



Discriminative grandparental investment – the impact of grandchild’s gender and sociodemographic parameters

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ABSTRACT: *Homo sapiens* is a typical cooperative breeder and grandparents are among the most important caregivers besides the mothers. Grandparental investment however differs markedly between maternal and paternal grandparents but also between grandmothers and grandfathers. From an evolutionary viewpoint this differential grandparental investment is mainly explained as a result of paternity uncertainty. On the other hand emotional support and child care help from grandparents may also be associated with sociocultural factors. The present study focused on the impact of grandchild’s gender, but also grandparental age and occupation on discriminative grandparental investment, i.e. solicitude, contact frequency and quality of relationship. 272 adults persons between the age 18 and 35 years ($x = 23.5$ yrs; ± 3.7) were enrolled in the study. Patterns of grandparental investment during childhood as well as quality of the grandparent-grandchild relationship were collected retrospectively using a 57 item questionnaire. As to be expected maternal grandmothers showed the highest contact frequency and the highest solicitude while -as to be expected – the paternal grandfather exhibited the lowest degree of investment. Grandparental investment was independent of grandparent category mainly influenced by residential distance. Grandchild’s gender and sociodemographic characteristics of the grandparents in contrast had a minor impact on grandparental caregiving and contact frequency. Contrary, grandchild’s gender was related significantly with the quality of relationship and emotional closeness.

KEY WORDS: grandparental investment, grandparent – grandchild relationship, grandparental solicitude, grandparent – grandchild contact

Introduction

Homo sapiens is a typical cooperative breeder and grandparents are among the most important caregivers besides the parents (Mace and Sear 2005). Cooperative breeding enhances reproductive success and enables *Homo sapiens* to bring

up more offspring successfully than our closest relatives, the nonhuman primates (Bogin and Smith 1996; Hill and Kaplan 1999). From the viewpoint of evolutionary anthropology cooperative breeding represents an adaptive strategy to overcome the hazards of specific patterns of human life history such as a short gestational period resulting in helpless

newborn, followed by a long period of dependence, shortened birth intervals and a general slow childhood growth and development (Bogin and Smith 1996). Consequently the dependence during subadult phase of life is extended among *Homo sapiens* and increases necessary parental investment markedly.

As pointed out above grandparents are the most important caregivers beside biological parents (Wheelock and Jones 2002; Blurton Jones et al. 2005; Mace and Sear 2005; Smorti et al. 2012). This is especially true of grandmothers, whose substantial investment in their grandchildren increases fertility of their children and reduces death rates among their grandchildren (Sear et al. 2000; Sear 2008; Sear and Mace 2008; Coall and Hertwig 2010). This beneficial effect of maternal grandmother on reproductive success was described for historical populations (Jamison et al. 2002; Beise and Voland 2002; Beise 2005), contemporary traditional societies (Gibson and Mace 2005; Sear et al. 2000) but also for western industrialized societies (Pollet et al. 2006, 2007, 2008; Coall et al. 2014; Tanskanen and Rotkirch 2014).

From the viewpoint of evolutionary anthropology the high levels of investment provided by grandmothers is mainly seen within the framework of the prolonged period of female reproductive senescence, or with others words the long period of postmenopause (Hawkes et al. 1997, 1998; Hawkes 2003; Jamison et al. 2005; Kuzawa and Bragg 2012). Postmenopausal women with no young children of their own help to feed and to take care of the offspring of their daughters and near relatives (Hawkes et al. 1998; Sear et al. 2000). In this way postmenopausal women increase the reproductive success of themselves and

near relatives. The so called grandmother hypothesis as an evolutionary explanation of female menopause was a consequence of such ideas (Hawkes et al. 1997, 1998; Hawkes 2003; Lahdenperä et al. 2004). The strong association between prolonged postmenopausal period and the high degree of grandmaternal investment is supported by the fact, that both phenomenon – female postgenerative longevity as well as grandmaternal solicitude – are nearly exclusively found among humans.

The evolutionary basis of grandparental help in bringing up offspring is interpreted as a typical example of kin selection. According to Hamilton (1964) in highly social species, such as humans, individuals can increase their inclusive fitness by supporting their kin and consequently the altruistic investment in genetically related offspring is clearly adaptive (Hamilton 1964). Relatives share common genes by descent and consequently natural selection can favour genes that enables individuals to support their relatives to reproduce successfully (Hamilton 1964).

