The ripple effect in family networks

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DOI:
10.33612/diss.126812050

Publication date:
2020

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Substitution of Grandparental Ties

The relationship between children and their grandparents is dependent on the relationship between children and their parents, and on the relationship between parents and the grandparental generation (Becker & Steinbach, 2012; Jappens & Van Bavel, 2016; Monserud, 2008). Contact between children, parents, and grandparents is less self-evident in divorced families compared to non-divorced families (e.g., Jappens & Van Bavel, 2016; Kalmijn, 2013; Westphal, Poortman, & Van der Lippe, 2015).

In this chapter we extend the three-generational approach of previous research (e.g., Becker & Steinbach, 2012; Jappens & Van Bavel, 2016; Monserud, 2008) by not only taking into account the interdependencies between the three generations, but also between the two lineages, which requires a family network approach. Our research question is two-fold. We first investigate whether the family networks of divorced families are more disjoint than the family networks of non-divorced families by comparing cross-lineage contact, i.e., between father and maternal grandparents and between mother and the paternal grandparents, with within-lineage contact i.e., between parents and their own parents. We expect cross-lineage contact to be less frequent than within-lineage contact in all families, but more so in divorced families compared to non-divorced families.

Second, we investigate whether lower contact frequencies on one side of the family – e.g. between child and maternal grandmother – are associated with higher contact frequencies with equivalent family members on the other side of the family, e.g. between child and paternal grandmother. If one tie is replaced by another tie or when it is re-activated (Zettel & Rook, 2004), this is interpreted as substitution. In this chapter substitution is investigated by studying the associations between the child-paternal grandparental dyads and the child-maternal grandparental dyads, as well as between the parent-paternal grandparental dyads and the parent-maternal grandparental dyads, which we expect to be lower than the within-lineage dyad associations and more so in divorced families.

A disjoint family network implies that some family members are harder to reach, which limits the possibilities to develop support relationships and other qualitatively meaningful relationships between these family members. Grandparents are important sources of support for the nuclear family members of both divorced (e.g., Doyle, O'Dywer, & Timonen, 2010; Lussier, Deater-Deckard, Dunn, & Davies, 2002) and non-divorced (e.g., Hagestad, 2006; Hank & Buber, 2009) families. If it is more difficult to have contact with grandparents, they will become a weaker source of support. Therefore, strengthening contact with the 'remaining' grandparents may be a solution. Therefore, it is important to study substitution for the contact relations with grandparents, as this will provide an indication that hindered support on one side of the family network is supplemented by support from the other side.

In this chapter we analyse family networks cross-sectionally, investigating differences between divorced and non-divorced families, but not the development of contact frequencies over time. Multi-actor family data from the Divorce in Flanders (DiF) study (Mortelmans et al.,

2011) are used to analyse 4,436 families with 1-5 family members reporting on contact with 1-7 family members: one child, both parents, and the four grandparents.

4.1 BACKGROUND

As explained in MAFNA (chapter 1), we expect that parental divorce not only affects the relationships between the divorcing parents, but also the relationships the parents have with other family members, such as the child-parent relationship, as well as relationships between other family members; e.g., between grandparents and grandchildren. We expect that – because of these linked interdependencies – cross-lineage contact in divorced families will be less frequent than in non-divorced families. If cross-lineage contact in divorced families is lower, this implies that the family networks of divorced families are more disjoint than of non-divorced families. We call this family network separation.

Contact is a prerequisite for qualitatively meaningful family relationships, e.g., support and affection. Therefore, disjoint family networks, whether divorced or non-divorced, endanger the beneficial individual outcomes related to these qualitatively meaningful relationships, such as well-being (Merz, Schuengel, & Schulze, 2009; Polenick, DePasquale, Eggebeen, Zarit, & Fingerman, 2018; Thomas et al., 2017) and health (Umberson & Karas Montez, 2010). In order to avoid a deprivation of these beneficial individual outcomes, weaker ties on one side of the family can be compensated (for example Ormel et al., 1997; Zettel & Rook, 2004)[2] by stronger ties with equivalent family members on the other side of the family, which is referred to as substitution. We thus expect substitution, similar to separation, to occur in both divorced and non-divorced families. Because separation is expected to be stronger in divorced families, the need for substitution will also be stronger in divorced families. Previous research at one intergenerational level has indeed shown that children of divorced parents have a better relationships with one of the two parents (Kalmijn, 2013).

To summarize our expectations, the "sweparated network hypothesis" states that parents and grandparents have less frequent cross-lineage contact compared to within-lineage contact (H1a) and that parents and grandparents in divorced families have less frequent cross-lineage contact than non-divorced families (H1b). Next, the "substitution hypotheses" (see Figure 1) postulate negative associations between the child-paternal grandparental dyads and the child-maternal grandparental dyads (H2a), as well as between the father-paternal grandparental dyads and the father-maternal grandparental dyads (H3a), and between the mother-paternal grandparental dyads and the mother-maternal grandparental dyads (H4a). We expect that these substitution effects are stronger in divorced families (H2b, H3b, H4b).

2 As already noted in chapter 2, 'compensation' and 'substitution' are often used interchangeably. Differences between the two concepts are discussed in the conclusion and discussion (chapter 7).

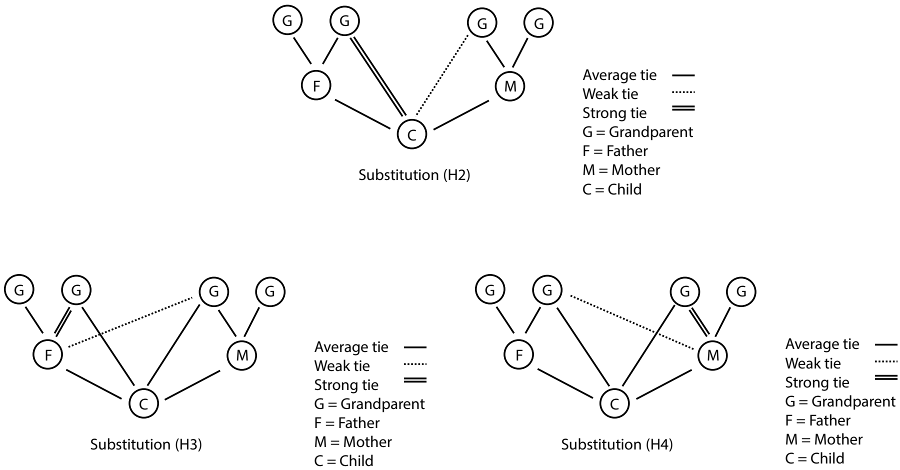

Figure 4.1: Stylized representation of substitution hypotheses tested in the family networks

4.2 METHOD

4.2.1 Data

Divorce in Flanders (DiF) is a cross-sectional multi-actor study, in which couples and oversampled former couples were interviewed (Pasteels et al., 2011). The (former) couples got married between 1971 and 2008 and were either divorced or still married at the time of the interview. The DiF data were collected between 2009 and 2010. The data consists of 4,499 families of which 1,006 are intact and 3,493 divorced. Besides the two (former) partners, one selected parent of the (former) partners (if alive), one child, and the new partners of divorced parents were contacted in the study. Resident children as well as their parents were interviewed with computer assistance (CAPI) by a trained interviewer at home. Non-resident children and grandparents received a questionnaire by post or online. Of a grandparental couple, only one grandparent filled out the questionnaire. More detailed information of the available data in DiF and the derivation of the analytical sample is presented in section 4.D of the online supplementary material.

