SUPPLEMENTARY INFORMATION

Supplemental Information #1. As discussed in the text, adaptationist principles of good Bayesian design predict that the computational architecture of the kin detection system will weight the coresidence duration cue less (or not at all) when MPA—the higher quality cue—is available to the system. This predicts that outcome measures for the two motivational systems (altruism and sexual aversion) should be high when MPA is present, and that the MPA and coresidence cues will interact. As can be seen from Figure S1 and Tables S1a, b presented below, both are true.

The scatterplots shed light on the procedures the brain uses to compute the kinship index, that is, on the kinship estimator. When present, MPA produces elevated levels of all outcome measures (black lines) indicating that, upon detection, the kinship estimator translates this highly reliable cue into a variable whose magnitude represents high relatedness. In contrast, when MPA is absent and coresidence is used as a cue to relatedness, the kinship estimator appears to more slowly ratchet up the magnitude of this variable, generating a gradual increase in altruistic motivations and sexual aversions (red lines). The point at which the lines cross suggest that 14-18 years of coresidence duration for MPA absent individuals sets the kinship index to the same magnitude as for individuals with cues to MPA. Table S1b provides descriptive statistics and comparisons for each dependent measure according to whether MPA is absent or present.

The predicted interactions exist between MPA and coresidence duration for both motivational systems (altruism and sexual aversion). Interactions for three of the four outcome measures (altruism and the two sexual disgust measures) were significant (Table S1a shows that moral opposition elicited the same pattern of effect sizes as the other three measures, but had >150 fewer subjects than the other measures did; indeed, the interaction effect sizes for moral opposition and altruism are the same). Consistent with these interactions, each of the four outcome measures show significant correlations with coresidence duration when MPA is absent, but no correlation when it is present; for each measure, the drop in effect size was significant (see SI#2).

The similar pattern of data across different outcome measures indicates that both altruism and sexual aversion are regulated by a common internal regulatory variable—a kinship index. It also suggests that the kinship index is set on the basis of two distinct cues. While caution is required in interpreting any correlational research, the data show that two of the cues used are duration of coresidence and MPA—or else other cues that are highly correlated with them.