The four biological grandparents of an individual however, differ in the certainty of genetically relatedness with their grandchildren. While maternal grandmothers can be certain of her own as well as of her daughter's maternity, the paternal grandfather is the most uncertain. He can be neither certain of his own nor of his son's paternity (Euler and Weitzel 1996). The paternal grandmother and the maternal grandfather have both the same degree of uncertainty of grandparenthood. These differences in paternity certainty seem to influence grandparental investment because fundamental differences in solicitude between maternal and paternal

grandparents were documented. This so called differential grandparental investment was documented among historical (Beise and Voland 2002; Jamison et al. 2002; Beise 2004, Kemkes-Grottenthaler 2005) as well as among modern societies (Euler and Weitzel 1996; Gibson and Mace 2005; Michalski and Shackelford 2005; Anderson 2006; Chrastil et al. 2006; Pollet et al. 2006, 2008; Bishop et al. 2009; Danielsbacka et al. 2011). It could be shown that maternal grandparent's investment was significantly higher than that of the paternal ones (Chan and Elder 2000; Pollet et al 2006; Pollet and Nettles 2007; Pollet et al. 2008). In particular maternal grandmothers invest most in their grandchildren, while paternal grandfathers invest least (Kahana and Kahana 1970; Eisenberg 1988; Rossi and Rossi 1990). The typical investment of maternal grandfathers and paternal grandmothers lays between that extremes. These findings may be interpreted as a consequence of differential paternity uncertainty. The association between paternity certainty and discriminative grandparental investment is supported by the observation that phenotypic resemblance increase grandparental investment and improves the relationship between grandparent and grandchild. The impact of phenotypic resemblance is especially high among paternal grandfathers, who may interpret phenotypic resemblance with their grandchildren as an indicator of genetic relatedness (Euler and Weitzel 1996; Schlee and Kirchengast 2015). Beside this evolutionary basis of differential grandparental investment we should not forget the impact of sociocultural factors. Contact frequency between grandparents and grandchildren but also grandparental solicitude are also

influenced by residential distance, sociocultural factors such as patrifocal or matrifocal lifestyles but also socioeconomic factors (Pashos 2000; Holden et al. 2003; Pashos and McBurney 2008; Kaptjin et al. 2013).

The impact of grandchild's gender on discriminative grandparental investment however was mainly discussed from the viewpoint of x chromosome relatedness theory (Chastril et al. 2006; Fox et al. 2009; Rice et al. 2010; Tanskanen et al. 2011), while the impact of grandchild's gender on the grandchild grandparent relationship was rather neglected in biological anthropology. Therefore in the present study the following hypotheses were tested:

Hypothesis 1: Grandparental investment increased with increasing paternity certainty.

Hypothesis 2: Grandchild's gender has a major impact on grandparental caregiving, contact frequency and emotional closeness between grandparents and grandchildren.

Material and methods

Subjects

272 adult persons between the ages 18 and 35 years ($x=23.5\text{yrs}$; ± 3.7) were enrolled in the study. The sample consisted of 78 male subjects ageing between 19 and 33 years ($x=24.3 \pm 3.1$) and 194 female subjects with a mean age of 23.2 years (± 3.9). All participants were students at the University of Vienna. The strict inclusion criterion was that all four biological grandparents had to be alive during childhood and adolescence of the participant. Additionally the grandparents had to origin from central Europe

in order to exclude cultural factors which might influence grandparent –grandchild relationship.

Procedure

After a pilot study comprising 40 participants in order to test the validity of the instrument (adapted structured questionnaire) data collection took place between June and December 2008. The participants were mainly contacted personally at the University of Vienna, only few were recruited via snowball system among friends of one investigator (B. Putz). Participants were interviewed face-to-face based on a structured questionnaire, developed by the authors based on the questionnaire of Euler and Weitzel (1996). The participants were asked about their memories of received grandparental care during childhood and early adolescence (between age 7 and 12 years) as well as about the quality of relationship between them and their grandparents. The authors decided to interview grandchildren only because it has been assumed that ratings by grandchildren may better indicators of grandparental care because ratings by grandparents may be influenced by equity norms (Euler and Weitzel 1996; Euler and Michalski 2007). Analysis was limited to biological relatives.

Questionnaire

The structured questionnaire contained 57 items concerning the participants, their siblings, their biological parents and their maternal and paternal biological grandparents. As pointed out above this questionnaire was adapted from that of Euler and Weitzel (1996). Beside a detailed documentation of socioeconom-

