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Spousal Age Differences and Sex Differences in Life Expectancy are Confounders of Matrilateral Biases in Kin Investment

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Several evolution-based theories predict discriminative kin investment in humans. Previous research indicates that a matrilateral bias exists, such that maternal relatives invest the most in grandchildren due to the high degree of certainty of biological relatedness. In a sample of 321 Austrian adults, we failed to replicate previous findings using retrospective solicitude ratings and ratings of emotional closeness for grandparent–grandchild and aunt/uncle–niece/nephew relationships. However, exposure time to (i.e., number of years where relative was alive), and residential distance from, the relatives were found to be confounding variables on these commonly used measures of investment.

Evolution-based theories, such as parental investment theory (Trivers, 1972) and paternity confidence theory (Daly, Wilson, & Weghorst, 1982), predict matrilateral biases in human kin investment, such that maternal relatives invest more in kin than paternal relatives. Maternity dictates that a female is biological related to her child, but this level of certainty does not exist for males because males do not physically give birth. Given that females could engage in extrapair copulations unbeknownst to their male partner, males are constantly faced with this issue of paternity uncertainty. Consequently, paternal grandparents cannot be certain that their sons' children are genetically related to them. Whereas paternal grandmothers maintain one degree of uncertainty due to paternity uncertainty, paternal grandfathers maintain two degrees. That is, a paternal grandfather might not be his son's biological father, and his son may not be the biological father of his children. In contrast, maternal grandmothers maintain no degree of uncertainty regarding the biological relatedness to their daughters' children, whereas maternal grandfathers exhibit one degree. In terms of investment, this pattern of uncertainty with respect to biological relatedness suggests that maternal grandmothers should invest the most in grandchildren, followed next by maternal grandfathers and paternal grandmothers, and with least investment by paternal grandfathers. Moreover, this evolution-based hypothesis of discriminative kin investment can also be extended to another class of second-degree relatives, aunts and uncles, in an analogous way. Matrilateral relatives should invest more in nieces and nephews, due to a greater certainty of genetic relatedness, than patrilateral relatives.

Conclusions regarding discriminative biases in investment that are based on empirical research are mostly consistent. The predominant line of research in this area utilizes retrospective ratings of adults' received

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solicitude from relatives during childhood or their ratings of emotional closeness. Support for predictions stemming from relational uncertainty have been documented by Russell and Wells (1987), who showed that emotional closeness to matrilateral relatives is significantly higher than to patrilateral relatives. Similarly, Euler and Weitzel (1996) established a rank-ordering of received solicitude ratings for grandparents, such that the maternal grandmother scored the highest, followed by maternal grandfather, paternal grandmother, and paternal grandfather. This research was conducted using a German sample and has since been replicated by Steinbach and Henke (1998); Laham, Gonsalkorale and von Hippel (2005); and Chrastil, Getz, Euler, and Starks (2006) in French, German, and American samples. Euler and Weitzel (1996) found sex and laterality effects, with the former being stronger than the latter, such that with grandmothers invest more than grandfathers and maternal grandparents invest more than paternal grandparents. As both paternal grandmother and maternal grandfather maintain one degree of uncertainty towards grandchildren, Laham et al. (2005) showed that a significant lower investment of the paternal grandmother compared to the maternal grandfather may occur in the presence of kin with whom there is more certainty (e.g., paternal grandmother also has grandchildren through a daughter). Reversing the usual study design, Michalski and Shackelford (2005) collected data from older American adults to analyze their investment toward grandchildren. They found that maternal grandmothers invest the most and that grandparents invest more in a daughter's, than in a son's, children. This finding was based on money spent on a grandchild per month, time spent with a grandchild per week, and ratings of emotional closeness to grandchildren.

Gaulin, McBurney, and Brakeman-Wartell (1997) showed that, in an American sample, predictions made from relational uncertainty also hold in relationships between aunts or uncles with nieces or nephews. Matrilateral relatives scored higher in adults' retrospective solicitude ratings than patrilateral relatives and aunts scored higher than uncles. In these data, the sex effect again turned out to be more pronounced than laterality. This finding was replicated by Hoier, Euler, and Hänze (2001) in a German sample and by McBurney, Simon, Gaulin, and Geliebter (2002) in an Orthodox Jewish college student sample.

