Twin relationships in old age: A developmental perspective

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ABSTRACT

The relationship development of 133 monozygotic (MZ) and 60 same-sex dizygotic (DZ) older twin pairs was studied retrospectively and contrasted with their other sibling relationships. Results indicate: (i) Since adolescence, MZ twins lived closer to one another and had more frequent contact, social support, and emotional closeness. For both MZ and DZ pairs, contact and emotional closeness decreased since early adulthood, but increased again in old age. Dyadic differences in these variables were highly stable over time. (ii) Compared with their other sibling relationships, the relationships between MZ and DZ twins were more intense with respect to all relationship domains (e.g., contact, intimacy, conflict, and support). (iii) Whereas higher attachment security and relationship satisfaction in MZ pairs were independent of contact frequency, security and satisfaction were less intense in DZ pairs and strongly dependent on their contact. It is concluded that MZ and DZ twin relationships are different kinds of sibling relationships in old age.

KEY WORDS: dyadic relationships • older twins • siblings

Twinning is an experiment of nature that sends genetically identical or similar individuals into separate lives and exposes them to diverse environmental conditions. Although the genetic factor is unambiguously manipulated (i.e., complete or about 50% similarity), the environmental conditions are fairly uncontrolled and hard to predict. The ultimate outcomes have

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been studied extensively by behavioral geneticists and have strongly confirmed the genetic basis as well as the multiple environmental conditions of human behavior even in old age (Pedersen et al., 1991; Plomin 1986). Although twins have thus received much attention as a tool to understand the roots of *individual differences*, it has been scarcely noticed that they are pairs that provide a unique challenge to study *dyadic differences* (i.e., differences between dyads), and, from a more general perspective, the consequences of genetic and environmental conditions for the development of close dyadic relationships. The present study takes advantage of this special condition and focuses on differential features of relationships between monozygotic (MZ) and dizygotic (DZ) twins in old age.

Sibling relationships in old age

Sibling bonds are specific types of close relationships, which typically last as long as one's life. Older siblings share life-long biographical and historical experiences and are often the only remaining persons who have known each other as a child, adolescent, and adult. In later life, siblings may become the last remainder of one's family of origin and, thus, represent important aspects of one's early and shared past (Lang & Carstensen, 1998). Although sibling relations in childhood have been investigated extensively (see Brody, 1998, for a review), siblings in old age have been rarely selected for the study of intimate relationships. Cicirelli (1989, 1995) found for the US that almost 78% of people over 60 years of age had at least one sibling with whom they still communicated. When the cross-sectional age trends from late adolescence through adulthood and into old age were examined, it appeared that mean emotional closeness to siblings increased with the age of the cohort.

Siblings may be also viewed in the broader context of other relationships in the personal network, such as family and friendship. For example, according to the *social convoy model* of Kahn and Antonucci (1980), people maintain relationships that can satisfy their age-related emotional and instrumental needs. Compared with younger or middle-aged adults, older people usually have fewer relationships and less contact, which may be partly due to the mortality or morbidity of relationship partners, but could also be a result of deliberate choices (e.g., Lang, 2000). Relationships with siblings, however, are among the types of relations that are likely to be continued in old age, and contribute significantly to emotional and social well-being (Antonucci & Akiyama, 1995; Bedford, 1995; Bedford & Avioli, 1996; Cicirelli, 1996; Connidis & Davies, 1992). From the perspective of *socio-emotional selectivity theory*, it has been argued that older people prefer social interactions and maintain relationships that are meaningful and lead to positive emotional experiences (Carstensen, Isaacowitz, & Charles, 1999), and even more so when feeling near to death (Lang, 2000).

The theoretical assumptions and empirical findings about the changing nature and functions of social relationships across the life span suggest that the general development of sibling relationships over the life course follows a U-shaped curve. When siblings reach reproductive age, they may wish to

dissociate themselves from one another and be more concerned with mating, building a nest and having children, or struggling with their careers. Also, situational factors beyond their control (e.g., location of job or residence) may force siblings to withdraw from each other in middle age, although they still play a potentially supportive and affective role. After this reproductive and generative period, however, siblings may intensify their bonds and rediscover each other as a potential source of support, for example, in the case of partner loss.

The study of older twin relationships may offer new insights into why most siblings continue to maintain more or less intense bonds even until late in life. This research explores the genetic and environmental conditions that underlie the general patterns and dyadic differences in sibling relationships over the adult life course.

Twins as siblings

Although a few studies have focused on twin relationships in childhood (e.g., Koch, 1966), twin relationships in old age have – to the best of my knowledge – not been studied before. Twins are characterized by genetic similarity and their high familiarity. As the human genome remains constant throughout one's life, older MZ twins still share 100% of their genes, whereas DZ twins share about 50% of their genetic material. This also has implications for the dyadic relationship among twins, which is shaped by both genetic and environmental influences. Whereas the genetic influence can be conceptualized in terms of gene→environment effects, environmental influences are more diverse and can be shared and unshared by the twins.

Gene→environment effects are thought to stem from processes that predispose genotypes to look for, create, and simply find themselves in environments that suit them and that may, in turn, influence phenotypic developments (Plomin, DeFries, & Loehlin, 1977; Scarr & McCartney, 1983). These processes can lead to active, reactive, and passive gene→environment effects. As parents provide fitting environments for their children due to their genetic similarity, gene→environment effects in childhood are considered mainly as passive (e.g., socioeconomic status). When children grow up, these passive effects decrease because young adults are likely to seek environments that suit them (e.g., friends, dating partners, college course, job), thus creating an active effect. At the same time, they may also find themselves in environments that change to suit them (e.g., school class), which is understood as a reactive effect. Although passive effects appear to decrease with age, there is evidence that reactive effects persist throughout the whole life, whereas active effects become even stronger over the life course (Plomin et al., 1977).