ic and sociodemographic parameters of the participants family, participants were asked about their living conditions and experiences they made during childhood and early adolescence (7 to 12 years), in relation to each grandparent type (maternal grandmother (MGM), maternal grandfather (MGF), paternal grandmother (PGM) and paternal grandfather (PGF)). Residential distance between grandchild and each grandparent was estimated on a scale of 1 to 10, which had been slightly adapted from Euler and Weitzel (1996): (1) in the house, (2) in the neighbourhood, (3) short distance away (e.g. in the same village or in the same quarter of a city), (4) in the city or neighbouring village, (5) surrounding area, (6) in the region, (7) daytrip, (8) a day's journey, (9) long distance travel, (10) flight. Furthermore, participants were asked to rate frequency of contact with each grandparent on a scale of 1 to 10 (1=no contact, 2=less than once a year, 3=once a year; 4=several times a year, 5=less than one meeting per month; 6=minimum one meeting per month; 7=several times a month; 8=once a week; 9=several times a week, 10 every day). Moreover, they were asked how much each grandparent had cared for them. The intensity was rated on a likert scale of 1 to 5 (1=not at all; 2=almost not; 3=average; 4 considerable; 5= extraordinary) which had been slightly adapted from Euler and Weitzel (1996). The quality of relationship with each grandparent was rated on a scale of 1 to 5 (1=very bad relationship; 2=rather bad; 3 neither good nor bad, 4=rather good, 5=very good relationship). In addition the participants were asked to whom of their grandparents they feel close to and to give the reasons for their decision. Cronbachs Alpha was cal-

culated in order to test the internal consistency of these measurements.

Statistical analysis

Statistical analyses were carried out by means of SPSS for Windows program Version 22.0. After calculating descriptive statistics (means, SDs, range, absolute and relative frequencies), nonparametric procedures (Friedman test) were applied. Cronbach's alpha was calculated in order to test the reliability of variables describing the relationship between grandchild and grandparent. Crosstabs (Chi-squares) were calculated to test frequency differences with respect to their statistical significance. Multiple regression analyses were computed in order to test the impact of grandparental age, residential distance and grandparental occu-

pation on contact frequency, grandparental solicitude and emotional relationship for each grandchild's gender separately.

Results

Sample characteristics

The vast majority of participants (85.2%) grew up together with their biological parents and 1.3 (± 1.2) biological siblings on the average. More than 80% of the participants had 1 or 2 siblings, while only 6.5% grew up as single child. 10.3% had 3 or more biological siblings. Socio-demographic characteristics of the grandparents, such as age, occupation, and family status during participant's childhood (at the age of 7 years) are presented in Table 1. As to be seen maternal grand-

Table 1. Demographic description of grandparents situation during childhood of the participants) Chi-squares.

Age group	MGM	MGF	PGM	PGF	Sign. Chi-square
< 50 years	12.0%	6.5%	3.7%	0.9%	p=0.0001 (30.2)
50–59 years	42.6%	38.9%	29.6%	25.9%	
60–69 years	35.2%	37.0%	44.4%	47.2%	
70–79 years	8.3%	11.1%	13.0%	16.7%	
> 80 years	0.0%	0.0%	0.9%	0.0%	
No information	1.9%	6.5%	8.3%	9.3%	
Occupational status					
Fulltime job	15.8%	54.7%	19.0%	51.4%	p=0.02 (13.1)
Part time job	16.3%	4.6%	11.1%	1.0%	
Housewife/not working	33.0%	0.9%	28.2%	0.0%	
Retired	31.1%	32.4%	34.0%	41.9%	
No information	3.8%	7.4%	4.9%	5.7%	
Family status					
	maternal grandparents		paternal grandparents		
Married	77.8		81.1		p=0.07
divorced	10.2		9.4		
partnership	8.3		7.5		
Separated	3.7		1.9		

MGM = maternal grandmother; MGF = maternal grandfather, PGM = paternal grandmother; PGF = paternal grandfather.

Table 2. Residential distance according to grandparental category (Friedman-Test).

Residential Distance	MGM	MGF	PGM	PGF	Sig.
Same house	5.6%	2.8%	14.2%	15.1%	p=0.19
neighborhood	6.5%	6.6%	8.5%	7.5%	
Short distance (village, quarter of city)	16.7%	17.9%	16.0%	13.2%	
City, neighboring village	26.9%	24.5%	19.8%	20.8%	
Surrounding area	10.2%	10.4%	7.5%	7.5%	
Region	10.2%	10.4%	9.4%	10.4%	
Day trip	10.2%	10.4%	10.4%	10.4%	
Day's journey	6.5%	8.5%	3.8%	3.8%	
Long distance travel	2.8%	2.8%	6.6%	6.6%	
Flight	4.6%	5.7%	3.8%	4.7%	

Legend: MGM = maternal grandmother; MGF = maternal grandfather, PGM = paternal grandmother; PGF=paternal grandfather.

parents were significantly younger than paternal grandparents. While maternal and paternal grandparent's family status did not differ significantly – the vast majority of biological grandparents (about 80%) were married – significant sex differences in occupational status were observable. Significantly more grandfathers had a fulltime job, none of them worked exclusively in the household. The majority of grandmothers were housewives or worked part time. Residential distance to the grandparents during childhood is presented in Table 2. More than 70% of the grandparents (independent of grandparental category) lived quite near to their grandchildren. No significant differences in residential distance between the four grandparent categories could be documented.