One study that yielded contrary findings with respect to relational uncertainty was Pashos (2000). In an attempt to replicate Euler and Weitzel (1996), he found laterality effects to be reversed in a rural Greek sample. Contrary to previous interpretations, Pashos proposed that female caregiving should be attributed to biological causes, whereas laterality effects are socially engendered. For example, in the case of rural Greece, laterality may be understood in context of patrilocality (i.e., married couples live with or near the husband's parents).

In previous research, investigators have tried to control for a number of possible moderator and confounding variables, including the following three variables. First, the number of living grandparents and the age of grandparents do not seem to influence discriminative solicitude (Euler & Weitzel, 1996; Pashos, 2000). Second, the age of participants appears to be a possible confounder, as older participants rate maternal grandmothers' investment lower than younger participants (Pashos, 2000). Third, although residential distance of relatives during participants' childhood may impact on solicitude (Euler & Weitzel, 1996; Pashos, 2000; Steinbach & Henke, 1998), it may not completely explain differences in solicitude. Furthermore, although these findings are interesting, it should be noted that none of these researchers treated possible confounders as covariates in their statistical analyses (i.e., statistically removed the confounders' influence on the rating data). The one exception, Michalski and Shackelford (2005), used residential distance of relatives as a covariate, but the findings are not comparable because their study was methodologically different, as aforementioned.

Researchers who examined aunt and uncle investment bias have been more diligent in their treatment of covariates. Foe example, Gaulin et al. (1997) and Hoier et al. (2001) found that, in an aunt's or uncle's relationship with a niece or nephew, the main effects of laterality and sex of relative seemed to remain unaffected by the age of relatives and residential distance. However, differences in both of these factors (i.e., the age of relatives and differences in residential distance) turned out be significantly correlated to differences in ratings (Gaulin et al., 1997), and younger relatives scored higher than older relatives (Hoier et al., 2001). These authors, and McBurney et al. (2002), tried to control for age and residential distance by conducting analyses of covariance with repeated measures, with confounders treated as covariates. This statistical approach is, however, problematic, as is discussed shortly.

The intention of the present study is to integrate three important aspects in this line of research. First, the potential confounder of exposure time of participants to their relatives has been overlooked in previous research. We discuss this issue in more detail next. Second, statistical analyses conducted in previous research appear to be suboptimal or flawed, which also is elaborated upon later. Third, possible differences between emotional closeness and solicitude ratings ought to be systematically addressed. Some researchers only analyzed the former (Michalski & Shackelford, 2005; Russell & Wells, 1987), whereas others only utilized the latter (Chrastil et al., 2006; Euler & Weitzel, 1996; Gaulin et al., 1997; Hoier et al., 2001; Laham et al.,

2005; McBurney et al., 2002; Pashos, 2000). Only Steinbach and Henke (1998) analyzed both types of ratings, finding that closeness ratings did not support predictions made from relational uncertainty, whereas the reverse was true for solicitude ratings.

Spousal age differences and sex differences in life expectancy may create noticeable differences in exposure time of older relatives to younger relatives. Consider, as a real-life example, the family of one of the current authors. Born in 1966 and presently 42 years old, he has thus far had an exposure time of 42 years to both his mother and his father. However, there is an age difference of 12 years between the parents. As a consequence, because both sets of grandparents were relatively similar in age when they had children, the paternal grandparents have earlier years of birth than the maternal grandparents. On the author's father's side, he had no exposure to his paternal grandfather (1898–1952), but 9 years of exposure to his paternal grandmother (1902–1975). The spousal age difference was 4 years, and his paternal grandmother's lifetime was 19 years longer than his paternal grandfather's (i.e., 73 years vs. 54 years). On the mother's side, the author had 14 years of exposure to his maternal grandfather (1909–1980), but 41 years of exposure to his maternal grandmother (1907–2007). The spousal age difference was 2 years, and his maternal grandmother's lifetime was 29 years longer than his maternal grandfather's (i.e., 100 years vs. 71 years).

This real-life example illustrates a very likely confounding factor to matrilateral effects in kin investment that is produced by the following two current demographical facts. First, on average, women live about 6 to 7 years longer than men. In the case of Austria, the current life expectancy at birth is 76.5 years for men and 82.4 years for women (CIA World Fact Book, 2008; https://www.cia.gov/library/publications/the-world-factbook/geos/au.html). Second, men tend to marry women who are about 2 or 3 years younger in age, and this difference is temporally stable. For example, in Austria, median ages of bridegrooms and brides were 28.1 and 25.5 years, respectively, half a century ago, and more recently, they are 32.0 and 29.2 years (data as of 1951 and 2001; Statistics Austria; www.statistik.at/jahrbuch_2006/pdf/K02.pdf).