It seems appropriate to apply gene→environment effects to the dynamic of the twin relationship itself, because a twin serves his or her co-twin as an important part of the social environment with whom he or she uniquely interacts. However, because of their different genetic relatedness, MZ and DZ twins may feel differentially attracted towards their co-twin. Although since childhood the twin relationship is predetermined for both MZ and DZ

twin pairs (passive effect), it can be expected that over the life course adult MZ twins are more likely than DZ twins to choose their co-twin as a close relationship partner (active effect) and, simultaneously, to be chosen by their co-twin (reactive effect). Because active gene→environment effects pertain to one's social reactions to the genome of the co-twin and reactive effects are produced by the co-twin's social reactions to one's genome, these effects can be viewed as equivalent in the special case of twins. Consequently, they appear stronger in MZ than DZ twins. Driven by these genetically based effects that accumulate in MZ twins, these MZ twins should exhibit higher levels of relationship qualities (e.g., co-twin attachment, relationship satisfaction, and social support), as well as increasing interdependence (i.e., similarity) in their perception of these qualities. The same gene→environment effects, however, operate in DZ twins, but may be less strong and may decrease with the intensity of contact and interdependence in other relationship qualities, because DZ twins will look for different environments, and in turn for a less close co-twin relationship. Gene→environment effects are not limited to twin relationships, because they are likely to work in romantic couples due to assortative mating (Lykken & Tellegen, 1993), and may also explain why, for example, adult friendships are strongly determined by the similarity of relationship partners (Blieszner & Adams, 1992; Rawlins, 1992).

Beyond these genetic effects, twin relationships are also influenced by environmental conditions, such as family, school, and work environments. Higher rates of contact between MZ twins have been often interpreted as indicating the greater similarity of the environments in which MZ twins live. This situation has been expected to increase the phenotypic similarity of MZ more than of DZ twins. However, the empirical evidence is mixed and should invite longitudinal research to disentangle whether social contact between twins leads to similarity (thus indicating an environmental effect) or whether similarity leads to contact (thus indicating a genetic or gene→environment effect) (Lykken, McGue, Bouchard, & Tellegen, 1990; Plomin, DeFries, McClearin, & Rutter, 1997; Posner, Baker, Hearth, & Martin, 1996; Rose & Kaprio, 1988; Scarr, 1993). Given these genetic and environmental conditions, however, the relations between older MZ and DZ twins are hypothesized as being different kinds of sibling relationships in old age, as shown by Koch (1966) for twin relationships in childhood (e.g., higher levels of emotional closeness in MZ than DZ twins).

The dyadic nature of twin relationships

Until now, older sibling relationships were mostly studied from the perspective of one individual person and not from the perspective of both members of a sibling or a twin dyad (e.g., Bedford, 1995; Cicirelli, 1995; Connidis & Davis, 1992). Although the study of social relationships from the perspective of the individual represents a research tradition in its own right (e.g., a personal network permits an investigation of many relationships simultaneously from the perspective of one respondent), it ignores the dyadic nature of social relationships.

But because so many central concepts of the psychology of social relationships – such as similarity, compatibility, reciprocity, and mutuality – are inherently dyadic, the study of dyads rather than just individuals is very much required (Kenny, 1988; Maguire, 1999). Thus, it seems likely that the subjective views of dyad members regarding their relationship are not independent of each other. In a study on dyadic perception between older twins, for example, Neyer, Banse, and Asendorpf (1999) observed that the perception of oneself and the co-twin, empathic accuracy, reciprocity, and projection were all highly interdependent between both dyad members. It was therefore one of the conclusions of this study that dyadic perception was primarily a result of dyadic processes and characterized a twin relationship rather than the individual personality.

The dyadic approach has several methodological implications. First, when general differences between MZ and DZ twin relationships are of interest, it has to be analyzed whether both members of a twin dyad agree in their evaluation of a relationship domain, such as contact frequency, support, and closeness. In the case of substantial agreement, both partners' evaluations are interdependent and may be averaged to a composite score, characterizing the dyad while ignoring intra-dyadic differences that reflect how the two members of a dyad behave or feel differently in a given relationship domain (Kenny, 1988).

Second, the dyadic interdependence of both partners' subjective views on their relationship can be modeled explicitly. For example, the association between the amount of contact and relationship satisfaction can be shared by both twins to a certain extent, although both may also differ in how satisfied they feel with their relationship as a consequence of differentially contacting the other. The *Pairwise Dyadic Model* can simultaneously test these dyadic and individual effects. Based on the concept of individual and group-level covariation by Kenny and LaVoie (1984, 1985), Griffin and Gonzalez (1995) (see also Gonzalez & Griffin, 1997) developed the Pairwise Dyadic Model and proposed estimates of *latent dyadic* and *latent individual correlations*. A substantial latent dyadic correlation between contact and satisfaction would indicate that those twin dyads whose members contact each other more frequently relative to other dyads are also the twin dyads whose members feel more satisfied with their relationships. In contrast, a substantial individual-level correlation between contact and satisfaction would indicate that the single twin who is more satisfied relative to his or her co-twin is also the twin who initiates more contact than the co-twin. But this correlation does not indicate the extent to which this association between contact and satisfaction is shared by both twins. (The computation of these correlations will be described in the Results section.)

The present study

The present study was part of the Genetic Oriented Life Span Study on Differential Development (GOLD) funded by the Max-Planck-Institut für psychologische Forschung, which investigated older twins from a multidisciplinary perspective (i.e., cognition, intellectual functioning, social

behavior, motivation, personality) (Weinert, 1997). The part of the study reported here was concerned with the twin relationship and applied different approaches. First, twins were interviewed separately from each other and asked about the biographical development of their sibling relationship since adolescence. Although a retrospective evaluation is no substitute for longitudinal research, it does take advantage of the rich biographical knowledge of the twins who should be sensitive to subtle changes in the developmental course of their relationship. Second, the co-twin relationship was compared with one's relationships with other siblings in order to analyze whether twin relationships are unique or have similar properties to relationships with other siblings. Third, different relationship qualities (i.e., attachment security, dependency, and satisfaction) were studied at the dyadic and individual levels. In particular, it was investigated whether and to what extent these relationship qualities were dependent on the amount of interactions between twins.

Given these theoretical and methodological considerations, the present research was guided by the following questions:

1 How do differences between MZ and DZ twin relationships change over adulthood?
2 Is one's co-twin relationship unique as compared with one's relationships to other siblings?
3 Are the dyadic qualities of twin relationships a function of the twin's social interactions?

The first question demands the dyad as the unit of analysis, whereas the second can be answered from the individual perspective. The third question requires dyadic data analyses that account for the interdependence of the relationship data and that analyze them at the individual as well as the dyadic level.

Methods

Participants

Participants were invited to visit the Max-Planck-Institut für psychologische Forschung for five daily sessions and to participate in an extensive psychological test program focusing on various psychological issues such as memory, learning and intelligence, moral attitudes, personality and motivation, and social behavior. The sample considered here consisted of 193 same-sex twin pairs (133 MZ and 60 DZ). Twin status was established by DNA analyses (based on blood samples that were obtained by finger pricks). Table 1 displays the sociodemographic properties of the sample.