Grandparental investment

In a first step the internal consistency of the variables describing the grandchild-grandparent relationship were tested. Contact frequency (4 items) yielded a Cronbach alpha of 0.72. Grandparental solicitude (4 items) yielded a Cronbach Alpha of 0.79 and the quality of relation-

ship (4 items) yielded a Cronbach alpha of 0.71. Consequently a high internal consistency can be assumed. In a second step a descriptive analysis of grandparental's investment was carried out and compared between the different grandparental categories. As to be expected grandparental investment differed significantly according to grandparental category. As demonstrated in table 3 contact frequency was significantly highest ($p < 0.002$) between grandchild and maternal grandmother, while the lowest contact frequency was found between grandchild and paternal grandfather. The contact frequency with the maternal grandfather was slightly higher than with the paternal grandmother. Concerning solicitude the highest scores were also reported for maternal grandmother and – as to be expected- the lowest scores were found for the paternal grandfather. Paternal grandmother and maternal grandfather differed only slightly in the intensity of care giving. Furthermore the grandparent categories differed significantly in the quality of relationship with the grandchild. As demonstrated in table 3 more than 60% of the participants described the relationship with the mater-

Table 3. Contact frequency, solicitude and quality of relationship by grandparent category (Friedman test).

	MGM	MGF	PGM	PGF	Sign.
Contact frequency					
Every day	16.0%	10.5%	18.7%	17.0%	
Several times a week	32.1%	29.5%	12.1%	10.4%	
Once a week	10.4%	13.3	14.0%	12.3%	
Several times a month	9.4%	9.5%	8.4%	10.4%	
Minimum of one meeting per month	8.5%	9.5%	12.1%	11.3%	p=0.002
Less than one meeting per month	4.7%	4.8%	7.5%	5.7%	
Several times a year	11.3%	12.4%	13.1%	14.2%	
Once a year	4.7%	5.7%	4.7%	4.7%	
Less frequently	1.9%	0.0%	1.9%	3.8%	
Never/no contact	0.9%	4.8%	7.5%	10.4%	
Solicitude					
Not at all	2.8%	13.9%	11.1%	21.5%	
Almost not	10.2%	15.7%	14.8%	15.9%	p=0.0001
Average	14.8%	27.8%	28.7%	30.8%	
Considerable	36.1%	23.1%	31.5%	24.3%	
Extraordinary	36.1%	19.4%	13.9%	7.5%	
Quality of Relationship					
Very bad	1.9%	11.1%	9.5%	11.7%	p=0.0003
Rather bad	4.6%	3.7%	10.5%	11.7%	
Neither good nor bad	7.4%	16.7%	21.9%	25.2%	
Rather good	25.0%	24.1%	21.9%	26.2%	
Very good	61.1%	44.4%	36.2%	25.2%	

MGM = maternal grandmother; MGF = maternal grandfather, PGM = paternal grandmother; PGF=paternal grandfather.

nal grandmother as very good, while only 1.9% of the participants rated the quality of this relationship as very bad. Contrary only 25.2% of the participants described the relationship to their paternal grandfather as very good, and more than 20% rated this relationship as bad or very bad (Table 3).

Differences in grandchild-grandparent relationship according to grandchild's gender

In a third step differences in grandchild – grandparent relationship according to grandchild's gender were described. Considering grandchild's gender it

turned out, that the contact frequency between granddaughters and maternal grandmother was significantly higher than between grandsons and maternal grandmothers (Table 4). This was also true of the relationship between maternal grandfathers and granddaughters as well as grandsons. Contrary the contact frequency between grandchildren and paternal grandparents did not differ significantly according grandchild's gender. In contrast, it could be shown that more grandsons than granddaughters had daily contact with their paternal grandparents (Table 4). Concerning grandparental solicitude no statistically significant differences between granddaughters and

grandsons could be observed. This was true of all four grandparental categories. Concerning the quality of relationship, no significant between granddaughters and grandsons were found for maternal grandparents. Male participants, however rated the quality of relationship to the paternal grandmother and to the paternal grandfather higher than female participants. Among paternal grandmother this difference was of statistical significance (Table 4). The feeling of emotional close-

ness according the grandparent category differed between male and female participants. As demonstrated in figure 1 more than 70% of female participants felt closest to the maternal grandmother, while only 13.5% of the female participants felt closest to the maternal grandfather and only 2.5% of the female participants described the relationship to the paternal grandfather as the emotionally closest one. In contrast, 37.9% of the male a felt closest to the maternal grandfather

Table 4. Contact frequency, solicitude and quality of relationship by grandparent category according to grandchild's sex (Friedman test).