From the multi-actor data, family networks of seven family members were derived: one child, two parents, four grandparents. Of these seven family members, five family members are respondents: one child, two parents and one grandparent on both sides. Between these seven family members, 30 relationships in 15 dyads are examined. The child was asked to report about six relationships: with both parents and four grandparents. Both parents were asked to report about six relationships as well: the relationships with each other, their child and all four grandparents, i.e., their own parents and their (ex-)parents in law. A grandparent (or grandparental couple) reported about three relationships: with their grandchild, their own child, and the (former) partner of their child. See Table 4.1 for the response matrix.

4.2.2 Measures

Contact frequency is measured as the mean of two questions, about face-to-face contact ("How often do you see X?") and phone, mail, internet contact ("How often do you have contact with X by telephone, mail or the Internet?"). Children and grandparents reported on a scale from 1-7 (1= never, 2 = less than once a month, 3 = once a month, 4 = several times per month (but not weekly), 5 = once a week, 6 = several times per week (but not daily), 7 = daily). The parents answered both contact questions by reporting on two items per question: a frequency scale ranging from 1-50 and an item indicating the time frame (times per week (1), month (2), year (3)). After recoding score 1-3 of the second item into score 52, 12, and 1 respectively, this item was combined with the first item to obtain the number of annual contacts. This annual contact frequency was recoded into the same 1-7 scale used for child and grandparents. For more details please consult Appendix 4.A.

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Table 4.1. Response matrix

How often do you (column names) see "X" (row names)?
How often do you (column names) have contact with "X" (row names) by telephone, mail or the Internet?

		"You" (i.e., the respondent)				
		Father	Mother	Child	Paternal GF or GM	Maternal GF or GM
	Father		✓*	✓*	✓	✓
	Mother	✓*		✓*	✓	✓
	Child	✓*	✓*		✓	✓
"X"	Paternal grandfather	✓	✓	✓		
	Paternal grandmother	✓	✓	✓		
	Maternal grandfather	✓	✓	✓		
	Maternal grandmother	✓	✓	✓		

* Contact is not asked if people share the same household, which is mostly the case for all non-divorced couples and their resident children. If children of divorced families co-reside with both parents they are also not asked about contact with their parents.

Contact relationships are reported only for non-deceased family members not sharing the same household. This means that for intact families, contact information between parents and between parents and child often is not available. For the divorced families, contact information between parents and a resident target child is also missing. For more details please consult section 4.D of the online supplementary material.

Variables describing child characteristics are the age of the child as reported by the parent(s) divided in five mutually exclusive groups: 0-9 years (too young to participate themselves, children from 374 families) and hence not selected as target child, 10-18 years (mostly resident, children from 1,310 families), 19-25 years (partly resident, partly non-resident, children from 927 families), over 25 years (mostly non-resident, children from 860 families) and non-reported (children from 965 families, reference group).

Variables describing available network data for families are a) a dummy variable for missing one or both grandparental responses (due to being deceased, or unable or unwilling to respond, occurring for 4,159 families), b) a dummy variable for missing responses of a child, father or mother's response (occurring for 3,634 families), or c) families in which there were no missing family members (the child, the parents and the grandparents) reporting about their family relationships (representing 118 families). Note that the variables mentioned under a and b are not mutually exclusive.

4.2.3 Analytical sample

We obtained an analytical sample of 4,436 families (3,474 divorced and 962 non-divorced, hereafter all numbers indicated in this order) with 1-5 reporting family members. From the 4,499 available families, one family is excluded because their marital status was unclear and 62 (19/43) families are excluded because relational information was reported by none of the family members. Of the participating parents, 3,345 mothers (2,432/913), on average 45.4 (SD = 8.0) years old, and 2,912 fathers (2,129/783), on average 47.4 years old (SD = 8.0) report on one or more family relationships. Of the 1,543 children (1,083/460) who participated, 1,437 children (990/447) report about their family relationships; 1,122 resident children (777/345), on average 17.4 years old (SD = 4.7), and 315 non-resident resident children (213/102), on average 29.1 years old (SD = 4.1). The sample contains reports of 863 grandparents on father's side (561/302), covering 311 grandfathers and 552 grandmothers, on average 71.4 years old (SD = 9.1). 24 grandparents on father's side share their household with father (their son) (22/2) and 3 share their household with mother (3/0). 323 (255/68) grandparents on father's side are divorced. The sample contains reports of 1,112 grandparents on mother's side (740/372), covering 381 grandfathers and 731 grandmothers, on average 70.0 years old (SD = 9.0). 4 grandparents on mother's side share their household with father (3/1) and 13 with mother (their daughter) (12/1). 426 (340/86) grandparents on mother's side are divorced.

Table 4.2 shows the descriptive statistics for all contact relationships and also presents the differences in contact frequencies between divorced and non-divorced families. Table 4.2 shows that contact is most frequent among mothers and their mothers and least frequent among fathers and the maternal grandmother. Contact between family members is often less frequent in divorced families, except for contact between father and his parents.

Comparing the descriptive statistics of the complete, i.e., when all five family members participated (N = 118) vs. non-complete (N = 4,318) families – not distinguishing divorced from non-divorced families – showed that parents in non-complete families have substantially less frequent contact with each other (more than half a point). This also holds for the contact frequencies of mothers with their child, of the child with the paternal and maternal grandmother, of fathers with their in-laws and mothers with in-laws and her own parents (additional descriptive statistics available upon request, additional analyses investigating the possible bias due to the composition of the analytic sample are available in the online supplementary material section 4.E).

Table 4.3 presents the correlations of contact frequencies between all pairs of family members, separate for divorced and non-divorced families. Table 4.3 shows that the number of available relational combinations varies, which is one of the reasons why we continue our analyses by studying dyads. Studying correlations is a first step in investigating associations between family relationships, such as substitution. On the diagonal are the paternal/maternal correlations for children and cross-lineage correlations for parents. In non-divorced families, all correlations on the diagonal are positive. This means that paternal/maternal and cross-lineage contact frequencies are positively associated. However, the paternal grandfather-mother relationship is negatively correlated with the mother-maternal grandmother relationships. In divorced families, most correlations on the diagonal are also positive, with the exception of the father-child relationship, which is negatively correlated with the mother-child relationship and the father-paternal grandfather relationship, which is negatively correlated with the father-maternal grandfather relationship. Another, although very small, negative correlation on the diagonal is found between mother and her own father and mother and paternal grandfather. Furthermore, the relationship between father and his own father is negatively correlated with the relationship between the grandmother on mother's side and the father.