As the aforementioned example showed, individual differences can obviously be much larger than average national statistics. Sex differences in life expectancy and spousal age differences operate in the same direction with regards to exposure time to older relatives, such that they accumulate across generations. Consequently, there is a pronounced laterality effect for exposure time to relatives. A middle-aged adult should have a shorter exposure time to older male relatives (including his father, uncles, grandfathers, and especially paternal grandfather) than to older female relatives (including his mother, aunts, grandmothers, and especially maternal grandmother). Clearly, total investment in kin should be at least partly dependent on available time for exposure to a given relative. There are, of course, exceptions to this trend. One such example was provided by a reviewer of this article. The reviewer remarked that there might be cases where exposure time is not necessary for investment, such as when a rich relative bequeaths a large amount of money to future grandchildren. However, for the majority of people, it seems reasonable to assume that retrospective ratings of solicitude or closeness should be partially based on interpersonal processes that require time, and hence exposure, to unfold.

Previous analyses either did not statistically remove the influence of possible confounders like age of relatives and residential distance from the data (Euler & Weitzel, 1996; Pashos, 2000; Steinbach & Henke, 1998) or did so in an inappropriate way (Gaulin et al., 1997; Hoier et al., 2001; McBurney et al., 2002). In the latter studies, researchers attempted to correct for confounders by using an analysis of covariance with repeated measures (ANCOVA-RP), which is problematic because of at least two distinct reasons.

First, ANCOVA-RP can analyze correlated dependent variables; however, both the dependent variables (i.e., the ratings) and the covariates are measured repeatedly. The current study design demands an alternative approach, such that the covariates are matched with corresponding dependent variables, a feat that cannot be accomplished with ANCOVA-RP in SPSS, but can be done with BMDP 2V, for instance. The data-analytic problem is as follows: Introducing four covariates (i.e., exposure time to, or residential distance of, the four grandparents) into an ANCOVA-RP design will result in these four covariates being removed from the measurements at *each* of the four levels of the within-subjects factor (i.e., participants' solicitude or closeness ratings with regard to their four grandparents). In contrast, each of the covariates should be removed from the *respective* level of the within-subjects factor only (e.g., exposure time to paternal grandfather should be the covariate for the closeness rating for the paternal grandfather, etc.).

Second, ANCOVA-RP requires a complete set of measures from all participants. This approach excludes participants who lack data on some types of relatives (e.g., due to their relatives' early death, or because participants simply have no paternal aunt). Thus, previous analyses were unnecessarily restricted to include participants with a full set of relatives (all four types of grandparents and/or all four types of aunts/uncles), which was only due to the constraints of data analysis. Using an alternative procedure that includes all participants, such as those with only some living relatives, is beneficial in that it allows the data to be more generalizable.

None of the researchers specified which statistical program was used to carry out analysis, with the only exception being McBurney et al. (2002), who stated that BMDP 2V was used. As well, no statements on the adequacy of the statistical design were included in the reviewed studies. Thus, the obtained results seem questionable with respect to their statistical design.

Our goal in the present study was to investigate matrilateral bias in an Austrian sample, while taking into account the novel and potentially confounding variables of exposure time and residential distance, and by using an appropriate statistical design. In particular, we investigated matrilateral bias in dyads composed of a grandparent and grandchild, or an aunt or uncle with a niece or nephew, by analyzing retrospective ratings of solicitude and emotional closeness. We used the approach of previous research in that we used the adult grandchild (the niece/nephew, respectively) as the source of information.

We hypothesized that the potential confounders of exposure time and residential distance exert a noteworthy influence on ratings of closeness and received solicitude and may partly account for laterality effects. Furthermore, regarding the inconsistencies of previous research and the omission of possible exposure effects, we tried to ascertain whether retrospective ratings reliably capture the matrilateral bias in human kin investment. As some researchers (Gaulin et al., 1997; Russell & Wells, 1987) even have based estimates for nonpaternity rates on such data, the question of reliability has twofold importance.

METHODS

Participants

The sample comprised 321 Austrian adults (168 female, 153 male). Participants' age ranged from 15 to 68 years ($M = 27.4$, $SD = 9.7$). According to their self-reports, 41.4% of the sample grew up in urban areas and 58.6% in rural environments. Participants were recruited in Vienna and surrounding eastern Austrian areas through personal referral and word of mouth outside of academia. Therefore, our data should be considered as representing a community sample. Moreover, psychology students were not eligible for participation. The sample includes a variety of educational and occupational backgrounds.

