influences separately on body size, overall intake levels and even the microstructure of eating, including meal size, frequency and composition. This was interesting, adding to the list of influential variables, but it did not address the issue of how all the many pieces might be put together into a meaningful control system. However, the most recent analyses of the twin data are beginning to provide a glimpse of how the behavior may be controlled. It appears from the data that genes do not just affect the physiology of the individual, but they also appear to influence the environment of the individual including the social surroundings (de Castro, 2001b).

Thus, while acknowledging genetic influence on "macrostructure measures," such as body size and overall intake, de Castro is more concerned with "microstructure measures," such as number and timing of meals and drinks, all of which show genetic influence apart from overall intake (de Castro, 2001c). He focuses further on subtleties of physiologic measures, such as amount of food present in the stomach before and after eating, and degree of restraint in quantity of food ingested due to filling of the stomach. He also accords significant weight to social factors, such as number and type of people present at each meal, and the effects of company on food intake. Interestingly, greater quantities of food are consumed when more people are present.

Palatability constitutes another key domain of hereditary influence on dietary consumption to which de Castro pays serious attention. Palatability refers to subjective states of hunger and food appreciation, both of which may shift over the course of a meal, affecting intake. Genetic influence also extends to the reciprocal relationship between hunger and intake; in other words, effects of hunger on intake, and effects of intake on hunger, have shown heritable components. More intriguing, perhaps, is the finding that impact of palatability on intake may be heritable.

A final set of influences on food intake has been defined by one's circadian and diurnal rhythms, for which genetic effects have been demonstrated. This finding, in addition to what is known about genetic effects

https://doi.org/10.1375/twin.4.6.478 Published online by Cambridge University Press

on food intake, lead de Castro to suggest that diurnal intake may be partly regulated by genetic factors. This is the phase of his ongoing study that I found abstracted on the Internet. Main points are highlighted here, while fine points are available in the set of references below, especially de Castro (2001c).

The study is innovative and far-reaching. The twin sample included 110 MZ twin pairs, 102 same-sex DZ twin pairs and 53 opposite-sex twin pairs. Males and females were evenly distributed among same-sex sets. Participants were identified through twins' associations, the Minnesota Twin Registry, newspaper advertisements and personal referrals. Zygosity was established by twins' responses to a physical resemblance questionnaire. Average age of participants was 40.2 years (*SD* = 10.6) and average weight was 71.1 kg (*SD* = 15.5). Twins were all adults living apart who were neither dieting, pregnant or alcoholic.

The procedure was engaging, but demanding. First, participants received a one-day pocket diary for recording items eaten and amounts consumed. Additional questions concerned time of meal or snack, food preparation, dining companions, food attractiveness and perceived hunger, thirst, anxiety and depression — the last five items were answered before *and* after eating. Preliminary forms were reviewed by study staff. When it was determined that respondents recorded data properly, each received a larger diary with forms to be completed over a seven-day period. The number of forms corresponded to the number of snacks and meals consumed. Some people who used few forms may actually have consumed greater quantities than people who used many if their meals were larger. (While preparing this report, I was amazed to discover some unused forms in an old file labeled, "Diet Study — GA.")

Completed diaries were again reviewed by investigators who additionally contacted two of the twin's eating companions for data verification. Food items were coded according to one of 3,500 labels and kJ of food energy were calculated. Key findings are summarized below:

1. Intake

- Average meal time within the morning, afternoon and evening periods showed genetic influence, explaining 24%, 18% and 22% of the variance, respectively.
- Total and macronutrient intake showed genetic influence, explaining 45% to 22% of the variance in intakes.
- Proportion of intake for total and macronutrient intake showed genetic influence for all periods except the afternoon, explaining 41% to 17% of the variance. (Intake at each meal is confounded with overall intake that is heritable in and of itself. Expressing the data as proportions of intake during each period allowed assessment of the diurnal pattern independent of overall intake.)
- Common environmental effects were not detected for any of these measures.

2. Differences in Intake Between Time Periods

- Differences in total and macronutrient intake between time periods (e.g., morning vs. afternoon) showed genetic influence, explaining 40% to 16% of the variance in intake differences.
- Differences in the proportion of total and macronutrient intake showed genetic influence for morning vs. afternoon, evening vs. morning and evening vs. afternoon, showed percentages of 13%, 29% and 16%, respectively. Genetic effects explained 37% to 13% of the variance in percentage differences. (Again, the data were confounded with overall intake. Expressing the data as differences in the proportions of intake between periods allowed assessment of the diurnal pattern independent of overall intake.)
- Common environmental effects were not detected for any of these measures.