Table 4.2: Descriptive Statistics

		Total (*N* = 4,436)					Divorced (*N* = 3,474)					Non-divorced (*N*=962)					
From	To	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max	N	t
Child	Father	4.04	1.51	1.00	7.00	419	3.80	1.52	1.00	7.00	330	4.92	1.08	1.50	7.00	89	-7.87*
Father	Child	4.20	1.66	1.00	7.00	1207	4.06	1.69	1.00	7.00	1053	5.15	1.01	1.00	7.00	154	-11.34*
Child	Mother	4.75	1.41	1.00	7.00	317	4.57	1.53	1.00	7.00	220	5.15	0.96	2.00	7.00	97	-4.14*
Mother	Child	4.94	1.47	1.00	7.00	791	4.80	1.55	1.00	7.00	619	5.43	0.96	1.00	7.00	172	-6.48*
Father	Mother	2.41	1.62	1.00	7.00	2085	2.41	1.62	1.00	7.00	2075	3.60	1.90	1.00	6.50	10	-1.98
Mother	Father	2.31	1.55	1.00	7.00	2377	2.30	1.55	1.00	7.00	2362	3.23	1.15	1.00	5.50	15	-3.12*
Child	GF (F)	3.03	1.35	1.00	7.00	459	2.82	1.32	1.00	7.00	273	3.33	1.34	1.00	6.50	186	-3.95*
GF(F)	Child	3.48	1.28	1.50	7.00	226	3.43	1.30	1.50	7.00	137	3.56	1.24	1.50	6.50	89	-0.73
Child	GM (F)	3.14	1.41	1.00	7.00	661	2.97	1.40	1.00	7.00	400	3.41	1.38	1.00	6.50	261	-3.99*
GM (F)	Child	3.48	1.26	1.50	7.00	382	3.37	1.26	1.50	7.00	228	3.66	1.25	1.50	7.00	154	-2.20*
Child	GF (M)	3.35	1.43	1.00	7.00	717	3.29	1.43	1.00	7.00	490	3.47	1.43	1.00	6.50	227	-1.57
GF (M)	Child	3.91	1.29	1.50	7.00	281	3.87	1.28	1.50	6.50	172	3.98	1.31	1.50	7.00	109	-0.73
Child	GM (M)	3.67	1.44	1.00	7.00	1000	3.62	1.45	1.00	7.00	673	3.77	1.40	1.00	7.00	327	-1.53
GM (M)	Child	4.10	1.34	1.50	7.00	548	4.04	1.36	1.50	7.00	347	4.19	1.29	1.50	7.00	201	-1.21
Father	GF (F)	4.07	1.49	1.00	7.00	1491	4.05	1.54	1.00	7.00	1056	4.10	1.37	1.00	7.00	435	-0.62
GF (F)	Father	4.68	1.17	2.00	7.00	300	4.76	1.19	2.00	7.00	198	4.51	1.14	2.00	7.00	102	1.76
Father	GM (F)	4.45	1.38	1.00	7.00	2034	4.49	1.42	1.00	7.00	1477	4.35	1.27	1.00	7.00	557	2.15*
GM (F)	Father	4.80	1.15	1.00	7.00	536	4.86	1.19	1.50	7.00	343	4.69	1.07	1.00	7.00	193	1.71
Father	GF (M)	2.04	1.40	1.00	6.50	1564	1.41	0.83	1.00	6.50	1090	3.47	1.39	1.00	6.50	474	-29.94*
GF (M)	Father	3.41	1.43	1.00	7.00	196	2.38	1.25	1.00	6.50	64	3.91	1.23	1.50	7.00	132	-8.10*

*$p < .05$, two-sided p value

Table 4.2: Descriptive Statistics (continued)

		Total (N = 4,436)					Divorced (N = 3,474)					Non-divorced (N=962)					
From	To	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max	N	t
Father	GM (M)	2.12	1.46	1.00	6.50	2080	1.45	0.88	1.00	6.50	1473	3.74	1.32	1.00	6.50	607	-39.67*
GM (M)	Father	3.40	1.40	1.00	7.00	339	2.27	1.03	1.00	6.50	109	3.93	1.22	1.50	7.00	230	-13.06*
Mother	GF (F)	2.03	1.34	1.00	6.50	1658	1.44	0.83	1.00	6.50	1146	3.37	1.31	1.00	6.50	512	-30.60*
GF (F)	Mother	3.46	1.38	1.00	6.50	149	2.34	1.01	1.00	6.00	47	3.98	1.21	2.00	6.50	102	-8.67*
Mother	GM (F)	2.19	1.50	1.00	6.50	2228	1.54	0.95	1.00	6.00	1588	3.81	1.38	1.00	6.50	640	38.12*
GM (F)	Mother	3.51	1.40	1.00	7.00	293	2.49	1.14	1.00	7.00	102	4.06	1.21	1.50	7.00	191	-11.04*
Mother	GF (M)	4.24	1.54	1.00	7.00	1927	4.21	1.56	1.00	7.00	1356	4.30	1.50	1.00	7.00	571	-1.24
GF (M)	Mother	4.98	1.18	1.50	7.00	370	4.97	1.16	1.50	7.00	238	4.99	1.22	2.00	7.00	132	-0.17
Mother	GM (M)	4.94	1.41	1.00	7.00	2534	4.87	1.45	1.00	7.00	1815	5.12	1.28	1.00	7.00	719	-4.38*
GM (M)	Mother	5.31	1.07	2.00	7.00	725	5.27	1.09	2.00	7.00	490	5.41	1.02	3.00	7.00	235	-1.79
Average # of ties		6.74	3.94	1.00	22.00	4436	6.32	3.71	1.00	21.00	3474	8.24	4.36	1.00	22.00	962	-12.4*

*p < .05, two-sided p value

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Table 4.3: Pearson Correlations

	Divorced (N = 3,474)								Non-Divorced (N = 962)								
	C-F	(N)	F-C	(N)						C-F	(N)	F-C	(N)				
C-M	0.072	80	-0.064	77					C-M	0.855	84	0.510	84				
M-C	-0.021	78	-0.026	229					M-C	0.300	84	0.635	142				
	C-GFF	(N)	GFF-C	(N)	C-GMF	(N)	GMF-C	(N)		C-GFF	(N)	GFF-C	(N)	C-GMF	(N)	GMF-C	(N)
C-GFM	0.072	124	0.317	13	0.053	178	-0.103	46	C-GFM	0.247	108	0.117	31	0.300	150	0.111	42
GFM-C	0.202	18	-1.000	3	-0.086	31	-0.085	22	GFM-C	0.249	24	0.241	14	0.327	33	0.389	24
C-GMM	0.117	154	-0.032	20	0.115	224	0.092	54	C-GMM	0.223	142	0.169	38	0.302	199	0.167	66
GMM-C	0.008	50	0.219	12	-0.017	64	0.170	30	GMM-C	0.096	50	0.064	36	0.198	72	0.338	53
	F-GFF	(N)	GFF-F	(N)	F-GMF	(N)	G-MFF	(N)		F-GFF	(N)	GFF-F	(N)	F-GMF	(N)	G-MFF	(N)
F-GFM	-0.018	621	0.102	119	0.049	838	0.074	208	F-GFM	0.117	315	0.058	79	0.075	392	0.230	129
GFM-F	0.337	19	—	1	0.189	27	0.268	10	GFM-F	0.199	74	0.0038	20	0.169	85	0.076	33
F-GMM	0.00090	781	0.095	153	0.021	1067	0.070	261	F-GMM	0.199	358	0.059	89	0.130	451	0.148	151
GMM-F	-0.287	27	-0.895	6	-0.064	38	0.298	8	GMM-F	0.067	127	0.174	43	0.066	157	0.112	69
	M-GFF	(N)	GFF-M	(N)	M-GMF	(N)	G-MFM	(N)		M-GFF	(N)	GFF-M	(N)	M-GMF	(N)	G-MFM	(N)
M-GFM	-0.010	751	-0.085	9	0.041	983	0.193	40	M-GFM	0.117	373	0.012	77	0.097	454	0.208	125
GFM-M	-0.0038	138	-1.000	2	0.011	174	0.603	7	GFM-M	0.151	92	0.172	19	0.133	101	0.286	34
M-GMM	0.0073	925	0.460	14	0.047	1254	-0.048	45	M-GMM	0.059	433	-0.077	86	0.133	533	0.187	145
GMM-M	0.086	276	0.333	4	0.080	353	0.469	12	GMM-M	0.137	153	0.144	42	0.184	183	0.227	68