	MGM		MGF		PGM		PGF	
	female	male	female	male	female	male	female	male
Contact frequency								
Every day	18.2%	10.3%	10.5%	10.3%	15.4%	27.6%	15.6%	20.7%
Several times a week	39.0%	13.8%	34.2%	17.2%	14.1%	6.9%	11.7%	6.9%
Once a week	9.1%	13.8%	11.8%	17.2%	14.1%	13.8%	13.0%	10.3%
Several times a month	6.5%	17.2%	5.3%	20.7%	6.4%	13.8%	7.8%	17.2%
Minimum of one meeting per month	3.9%	20.7%	6.6%	17.2%	10.3%	17.2%	10.4%	13.8%
Less than one meeting per month	2.6%	10.3%	2.6%	10.3%	5.1%	13.8%	2.6%	13.8%
Several times a year	11.7%	10.3%	14.5%	6.9%	15.4%	6.9%	16.9%	6.9%
Once a year	5.2%	3.4%	7.9%	0.0%	6.4%	0.0%	5.2%	3.4%
Less frequently	2.6%	0.0%	0.0%	0.0%	2.6%	0.0%	3.9%	3.4%
Never/no contact	1.3%	0.0%	6.6%	0.0%	10.3%	0.0%	13.0%	3.4%
Significance	p=0.03		p=0.02		p=0.12		p=0.09	
Solicitude								
Not at all	2.5%	3.4%	13.9%	13.8%	13.9%	3.4%	23.1%	17.2%
Almost not	12.7%	3.4%	20.3%	3.4%	16.5%	10.3%	17.9%	10.3%
Average	13.9%	17.2%	27.8%	27.6%	30.4%	24.1%	28.2%	37.9%
Considerable	31.6%	48.3%	21.5%	27.6%	25.3%	48.3%	23.1%	27.6%
Extraordinary	39.2%	27.6%	16.5%	27.6%	13.9%	13.8%	7.7%	6.9%
Significance	p=0.09		p=0.12		p=0.07		p=0.13	
Quality of Relationship								
Very bad	1.3%	3.4%	13.9%	3.4%	13.2%	0.0%	13.5%	6.9%
Rather bad	6.3%	0.0%	3.8%	3.4%	6.6%	20.7%	10.8%	13.8%
Neither good nor bad	7.6%	6.9%	19.0%	10.3%	25.0%	13.8%	29.7%	13.8%
Rather good	21.5%	34.5%	19.0%	37.9%	19.7%	27.6%	23.0%	34.5%
Very good	63.3%	55.2%	44.3%	44.8%	35.5%	37.9%	23.0%	31.0%
Significance	p=0.09		p=0.09		p=0.04		p=0.11	

MGM = maternal grandmother; MGF = maternal grandfather, PGM = paternal grandmother; PGF=paternal grandfather, n.s. = not significant.

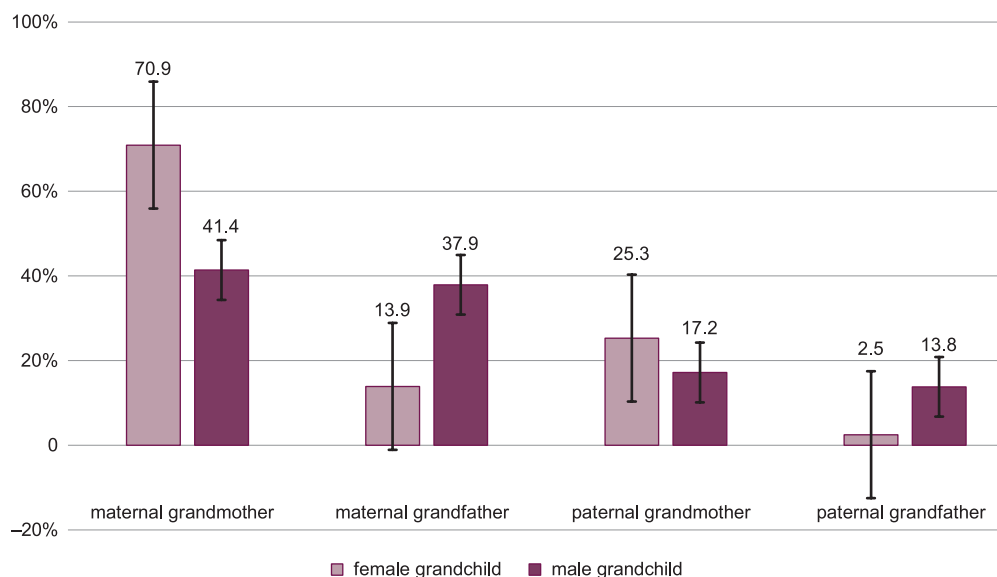


Fig. 1. Extraordinary high emotional relationships between grandparents and grandchildren according to grandchild's gender.

and 13.8% rated the relationship to the paternal grandfather as the emotionally closest one (Fig. 1).