3. Time of Day and Size of Meal

- Correlations between meal time and meal size were small.
- Despite small correlations between time and size of meals, significant genetic effects were found for relations between meal time, total intake and intakes of fat, protein and alcohol, but not carbohydrate.

The most compelling result to emerge from this study is that genetic factors affect the quantities of food consumed at different times during the day. How does de Castro interpret this novel finding? He explained that:

> The genes may [influence the individual's social environment] indirectly by promoting traits such as sociability and extraversion. Nevertheless, they [genetic factors] appear to predispose the individual to prefer and seek out particular environments and stimuli. Further, the genes appear to affect the individual's reactivity to these environments. Hence, the twin data provide a picture of a genetically encoded control system that has influences affecting all of the wide ranging physical, psychological and social influences on intake. The genes can be seen to affect preferred levels and reactivities to multiple variables. The integration of all these influences produces the observed levels of intake and body weight which have distinct individual differences encoded by the genes (de Castro, 2001b).

It would be fascinating to administer diet diaries to twins living in different cultures to determine how variation in food availability and dietary practices affect the composition and timing of food intake. I suspect that MZ twins might be slightly less alike than they were in this study — after all, de Castro is aware that external influences may affect one's dietary intake system. He suggests, for example, that environmental factors (e.g., sedentary life style) could explain current trends toward obesity despite genetic effects on body weight. Still, I wondered if de Castro had considered this cross-cultural question or if he had plans to pursue it:

> I would like to pursue this kind of question. But, logistical issues such as accurate tables of nutrient compositions of local diets, dieticians familiar with the makeup of local dishes and the availability of

https://doi.org/10.1375/twin.4.6.478 Published online by Cambridge University Press

twin registries make it very difficult to pursue such a question (de Castro, 2001b).

Dr. John M. de Castro is a fine example of an investigator whose interests guided him toward twin methods, despite professional training in other approaches. I am grateful to Mike Miller for e-mailing a steady stream of noteworthy twin reports, this work being one of them.

Hearty Research Fare*

(*The title of this section was inspired by the content of the previous report.)

Food Supplements and Twinning Rates

Factors affecting twinning rates continue to interest investigators everywhere. A striking array of findings linking food supplements and twinning rates has accumulated in recent years, the latest coming from Nepal (Olsen, 2001). Interestingly, these discoveries have been accidental. They began with a 1992 Hungarian study comparing effects of different pre- and post-conception supplements on the frequency of neural tube defects in infants. The sample included 4,000 women randomized with respect to receiving (1) a supplement containing vitamins, minerals and trace elements, or (2) a supplement containing only trace elements plus small quantities of vitamin C. Neural tube defects were reduced among the higher supplement group vs. the lower supplement group (0 vs. 6). In addition, twinning rates were higher in the high supplement group than in the low supplement group (3.8% vs. 2.7%). Frequencies of both MZ and DZ twins were increased, although the numbers were too small to detect a meaningful difference between twin types. These findings were subsequently replicated in four of five United States data sets, although information was gathered retrospectively in these studies. However, the association between supplements and twinning emerged only when supplements were administered prior to conception.

Recent analyses from Nepal reveal a positive association between dietary supplements and twinning: Twinning rates were higher among women receiving retinol (99/5,591) or beta-carotene (89/5,148), compared to women receiving a placebo (65/5,146). The question of whether supplements enhanced twin conceptions or enhanced twin survival was unresolved.

Birthweight in DZ-SS/OS Twins Compared

Simple comparisons may disclose complex processes. New data from Belgium underline the significance of DZ twins' sex composition with respect to gestational length and birthweight (Loos et al., 2001). These measures were recorded for twins from 1,929 same-sex and opposite-sex pairs. The gestational length of DZ opposite-sex twin pairs was significantly greater than that of DZ male twin pairs, but did not differ from that of DZ female twin pairs. In addition, the birth weight of male twins from DZ opposite-sex pairs significantly exceeded that of male twins from DZ same-sex pairs. In contrast, the birth weight of female twins from opposite-sex pairs did not differ from that of female twins from DZ same-sex pairs. It was suggested that female twins in opposite-sex pairs extend gestational length, increasing the birth weight of their twin brothers.