C = Child, F = Father, M = Mother, GFF = Paternal grandfather, GMF = Paternal grandmother, GFM = Maternal grandfather, GMM = Maternal grandmother

4.2.4 Statistical Analysis

The DiF dataset contains 1 to 5 family members reporting about their contact frequency with at least 1 up to 7 family members, leading to 1 to maximally 22 reports per family for non-divorced families with cohabitating parents and a non-resident child and 24 reports per family for divorced families on possibly 30 different contact relationships between family members (see response matrix in Table 4.1). The dependence of the contact frequency reports within families is taken into account in the statistical analysis.

The Social Relations Model (Kenny & La Voie, 1984) does so by distinguishing the 'actors' (individual family roles, 'child', 'mother', etc.) both as 'senders' and 'receivers' of directed relationships, and their 'dyadic' combinations ('mother-child', etc.). This model can be estimated as an ANOVA or a structural equation model (Kenny, Kashy, & Cook, 2006), or, equivalently, as a multilevel regression model emphasizing the nested structure of the data, with three levels, for the directed relationships (e.g., 'child-to-mother' and 'mother-to-child') nested in dyads (e.g., 'child-mother'), cross-nested in sending and receiving actors ('child', 'mother'), nested in families. This model specification was proposed by Snijders and Kenny (1999), and first applied to family data by Gerlsma, Snijders, van Duijn, and Emmelkamp (1997). Whereas the ANOVA approach of the Social Relations Model is aimed at quantifying the explained variance attributable to the various sources of variance, the regression approach emphasizes the effect of 'explanatory' variables, defined for dyads, actors, and/or families. Moreover, a multilevel model does not require complete family data and, for incomplete data, makes the assumption of relationships within families to be missing at random. It should be noted that this term means that the missingness is random given the covariates used in the analysis (Little & Rubin, 2019).

For the analyses in this chapter, a multilevel model was specified with a random part including family variance, sender and receiver variances for all family roles, and their covariances, as well as variances for all dyadic combinations (dyadic reciprocity), equivalent to the structural equation model specification in Eichelsheim, Deković, Buist, and Cook (2009 p. 1069). The specification of the fixed and random parts of the model for testing the hypotheses is explained below. The models were estimated using MlwiN (v. 3.04; Charlton, Rashbash, Browne, Healy, & Cameron, 2019).

To account for differences between families in contact frequency with the child, age of the child was included as a covariate in the final model. Residency status (living at home) was not included because it was only available for participating children. Other variables measuring the residence arrangement showed inconsistencies. Age was categorized such that it captures residency status to a large extent. Further information is available in the online supplementary material, section 4.D. Possible bias due to the composition of the analytic sample where most families do not have complete information, and for which the missing at random (MAR) assumption may be doubted, was investigated in additional analyses. This was done by including the family-level variables indicating patterns of missing or incomplete family observations to the model as main effects and as interaction effects with the variables used for testing the hypotheses. The indicator variables are the dummies a, b, and c described in the measures section. These additional analyses are presented in the online supplementary material, section 4.E.

4.2.5 Hypothesis testing

The separated network hypothesis can be tested by comparing contact frequencies in cross-lineage relationships between divorced and divorced families. We defined 9 dummy variables to represent the 15 dyads containing the 30 measured directed relationships. Three dummy variables are defined for the parental dyad (FM), dyads including a child (C), and the parental-grandparental dyads (PGP). Another set of six dummies further distinguishes between child-parent and child-grandparent dyads (CGP), between dyads of parents with their own parents or in-laws (cross-lineage main effect PGP_CL), between paternal (C) and maternal dyads of child-parent (C_M), between child-paternal (CGP) and maternal grandparents (CGP_M), father-grandparent dyads (PGP) and mother-grandparent dyads (PGP_M), and finally the distinction between the dyad of mother with her own parents and with her (former) in-laws (interaction effect of CL and MGP: MGP_CL), as represented in Table 4.4. The cross-lineage variables PGP_CL and MGP_CL, and their interaction with a divorce dummy are used to test the first hypothesis.

Table 4.4: Dummy variables

Undirected dyad			FM = Parental dyad	C = Dyads including a child	CM = Paternal (0) vs. maternal (1) dyads with the child	CGP = Child-parent (0) vs. child-grandparent (1)	CGP_M = Paternal (0) vs. maternal child-grandparent	PGP = Parental-grandparental dyads	PGP_CL = Parent-own parent (0) vs. cross-lineage (1)	MGP = Paternal (0) vs. maternal (1) parent-grandparent	MGP_CL = Paternal (0) vs. maternal (1) PGP_CL	Dummy combinations
1	Father	Mother	1	0	0	0	0	0	0	0	0	FM
2	Child	Father	0	1	0	0	0	0	0	0	0	C (*ref*)
3	Child	Mother	0	1	1	0	0	0	0	0	0	C + CM
4	Child	GP (F)	0	1	0	1	0	0	0	0	0	C + CGP
5	Child	GP (M)	0	1	0	1	1	0	0	0	0	C + CGP + CGP_M
6	Father	GP (F)	0	0	0	0	0	1	0	0	0	PGP (*ref*)
7	Father	GP (M)	0	0	0	0	0	1	1	0	0	PGP + PGP_CL
8	Mother	GP (F)	0	0	0	0	0	1	1	1	1	PGP + PGP_CL + MGP + MGP_CL
9	Mother	GP (M)	0	0	0	0	0	1	0	1	0	PGP + MGP

To test the substitution hypotheses we include and compare the covariances between the child-paternal grandparental (4) and child-maternal grandparental (5), the parent-paternal grandparental (6, 8) and parent-maternal grandparental dyads (7, 9), and covariances between the child-father (2) and child-mother (3) dyads. The covariances are estimated separately for divorced and non-divorced families. A negative covariance is interpreted as an indication for substitution: in addition to the differences in average contact due to the different roles and accounted for by the fixed part of the model, higher contact "residuals" in one dyad are associated with lower contact "residuals" in the other dyad.