Sex was distributed equally in both twin groups. Mean age was 71.5 years ($SD = 4.7$). Although female MZ pairs tended to be older than others ($F(3,190) = 2.92$, $p < .05$), post-hoc comparisons between subgroups revealed no substantial age differences (by Bonferroni's test for least significant differences). Differences in marital status were unrelated to twin status, but largely due to sex differences $\chi^2(3, N = 386) = 65.40$, $p < .001$; nearly all male participants

TABLE 1
Description of the twin sample

	MZ twins		DZ twins	
	Female–female	**Male–male**	**Female–female**	**Male–male**
Number of pairs	89	44	40	20
Age (years)				
M	72.54	70.76	70.69	70.10
SD	4.98	4.79	3.91	3.54
Marital status (%)[a]				
Single	11.2	2.3	8.8	–
Divorced	5.6	2.3	5.0	5.0
Widowed	32.0	2.3	38.8	7.5
Married	51.1	93.2	47.5	87.5
Parental status (%)[a]	82.4	95.3	78.5	97.5
Educational status (high school) (%)[a]	30.3	30.7	30.0	35.0
Socioeconomic status[b]				
M	50.01	53.68	49.14	52.09
SD	14.61	13.45	15.11	14.36

[a]Percentages refer to the proportion of respondents in a subgroup with a given characteristic.
[b]Socioeconomic status was measured as the occupational prestige of the most recent professional status of the participant (or of a housewife's husband) (Treiman, 1975).

were still married, whereas the number of married females was reduced due to higher rates of widowed, divorced and single women. Parental status did not vary by twin status, but differed significantly between female and male participants, indicating that nearly all males were parents but not all females were parents, $\chi^2(1, N = 386) = 15.53$, $p < .001$. Educational status was measured in terms of the percentage of participants who had received a high school diploma, which was about one third in each subgroup. Socioeconomic status (SES) was measured by a standardized international scale developed by Treiman (1975), which operationalizes SES as occupational prestige, with scores ranging from 0 to 90 (e.g., farmer, $M = 32.4$, $SD = 14.6$; blue collar, $M = 33.1$, $SD = 10.8$; white collar, $M = 52.9$, $SD = 15.6$). Because all participants were retired, codings of occupational prestige were based on the last professional position of participants (or by a housewife's husband, if his prestige was higher). The occupational prestige did not vary between the subgroups, but the occupational prestige of the overall sample ($M = 51.23$, $SD = 14.38$) was higher than that of the average population level reported by Treiman (1979) ($M = 43.3$, $SD = 16.9$, $t(895) = 7.57$, $p < .001$, $d = .51$). All in all, however, sociodemographic variation was primarily a function of sex, but not of the twin status.

Procedures and measures

Interview on the biography of the twin relationship. An extensive interview was developed in order to study retrospectively the course of the twin relationship since adolescence. Twins were interviewed separately by two trained

research assistants, and informed that one was interested in their relationship with the co-twin at different stages in life, which are typically, but not normatively, passed by many people. Because it was assumed that people remember their biography due to meaningful life stages rather than due to their biological age, these life stages were defined in terms of the family life cycle. Participants were asked to remember how old they were at the beginning and the end of each stage. The family life cycle consisted of six stages: (1) leaving the family of origin, (2) building a new nest, (3) living in a family with children, (4) living in a family with adolescents, (5) living in an empty nest, and (6) up to the present. The 58 individual participants (15% of the sample) who had not passed through a family life cycle, because they had not become parents, were primed to alternative life events that were likely to occur at a given stage of the family life cycle (e.g., first employment, reaching age 40, becoming retired).

When the reconstruction of the life course was completed, participants were instructed to try to remember each of these stages and the related age periods as precisely and deeply as possible. They were then asked to rate for each of the six stages, (1) the frequency of contact on a 7-point-scale (1 *never* to 7 *every day*), (2) the active social support provided to the co-twin on a 5-point-scale (1 *never* to 5 *very often*), (3) the passive social support received by the co-twin (1 *never* to 5 *very often*), (4) their spatial closeness, which was operationalized in terms of the time the twins had to invest in order to meet each other (ranging from 1 *very far away*, 2 *in another area but less than one hour away*, 3 *same area but more than 15 minutes away*, 4 *same district*, 5 *neighborhood*, 6 *same house*), and (5) the emotional closeness (ranging from 1 *very distant* to 5 *very close*).

Social network interview

Twins were interviewed on their social networks separately from each other using a modified semi-projective technique that had been originally developed by Kahn and Antonucci (1980). Twins were presented a diagram of three concentric circles and explained that they should imagine themselves in the center being surrounded by people with whom they felt very close (circle 1), less close (circle 3), or in between (circle 2). The twins were then presented a list of 18 relationship categories (including co-twin and other siblings), and instructed to name these persons and to place them according to their subjectively felt closeness into one of the three circles. The named persons were specified by their sex, age, and their membership in a specific relationship category. After this network generating procedure, participants were asked with respect to each named person (1) how often he or she entrusted the other with personal concerns (thus reflecting the level of *intimacy*), (2) how often he or she *felt encouraged* by the other (e.g., in the case of feeling blue or sad), (3) how often *conflict* occurred with this person, (4) how often he or she *received social support* from the other (e.g., in case of illness), (4) how often he or she *received instrumental* support from the other (e.g., household), and (5) how often he or she had *contact* with this person. Frequency of contact was rated on a 7-point-scale (1 *never* to 4 *once a month* to 7 *every day*); the other items were rated on 5-point-scales (1 *never* to 5 *very often*).

For the purpose of within-subject comparisons of one's co-twin relation with one's other sibling relations, only these network ties were analyzed. One hundred and forty-six MZ participants and 68 DZ participants reported on their co-twin relationship *and* on relationships with other siblings. If a respondent reported more than one other sibling (50.2% of cases), data were aggregated

across these siblings. This subgroup reported a mean number of 2.02 other siblings (SD = 1.5), and no differences were observed between MZ and DZ respondents. As dependent comparisons between the placement of co-twins and other siblings within the concentric diagram revealed, the other siblings were placed further out by MZ participants ($t(145) = 9.30$, $p < .001$), and by DZ participants ($t(67) = 3.14$, $p < .01$).

Measures of the quality of twin relationships. When leaving the Max-Planck-Institut after five consecutive days of testing, the twins were thanked and given additional questionnaires to complete when they were home and separated again. These questionnaires included scales that focused on the twins' attachment security and dependency with respect to the co-twin, and the satisfaction with the twin relationship.