Factors influencing grandparental investment

In a fourth step the impact of potential cofactors on grandchild-grandparent relationship was analysed for each grandchild's gender separately. In detail sociodemographic factors, such as grandparent's age, occupation and residential distance on grandparental investment and the grandchild-grandparent relationship were analysed by means of multiple regression analyses. As demonstrated in Table 5, contact frequency with all grandparents was significantly influenced by residential distance. In general the lower the residential distance the higher was the contact frequency. This was true of male as well as female grandchildren and for all grandparent categories (Table 5).

In contrast residential distance was significantly negatively related to solicitude and of maternal grandparents. This relationship between residential distance grandchildren and grandparents was only found among female grandchildren. Furthermore residential distance had a significant negative impact on the quality of grandchild-grandparent relationship. This relation was found for female grandchildren and maternal grandparents as well as paternal grandfather. Grandparent's age had no significant impact on contact frequency, solicitude and quality of relationship. This was true of male as well as female grandchildren. Occupational status, which describes the time opportunity, influenced neither contact frequency nor solicitude. The only significant impact of grandfather's occupation was found for the impact of maternal grandfather's occupation on the quality of relationship with granddaughters. Among male grandchildren Grandparen-

Table 5. Impact of residential distance, grandparents age and grandparents occupation on contact frequency, solicitude and quality of relationship according to grandparental category for female and male grandchildren separately (multiple regression analyses).

	Contact frequency			Solicitude			Quality of relationship					
	R ²	Reg. Coeff.	Sign.	95% confidence interval	R ²	Reg. Coeff.	Sign.	95% confidence interval	R ²	Reg. Coeff.	Sign.	95% confidence interval
Female grandchildren												
Maternal grandmother												
Residential distance		0.83	0.001	0.67-0.98		-0.21	0.001	-0.31--0.11		-0.11	0.016	-0.21--0.02
Grandmothers age	0.79	-0.19	0.360	-0.59-0.22	0.45	-0.06	0.633	-0.33-0.20	0.30	-0.07	0.564	-0.32-0.17
Grandmothers occupation		0.02	0.782	-0.11-0.15		-0.02	0.712	-0.10-0.07		-0.03	0.452	-0.11-0.05
Maternal grandfather												
Residential distance		0.86	0.001	0.69-1.03		-0.18	0.003	-0.29--0.06		-0.20	0.002	-0.33--0.08
Grandfathers age	0.79	-0.08	0.690	-0.46-0.30	0.42	-0.03	0.838	-0.28-0.23	0.48	0.04	0.771	-0.24-0.32
Grandfathers occupation		0.08	0.131	-0.46-0.30		-0.06	0.095	-0.13-0.01		-0.09	0.018	-0.17--0.02
Paternal grandmother												
Residential distance		0.65	0.001	0.44-0.87		-0.06	0.270	-0.18-0.05		-0.06	0.396	-0.18-0.07
Grandmothers age	0.61	-0.09	0.770	-0.51-0.38	0.19	-0.02	0.271	-0.27-0.22	0.16	0.02	0.885	-0.25-0.29
Grandmothers occupation		0.12	0.145	-0.04-0.28		-0.05	0.890	-0.14-0.04		-0.05	0.327	-0.15-0.05
Paternal grandfather												
Residential distance		0.70	0.001	0.49-0.92		-0.09	0.123	-0.20-0.02		-0.14	0.023	-0.26--0.02
Grandfathers age	0.65	0.08	0.735	-0.38-0.54	0.36	-0.21	0.086	-0.45-0.03	0.34	-0.16	0.220	-0.42-0.09
Grandfathers occupation		0.12	0.117	-0.03-0.27		-0.07	0.065	-0.15-0.01		-0.02	0.591	-0.11-0.06
Male grandchildren												
Maternal grandmother												
Residential distance		0.53	0.005	0.17-0.88		-0.17	0.082	-0.36-0.02		-0.09	0.298	-0.29-0.09
Grandmothers age	0.56	-0.06	0.902	-0.96-0.85	0.41	-0.04	0.885	-0.53-0.46	0.24	-0.01	0.996	-0.49-0.49
Grandmothers occupation		0.05	0.697	-0.21-0.30		-0.09	0.217	-0.22-0.05		0.02	0.804	-0.12-0.15