4.3 RESULTS

4.3.1 Separated network

The estimates of the fixed effects are presented in Table 4.5 and represent the parameters of the dyad dummy variables and the bias control variables. The first column of the table shows the main effects and the second column shows the interaction effects with the divorce dummy variable. Model H (Appendix 4.B) is considered to be final model and its estimates are presented in Table 4.5. From the estimates of the dyad dummy variables we can derive estimated average contact for the 9 dyads as presented in Table 4.4. These calculations are shown in Table 4.6.

The first dummy "PGP" represents the reference dyad 'father and his parents'. From Table 4.5, we obtain the information that the average contact between father and his parents is 4.136 (S.E. = 0.076), hence approximately several times per months (but less than weekly). The contact between a divorced father and his own parents is 0.189 higher (S.E. = 0.055). The negative effect of PGP_CL (*b* = -0.613, S.E. = 0.054) indicates that contact between the father and his parents-in-law is lower, approximately once a month or slightly more (average contact is 3.523, see Table 4.6). This effect provides support for the first part of the separated network hypothesis (H1a) for fathers and their parents-in-law. The effect of cross-lineage contact is much stronger for divorced fathers (*b* = -2.302, S.E. = 0.064), who see their ex-parents-in-law almost never (average contact is 1.410, see Table 4.6). This result provides support for the second part of the separated network hypothesis (H1b) for divorced fathers and their ex-parents-in-law.

The dummy MGP represents the difference between fathers and mothers in contact with the grandparental generation, from which we can derive that non-divorced mothers have (*b* = 0.580, S.E. = 0.059) more contact with their own parents compared to fathers, meaning that mothers see their parents once a week or slightly less (average contact is 4.716), but that this difference is smaller (*b* = -0.259, S.E. 0.070 lower, average contact is 4.646) for divorced mothers.

Testing the first part of the separated network hypothesis for mothers, the effect of MGP_CL (*b* = -0.607, S.E. = 0.081) indicates a stronger cross-lineage effect in comparison to that of fathers (PGP_CL). This effect, however, is cancelled out by the positive effect of MGP, resulting in an estimated contact frequency of 3.496 (approximately once a month or slightly more) between non-divorced mothers and their parents-in-law, which is similar to how often fathers see the maternal grandparents (average contact 3.523). Divorced mothers see their own parents slightly less than non-divorced mothers (4.646 vs. 4.716), whereas their contact with the former parents-in-law is much lower (1.492). This difference is similar as for the divorced fathers (average 1.492 vs. 1.410) due to the cancelling effects of MGP x divorced and MGP_CL x divorced. The results for non-divorced and divorced mothers also provide support for both parts of the separated network hypothesis (H1a and H1b). From Table 4.6 we conclude that contact between the parent and the grandparental generation is highest between mothers and her parents.

Children have less contact (b = -2.255; S.E. = 0.127) with their grandparents compared to the referential child-father relationship, whereas children of divorced parents have more contact (b = 1.019; S.E. 0.138) with the grandparents compared to children in non-divorced families. Children of non-divorced parents see their paternal grandparents once a month (average contact is 3.205) and their maternal grandparents several times a month or less (average contact is 3.622), whereas children of divorced parents see their paternal grandparents slightly less (average contact is 0.229 less for paternal grandparents) and their maternal grandparents as often (average contact is 0.039 less for maternal grandparents). The estimates for FM, representing the father-mother relationship can only be interpreted meaningfully for divorced parents, because non-divorced parents mostly share the same household and should therefore not have reported on contact. The dummy variable C and CM is interpretable for non-resident children and shows that children of divorced parents have less contact with their parents compared to non-resident children of non-divorced parents. Divorced fathers have lowest contact with their child, followed by divorced mothers, non-divorced fathers, and non-divorced mothers who have most contact with the child.

4.3.2 Substitution

The covariances presented in the random part of our model (Table 4.5) are negative for all dyadic combinations involving the child and the grandparents and the parents and the paternal and maternal grandparents. This indicates that for children and parents lower contact frequencies with grandparents on one side of the family are associated with higher contact frequencies with grandparents on the other side of the family. These findings provide support for the first part of the substitution hypothesis (H2a, H3a, and H4a).

When comparing the covariances between divorced and non-divorced families, we see that the covariances for the child-grandparental dyads in divorced families are approximately 0.2 lower with the largest difference for the child - maternal grandfather and child - paternal grandmother dyads (-0.442 vs -0.706) and the smallest difference between the maternal and paternal grandmother-child dyads (-0.460 vs. -0.572).

The covariances for contact between father and the paternal and maternal grandparents, as well as the covariances for contact between mother and the paternal and maternal grandparents, show a different pattern with four covariances in divorced families being larger than those in non-divorced families and four being smaller with an overall absolute difference of 0.1. The largest positive difference between divorced and non-divorced families is found in mother-maternal and mother-paternal grandmother dyads (-0.319 vs. -0.390), the largest negative difference between divorced and non-divorced families can be found in the father-maternal grandfather and father-paternal grandmother dyads (-0.509 vs. -0.367). None of the parent-grandparental dyadic covariances differ significantly from each other. Hence no support was found for the second part of the substitution hypothesis (H2b, H3b, and H4b).

Table 4.5: Social Relations Model on contact between family member (*N* = 4,436 families, 24,777 dyads, 29,894 relationships)

	Non-divorced		(x Divorced)	
	Estimate	S.E.	Estimate	S.E.
Fixed Part				
Dyad dummy variables				
PGP	4.136	(0.076)	0.189	(0.055)
PGP_CL	-0.613	(0.054)	-2.302	(0.064)
MGP	0.580	(0.059)	-0.259	(0.070)
MGP_CL	-0.607	(0.081)	0.368	(0.095)
C	5.460	(0.136)	-1.248	(0.131)
CGP	-2.255	(0.127)	1.019	(0.138)
CGP_M	0.417	(0.063)	0.190	(0.082)
FM	3.921	(0.321)	-1.559	(0.316)
CM	0.285	(0.089)	0.597	(0.118)
Random part				
Covariances of the dyadic combinations				
Child-mother and child-father	1.290	(0.097)	-0.201	(0.148)
Child-maternal GF and child-paternal GF	-0.382	(0.074)	-0.596	(0.078)
Child-maternal GF and child-paternal GM	-0.442	(0.070)	-0.706	(0.068)
Child-maternal GM and child-paternal GF	-0.507	(0.070)	-0.639	(0.072)
Child-maternal GM and child-paternal GM	-0.460	(0.066)	-0.572	(0.065)
Father-maternal GF and Father-paternal GF	-0.441	(0.062)	-0.487	(0.046)
Father-maternal GF and Father-paternal GM	-0.509	(0.053)	-0.367	(0.038)
Father-maternal GM and Father-paternal GF	-0.351	(0.058)	-0.380	(0.042)
Father-maternal GM and Father-paternal GM	-0.440	(0.049)	-0.410	(0.034)
Mother-maternal GF and mother-paternal GF	-0.284	(0.059)	-0.322	(0.045)
Mother-maternal GF and mother-paternal GM	-0.434	(0.058)	-0.369	(0.043)
Mother-maternal GM and mother-paternal GF	-0.525	(0.048)	-0.463	(0.036)
Mother-maternal GM and mother-paternal GM	-0.319	(0.049)	-0.390	(0.035)
Other covariances at level 3 and 2	*[Omitted: see Appendix 4.B]*			

Table 4.6: Estimated dyad contact frequencies based on Model H (**Table 4.5**) estimates.