Attachment security and *dependency* were measured by scales developed by Asendorpf, Banse, Wilpers, and Neyer (1997) (see also Asendorpf & Wilpers, 2000). In a German large-scale study with five different samples covering a representative sample of adults (N = 1179), Asendorpf et al. (1997) tested a model of adult attachment with two related dimensions, one *secure–fearful* dimension and a second *dependent–independent* dimension. The scales showed sufficient reliability, and good convergent and discriminant validity with regard to different qualities of close relationships. Differences in attachment ratings across different relationships revealed a high relationship specificity of attachment representations, as observed by Baldwin, Keelan, Fehr, Enns, and Koh-Rangarajoo (1996).

A bipolar 6-item scale measured attachment security and an 8-item bipolar dependency scale measured the degree to which a person feels dependent on the other. For the present study, all items were formulated with respect to the co-twin-relationship (e.g., 'I find it difficult to rely on my co-twin,' 'I find it easy to become emotionally close to my co-twin' are items for security, whereas 'My co-twin must be there when I have problems' and 'I avoid being dependent on my co-twin' measure (non)dependency). The internal consistencies for dependency (α = .85) and security (α = .82) were satisfactory.

A modified German 6-item version of the Relationship Assessment Scale was given to participants in order to assess *relationship satisfaction* (Hendrick, 1988; Sander & Böcker, 1993). Items were reformulated with respect to the co-twin (e.g., 'How positive is your relationship with your co-twin as compared with others?'), and the internal consistency was high (α = .93).

Results

Biography of the adult twin relationship

The adult life courses of the twins were reconstructed alongside the family life cycle that consisted of six typical stages (mean ages and standard deviations in years are reported for the beginning and the end of each stage): (1) leaving the family of origin: M = 17 (SD = 2.6) to M = 23 (SD = 3.7), (2) building a nest: M = 24 (SD = 3.6) to M = 33 (SD = 4.6), (3) living in a family with children: M = 34 (SD = 4.6) to M = 42 (SD = 5.0), (4) living in a family with adolescents: M = 43 (SD = 5.0) to M = 52 (SD = 5.3), (5) living in an empty nest: M = 53 (SD = 5.4) to M = 62 (SD = 5.3), and (6) up to the present: M = 63 (SD = 4.52) to M = 71 (SD = 4.7). Although not extremely high, the standard deviations reflect

that these life stages were not normatively defined, but showed considerable variability.

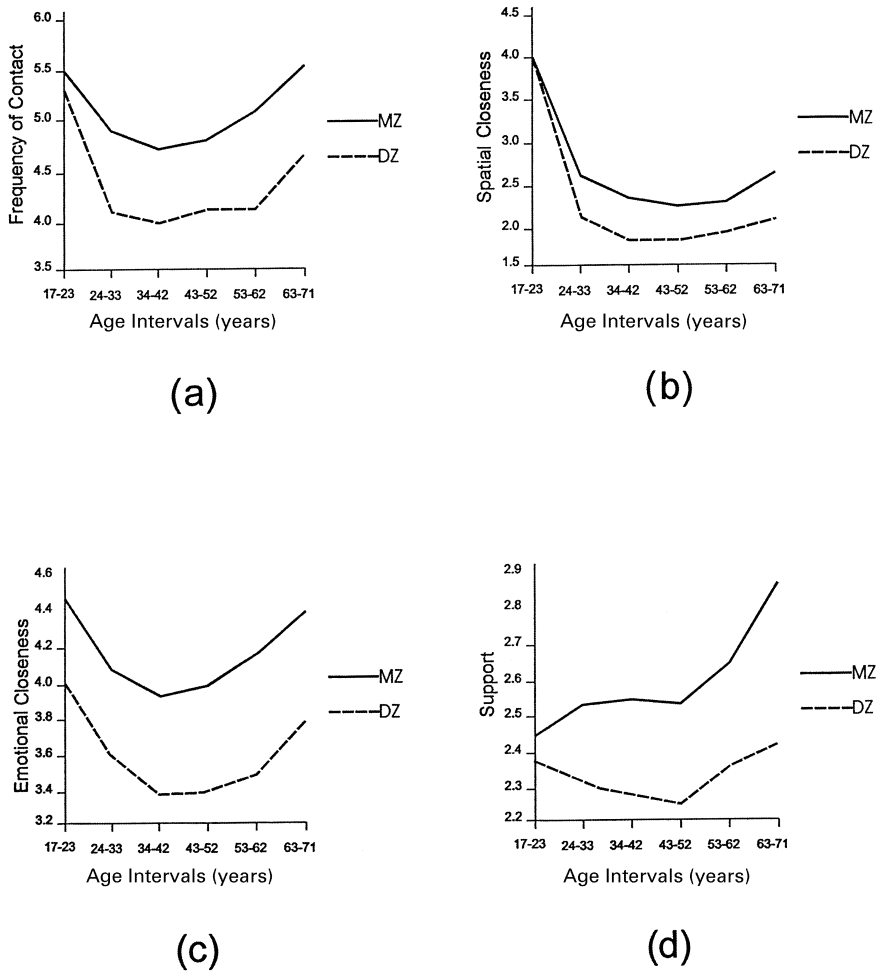
Despite this variability, twin dyad members were highly consistent in their ratings of the relationship domains across the six life stages: MZ twins agreed very much regarding the spatial closeness they lived to one another (mean intraclass correlation $ICC = .80$, $p < .001$), and the same was true for DZ twins (mean $ICC = .70$, $p < .001$). The twins also agreed in their reports on frequency of contact (MZ twins: mean $ICC = .68$; DZ twins: mean $ICC = .65$, both ps $< .001$), and in ratings of emotional closeness (mean $ICC = .53$, $p < .001$, for both MZ and DZ twins). Because the individual ratings of active and passive support were highly correlated (mean $r = .69$, $p < .001$), it seemed appropriate to use a composite score of support (consisting of the averaged scores of active and passive support). The twins' dyadic consistency in this social support composite was moderate (MZ twins: mean $ICC = .35$; DZ twins: $ICC = .41$, both ps $< .01$).