MZ Twins From Early Blastocyst Transfer

We have witnessed dramatic increases in twinning rates in recent years, especially among older mothers. Between 1980–82 and 1995–97, twin births increased by 12% for teenage mothers, by 41% for mothers in their thirties, by 63% for mothers 40–44 years of age and by nearly 1,000% for mothers 45–49 years of age (Martin & Park, 1999). Many assume that increased DZ twinning is responsible for this rise — after all, naturally conceived DZ twins are more likely to occur among older mothers. In addition, older women are more likely to experience fertility problems than younger women, prompting them to seek assistance from artificial reproductive technologies (ART). Curiously, a less pronounced increase in MZ twinning, also associated with ART, also appears to be inching twinning rates upward. One study found a 3.2% rate of monochorionic twinning among 218 ART pregnancies. This figure reflected an eightfold increase over the general MZ twinning rate (0.4%), accounting for 9.8% of the ART multiple births (Wenstrom et al., 1993).

Two recently described monochorionic MZ twin cases following blastocyst transfer are exemplary of this trend (Sheiner et al., 2001). (In mammalian development, cleavage [of the fertilized egg] produces a thin walled hollow sphere, whose wall is the trophoblast, with the embryo proper being represented by a mass of cells at one side. The blastocyst is formed before implantation and is equivalent to the blastula) (On-line Medical Dictionary, 1995–1998). The first case involved a 28-year-old woman in whom two blastocysts from among eighteen fertilized by standard insemination were implanted. A second case involved a 35-year-old woman in whom one blastocyst from among seven that were fertilized by ICSI (intracytoplasmic sperm injection, or microinjection of a sperm cell into an egg cell) was implanted. In both cases, transfer occurred at 5 days post-fertilization. Unfortunately, neither of the twin pairs survived the first trimester. The investigators agreed with earlier conclusions that delayed transfer of an embryo in the blastocyst stage may increase damage due to exposure and manipulation of the zona pelucida (a translucent layer surrounding the ovum), a consequence of which may be MZ twins.

"Twin Language" Decoded

A British study has endeavored to illuminate many misunderstood and misconceived aspects of twins' language development (Thorpe et al., 2001). This was accomplished with assistance from parents of 24 MZ and 52 DZ twin pairs. A group of 80 near-in-age sibling pairs (i.e., singleton siblings whose mean age difference was 22 months, with a range of 14–30 months) comprised the comparison group. Visits to participants' homes occurred at 20 months and at 36 months. Primary caretakers (usually mothers) provided detailed descriptions of their children's speech with special reference to

https://doi.org/10.1375/twin.4.6.478 Published online by Cambridge University Press

unintelligible words or phrases, use of such speech with individuals outside the twinship and other distinctive features. Standard language assessment protocols were also administered. Parent-child observations in three different settings were conducted during the 20-month visit. A six-year follow-up was arranged for families in which children's secret language was persistent and severe.

So-called "secret language" utterances were assigned to one of two categories:

1. *Private language*: communication used exclusively within the child pair, but which is unintelligible to others.
2. *Shared verbal understanding*: communication used within the pair *and* with others, but which is unintelligible to others.

Many findings from this study are of interest. Private language and shared understanding were observed among non-twin pairs, as well as twin pairs, although both were more frequent among the latter at both ages. (Private language at 20/36 months: twins: 11.8%/6.6% vs. non-twins: 2.5% /1.3%; Shared verbal understanding at 20/36 months: 50%/19.7% vs. non-twins 27.5%/2/5%). Shared verbal understanding showed continuity across ages, while private language did not. Children showing shared understanding or private speech obtained lower scores on most cognitive ability measures than those who did not — this was especially true for the small number of children showing private language at 36 months. Parental occupation, education and vocabulary were unrelated to child outcomes. However, home measures (e.g., learning stimulation and warmth) were lowest among families whose children showed private language at the 36-month assessment.

The investigators concluded that shared verbal understanding is a normal developmental feature in twins and near-in-age siblings. In contrast, private language is less frequent (although assessment may be problematic at 20 months of age when children are learning to talk). Three of the seven pairs displaying private language at 36 months did so in conjunction with normal speech, while the other four pairs did not. Organizing twin pairs according to these language characteristics may inform further research and intervention.

Comment: A mother of twins informed me that an older sibling understood her twins' "secret language", serving as an able translator for her and her spouse. However, the singleton sibling did not use the twins' language features in his own conversations. I wonder if Thorpe and colleagues would consider approaching twins' older brothers and sisters to determine if this were generally true. Meaningful differences might emerge between speech that is unintelligible to everyone and speech that is unintelligible to parents, but not to other siblings or peers.