Measures

The questionnaire asked participants to rate the solicitude they received during their childhood, which was defined as the period prior to entering elementary school, on a 7-point scale ranging from *not at all* to *very much*. We thereby replicated Euler and Weitzel (1996), who asked participants to rate their grandparents' solicitude up to the respondent's age of 7 years. Like these authors, we used the German verb *kümmern* in referring to solicitude. All four types of grandparents and all four types of aunts and uncles were listed for rating, and participants were instructed to rate the oldest aunt or uncle if they had more than one of a type. Care was taken to ensure that participants only rated biologically related aunts and uncles. Another eight items asked participants to rate their emotional closeness to their grandparents, aunts, and uncles, simultaneously considering their current and past experiences, using the same 7-point scale.

In addition, participants were asked to include their relatives' years of birth and, if applicable, years of death. They also rated the residential distance of these relatives to their home during childhood on a 6-point scale. The scale resembled the logarithmic scale of residential distance of Euler and Weitzel (1996) and asked participants to state how long it took them to get to their relatives. It had the values of 0 (*up to five minutes*), 1 (*one hour*), 2 (*a few hours*), 3 (*a half day's journey*), 4 (*a day's journey*), and 5 (*more than a day's journey*).

Data Analysis

Accounts of years of birth, years of death, and participants' age were used to compute the exposure time of participants to their grandparents, aunts, and uncles (i.e., their lifetime shared with relatives). For ratings of solicitude and closeness to be included, exposure time had to be at least 7 years for each relative, that is, participants' ratings covered at least up until they were 7 years of age. For ease of interpretation, scales of solicitude and emotional closeness were centered around zero for statistical analysis. Hence, a zero-rating represents the average extent of solicitude or closeness. Statistical analysis was carried out using SPSS 15.0, and the Linear Mixed Models (LMM) procedure was implemented. The LMM expands the general linear model (GLM; the aforementioned ANCOVA-RP is a GLM) so that error terms and random effects can be correlated and heterogeneous (i.e., of varying magnitude; cf. Khuri, Mathew, & Sinha, 1998; Singer, 1998; see SPSS Advanced Models at http://www.spss.com/advanced_models/data_analysis.htm). The LMM allows for correlated dependent variables and correlated covariates, which is precisely the nature of the present data, as covariates are matched with corresponding dependent variables. In addition, the LMM uses all available data points to estimate parameters for missing data, whereas GLM excludes respondents with missing data from the analysis. For parameter estimation, the Restricted Maximum Likelihood method was chosen. The ratings

were implemented in the LMM as repeated measures (i.e., sex of parent and sex of relative as fixed effects), with sex of participant as a between-subject effect, and exposure time and residential distance as covariates. Effects tests were carried out without imposing any restrictions on the covariance matrix (i.e., it was an unstructured covariance model). To compare the LMM procedure, utilized here for the first time in this line of research, with the method used previously (i.e., ANCOVA-RP), we also report the results obtained with the GLM. In addition, as Pashos (2000) found marked differences in urban and rural samples, tests were also carried out separately for participants who grew up in urban areas and for those who grew up from rural environments, for the purpose of exploration. Significance was set at $p < .05$.

RESULTS

Grandparental Ratings

Of the 321 participants, 285 included ratings for all four grandparents who were alive up until the respondent was 7 years of age. Thirty-four participants did not supply information for one grandparent, and a further 2 participants did not supply information for two grandparents. Less than 5% of all ratings per grandparent were deemed invalid because of an exposure time less than 7 years. For the GLM, only data of these 285 complete cases could be analyzed, whereas for the LMM data from all 321 participants were implemented. The solicitude and closeness ratings correlated with $r = .85$ for maternal grandmother, $r = .77$ for maternal grandfather, $r = .72$ for paternal grandmother, and $r = .69$ for paternal grandfather (all $ps < .001$).

Solicitude of Grandparents

Table 1 shows the means and standard deviations of solicitude ratings, exposure time, and residential distance in the sample. The average ratings for maternal grandfather and paternal grandmother were switched, relative to the rank order predicted by Euler and Weitzel (1996). In addition, the mean differences appeared to be smaller for maternal grandparents than for paternal grandparents (see Table 1). The results of the LMM are reported in Table 2.