	Non-Divorced					Divorced				
Father- Mother	3.921				= 3.921	-1.559				= 2.362
Child-Father	5.460				= 5.460	-1.248				= 4.212
Child-Mother	5.460	+ 0.285			= 5.745	-1.248	+ 0.597			= 5.094
Child-Paternal GP	5.460	– 2.255			= 3.205	-1.248	+ 1.019			= 2.976
Child-Maternal GP	5.460	– 2.255	+ 0.417		= 3.622	-1.248	+ 1.019	+ 0.190		= 3.583
Father-Paternal GP	4.136				= 4.136	0.189				= 4.325
Father-Maternal GP	4.136	– 0.613			= 3.523	0.189	– 2.302			= 1.410
Mother-Paternal GP	4.136	– 0.613	+ 0.580	- 0.607	= 3.496	0.189	– 2.302	– 0.259	+ 0.368	= 1.492
Mother-Maternal GP	4.136		+ 0.580		= 4.716	0.189		– 0.259		= 4.646

No hypothesis was postulated for the covariances for contact between the child –parent dyads which are discussed for the sake of completeness. These covariances can be interpreted meaningfully for non-resident children and are positive for non-divorced families and negative but non-significant for non-divorced families. In non-divorced families, more frequent contact between a non-resident child and father is associated with more frequent contact between child and mother.

4.4 CONCLUSION AND DISCUSSION

In this study we found that cross-lineage contact frequencies are lower than within-lineage contact frequencies, with much lower contact frequencies for the parent-grandparental contact frequencies in divorced families. These findings support the separated network hypotheses H1a and H1b. Second, we found negative covariances between the child-paternal grandparental dyads and the child-maternal grandparental dyads, as well as between the parent-paternal grandparental dyads and the parent-maternal grandparental dyads, providing support for the first part of the substitution hypotheses (H2a, H3a, and H4a). Substitution provides a plausible interpretation for parental-grandparental dyads: More frequent contact of parents with their parents goes together with less frequent contact with the parents-in-law, which is not stronger in divorced families. For the children-grandparental dyads, it shows that it is common to have more frequent contact with one set of grandparents than with the other set of grandparents.

Our results are in line with previous studies investigating smaller subsets of the family network, which showed that contact between children and grandparents is less self-evident, thus lower, when parents are divorced (Jappens & Van Bavel, 2016; Westphal et al., 2015). These studies on grandchild and grandparent relationships focused on the question to what extent such effects can be explained by the child's residence arrangement, whereas our focus was to study associations with other relationships. Substitution patterns between children and their parents have been investigated before (Kalmijn, 2013), then called compensation, the parent having the stronger tie with the child compensates for the parent having the weaker tie with child.

In additional analyses (Section 4.E of the online supplementary material) we investigated the robustness of models G and H in table 4.5 by controlling for several age groups of the children and by controlling for complete vs. less complete families. The conclusion about the separated family hypothesis does not change in view of these robustness checks, cross-lineage effects are overall somewhat stronger. Contact in families with younger children is on average higher. Contact in complete families is substantially higher than in families with missing family members.

In this study we compared contact frequencies in divorced and non-divorced families. We did not study longitudinal family network data over time and were hence not able to study whether lower contact frequencies were caused by the parental divorce and whether potentially lost ties by the divorce were subsequently substituted by strengthening ties with other family members. Furthermore, we used contact frequency as a relational dimension. Contact is a prerequisite for a qualitatively meaningful family relationships, e.g., support and affection, which makes it a useful tool to explore the family network's infrastructure to qualitatively meaningful substitution. Whether support and affection are indeed established via these contact relationships, and whether contact frequency indeed facilitates substitution on a more substantive level, would require longitudinal data and the collection of such data will be explained in the next chapter.

4.A APPENDIX: RECODE CONTACT VARIABLE REPORTED BY THE PARENTS

0 times a year is recoded into never (1), 1-11 times a year is recoded into less than once a month (2), 12 times a year is recoded into once a month (3), 13-51 times a year is recoded into several times per month (but not weekly) (4), 52 times a year is recoded into once a week (5), 53-363 times a year is recoded into several times per week (but not daily) (6), and 364 times a year or higher is recoded into daily (7).

4.B APPENDIX: FULL MODEL INCLUDING RANDOM PART (AS PRESENTED IN MANUSCRIPT)

Table 4.7: Full model (*N* = 4,436 families, 24,777 dyads, 29,894 relationships)

	Model A		Model B		Model C		Model D		Model E		Model F		Model G		Model H	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Fixed Part																
Constant	3.288	(0.015)														
PGP			4.238	(0.044)	4.247	(0.046)	4.227	(0.049)	4.234	(0.047)	4.226	(0.046)	4.223	(0.046)	4.136	(0.076)
PGP_CL			-0.626	(0.052)	-0.619	(0.048)	-0.621	(0.048)	-0.629	(0.049)	-0.633	(0.055)	-0.629	(0.054)	-0.613	(0.054)
MGP			0.532	(0.051)	0.570	(0.055)	0.577	(0.062)	0.583	(0.060)	0.557	(0.059)	0.562	(0.059)	0.580	(0.059)
MGP_CL			-0.554	(0.072)	-0.613	(0.067)	-0.601	(0.075)	-0.598	(0.076)	-0.573	(0.083)	-0.582	(0.081)	-0.607	(0.081)
C			5.222	(0.100)	5.221	(0.118)	5.307	(0.119)	5.331	(0.120)	5.449	(0.125)	5.424	(0.122)	5.460	(0.136)
CGP			-1.816	(0.112)	-1.816	(0.127)	-2.022	(0.125)	-2.050	(0.126)	-2.168	(0.130)	-2.141	(0.128)	-2.255	(0.127)
CGP_M			0.347	(0.069)	0.345	(0.067)	0.418	(0.055)	0.425	(0.057)	0.402	(0.063)	0.405	(0.063)	0.417	(0.063)
FM			3.475	(0.266)	0.346	(0.309)	3.747	(0.306)	3.783	(0.309)	3.984	(0.318)	3.963	(0.318)	3.921	(0.321)
CM			0.254	(0.128)	0.347	(0.152)	0.242	(0.148)	0.243	(0.148)	0.236	(0.154)	0.267	(0.092)	0.285	(0.089)
PGP x divorced			0.074	(0.052)	0.348	(0.054)	0.095	(0.057)	0.074	(0.056)	0.068	(0.054)	0.070	(0.054)	0.189	(0.055)
PGP_CL x divorced			-2.279	(0.062)	0.349	(0.057)	-2.305	(0.057)	-2.284	(0.059)	-2.283	(0.065)	-2.286	(0.064)	-2.302	(0.064)
MGP x divorced			-0.248	(0.061)	0.350	(0.066)	-0.264	(0.073)	-0.259	(0.072)	-0.233	(0.070)	-0.238	(0.070)	-0.259	(0.070)
MGP_CL x divorced			0.318	(0.086)	0.351	(0.080)	0.354	(0.088)	0.348	(0.089)	0.340	(0.097)	0.348	(0.095)	0.368	(0.095)
C x divorced			-1.180	(0.108)	0.352	(0.126)	-1.206	(0.127)	-1.217	(0.128)	-1.280	(0.135)	-1.254	(0.132)	-1.248	(0.131)
CGP x divorced			0.685	(0.125)	0.353	(0.140)	0.897	(0.137)	0.920	(0.138)	0.964	(0.141)	0.933	(0.139)	1.019	(0.138)
CGP_M x divorced			0.261	(0.088)	0.354	(0.084)	0.191	(0.071)	0.179	(0.074)	0.205	(0.082)	0.202	(0.082)	0.190	(0.082)
FM x divorced			-1.154	(0.267)	0.355	(0.310)	-1.430	(0.307)	-1.467	(0.310)	-1.669	(0.319)	-1.649	(0.319)	-1.559	(0.316)
CM x divorced			0.589	(0.142)	0.356	(0.168)	0.599	(0.164)	0.601	(0.164)	0.621	(0.172)	0.592	(0.120)	0.597	(0.118)
Controls																
Age child (unknown* = *ref.*)																
0-9 years															0.483	(0.047)
10-18 years															0.288	(0.035)
19-25 years															0.053	(0.039)
> 25 years															-0.082	(0.042)