Limiting the non-twin sibling age difference to 30 months was decided by the need to "have an age gap that was sufficiently narrow for some interaction between the children and between the mother and the pair, but sufficiently wide for the children to be at a different developmental level (to provide a contrast with the twins)" (p. 46). However, shared play opportunities were probably more frequent for twins than for the non-twins; this could partly explain the reduced frequencies of both shared understanding and private language among the siblings. This would be especially true if older siblings attended playgroups and younger children did not. The ages of the siblings in the study were not given, but if younger children were 20 months (or 1.6 years) when the study began, it is conceivable that his, or her, older sibling was 50 months (or 4.2 years). The possibility that unusual language characteristics would evolve between such widely spaced siblings seems slim. I would suggest a different type of comparison group: I am currently studying a unique sibship called virtual twins (VTs), defined as same-age unrelated children reared together since infancy (Segal, 2000a). The small age difference for 90 VT pairs (2.96 months, *SD* = 2.72, range = 0 – 9.2 months) creates a rearing situation mimicking twinship, albeit without biological relatedness. (Twinship is replayed in the sense that children are in the same school grade and experience key developmental events together.) The frequency of secret speech in this sample has not been explored, but at least one mother mentioned its presence in her pair. I suspect that secret speech would occur less frequently among VTs than among MZ twins (whose matched abilities and personalities most likely underlie such behavior). However the frequency of secret speech among VTs might approach that of DZ twins and exceed that of siblings in the British study.

I thank the authors of this study for their informative work and the impetus to pursue these issues in my own laboratory.

Twin Towers: Personal Perspective

It is difficult to close this column without reference to the terrorist attack on individuals in the World Trade Towers on September 11, 2001. With the passage of time, communal grief adopts unique casts fashioned by each individuals' memories and experiences. Here is one personal perspective.

Like many New Yorkers, I was accustomed to seeing the "proud pair" from many locations throughout Manhattan and beyond. Flying into the city from the West Coast, the towers were always welcoming, a sign of assurance that I was finally home. My twin sister, Anne, celebrated her wedding at the top of the Twin Towers in 1987. We both found it fitting that the venue for the occasion came with a multiple theme.

Anne was at work in the World Financial Center, just across the street from the World Trade Center, when the first blast occurred. Hearing the news on the radio in California, I dialed her office, but she had left soon after the second blast occurred. Over an hour passed until I learned she was safe. I do not know how many families lost one, or both, twins in that set of explosions, or in attacks involving the Pentagon in Washington, D.C. and United Airlines plane outside Pittsburgh. The first twin case I learned of involved Nigel Thompson, of Sheffield, England. Thompson was

https://doi.org/10.1375/twin.4.6.478 Published online by Cambridge University Press

a broker working for Cantor Fitzgerald on the 105th floor of the north tower (Miller, 2001). The last person he spoke with by telephone was his twin brother, Neil, who worked elsewhere in the city. He was telling his twin brother that the building was being evacuated when the line went dead. He was thirty-three years old.

The uniquely devastating effects of losing a twin, both for the surviving co-twin and family members, are well documented by life histories (Diskin, 2001) and formal investigations (Segal, 2000b). These stories and studies explain why it was so distressing for me to discover a "fabricated" account of a missing twin amidst the chronicles of lives lost. I wondered: why invent a twin? Many causes are credible, yet perhaps this falsification was inspired by the intense interest twins arouse among professionals, the media and the general public. The idea of twins separated by terrorist acts is deeply affecting, no doubt explaining its attention from journalists until the truth was known. The story surely saddened many readers as it did me — at least for a time.

Recent events have affected our lives in countless major ways, including work schedules, travel plans and entertainment choices. It has also produced less apparent (but still significant) effects in areas of interest to twin researchers. Twinsworld.com, a twin-based web site listing social events, media opportunities and other information, expressed regrets for coverage of their June 6, 2001 Twin Towers Event, noting that preparation of text and photos occurred prior to September 11th. Similarly, I omitted the otherwise fitting "twin towers" metaphor from recent description of a sturdy MZ pair. Shortly thereafter, I discovered the identical characterization of college basketball players, Jason and Jaron Collins ("Twin Towers Drive Stanford's Title Hunt") by Spousta (2001). "Twin Towers" is well-suited to the kind of word play prompted by some pairs, but we will not see this one again.

I am grateful to colleagues from around the world for their many kind thoughts. I would also like to hear from twins and their relatives who were affected by September's events. Finally, this column is dedicated to everyone, and anyone, whose lives changed immeasurably on the eleventh of last month.