Sex of the grandparent was the only significant main effect, whereas laterality (i.e., sex of parent) failed to reach statistical significance (see Table 2). The difference of the estimated marginal means (assuming a mean exposure of 22.32 years and a mean distance of 0.90 on the logarithmic scale) concerning sex of the grandparent was 0.35 ($SE = 0.08$, 95% confidence interval [CI] = [0.21, 0.50]), favoring grandmothers. The effect of laterality was 0.18 ($SE = 0.12$, 95% CI = −0.04; 0.41]), favoring matrilateral grandparents. Stated in units of Cohen's d, sex of grandparent exerted an effect that was nearly three times larger than the effect of laterality ($d = 0.26$ vs. $d = 0.09$).

Both covariates were significant in the LMM; the longer the exposure, the higher the solicitude, whereas the greater the distance, the lower the solicitude. For every year of exposure, ratings increased by +0.02 ($SE = 0.01$, 95% CI = [0.01; 0.04]); for every step on the logarithmic scale of residential distance, ratings decreased by −0.37 ($SE = 0.06$, 95% CI = [–0.50; −0.25]). However, the covariates did not account for a matrilateral bias that might have otherwise emerged in our data: Omitting covariates from the analysis resulted in comparable p values for the fixed-effects tests. Moreover, the results were virtually indistinguishable between urban and rural subsamples (details omitted for brevity).

In agreement with the results of the LMM, the only significant effect in the GLM (without covariates) was the sex of grandparent. Adding covariates to the model (which can only be done in an erroneous way in SPSS, as previously pointed out) did not change results of the fixed-effects tests. However, none of the covariates appeared to have any impact on the ratings ($ps > .05$; detailed results omitted for brevity).

TABLE 1
Solicitude and Emotional Closeness Ratings, Exposure, and Residential Distance

Relative	*Solicitude*	*Closeness*	*Exposure*	*Distance*
Maternal grandmother	0.67 (1.97)	0.88 (1.93)	23.96 (7.15)	0.95 (1.09)
Maternal grandfather	0.33 (1.86)	0.66 (1.91)	21.40 (7.64)	0.93 (1.02)
Paternal grandmother	0.56 (2.03)	0.69 (1.93)	22.88 (7.55)	0.82 (0.91)
Paternal grandfather	0.11 (2.06)	0.52 (1.98)	20.96 (8.36)	0.88 (0.89)
Matrilateral aunt	0.04 (1.82)	0.19 (1.75)	25.83 (8.39)	1.29 (1.09)
Matrilateral uncle	−0.27 (2.04)	0.18 (1.84)	25.30 (7.87)	1.27 (1.17)
Patrilateral aunt	−0.20 (2.06)	0.11 (1.80)	25.51 (8.25)	1.24 (1.18)
Patrilateral uncle	−0.29 (2.09)	−0.03 (1.82)	24.46 (7.19)	0.94 (0.87)

Note. Table entries represent means (standard deviations in parentheses).

TABLE 2
Fixed-Effects Tests for Solicitude and Emotional Closeness Ratings of Grandparents

	Solicitude			*Closeness*		
Source of Variance	*F*	*df*	*p*	*F*	*df*	*p*
Between subjects						
Sex of participant	0.36	313.97	.547	0.66	312.28	.416
Within subjects						
Sex of parent (laterality)	2.53	320.17	.113	2.45	321.42	.118
Sex of grandparent	21.83	343.93	<.001	5.31	347.28	.022
Sex of Participant × Parent	0.23	318.77	.636	0.05	320.00	.832
Sex of Participant × Grandparent	1.23	320.21	.268	0.09	321.70	.770
Sex of Parent × Grandparent	1.17	310.58	.281	0.07	313.95	.789
Sex of Participant × Parent × Grandparent	0.78	309.33	.377	4.63	312.62	.032
Covariates						
Exposure	9.57	1007.26	.002	7.19	1035.58	.007
Residential distance	33.89	823.96	<.001	26.67	823.56	<.001

Note. df = denominator degrees of freedom for the F tests (numerator dfs are one in each case).

Emotional Closeness to Grandparents

Table 1 shows the means and standard deviations of the closeness ratings. Again, the rank order contradicted previous findings, as the average rating of paternal grandmother was slightly larger than that of maternal grandfather. However, the differences were smaller for the ratings of closeness than for solicitude, and the overall mean was higher. The results according to the LMM are reported in Table 2.