Because of the consensual agreement between the twins, the ratings of spatial closeness, contact, and emotional closeness were thus averaged across dyad members. Although there was less agreement for the support composite (albeit significantly correlated between twins), it also seemed appropriate to aggregate a dyadic score. These aggregated scores were subsequently analyzed by repeated measure MANOVA procedures, with the life stage serving as a within-pair and the twin type and sex as between-pair factors. The main effects for twin type and sex were significant for each relationship domain. Compared with DZ twin pairs, MZ twin pairs contacted each other more frequently throughout their adult lives ($F(1,189) = 16.76$, $p < .001$), and female twin pairs contacted each other more frequently than male pairs ($F(1,189) = 15.33$, $p < .001$). Similarly, MZ twins felt much closer towards each other than DZ twins ($F(1,189) = 22.61$, $p < .001$), and female pairs reported greater closeness than male pairs ($F(1,189) = 7.33$, $p < .01$). MZ twin pairs lived spatially closer to one another than DZ pairs ($F(1,189) = 6.21$, $p < .01$), but no sex differences were found in spatial closeness. Finally, MZ twins provided one another with more support than DZ twins ($F(1,189) = 3.81$, $p < .05$), and female twin pairs provided one another with more support than male twin pairs ($F(1,189) = 11.28$, $p < .001$). Statistical interactions between twin type and sex were nonsignificant in each domain.

The differences between male and female twin pairs replicated established findings on sex differences in sibling relationships (e.g., Cicirelli, 1995). Moreover, these differences also seem to reflect general sex effects in the social behavior of older people (e.g., Antonucci & Akiyama, 1987; Baltes, Freund, & Horgas, 1999) that are likely to accumulate in same-sex twin pairs, indicating female twin pairs as closer, more supportive, and in more frequent contact throughout the adult life course. But because sex did not interact with twin status, and zygosity differences were the main focus of the present study, sex was entered as a covariate in the following analyses of the developmental course of twin relationships. Thus, the developmental courses of twin relationships were then examined separately for MZ and DZ twin pairs by repeated measure MANCOVA procedures with life stage serving as a within-pair factor and sex as a covariate. The results are shown in Figure 1.

The retrospective evaluations of the twin relationship yielded a significant developmental course for each relationship domain in MZ as well as in DZ twin pairs. As confirmed by quadratic contrasts, the development of contact frequency across adulthood was U-shaped for both MZ ($F(1,132) = 51.21$, $p < .001$)

FIGURE 1
Development of MZ and DZ twin relationships from adolescence to old age. a) Frequency of contact. b) Spatial closeness. c) Emotional closeness. d) Support.



and DZ twin pairs ($F(1,59) = 45.32$, $p < .001$). Similarly, the development of emotional closeness was U-shaped, because quadratic contrasts were also significant in MZ twin pairs ($F(1,132) = 100.68$, $p < .001$) and in DZ twin pairs ($F(1,59) = 65.21$, $p < .001$). Effect sizes for quadratic trends in closeness and contact were $\eta^2 = .43$ and $\eta^2 = .28$ in MZ dyads and $\eta^2 = .52$ and $\eta^2 = .43$ in DZ dyad, respectively.

After leaving their family of origin in late adolescence, the spatial closeness decreased linearly in both MZ twin pairs ($F(1,132) = 34.42$, $p < .001$, $\eta^2 = .20$) and DZ twin pairs ($F(1,59) = 28.14$, $p < .001$, $\eta^2 = .32$). The further development of spatial closeness across adulthood showed a slight increase when approaching the empty nest phase, as reflected by quadratic contrasts in MZ twin pairs

($F(1,132) = 74.43$, $p < .001$, $\eta^2 = .36$) and DZ twin pairs ($F(1,59) = 66.04$, $p < .001$, $\eta^2 = .52$). However, both linear and quadratic trends revealed overall effects, showing that across adulthood the decrease in spatial closeness was stronger than its increase.

A different developmental pattern was observed for MZ and DZ twin pairs for the social support domain: Because the actual support between DZ siblings decreased in young adulthood, and increased again when the twins got older, its development appeared as a U-shaped curve, as was confirmed by quadratic contrasts ($F(1,59) = 4.83$, $p < .05$, $\eta^2 = .08$). The development of support in MZ twins, however, was characterized by linear effects ($F(1,132) = 13.36$, $p < .001$, $\eta^2 = .09$) as well as quadratic effects ($F(1,132) = 3.86$, $p < .05$, $\eta^2 = .03$). It appeared that the actual support increased in early adulthood, and then remained constant until the forties. After this age, the support provided by MZ twins towards each other increased dramatically.

These significant mean differences between MZ and DZ twin dyads regarding the retrospective evaluations of relationship development in different domains did not show, however, how stable or unstable the dyadic differences were over time. That is, despite robust mean differences, some dyads could have changed more than others, although a few could have remained constant throughout adulthood. The stability of these dyadic differences was clarified by further correlational analyses (while controlling for possible sex differences, see Table 2).

For MZ and DZ twin pairs, the dyadic differences appeared highly stable in each relationship domain as indicated by consistently high correlations in ratings of emotional closeness and support provided across the life stages. Dyadic differences in MZ and DZ pairs regarding the frequency of contact and spatial closeness, however, were less stable between 'leaving the family of origin' and 'building a new nest' (mean $r = .34$, ps $< .05$), becoming highly stable only after young adulthood.

Co-twin versus other sibling relationships

For a within-subject comparison between the co-twin and other sibling relations, data were analyzed at the individual level for 146 MZ participants and 68 DZ participants. This approach was appropriate because the relationships to the other siblings were studied from the individual perspective. A MANOVA was calculated that used twin type (MZ versus DZ) as a between-subject factor and sibling type (co-twin versus sibling) as a within-subject factor. Dependent measures were items from the social network inventories, enabling different individual perspectives on co-twin and sibling relationships to be compared. Results are shown in Table 3.

The strongest effects were observed from within-subject comparisons, reaching a significant level for each relationship domain (ps $< .001$). That is, both MZ and DZ participants reported more frequent contact with their co-twins than their other siblings. The same was true for intimacy (i.e., entrusting the other with personal concerns), for feeling encouraged by the other (e.g., in the case of feeling sad), for conflict, and for social and instrumental support (e.g., in case of illness or related to other daily issues). Additional dependent comparisons were conducted separately for MZ and DZ participants, and indicated for each domain that sibling relationships differed from co-twin relationships to a substantial extent in MZ participants (ts$(145) > 4.3$, ps $< .001$) and in DZ participants (ts$(67) > 3.7$, ps $< .001$).