In light of the terrorist attacks on September 11, 2001, T.W.I.N.S (Twinsworld International Networking Society) will be hosting an event in New York City, on February 2, 2002, on behalf of twin victims, their families and children. Please direct inquiries to: T.W.I.N.S, 333 East 89TH Street, Suite # B, New York, NY 10128, USA, 1-800-RU-TWINS

A Colleague Passes Away

Dr. Donald J. Cohen, Sterling Professor of Child Psychiatry, Pediatrics and Psychology, at Yale University, in New Haven, Connecticut, passed away on October 2, 2001. Dr. Cohen was well known for his work on autism and Tourette Disorder, as well as for his humanitarian efforts on behalf of children and families around the world. The Tel Aviv Mental Health Center and Tel Aviv University recently established the Cohen-Harris Center for the Study of Trauma in his honor ("Renowed Child Psychiatrist Dies," 2001).

Missing from several published tributes I have read were references to Dr. Cohen's contributions to twin research. Many will recall his well-known 1973 paper on assigning twins as MZ or DZ (Cohen et al., 1973). Based on mothers' answers to physical resemblance and twin confusion items, accuracy of zygosity assignments reached 98%. That paper also urged readers to consider the research and rearing implications raised when MZ co-twins are mistaken for one another. This work was followed by a report presenting eight case studies of twins' psychosocial development during puberty (Frank & Cohen, 1980). Additional information about Dr. Cohen's career is available at Yale University's web site (www.yale.edu).

References

Cohen, D. J., Dibble E., Grawe J. M., & Pollin, W. (1973). Separating identical from fraternal twins. *Archives of General Psychiatry, 29*, 465–469.

de Castro, J. M. (2000). Eating behavior: Lessons from the real world of humans. *Nutrition, 16*, 800–803.

de Castro, J. M. (2001a). Palatability and intake relationships in free-living humans: The influence of heredity. *Nutrition Research, 21*, 935–945.

de Castro, J.M. (2001b). Personal communication.

de Castro, J.M. (2001c). Heritability of dirunal changes in food intake in free-living humans. *Nutrition, 17*, 713–720.

de Castro, J. M., & Plunkett,S. S. (2001). How genes control real world intake: Palatability-intake relationships. *Nutrition, 17*, 266–268.

Diskin, S. (2001). *The end of the twins: A memoir of losing a brother*. New York: Overlook Press.

Frank, R. A., & Cohen, D. J. (1980). Preadolescent development: Case studies in twins. *Yale Journal of Biology and Medicine, 53*, 471–483.

Loos, R., Derom, C., Eckels, R., Derom, R., & Vlietinck, R. (2001). Length of gestation and birthweight in dizygotic twins. *Lancet, 358*, 560–561.

Martin, J. A., & Park, M. M. (1999). Trends in twin and triplet births. *National Vital Statistics Reports, 47*, 1–16.

Olsen, S. F. (2001). Commentary: Does use of food supplements influence the twin rate? New evidence from a randomized trial. *International Journal of Epidemiology, 30*, 807–808.

On-line Medical Dictionary (1995–1998). Available: omd@www.graylab.ac.uk.

Miller, M. (2001, September 15). Britons share anguish of waiting for news. *Los Angeles Times*, p. A-29.

Renowed child psychiatrist Dr. Donald J. Cohen dies. (2001, October 12). *Yale Bulletin and Calendar, 30*.

Rose, R. J., & Ditto, W. B. (1983). A developmental-genetic analysis of common fears from early adolescence to early adulthood. *Child Development, 54*, 361–368.

Segal, N. L. (2000a). Virtual twins: New findings on within-family environmental influences on intelligence. *Journal of Educational Psychology, 92*, 442–448.

https://doi.org/10.1375/twin.4.6.478 Published online by Cambridge University Press

Segal, N. L. (2000b). *Entwined lives: Twins and what they tell us about human behavior*. New York: Plume.

Sheiner, E., Kivilevitch Z., Levitas, E., Sonin,Y., Albotiano S., & Har-Vardi, I. (2001). Monozygotic twins following blastocyst transfer: A report of two cases. *European Journal of Obstetrics and Gynecology, 98*, 135–138.

Spousta, T. (2001, March, 21). Twin Towers drive Stanford's title hunt. *New York Times*, p. D-3.

Thorpe, K., Greenwood, R., Eivers, A., & Rutter, M. (2001). Prevalence and developmental course of 'secret language'. *International Journal of Language and Communication Disorders, 36*, 43–62.

Wenstrom, K. D., Syrop, C. H., Hammitt D. G., & Van Voorhis, B. J. (1993). Increased risk of monochorionic twinning associated with assisted reproduction. *Fertility and Sterility, 60*, 510–514.

Zandonella, C. (2001). Dining habits governed by your genes. In *New Scientist* [Online]. Available: *www.newscientist.com/news*.

https://doi.org/10.1375/twin.4.6.478 Published online by Cambridge University Press