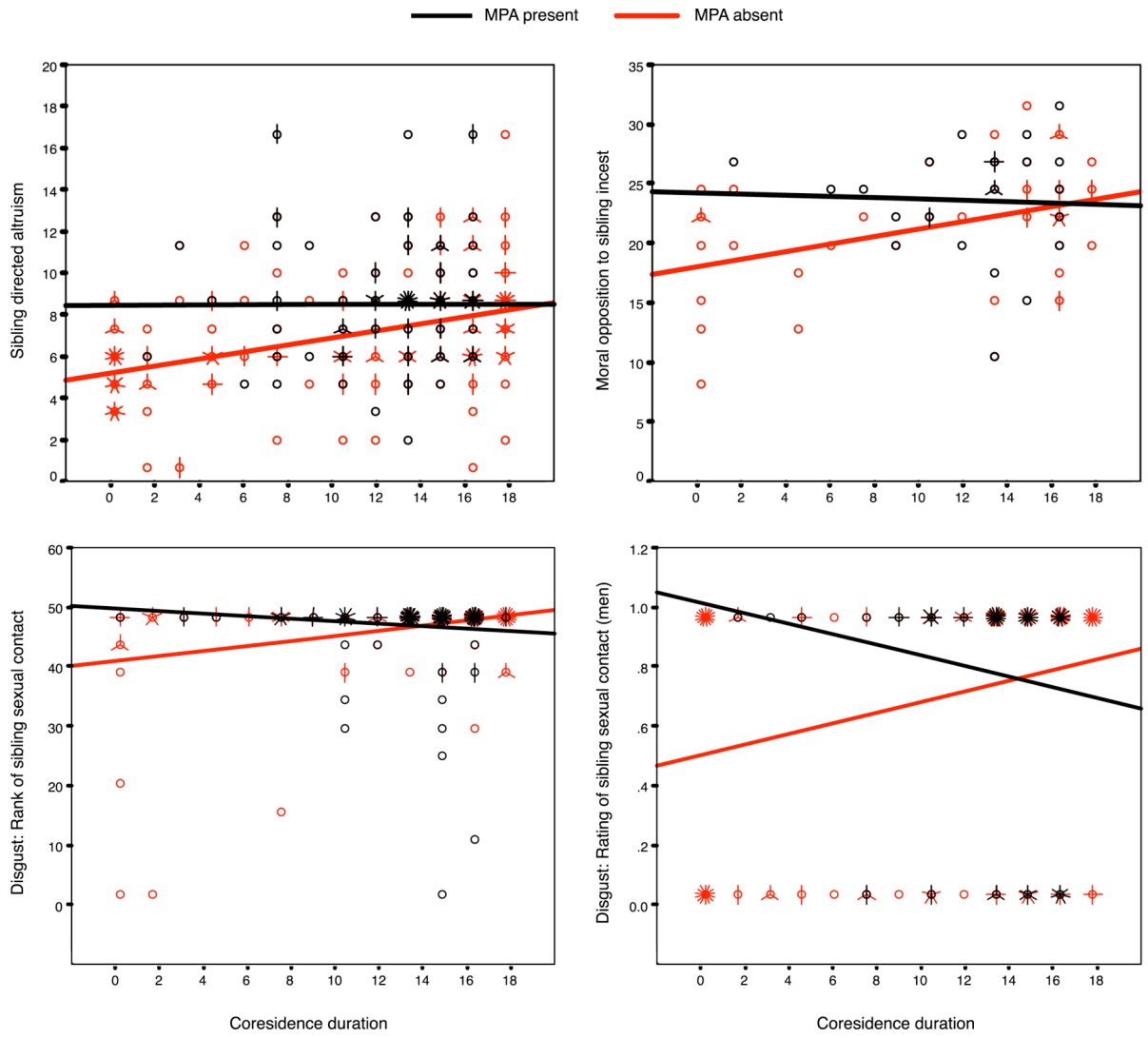

Figure S1. Interaction analysis: the effects of coresidence duration are conditional on the presence of MPA. When the MPA cue is present, levels of outcome measures are high regardless of sibling's duration of coresidence with subject (accumulated over subject's age 0-18). Accordingly, the slopes of the black lines are ~0 for all of the continuous outcome measures (sexual disgust (Likert) is dichotomous). In contrast, when the MPA cue is absent, coresidence duration is positively associated with outcome measures. The regression lines predicting outcome measures (y) as a function of duration of coresidence (x) when MPA is absent are described by the following equations (standardized beta coefficients). altruism: y = .415x; moral opposition: y = .397x; sexual disgust (rank): y = .323x; sexual disgust (Likert; men): y = .253x. Sample sizes across measures (MPA present, MPA absent): altruism (102, 185), moral opposition (27, 47), sexual disgust (rank) (129, 114), sexual disgust (Likert; men) (90, 156).

Table S1a. Interaction analysis (MPA and coresidence duration).

	Effect sizes (r) Coresidence duration (0-18) MPA Absent*	MPA Present	Univariate ANOVA (interaction between coresidence and MPA) Directed test[43], *t* statistic
Altruism (n=287)	.41	.05	1.97 (*P* = .03)
Moral opposition to incest (n=74)	.38	-.01	1.12 (*P* = .12)
Sexual disgust: Likert (n=246)	.24	-.18	2.19 (*P* = .02)
Sexual disgust: Rank (n=243)	.33	-.10	2.83 (*P* = .003)

*for *r*s, MPA absent: $.003 \leq P < 10^{-7}$ (exact values in text; composite altruism, r=.41: $P= 3x10^{-9}$ ($4 x10^{-9}$))

Table S1a shows the effect sizes between the dependent measures and coresidence duration for individuals with and without access to the MPA cue (see also Figure 2). Directed univariate tests show a significant interaction between coresidence and MPA for 3 of the 4 outcome measures. Coresidence and MPA were not highly correlated in these samples ($.10 \leq r\text{s} \leq .17$).