TABLE 2
Stability of contact, spatial closeness, emotional closeness, and support since adolescence

		Stage 2 24–33 years	Stage 3 34–42 years	Stage 4 43–52 years	Stage 5 53–62 years	Stage 6 63–71 years
Contact frequency						
	MZ	.30	.72	.81	.84	.78
	DZ	.37	.70	.86	.92	.84
Spatial closeness						
	MZ	.36	.69	.75	.84	.70
	DZ	.33	.55	.87	.90	.87
Emotional closeness						
	MZ	.71	.81	.92	.85	.85
	DZ	.82	.83	.95	.78	.81
Support						
	MZ	.69	.72	.76	.85	.69
	DZ	.73	.85	.90	.87	.91

Note. Stability was measured by partial correlations between ratings at the stage indicated and the antecedent stage (accounting for sex differences).

In order to test for possible sex differences in sibling relationships within the social networks of the twins, dependent comparisons were computed between qualities of same-sex and different-sex siblings. Thirty-two female MZ participants who maintained relationships with other sisters and brothers were more intimate with their sisters, felt more encouraged, and received more social and instrumental support by their sisters than by their brothers ($ts(31) > 2.3$, $ps < .05$). Similarly, 15 female DZ participants with relationships to other sisters and brothers reported higher levels of intimacy and conflict with their sisters than brothers ($ts(14) > 2.2$, $ps < .05$). Twelve male MZ participants who had other sisters and brothers reported higher levels of contact with and social support from sisters ($ts(11) > 2.2$, $ps < .05$). No comparable differences were found in 10 male DZ participants. These results again confirm established sex differences in sibling relationships, and suggest that, compared with male participants, the female twins were more likely to differentiate between their non-twin sisters and brothers.

Because of the high variability of age differences between siblings that could have also influenced their interactions, additional independent comparisons were calculated between siblings who were fewer than four years apart ($n = 114$) and siblings who were five or more years older or younger than the participants and their co-twins ($n = 100$). With the exception of a higher conflict rate with siblings of similar age ($t(144) = 2.09$, $p < .05$), MZ participants reported no differences in the other interaction domains with siblings of similar or different age. In contrast, DZ participants reported on their relationships with siblings of similar age that they experienced higher amounts of intimacy ($t(66) = 2.45$, $p < .05$), of feeling encouraged ($t(66) = 2.64$, $p < .05$), and of receiving social support ($t(66) = 3.32$, $p < .001$) and instrumental support from the siblings ($t(66) = 1.95$, $p < .05$). No differences appeared, however, in the frequency of conflict and overall contact. Thus, the other sibling relationships of DZ participants

TABLE 3
Differences between co-twin and other sibling relationships

		MZ twin		DZ twin		Multivariate effects		
		Co-twin	Sibling	Co-twin	Sibling	Twin type $F(1,212)$	Sibling type $F(1,212)$	Twin × Sibling $F(1,212)$
Frequency of contact								
	M	5.42	4.22	4.91	4.20	4.02*	78.34***	4.95*
	SD	(1.2)	(1.2)	(1.1)	(1.1)			
Intimacy								
	M	4.17	2.94	3.70	3.01	2.94	140.17***	11.20***
	SD	(0.9)	(1.0)	(1.0)	(0.9)			
Feeling encouraged by the other								
	M	3.97	3.00	3.61	2.89	3.21	100.25***	2.24
	SD	(1.1)	(1.1)	(1.0)	(0.9)			
Conflict								
	M	2.08	1.73	2.26	1.84	2.03	29.34***	0.18
	SD	(1.0)	(0.7)	(0.9)	(0.7)			
Receiving social support								
	M	3.91	2.78	3.42	2.54	6.42**	121.63***	1.91
	SD	(1.2)	(1.2)	(1.2)	(1.0)			
Receiving instrumental support								
	M	3.33	2.39	2.89	2.05	6.31 *	101.81***	0.32
	SD	(1.4)	(1.2)	(1.2)	(1.0)			

Note. Comparisons were made by MANOVA with twin type as a between-subject factor (MZ versus DZ twin) and sibling type as a within-subject factor (co-twin versus sibling). One hundred and forty-six MZ individuals and 68 DZ individuals who reported on their co-twin and sibling relationships were included in the analyses. Frequency of contact was reported on a 7-point scale (1 *never* to 7 *every day*), the other items were rated on 5-point scales (1 *never* to 5 *very often*).
*$p < .05$; **$p < .01$; ***$p < .001$.

appeared more dependent on age differences and the related position effects than the sibling relationships of MZ participants, which seemed (with one exception) relatively independent of age differences.

Between-subject comparisons were significant for the support items and the frequency of contact (ps < .05). MZ participants reported receiving more social support and instrumental help from both their co-twin and other siblings. Additional independent comparisons between co-twin relationships of MZ and DZ participants showed that, with the exception of conflict, the co-twin relations of MZ participants differed significantly from those of DZ participants ($ts(212) > 2.20$, ps < .05). In contrast, independent comparisons between sibling relationships of MZ and DZ participants yielded nonsignificant results, with the exception of instrumental support being reported more often by MZ participants ($t(212) = 2.04$, $p < .05$).

A significant statistical interaction effect appeared with regard to the reported contact frequencies ($p < .05$): Although MZ participants contacted their co-twin more frequently than DZ participants, both MZ and DZ participants were comparable in contacting their other siblings less frequently. A very strong interaction effect appeared for intimacy (i.e., entrusting the other) ($p < .001$). Whereas mean intimacy did not differ between MZ and DZ individuals, the differences between sibling types were stronger in MZ than in DZ individuals. In other words, the discrepancy between intimacy with one's co-twin and intimacy with other siblings was greater in MZ than DZ participants.

Relationship quality and contact frequency

Three measures of relationship quality (attachment security, dependency, and relationship satisfaction) were assessed. Higher dependency was observed in female twins ($t(312) = 4.49$, $p < .001$), but no sex effects were found in attachment security or relationship satisfaction. The measures of relationship quality appeared highly interdependent between twins. Attachment security was significantly correlated in MZ twin pairs ($ICC = .68$, $p < .001$) and in DZ twin pairs ($ICC = .47$, $p < .001$). Dependency was also correlated in MZ ($ICC = .65$, $p < .001$) and DZ pairs ($ICC = .32$, $p < .05$). Similarly, relationship satisfaction was also highly correlated in MZ ($ICC = .57$, $p < .001$) and DZ pairs ($ICC = .64$, $p < .001$). Although dyadic interdependence in satisfaction was comparable in MZ and DZ dyads, MZ twins were significantly more consistent in security and dependency than were DZ twins (Zs > 2.0, ps < .05). Because of the high interdependence, the individual scores were first controlled for sex differences and then averaged across dyad members for a dyadic composite of each quality. Compared with DZ twins, MZ twins felt more securely attached to as well as more dependent on the co-twin, and were much more satisfied with their relationship. The effect sizes ranged from $r = .20$ to $r = .39$ (Table 4).