Similar to the ratings of solicitude, the covariates exerted significant main effects, for ratings of emotional closeness, whereas the situation was somewhat different for the other effects. Alongside the sex of grandparent effect, the triple interaction of sex of the participant, sex of parent (laterality), and sex of grandparent turned out to be significant (see Table 2). This finding circumvented further interpretation of single main effects. Effect sizes of sex of grandparent and laterality were $d = 0.25$ and $d = 0.09$, respectively.

The parameter estimates of the covariates resembled those in the case of solicitude ratings: +0.02 for exposure ($SE = 0.01$, 95% CI = [0.01; 0.03]) and −0.32 for residential distance ($SE = 0.06$, 95% CI = [–0.44; −0.20]). Omission of covariates did not substantially change results of the fixed-effects tests. However, splitting the sample into rural and urban subsamples led to considerable changes: None of the main effects or interactions reached significance in either subsample, although the sex of grandparent was close to the significance threshold ($p = .056$) in the urban subsample. Whereas residential distance impacted ratings in both cases ($ps < .01$), exposure time appeared to influence ratings only in the urban subsample ($p = .020$). The effect sizes of laterality were $d = 0.13$ in the urban and $d = 0.08$ in the rural subsample, respectively, for the sex of grandparent, they were $d = 0.16$ and $d = 0.09$ (detailed results omitted for brevity).

The results of the GLM (without covariates) in the total sample were in agreement with results of the LMM. Implementing the covariates caused the sex of grandparent effect to lose its significance, although none of the covariates other than exposure time to paternal grandmother had any significant influence ($p = .048$, all other $ps > .05$). Splitting the total sample by urban versus rural and omitting the covariates revealed that the sex of grandparent was the sole significant effect in the urban subsample but not the rural subsample. None of the effects remained significant when covariates were implemented, and none of the covariates were significant either (detailed results omitted for brevity).

Aunts and Uncles Ratings

Of the 321 participants, 43 reported information for all four types of aunts and uncles, 64 on three types, 114 on two types, and 37 on one type. A total of 169 participants included data for a matrilateral aunt, 154 for a matrilateral uncle, 158 for a patrilateral aunt, and 148 for a patrilateral uncle. All of the ratings were included because exposure time was greater than 7 years. Because of missing values, data of only 43 participants were included in the GLM analysis, whereas data of 258 participants were used in the LMM analysis. The solicitude and closeness ratings correlated with $r = .77$ for matrilateral aunts, $r = .59$ for matrilateral uncles, $r = .62$ for patrilateral aunts, and $r = .52$ for patrilateral uncles (all $ps < .001$), which were weaker correlations than in the case of grandparents.

Solicitude of Aunts and Uncles

Table 1 exhibits means and standard deviations of ratings, exposure time, and residential distance. The

reported solicitude matches the rank-order findings of Gaulin et al. (1997) and Hoier et al. (2001). The results of the LMM for the solicitude ratings are reported in Table 3.

Of the main effects, only the sex of relative effect was significant, favoring aunts (difference of estimated marginal means assuming a mean exposure of 25.28 years and a mean distance of 1.19 on the logarithmic scale: 0.25, $SE = 0.11$, 95% CI = [0.02; 0.47]). This result is in accordance with previous findings. However, no relevant main effect of laterality and no sex of parent (i.e., laterality) by sex of relative interaction (cf. Hoier et al., 2001) could be detected. Effect sizes of sex of relative and laterality were $d = 0.17$ and $d = 0.10$, respectively.

The covariates again exerted significant main effects. However, compared to the grandparent findings, the influence of exposure time changed direction, such that the *lower* the exposure, the higher the rating (−0.03 per year, $SE = 0.01$, 95% CI = [–0.05; −0.01]). Age of relative and exposure time (corrected for participants' age) were significantly correlated (rs = .17–.23, ps < .05). This result is in accordance with Hoier et al. (2001), who found that younger relatives scored higher for solicitude than older relatives. The effect of residential distance was in the expected direction (−0.28 per step on the logarithmic scale, $SE = 0.07$, 95% CI = [–0.42; −0.14]). Omitting covariates resulted in the sex of relative effect to *lose* its significance. Implementation of the covariates seemingly removed variance in the ratings that would otherwise be attributable to this factor. Splitting of the total sample by urban versus rural revealed that the sex of relative effect was only present in the rural subsample ($p = .011$), with effect size $d = 0.25$ (in the urban subsample $d = 0.01$). However, in the urban subsample a significant interaction of sex of participant by sex of parent (laterality) emerged. Patrilateral relatives had higher ratings among male participants, and matrilateral relatives had higher ratings among female participants ($p = .012$), mirroring the results of Hoier et al. (2001), who found a Sex of Parent (laterality) × Sex of Relative interaction. Again, residential distance influenced ratings in both subsamples (ps < .02). In contrast to the ratings of grandparents, exposure time appeared to be important only in the rural subsample ($p < .001$ – further details omitted for brevity).