Table S1b. Descriptive statistics for sibling pairs with and without MPA.

	MPA absent Mean (St. Dev.)	MPA present Mean (St. Dev.)	Univariate ANOVA Directed test[43], *t* statistic
Altruism	6.97 (2.72)	8.49 (2.66)	4.58 [a]
Moral opposition to incest	21.60 (5.28)	23.59 (4.40)	1.66 [b]
Sexual disgust: Likert	.69 (.47)	.78 (.42)	1.54 [c]
Sexual disgust: Rank	46.25 (7.75)	46.92 (6.43)	0.74

[a] $P=4x10^{-6}$; [b] $P=.06$; [c] $P=.08$

Table S1b shows that levels of outcome variables are as high or higher for sibling pairs when the MPA cue is present as when it is absent. This indicates that individuals who have not coresided for long periods can still acquire a high kinship index for a potential sibling, provided they have been exposed to their biological mother caring for that potential sibling during his/her first year of life (the MPA cue). (The MPA absent groups include individuals with low and high coresidence durations, sometimes resulting in lower means.) Sample sizes are the same as those listed in Figure S1 caption above.

Supplemental Information #2. Coresidence duration was hypothesized to drop in importance as a cue when MPA is present compared to its effects when MPA is absent—and it did (as evidenced by the significant interaction terms presented in Table S1a and as depicted in Figure 2). The dramatic drop in the coresidence effect sizes evident in Figure 2 (and Table S1a) was significant for each measure: $.0003 \leq P\text{s} \leq .053$ (altruism: Z=3.09, *P* = .001 (.0013); moral opposition: Z=1.62, *P* = .053 (.066); sexual disgust (Likert; men): Z=3.17, *P* = .0008 (.001); sexual disgust (rank): Z=3.40, *P* = .0003 (.00038). MPA present analyses: Ns=102, 27, 90, 129 for altruism, moral opposition, sexual disgust (Likert; men), and sexual disgust (rank), respectively). The small effect sizes for sexual aversion measures when MPA is present were not because some (younger) siblings might be prepubescent (thereby eliciting greater disgust and wrongness ratings, regardless of coresidence); controlling for sibling age, the relationship between coresidence and sexual aversion remains slightly negative (-.12, -.05, -.12, respectively).

Supplemental Information #3. Is MPA just a proxy for beliefs about relatedness or for coresidence having started at the sibling's birth? No. MPA predicts altruism toward younger siblings better than either of its component parts (having the same mother + sibling coresidence beginning at the sibling's birth; N = 128, stepwise multiple regression, partial *r*s: MPA *r* = .32 (*P* < .001), same mother *r* = -.09, coresidence at sibling's birth *r* = .03; the same relationship among variable holds if the regression is not stepwise).

Supplemental Information #4. The effects of coresidence are very specific: In our study, coresidence does not predict moral judgments about any behaviors unrelated to incest, it does not predict disgust associated with nonintentional sexual acts or acts involving a parent, nor does it predict non-sibling specific generosity. Each domain is discussed in turn.

Moral judgments. In the instrument assessing moral opposition, subjects were asked to rank order 19 acts in terms of how morally wrong they perceived each act to be. All acts were said to describe unknown third parties. Ranked scores were inverted such that *higher means indicate greater moral opposition.* Included in the following table are the means and standard deviations of the 19 acts for subjects with one opposite sex sibling (see Methods). Also included is the relationship of each act with coresidence duration for individuals with and without MPA. The dependent measure, moral opposition, is listed at the top of the table for comparison purposes. If the correlations found between coresidence duration and our dependent measure moral opposition for individuals with and without MPA were spurious and a result of more general processes, then other moral acts should follow the same pattern. They do not. Coresidence duration is not positively correlated with moral judgments about any behaviors unrelated to incest. Although the mother-son incest measure also correlates with sibling coresidence duration, this is likely to be a spurious correlation: Sibling coresidence correlates highly with duration of mother-subject coresidence (and far less with father-subject coresidence).