Maternal grandfather												
Residential distance	0.45	0.002	0.19	-0.71	-0.17	0.238	-0.46	-0.19	-0.19	0.662	-0.39	-0.01
Grandfathers age	0.75	-0.08	0.631	-0.42	-0.26	0.28	-0.36	-0.39	0.43	0.412	-0.16	-0.38
Grandfathers occupation	-0.38	0.003	-0.61	-0.15	0.05	0.670	-0.21	-0.31	-0.03	0.742	-0.21	-0.16
Paternal grandmother												
Residential distance	0.68	0.001	0.49	-0.87	-0.03	0.736	-0.20	-0.14	0.10	0.293	-0.08	-0.29
Grandmothers age	0.85	-0.04	0.821	-0.43	-0.35	0.21	-0.38	-0.33	0.35	0.207	-0.65	-0.15
Grandmothers occupation	0.15	0.244	-0.11	-0.40	0.10	0.366	-0.13	-0.34	0.05	0.668	-0.21	-0.32
Paternal grandfather												
Residential distance	0.69	0.001	0.43	-0.95	-0.11	0.211	-0.28	-0.07	-0.06	0.524	-0.25	-0.13
Grandfathers age	0.74	-0.42	0.077	-0.89	-0.05	0.32	-0.15	-0.48	0.27	0.509	-0.45	-0.23
Grandfathers occupation	0.02	0.898	-0.22	-0.25	-0.02	0.751	-0.18	-0.13	-0.08	0.347	-0.24	-0.09

tal's age and occupation had no significant impact on solicitude and quality of relationship.

Discussion

Grandparental investment – the term is based on Trivers' concept of parental investment (Trivers 1972) – refers to resources that grandparents transfer to their grandchildren in order to enhance their chance to survive up to adulthood. The positive effect of grandparental support in bringing up offspring successfully and to successfully reproduce was described for historical populations (Jamison et al. 2002, 2005; Beise and Voland 2002; Beise 2004, 2005) as well as for contemporary traditional societies (Sear et al. 2000; Gibson and Mace 2005). A detailed analysis of the importance of grandmotherhood from the viewpoint of evolutionary biology and human life history theory was provided by Voland et al. (2005). Especially in contemporary affluent societies the increase in life expectancy has greatly increased the importance of grandparents in the lives of their grandchildren (Kaptijn et al. 2013). Although kinship has been claimed to be of relatively low importance for social interactions in modern industrialized societies (Beck 1993, Giddens 1991) and childhood mortality rates are extremely low, grandparents provide practical help, food, substantial amounts of money and time but also emotional support for their grandchildren in order to bring them up (Wheelock and Jones 2002; Hayslip and Kaminski 2005; Pollet et al. 2008; Danielsbacka et al. 2011; Coall and Hertwig 2012; Kaptijn et al. 2013; Tanskanen and Rotkirch 2014). Even in affluent modern societies the investment of grandparents varies according to grandparental cate-

gory. In general maternal grandmothers showed the highest investment in grandchildren, while the lowest investment is described for paternal grandfather (Euler and Weitzel 1996; Euler et al 2001; Beise and Voland 2002; Jamison et al. 2002; Beise 2004; Euler 2004; Kemkes-Grotenthaler 2005; Gibson and Mace 2005; Michalski and Shackelford 2005; Anderson 2006; Chrastil et al. 2006; Pollet et al. 2006, 2008; Euler and Michalski 2007; Bishop et al. 2009; Danielsbacka et al. 2011). From the viewpoint of evolutionary anthropology these patterns of discriminative grandparental investment are mainly interpreted within the framework of paternity certainty, which is understood as the ultimate background variable to which the grandparental investment willingness has been adapted. On the other hand the proximate factors of grandparental investment regulation such as cultural prescriptions and economic factors were focused on (Pashos 2000; Kaptijn et al. 2013).

The present study tested the 2 hypotheses concerning differential grandparental investment among an Austrian sample. In detail contact frequency, solicitude and emotional closeness between grandchildren and grandparents are focused on. Before we start to discuss the results in detail, we have to state that the present study has certain limitations. The main shortcoming is the small sample size ($n=272$). This low number of participants is due to the strict inclusion criteria, only students ageing between 18 and 35 years whose four biological grandparents were alive during participants childhood (up to age 10 years) were enrolled in the present study. Another shortcoming is the retrospective design of the study and that only adult grandchildren were interviewed regard-

ing their perception of received grandparental solicitude during childhood and the quality of relationship.