In the GLM (without covariates), sex of grandparent was also a significant factor. However, the implementation of covariates resulted in the emergence of laterality as the only significant effect ($p = .039$), but the covariates were not significant themselves (ps > .05). Splitting the total sample by urban versus rural and omitting the covariates revealed sex of relative in the rural subsample as the only significant effect. Again, none of the effects remained significant when covariates were implemented, although none of the covariates were significant either (detailed results omitted for brevity).

Emotional Closeness to Aunts and Uncles

Table 1 shows the means and standard deviations of the closeness ratings, and Table 3 shows the fixed-effects tests of the LMM. The rank order of the closeness ratings did not match that of the solicitude ratings, as patrilateral aunt and matrilateral uncle switched places and there appears to be a matrilateral bias in the case of emotional closeness (see Table 1).

None of the main effects or interactions yielded significant results in the fixed-effects tests (see Table 3). The effect size of laterality was $d = 0.10$, and for sex of relative, $d = 0.08$. Only residential distance was a significant covariate (−0.22 per step on the logarithmic scale; $SE = 0.07$, 95% CI = [–0.35; −0.09]). Omitting the covariates did not change the results. Splitting the total

TABLE 3
Fixed-Effects Tests for Solicitude and Emotional Closeness Ratings of Aunts and Uncles

	Solicitude			*Closeness*		
Source of Variance	*F*	*df*	*p*	*F*	*df*	*p*
Between subjects						
Sex of participant	0.01	252.51	.916	0.17	247.08	.680
Within subjects						
Sex of parent (laterality)	2.06	226.28	.152	2.39	224.26	.123
Sex of relative	4.66	168.12	.032	0.99	171.47	.321
Sex of Participant × Parent	3.06	225.95	.082	2.43	223.65	.120
Sex of Participant × Relative	0.42	165.68	.520	0.11	169.19	.746
Sex of Parent × Relative	0.06	170.59	.814	1.25	166.89	.266
Sex of Participant × Parent × Relative	1.97	172.34	.162	0.18	168.24	.676
Covariates						
Exposure	7.07	323.95	.008	0.78	323.27	.379
Residential distance	15.45	514.83	<.001	10.98	535.47	.001

Note. *df* = denominator degrees of freedom for the *F* tests (numerator *df*s are one in each case).

sample by urban versus rural revealed a significant effect of laterality in the urban subsample ($p = .026$), confounded by a significant interaction of the sex of parent (i.e., laterality) by the sex of relative ($p = .032$). Whereas uncles received higher ratings of emotional closeness among matrilateral relatives, aunts received higher ratings among patrilateral relatives. Note that this interaction is inconsistent with the findings of Hoier et al. (2001), who showed that the matrilateral bias was larger for aunts than for uncles. Residential distance was the only significant covariate in the urban subsample ($p < .001$), whereas exposure time was the only significant covariate in the rural subsample ($p = .034$ – further details omitted for brevity).

The GLM (without covariates) identified sex of relative as the only significant effect in the total sample. This effect vanished when covariates were implemented, even though the covariates failed to reach significance themselves. Splitting the sample by urban versus rural and omitting the covariates revealed a significant sex of relative effect in the rural subsample, which again vanished after implementing the (insignificant) covariates (further details omitted for brevity).

DISCUSSION

The intention of the present study was to replicate and extend previous research concerning discriminative kin investment with an Austrian sample, while for the first time accounting for the potentially confounding variables of exposure time and residential distance, and to do so using a suitable statistical design. Whereas previous findings indicated that retrospective ratings of solicitude and closeness to grandparents, aunts, and uncles convey a matrilateral bias, the present results suggest three conclusions. First, ratings of solicitude and emotional closeness are not fully comparable, and thus they potentially tap into different constructs. Second, ratings of solicitude and emotional closeness are differentially influenced by confounders such as residential distance and exposure, which in turn is further mediated by the type of respondents' geographic history (viz., a rural vs. urban environment). Third, our study provides evidence that the use of proper methods for statistical data analysis reveals contrasting results with past research, and hence, past findings must be re-examined. For the most part, our results suggest that matrilateral biases in kin investment may not be accurately addressed via the retrospective ratings that are standard practice in this field.