Table S4a. Moral judgments of 19 acts: descriptive statistics and effect size with coresidence duration for MPA present and MPA absent sibling pairs.

	M ± S.D.	Correlations with coresidence when: MPA_{absent} N=47	$MPA_{present}$ N=27
Moral opposition (see Methods): Sex between a brother and sister (consensual) + Brother and sister marriage	22.19 ± 5.14	.38**	-.01
Individual Acts			
Molesting a child	17.48 ± 2.67	-.22	-.18
Rape	16.77 ± 2.92	-.19	-.19
A man killing his wife	14.92 ± 3.89	-.06	.05
A woman killing her husband	14.13 ± 3.49	-.15	.03
Sex between a father and daughter (consensual)	13.59 ± 3.40	.20	-.13
Sex between a mother and son (consensual)	13.00 ± 3.22	.30*	-.19
Father and daughter marriage	12.56 ± 3.17	.05	-.04
Mother and son marriage	12.52 ± 3.19	.32*	-.26
Sex between a brother and sister (consensual)	**11.53 ± 3.08**	**.27***	**-.19**
Brother and sister marriage	**10.65 ± 3.01**	**.39****	**.16**
Assault with a weapon	10.41 ± 2.94	-.11	.06
Robbing a bank	8.19 ± 3.11	-.16	.32
Selling cocaine	7.53 ± 3.58	-.17	.02
Breaking and entering	7.03 ± 2.80	-.00	.15
Embezzlement	6.67 ± 2.88	-.24	.06
Smuggling illegal aliens into the country	5.28 ± 2.68	.15	.05
Public drunkenness	3.23 ± 2.55	-.20	.24
Speeding on the highway	2.60 ± 2.97	-.02	.05
Smoking marijuana	2.29 ± 2.17	-.32*	.05

*p ≤ .05 (two-tailed); **p ≤ .01 (two-tailed)

Sexual disgust (rank). Subjects were asked to rank eight items on a scale of 0 (not disgusting at all) to 50 (extremely disgusting). These items included sexual contact with a parent and sibling short of sexual intercourse. They also included unintentional acts to test separate hypotheses regarding intentionality. As the following table shows, for individuals without MPA, coresidence predicts only the disgust associated with the intentional sibling sexual act; disgust associated with unintentional acts and those involving a parent did not correlate with sibling coresidence duration for individuals with MPA absent.

Table S4b. Rank of sexual act involving a sibling: descriptive statistics and effect size with coresidence duration for MPA present and MPA absent sibling pairs.

	M ± S.D.	Correlations with coresidence when: MPA_{absent} N=109	$MPA_{present}$ N=124^{+}
Individual Acts			
Parent fondling you$^{\Psi}$	48.44 ± 5.21	.00	.01
Sibling fondling you$^{\Psi}$	**46.60 ± 7.07**	**.29*** **	**-.10**
Parent intentionally laying on top of you	40.47 ± 13.04	-.09	-.02
Sibling intentionally laying on top of you	35.07 ± 15.90	.12	-.05
Parent unintentionally touches you$^{\Psi}$	20.78 ± 16.21	.03	.01
Sibling unintentionally touches you$^{\Psi}$	19.62 ± 16.11	.08	.02
Parent trips on shoes and falls on you	16.96 ± 16.16	-.06	-.14
Sibling trips on shoes and falls on you	14.81 ± 15.21	-.02	-.14

***p = .001; $^{+}$data include all subjects who ranked all eight items. $^{\Psi}$ Item was about brother or father for female subjects; sister or mother for male subjects. Unintentional touches were to same body areas as fondling item.