Table 4.7: Full model (N = 4,436 families, 24,777 dyads, 29,894 relationships) (continued)

	Model A		Model B		Model C		Model D		Model E		Model F		Model G		Model H	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Complete															0.031	(0.084)
Grandparental couple missing															-0.204	(0.055)
Child, father, mother missing															0.050	(0.033)
Random Part																
Family level																
Constant	0.353	(0.020)	0.421	(0.015)	0.379	(0.014)	0.192	(0.016)	0.188	(0.015)	0.217	(0.015)	0.217	(0.015)	0.175	(0.014)
Non-divorced																
Covariance dyads C-M and C-F													1.286	(0.100)	1.290	(0.097)
Covariance dyads C-GFM and C-GFF									-0.174	(0.072)	-0.378	(0.074)	-0.396	(0.075)	-0.382	(0.074)
Covariance dyads C-GFM and C-GMF											-0.445	(0.071)	-0.462	(0.072)	-0.442	(0.070)
Covariance dyads C-GMM and C-GFF											-0.496	(0.070)	-0.511	(0.071)	-0.507	(0.070)
Covariance dyads C-GMM and C-GMF									-0.186	(0.057)	-0.452	(0.066)	-0.463	(0.067)	-0.460	(0.066)
Covariance dyads F-GFM and F- GFF									-0.220	(0.055)	-0.494	(0.064)	-0.461	(0.063)	-0.441	(0.062)
Covariance dyads F-GFM and F-GMF											-0.573	(0.055)	-0.531	(0.053)	-0.509	(0.053)
Covariance dyads F-GMM and F-GFF											-0.411	(0.060)	-0.367	(0.059)	-0.351	(0.058)
Covariance dyads F-GMM and F-GMF									-0.202	(0.042)	-0.515	(0.052)	-0.459	(0.050)	-0.440	(0.049)
Covariance dyads M-GFM and M-GFF									-0.057	(0.054)	-0.382	(0.060)	-0.340	(0.059)	-0.284	(0.059)
Covariance dyads M-GFM and M-GMF											-0.494	(0.061)	-0.458	(0.059)	-0.434	(0.058)
Covariance dyads M-GMM and M-GFF											-0.619	(0.050)	-0.554	(0.049)	-0.525	(0.048)
Covariance dyads M-GMM and M-GMF									-0.104	(0.044)	-0.400	(0.051)	-0.335	(0.049)	-0.319	(0.049)
Divorced																
Covariance dyads C-M and C-F													-0.202	(0.150)	-0.201	(0.148)
Covariance dyads C-GFM and C-GFF									-0.270	(0.066)	-0.615	(0.079)	-0.613	(0.079)	-0.596	(0.078)
Covariance dyads C-GFM and C-GMF											-0.730	(0.069)	-0.723	(0.069)	-0.706	(0.068)
Covariance dyads C-GMM and C-GFF											-0.653	(0.074)	-0.651	(0.074)	-0.639	(0.072)
Covariance dyads C-GMM and C-GMF									-0.307	(0.053)	-0.581	(0.066)	-0.577	(0.066)	-0.572	(0.065)
Covariance dyads F-GFM and F- GFF									-0.413	(0.041)	-0.540	(0.046)	-0.536	(0.046)	-0.487	(0.046)

Table 4.7: Full model (N = 4,436 families, 24,777 dyads, 29,894 relationships) (continued)

	Model A		Model B		Model C		Model D		Model E		Model F		Model G		Model H	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Covariance dyads F-GFM and F-GMF											-0.407	(0.038)	-0.402	(0.038)	-0.367	(0.038)
Covariance dyads F-GMM and F-GFF											-0.430	(0.042)	-0.425	(0.043)	-0.380	(0.042)
Covariance dyads F-GMM and F-GMF									-0.311	(0.031)	-0.449	(0.034)	-0.445	(0.035)	-0.410	(0.034)
Covariance dyads M-GFM and M-GFF									-0.306	(0.041)	-0.390	(0.045)	-0.382	(0.045)	-0.322	(0.045)
Covariance dyads M-GFM and M-GMF											-0.421	(0.043)	-0.414	(0.043)	-0.369	(0.043)
Covariance dyads M-GMM and M-GFF											-0.508	(0.036)	-0.504	(0.036)	-0.463	(0.036)
Covariance dyads M-GMM and M-GMF									-0.292	(0.031)	-0.434	(0.035)	-0.427	(0.035)	-0.390	(0.035)
Variance child sender							0.638	(0.042)	0.684	(0.042)	0.929	(0.044)	0.932	(0.044)	0.904	(0.043)
Covariance child sender and receiver							0.294	(0.033)	0.336	(0.033)	0.559	(0.035)	0.563	(0.035)	0.546	(0.034)
Variance child receiver							0.306	(0.036)	0.358	(0.035)	0.601	(0.036)	0.603	(0.037)	0.591	(0.036)
Variance father sender							0.312	(0.020)	0.337	(0.019)	0.475	(0.021)	0.462	(0.021)	0.439	(0.020)
Covariance father sender and receiver							0.240	(0.021)	0.260	(0.020)	0.389	(0.021)	0.378	(0.021)	0.353	(0.020)
Variance father receiver							0.293	(0.030)	0.311	(0.029)	0.449	(0.029)	0.438	(0.029)	0.412	(0.029)
Variance mother sender							0.233	(0.019)	0.267	(0.018)	0.423	(0.020)	0.408	(0.020)	0.394	(0.019)
Covariance mother sender and receiver							0.212	(0.020)	0.245	(0.019)	0.388	(0.021)	0.372	(0.020)	0.348	(0.020)
Variance mother receiver							0.197	(0.029)	0.233	(0.028)	0.399	(0.029)	0.379	(0.028)	0.350	(0.028)
Variance GFF sender							0.786	(0.097)	0.732	(0.093)	0.627	(0.085)	0.626	(0.085)	0.631	(0.084)
Covariance GFF sender and receiver							0.342	(0.054)	0.300	(0.052)	0.181	(0.045)	0.178	(0.045)	0.204	(0.046)
Variance GFF receiver							0.379	(0.031)	0.351	(0.030)	0.233	(0.024)	0.228	(0.024)	0.260	(0.025)
Variance GMF sender							0.705	(0.068)	0.696	(0.067)	0.654	(0.064)	0.652	(0.064)	0.645	(0.063)
Covariance GMF sender and receiver							0.375	(0.041)	0.362	(0.040)	0.292	(0.036)	0.290	(0.036)	0.294	(0.036)
Variance GMF receiver							0.399	(0.029)	0.378	(0.028)	0.287	(0.024)	0.287	(0.024)	0.298	(0.024)
Variance GFM sender							0.689	(0.082)	0.638	(0.079)	0.577	(0.074)	0.578	(0.074)	0.593	(0.074)
Covariance GFM sender and receiver							0.264	(0.050)	0.218	(0.048)	0.152	(0.044)	0.151	(0.044)	0.177	(0.045)
Variance GFM receiver							0.439	(0.032)	0.399	(0.030)	0.322	(0.027)	0.320	(0.027)	0.343	(0.027)
Variance GMM sender							0.656	(0.055)	0.633	(0.054)	0.593	(0.053)	0.590	(0.053)	0.577	(0.052)
Covariance GMM sender and receiver							0.424	(0.035)	0.393	(0.034)	0.340	(0.032)	0.337	(0.032)	0.335	(0.031)