Beyond mean differences between the measures of relationship quality in MZ and DZ pairs, the dyadic differences in these characteristics are of critical importance for the study of twin relationships. In order to test whether relationship qualities were differentially influenced by the contact behavior of MZ and DZ twins, pairwise dyadic analyses were computed according to the Pairwise Dyadic Model (Griffin & Gonzalez, 1995).

In the present case, this model enables the correlations between contact and relationship qualities (reported by both dyad members) to be decomposed into the latent *dyadic correlations* r_d and the latent *individual correlations* r_i. The dyadic correlation r_d, for example between contact and dependency, is a latent

TABLE 4
Differences in the quality of MZ and DZ twin relationships

	MZ twin pairs		DZ twin pairs			
	M	*SD*	*M*	*SD*	*t*	*r*[c]
Attachment security[a]	.11	.84	–.28	.94	2.58**	.20
Dependency[a]	.22	.90	–.52	.71	5.18***	.39
Relationship satisfaction[b]	.17	.74	–.42	1.08	4.37**	.33

Note. Between-pair comparisons were based on standardized scores (controlled for sex) and averaged across twin dyads.
[a]Comparisons of attachment security and dependency were based on 109 MZ and 47 DZ pairs.
[b]Comparison of relationship satisfaction was based on 133 MZ and 60 DZ pairs.
[c]*r* represents approximated point-biserial correlations as effect size estimates.
$^{**}p < .01$; $^{***}p < .001$.

version of the cross-correlation between one's dependency and the amount of contact reported by the co-twin that is adjusted for the between-partner correlations between dependency and contact. A latent dyadic correlation r_d between contact frequency and dependency would indicate that the twin dyads with highly frequent contact would also be characterized by a high dependency or, in other words, the dependency felt by both dyad members would strongly depend on the amount of contact. Conversely, a latent individual correlation r_i is composed of the individual components of the correlation between dependency and contact that are adjusted for the individual variance in dependency and contact. Thus, the latent individual correlation reflects the extent to which a twin who feels more dependent on the co-twin (than the co-twin does to him- or herself) is also the one who contacts the other more frequently (Table 5).

As indicated by a high latent dyadic correlation r_d, attachment security was highly related to the contact frequency of DZ twins, whereas the attachment security of MZ twins was completely unrelated to the frequency of contact. Similarly, the latent dyadic correlation between contact and relationship satisfaction was high and significant in DZ twins, and low and nonsignificant in MZ twins. The latent dyadic correlation between dependency and contact was substantial in MZ and DZ twins, but was significantly weaker in MZ twin pairs. Compared with the latent dyadic correlations, none of the latent individual correlations r_i was substantial. This is due to the fact that actual contact frequency ratings were highly correlated between the twins ($ICC = .83$, $p < .001$ in MZ twin pairs, and $ICC = .78$, $p < .001$ in DZ pairs) and thus clearly represented a feature of the dyad. Therefore, the relations between contact and the qualities of the twin relationships were not due to individual effects.

Discussion

The results of the present research show that MZ and DZ twin relationships in old age are unique types of sibling relationships, as indicated by substantial differences in all relationship domains and dynamics. Over the adult life course, both twin groups were similar in the overall developmental

TABLE5
Pairwise latent dyadic and individual correlations between contact frequency and relationship qualities in MZ and DZ twin pairs

		MZ	DZ
Frequency of Contact – Attachment Security			
	r_d	$-.03_a$	$.56_b$***
	r_i	–.04	.07
Frequency of Contact – Relationship Satisfaction			
	r_d	$.10_a$	$.49_b$**
	r_i	.07	–.10
Frequency of Contact – Dependency			
	r_d	$.50_a$***	$.80_b$***
	r_i	.07	–.03

Note. Latent pairwise dyadic correlations r_d and latent individual correlations r_i were controlled for sex and computed according to the Pairwise Dyadic Model, and tested by *Z*-tests and *t*-tests, respectively (Griffin & Gonzalez, 1995). Correlations in a given row with different subscripts differ significantly from each other (*Z*s > 2.74; *p*s < .001)
**$p < .01$; ***$p < .001$.

patterns that seem to apply for sibling relationships in general. However, MZ twin pairs contacted each other more frequently and lived spatially closer to one another over the whole adult life course. Moreover, they provided more support and felt emotionally more closely related to one another. The co-twin relations of MZ and DZ twins differed from relations to other siblings in all studied interaction domains. Finally, the pairwise dyadic analyses established different relationship dynamics in MZ and DZ twin pairs, because they revealed that the quality of DZ twin relationships was largely dependent on how frequently they contacted each other, whereas this effect disappeared or was less strong in MZ twin relationships.

Twin relationships over the adult life course

Twins were interviewed separately on their relationship development by priming the participants to specific stages of the family life cycle, and high dyadic agreement of the twins indicated reliable estimations of the relationship developments. These dyadic evaluations of relationship development revealed a pattern that was, with one exception, consistent for MZ and DZ twin pairs. The general developmental pattern of contact frequency and the emotional closeness followed a similar U-shaped curve in MZ and DZ pairs. After leaving the family of origin, contact and emotional closeness decreased until twins reached their thirties and forties, when the twins were each involved in raising their children and/or in their careers. After these reproductive and generative ages, however, the intensity of both qualities increased again as the respondents approached the empty nest or retirement phase. The spatial closeness decreased linearly when the twins had left their family of origin, but later increased after the empty nest stage. The developmental course of the support the twins provided for each other was

certainly somewhat different between MZ and DZ pairs, but both patterns appeared roughly comparable with those observed in the other domains.

These general results clearly replicate the findings by Cicirelli (1995, 1996), who also observed similar age-related trends from the cross-sectional study of different birth cohorts. Moreover, these results support assumptions that siblings in old age will be reselected and reappear as emotionally important and supportive companions, probably because they share lifelong biographical and historical experiences and thus belong to one's convoy of close relationships (Bedford, 1995; Carstensen, 1992; Connidis & Davies, 1992; Kahn & Antonucci, 1980). The replication of these findings may also lead to the suggestion that this pattern is universal at least for Western cultures, and secular trends of social change may also contribute to it.