In general, evidence of laterality was very limited in our sample. For all four possible combinations of the type of target relative (grandparents vs. aunts and uncles) and for both ratings of solicitude and emotional closeness, the main effect of laterality failed to reach statistical significance in the total sample, and was only of small size, with ds = 0.09 to 0.10. In comparison, the main effect of sex of relative was significant in three out of four cases and, when significant, it was of considerably larger size, with ds ranging from 0.17 to 0.26. Effects of laterality emerged only in interactions with the factors of sex of participant and sex of relative, and were mediated by the type of target relative and the type of respondents' geographic history (i.e., urban vs. rural environment). Thus, laterality appeared to be an important factor in only two distinct cases. First, among participants who grew up in urban areas, men provided higher ratings of solicitude from patrilateral aunts and uncles, whereas women higher ratings of solicitude from matrilateral aunts and uncles. Second, participants who grew up in an urban area also provided higher ratings of emotional closeness toward matrilateral rather than patrilateral uncles, and higher ratings of emotional closeness toward patrilateral rather than matrilateral aunts. Otherwise, laterality did not impact on ratings in the present sample. These findings point towards a specific pattern of discriminative solicitude in niece/nephew and aunt/uncle dyads in urban areas, which diverges from predictions based on paternity uncertainty. To clarify, matrilateral relatives cared more for nieces and patrilateral relatives cared more for nephews; aunts and uncles differentiated between their brothers' and sisters' children according to their sex. That is, if a child is of the same sex as the parent who is biologically related to the aunt or uncle, the child is likely to receive more solicitude. This finding should be followed up in future research. Of interest, emotional closeness ratings did not match this pattern of reported solicitude, and it is left to future research to determine the underlying causes for this difference.

Based on our findings, it appears that the retrospective ratings of solicitude and emotional closeness are tapping at different aspects of kin's relationship dynamics, although the ratings share large amounts of variance in specific cases (from 72% in the case of maternal grandmother to 27% in the case of patrilateral uncle). However, it is possible that this difference in ratings of solicitude versus emotional closeness stem from the different wording of the questions used in study. The possible influence of the slight wording difference warrants further research, and this is a limitation of the current study.

As expected, exposure time and residential distance impacted on ratings. However, in our sample these covariates did not fully account for matrilateral biases; biases did not emerge in our data in the first place. In cases where both covariates proved influential, residential distance turned out to be of greater importance than exposure time. For all dyads, residential distance was negatively correlated with the solicitude ratings, and in

the case of grandparent–grandchild dyads, exposure time turned out to be positively correlated with the ratings. For the aunt/uncle with niece/nephew dyads, exposure impacted conversely on the ratings; ratings were higher with lower exposure which is consistent with observations of Hoier et al. (2001). Younger aunts and uncles were reported to care more for niece and nephews than older aunts and uncles.

Given the results from the ANCOVA-RP procedure obtained with these data, it appears that the effect of the covariates was underestimated or overlooked in previous research. Both covariates failed to be significant in most cases using ANCOVA-RP, presumably due to the faulty implementation of covariates, as well as by the impaired statistical power based on the fact that only complete datasets could be used. In addition, previous research has statistically removed only the effects due to the age of the target relative during participants' childhood years, which is different than actual exposure time.

It appears that retrospective rating data convey very little reliable information concerning the laterality effects that are putatively governed by relational uncertainty. In light of the current data, it seems that a number of crucial confounding variables and moderators may at least partly account for the observed differences in the retrospective ratings reported in prior research. Relating our key findings to previous evidence, we believe an interpretation congruent with that of Pashos's (2000) is appropriate. The extent of care provided by women exceeds that of men, which may well be due to biological causes, whereas laterality effects in caring might be socially engendered.

Finally, our findings point to several methodological problems pertaining to retrospective rating-scale formats, as used in the research of discriminative kin investment. A further consequence of these findings is that it is unlikely that meaningful estimates for nonpaternity rates can be derived from such ratings (see Gaulin et al., 1997; Russell & Wells, 1987). Therefore, in conclusion, the present research points to the necessity of exploring untapped yet potentially confounding factors that impact on discriminative kin investment, and in turn influence estimates of other phenomena that are based on these findings.

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