Table 4.7: Full model (N = 4,436 families, 24,777 dyads, 29,894 relationships) (continued)

	Model A		Model B		Model C		Model D		Model E		Model F		Model G		Model H	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Variance GMM receiver							0.415	(0.027)	0.374	(0.026)	0.317	(0.023)	0.314	(0.023)	0.321	(0.023)
Dyad level																
Reciprocity	2.440	(0.030)	0.914	(0.017)												
Variance C-F dyad					1.519	(0.086)	1.338	(0.087)	1.349	(0.087)	1.485	(0.091)	1.552	(0.093)	1.519	(0.092)
Variance C-M dyad					1.382	(0.101)	1.227	(0.102)	1.227	(0.103)	1.403	(0.113)	1.484	(0.115)	1.452	(0.113)
Variance F-M dyad					1.515	(0.053)	1.390	(0.054)	1.408	(0.054)	1.500	(0.056)	1.503	(0.056)	1.467	(0.055)
Variance C-GFF dyad					0.753	(0.080)	0.068	(0.049)	0.043	(0.046)	-0.147	(0.036)	-0.152	(0.036)	-0.162	(0.035)
Variance C-GMF dyad					0.752	(0.066)	0.144	(0.046)	0.072	(0.042)	-0.140	(0.034)	-0.146	(0.034)	-0.146	(0.034)
Variance C-GFM dyad					0.886	(0.074)	0.260	(0.053)	0.260	(0.052)	-0.001	(0.043)	-0.009	(0.043)	-0.011	(0.042)
Variance C-GMM dyad					0.950	(0.063)	0.315	(0.047)	0.268	(0.046)	0.071	(0.041)	0.065	(0.041)	0.055	(0.040)
Variance F-GFF dyad					1.297	(0.071)	1.169	(0.070)	1.027	(0.064)	0.711	(0.056)	0.726	(0.057)	0.747	(0.058)
Variance F-GMF dyad					0.993	(0.051)	0.886	(0.052)	0.745	(0.048)	0.467	(0.044)	0.480	(0.044)	0.511	(0.045)
Variance F-GFM dyad					0.257	(0.034)	-0.170	(0.031)	-0.140	(0.030)	-0.203	(0.027)	-0.202	(0.027)	-0.200	(0.027)
Variance F-GMM dyad					0.226	(0.029)	-0.142	(0.027)	-0.147	(0.026)	-0.199	(0.024)	-0.189	(0.024)	-0.179	(0.024)
Variance M-GFF dyad					0.209	(0.032)	-0.152	(0.031)	-0.139	(0.029)	-0.189	(0.026)	-0.178	(0.026)	-0.167	(0.026)
Variance M-GMF dyad					0.338	(0.031)	-0.024	(0.030)	-0.053	(0.029)	-0.096	(0.026)	-0.087	(0.026)	-0.084	(0.026)
Variance M-GFM dyad					1.581	(0.072)	1.247	(0.065)	1.213	(0.064)	0.970	(0.059)	0.980	(0.059)	1.002	(0.060)
Variance M-GMM dyad					1.089	(0.049)	0.877	(0.047)	0.829	(0.046)	0.569	(0.043)	0.585	(0.043)	0.608	(0.043)
Relationship level																
Residual variance	0.564	(0.011)	0.566	(0.011)	0.566	(0.011)	0.368	(0.013)	0.365	(0.013)	0.343	(0.012)	0.343	(0.012)	0.343	(0.012)
Deviance (LL)	114,386.2		98,225.7		96,819.2		94,832.9		94,370.9		93,430.8		93,366.2		93,110.5	

Note that for models D and further, where random sender and receiver variances and their covariances are included, some dyadic variances turn negative. This is not unusual for these models; it does not imply that the implied covariance matrix of the observations is not positive definite.

4.C APPENDIX: CONTROL MODELS WITH INTERACTIONS - INTERPRETATION

Table 4.7 (online supplementary material section 4.E) presents two additional analyses to investigate the robustness of models G and H in table 4.5. Model A investigates in more detail the effect of the child's age, used as a covariate in model H: whether contact frequencies of specific dyads depend on the child's age, and whether this is different for divorced and non-divorced families. Model A includes the interactions of the various age categories with the dyad dummies, as well as their three-way interactions with divorce. Model B investigates whether the parameters used for testing the hypothesis in model G change when controlling for possible sample bias due to incomplete family data. Models A and B have such a large number of variables that we refrain from testing all parameters, but restrict the inspection to the largest changes in parameters, and primarily focus on their impact on the conclusions about the model hypotheses.

The main effect of the dyad dummy variables in model A now represent the effect for the families with children younger than 10 years. The conclusion about the separated family hypothesis do not change in view of the similar effects of PGP_CL and its interaction with divorce. In the other age groups – in comparison to the youngest age group – several differences in contact frequencies are observed, for instance, more contact between children aged 10-18 with the father in non-divorced families, and less contact with the maternal grandparents, especially after divorce. Children aged 19-25 have less contact with their grandparents, both in divorced and non-divorced families. Their father's contact frequency with his parents-in-law is lower than in non-divorced families.

The main effect of the dyad dummy variables in model B represent the effect for complete families. Here the cross-lineage effect for mothers is somewhat stronger in both types of families. The contact frequencies of the child with all family member is substantially higher than in families with missing family members. No substantial cross-lineage effects were found.