The observed differences between MZ and DZ twin pairs, however, provide evidence for the possible roots of dyadic differences in these overall patterns. At nearly all ages, MZ twin pairs reported significantly higher levels of contact and closeness. These consistently observed differences obviously stem from genetic effects and environmental effects, which are likely to work differentially in MZ and DZ pairs. Because of their higher genetic similarity, MZ twins were more likely to choose each other as companions (active and reactive gene→environment effects) (Plomin et al., 1977; Scarr & McCartney, 1983).

Moreover, MZ twin pairs reported greater spatial closeness throughout adulthood. As spatial closeness was measured in terms of the psychological effort required in order to meet the co-twin (instead of kilometers or miles), ratings may have been confounded by other relationship qualities, such as contact frequency (i.e., participants may have perceived spatial distance also as a function of different relationship qualities).

The development of support that twins provided each other followed a different pattern for MZ and DZ pairs. Although the developmental course was again U-shaped in DZ pairs, the support between MZ twins increased slightly in the early family life cycle, remained constant until the empty nest stage, but then increased dramatically. These diverging later paths seem also to be related to gene→environment effects that may have become more powerful in old age, leading to a stronger increase of support in MZ than DZ twins.

Dyadic differences in these relationship domains were highly stable over time. For example, twins who contacted each other very often did so throughout adulthood regardless of the general age-related changes. Owing to the retrospective assessment, the assumed temporal stability of dyadic differences may have been partly influenced by dyadic response tendencies or consistency effects that were shared by both members of a twin dyad, although care was taken to interview them separately.

Co-twin versus other sibling relationships

Individual-level comparisons between one's co-twin relations revealed for both MZ and DZ twins that the co-twin relationship was unique regarding

each interaction domain. The differences between the MZ co-twin and other sibling relationships again highlight the importance of genetic and environmental effects. Because the genetic relatedness between the MZ twins and their other siblings is comparable with the situation in DZ twins (i.e., about 50%), the observed differences between the MZ co-twin and other sibling relations must be partly due to genetic and shared environmental effects. Furthermore, these differences may stem from unshared environmental effects as reflected by age differences and the related positional effects. As siblings are usually of different ages, they are exposed to different environments at the same time (e.g., school, starting a career, becoming parents).

In contrast, the differences between DZ participants and their other siblings may not have resulted from genetic effects, because both share their genes to a comparable extent. Instead, the differences seem largely due to unshared environmental effects. These unshared environmental effects were obviously related to age differences, as they were also found between DZ participants who were less or more than four years apart from their other siblings (see Stocker, Lanthier, & Futman, 1997, for similar results on siblings in young adulthood).

Contact and relationship quality

A simultaneous look at the individual-level and dyad-level relations between the relationship qualities and frequencies of contact may permit some conclusions about the differential dynamics in MZ and DZ twin relationships. Attachment security and dependency were assessed because there is empirical evidence for relationship-specific representations of attachment figures (Asendorpf et al., 1997; Asendorpf & Wilpers, 2000; Baldwin et al., 1996). Thus, the relationship with the co-twin is likely to be represented in the form of a specific working model, which is activated when there is a need for proximity and contact, or when there is distress and anxiety in the case of separation. Relationship satisfaction was measured as a more broadly defined relationship quality that should also be unique in the twin relationship.

It was expected that the application of the Pairwise Dyadic Model (Griffin & Gonzalez, 1995) would make possible the separation of latent dyadic correlations from latent individual correlations. It was found that DZ twins showed strong dyadic effects (as indicated by high latent dyadic correlations), whereas these effects in MZ twins were nonsignificant, with the exception of the relation between the feeling of dependency and contact frequency.

Although only longitudinal research can fully support this conclusion, these findings do suggest that in DZ twins the dyadic levels of attachment security and relationship satisfaction were to a large extent developed through their social interactions, which has been proved to be highly stable over their adult lives. In contrast, MZ twins experienced higher levels of each quality, but their attachment security and satisfaction were completely independent of their contact. The most plausible explanation for this finding

is that attachment security and relationship satisfaction in MZ pairs were largely dependent on genetic and the related gene→environment effects, whereas these qualities in DZ pairs were mainly a consequence of the interaction histories of these dyads.

The feeling of dependency was due to social contact in both DZ and MZ pairs, but this effect was significantly stronger in DZ pairs. Dependency in close relationships is likely to develop over time because it implies social exchanges or transfers, such as emotional and instrumental support (i.e., the more siblings interact with each other, the more both will feel dependent on the other).

Conclusion

Because twin relationships as such are special types of sibling relationships, their study may permit some conclusions about older siblings in general. The results from this twin study suggest that the pattern of a U-shaped development of sibling relationships across the life course is universal, at least in Western cultures, whereas the differential developmental patterns (i.e., some dyads remain very close, while others stay in less close contact) can be both due to genetic and environmental effects.

The general developmental patterns are consistent with assumptions of the *social convoy model* and *socioemotional selectivity theory* regarding the changing nature and function of close relationships across the life course. The social convoy is viewed as a network of relations that accompanies a person through life, changing in structure but providing continuity in support and affection. Although some people may stay within one's convoy, others may disappear or re-enter at later life phases, depending on individual needs or goals. Thus, twins or siblings may withdraw from each other in early adulthood, because they are concerned with different developmental tasks, such as generativity in family and/or work. After reproductive age, however, they may re-intensify their relationship with co-twins or siblings, because they have constantly belonged to their convoy, and are now favored over less close emotional relationships.

The main contribution of the study of twin relationships in old age, however, is the evidence of the differential importance of genetic and environmental factors that seem to drive the diverse courses of sibling relationships. The results of the present study suggest that the relative strength of these effects may largely be due to dyadic differences in genetic relatedness and the related strength of environmental influences (although both causes could not be disentangled by the cross-sectional design). The considerable variation in the genetic resemblance between full siblings (ranging from 33 to 66%, as estimated by Scarr and Gracek, 1982) may thus play an important role in the emergence of dyadic differences in sibling relationships. The importance of genealogical relatedness in different types of adult sibling relationships was also shown in a study by White and

Riedman (1992), who observed that step- and half-sibling relationships in adulthood were less intense than full-sibling relationships, although step- and half-siblings were acknowledged as kin and the relationship patterns appeared quite similar.

But beyond these universal and differential genetic and environmental determinants of sibling and twin relationships in old age, societal change during the last decades also has to be considered. Secular trends in public health and economic welfare have given rise to higher life expectancies, at least for people in the Western industrialized world. For our personal lives, these trends result in longer periods after our reproductive and career ages that require the reconstruction and stabilization of social resources, of which siblings may constitute an important part and who become increasingly rediscovered as dependable sources of social support and emotional satisfaction in later life.

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