According to hypothesis 1, grandparental investment increases with increasing paternity certainty. This hypothesis could be verified. As expected, maternal grandmothers showed the highest contact frequency, the highest degree of solicitude and the highest quality of personal relationship. Paternal grandfather in contrast, were characterized by the lowest contact frequency, the lowest degree of solicitude and the worst quality of relationship. Maternal grandfathers and paternal grandmothers differed not significantly in contact frequency, the degree of solicitude and the quality of relationship however, was higher among paternal grandmothers. These patterns of differential grandparental investment were in accordance with the results of several other studies (Euler and Weitzel 1996; Gibson and Mace 2005; Michalski and Shackelford 2005; Anderson 2006; Chrastil et al. 2006; Pollet et al. 2006; 2008; Bishop et al. 2009; Danielsbacka et al. 2011). The results of the present study indicate a higher investment in the matriline, with other words with increasing paternity uncertainty the investment decreased. This finding can be interpreted as a result of kin selection, because grandparental investment is a psychological and behavioural adaptation to kin selection, it is altruistic and it is typical of humans (Alexander 1974). As typical of internally gestating animals, human males and females differ in the degree of uncertainty of genetic relatedness to their offspring. In case of grandparents the maternal grandmother has zero degrees of uncertainty regarding her biological relationship with her daughter's offspring (Chrastil et al. 2006). Maternal

grandfathers and paternal grandmothers have one degree of uncertainty, while the paternal grandfather has two degree of uncertainty. According to the paternity uncertainty hypothesis differential grandparental investment is predicted according to the level of paternity uncertainty (Euler and Weitzel 1996; Laham et al. 2005; Anderson 2006; Bishop et al. 2009; Goetz and Shakelford 2009.) Consequently highest investment in grandchildren can be expected for maternal grandmothers, the lowest one for paternal grandfathers. The results of the present study are in accordance with this assumption.

According to hypothesis 2 grandchild's gender is related to grandparental investment. This hypothesis could be verified too. It could be shown that grandchild's gender was related with the contact frequency with maternal grandparents. In detail contact frequency between granddaughters and maternal grandparents was higher than that between grandsons and maternal grandparents. In contrast, the contact frequency between paternal grandparents and grandsons was higher – however, insignificantly – than that between paternal grandparents and granddaughters. This observation fits partly to idea that sex chromosome relatedness has an impact on discriminate grandparental investment (Chastril et al. 2006; Fox et al. 2009). According to Chastril et al. (2006) discriminative grandparental investment is not only influenced by paternity uncertainty but also by the asymmetric genetic relatedness between grandchildren and their maternal and paternal grandparents. While according to autosomes all four parents are equal related genetically to their grandchildren, this is not the case with sex chromosomes (Chastril et al. 2006). Males are heterozygous for

the sex chromosomes. Therefore paternal grandparents are not symmetrically related to granddaughters and grandsons (Chastril et al 2006). In detail for the sex chromosomes paternal grandmothers are more closely related to granddaughters than maternal grandmothers and paternal grandfathers are more closely related to grandsons than are maternal grandfathers. Especially the Y-chromosome from the paternal grandfather can be followed directly to their grandsons (Chastril et al. 2006). In the present study nearly 65% of grandsons rated their relationship with the paternal grandfathers as very good or rather good, this was only true of 46% of granddaughters. This observation may be interpreted as a result of asymmetric genetic relatedness. However, we should not forget that grandchild-grandparent relationship is also mainly influenced by exogenous factors such as residential distance. In the present study it could be shown, that according to the multiple regression analyses, the most important factor of contact frequency between grandchildren and grandparents was residential distance. This was true of female as well as male grandchildren.

On the other hand discriminate grandparental investment according to grandchild's gender can also be explained by cultural factors. In the present study male grandchildren rated the quality of the relationship with both grandfathers higher than female grandchildren. Furthermore male grandchildren described the solicitude of maternal as well as paternal grandfathers more often as extraordinary and considerable than female grandchildren. This observation may be explained by a closer relatedness between grandparents and grandchildren of the same sex. This observation is in clear contradiction to the findings of

Höpflinger and Hummel (2006). In this study no gender related differences of the grandchild-grandparent relationship could be documented. In the present study the investment of maternal and paternal grandmothers differed according to grandchild's gender. Granddaughters received a higher investment from maternal grandmothers than from their paternal ones and these findings are clearly in contrast to the x-chromosomal relatedness theory but are in accordance with the findings of Tanskanen et al. (2011), who reported a greater investment of maternal grandmother than paternal grandmothers in granddaughters.

Although we finally can state that both hypotheses could be verified, we have to state that grandparental investment is not only influenced by paternity uncertainty and grandchild's gender. From an evolutionary viewpoint the present results corroborate the paternity uncertainty theory. Additionally it could be shown that grandchild's gender influences the quality of relationship between grandchildren and grandparents. On the other hand residential distance showed the most important impact on grandchild – grandparent contact frequency and among female grandchildren and maternal grandparents also an important impact on solicitude and the quality of relationship.

Authors' contributions

SK put hypotheses, collected data, interpreted results, wrote the manuscript. BP collected data, performed statistical analysis. wrote the manuscript

Conflict of interest

Both authors declare that there is no conflict of interests.

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