Altruism. An alternate explanation of our findings is that there exist stable differences in general altruism between individuals with and without MPA and that coresidence duration somehow tracks this difference. If this were the case, the pattern of effects found between coresidence duration and kin-directed altruism for individuals with and without MPA should hold for more general, non-sibling related altruism. Our dataset allowed us to test this alternate hypothesis. In the Altruism instrument, subjects were asked two questions regarding their overall altruistic tendencies: "How generous would you consider yourself to be compared to your peers?" and "How generous would your peers consider you to be?" If *all* altruistic motivations are affected by MPA presence versus absence (or something particular to older versus younger siblings in general), then coresidence duration should predict these other indices of altruism in the same way they predict sibling directed altruism. They do not. Whereas coresidence duration with a sibling for whom MPA was absent predicts behavioral and dispositional measures of altruism directed toward that sibling (for combined altruism measure: r = .41, P= $3x10^{-9}$ ($4 x10^{-9}$), N = 185), it does not predict altruism as indexed by either generosity question (rs = .00, .01, Ps ≥ .43 (.54)). Similarly, coresidence duration does not predict either generosity question when MPA is present (r = .046, P = .37 (.46); r = .07, P = .31 (.39), respectively).

Supplemental Information #5: Start age.

When MPA is absent, the sibling's age when coresidence with the subject begins is highly correlated with total duration of coresidence from subject's ages 0-18 (rs ~ -.70; tolerances: .48-.57). When sibling's start age is controlled for, coresidence continues to significantly predict three out of four outcome variables: moral opposition (*partial r* = .26, *P* = .05 (.06)), altruism (*partial r* = .25, *P* = .0003 (.0004)), and sexual disgust (Likert; men) (*partial r* = .17, *P* = .018 (.023)). (Sexual disgust (rank) *partial r* = .10, *P* = .16 (.20)). In contrast, when coresidence is controlled for, sibling's start age fails to predict three out of four measures (*partial r*s ~0; .14 < *P*s < .48 (.18-.60); only sexual disgust (rank) yielded a significant *partial r* = -.26, *P* = .003 (.004), N=111).

Distinguishing the *subject's* start age from total duration of coresidence is more difficult because, among people with MPA absent, subject's start age is even more highly correlated with coresidence duration than is sibling's start age ($-.79 \leq r\text{s} \leq -.92$). Like sibling's start age, subject's start age fails to predict the same three outcome variables once coresidence is controlled for (moral opposition: *partial r* = -.14, *P* = .17 (.21), tolerance=.16; altruism: *partial r* = .11, *P* = .08 (.10), tolerance=.29; sexual disgust (Likert; men): *partial r* = .06, *P* = .25 (.31), tolerance=.20; only sexual disgust (rank) remained significant: *partial r* = -.19, *P* = .03 (.04), tolerance=.38). In contrast, total duration of coresidence continued to predict altruism (*partial r* = .32, P = $4\text{x}10^{-6}$ ($5\text{x}10^{-6}$)) and sexual disgust (Likert; men) (*partial r* = .16, *P* = .025 (.03)), even after controlling for subject's start age. Nevertheless, definitively distinguishing subject's start age from total coresidence duration for MPA absent individuals will require a sample in which they are not as highly correlated.

For MPA present individuals, subject's start age is not correlated with any outcome measure: altruism: *r* = .08, *P* = .21 (.26), N=102; moral opposition: *r* = .08, *P* = .35 (.44), N=26; sexual disgust (Likert; men): *r* = .11, *P* = .18 (.23), N=77; sexual disgust (rank): *r* = .09, *P* = .16 (.20), N=129.

Supplemental Information #6. Effects of beliefs.

MPA absent. Most individuals for whom MPA is absent are youngers detecting older sibs (≥88%), but a minority are olders detecting younger sibs. Olders not exposed to the MPA cue present a different profile from youngers, demographically, theoretically, and in dependent measures, in a way suggesting that being older than one's sibling may itself be a cue with probative value that the kin detection system is designed to use: The younger sibling of an older individual with MPA absent is almost always a step or paternal half sibling (indeed, the average degree of kinship for MPA absent olders is far lower than for MPA absent youngers (.14 versus .38, P < .001, and the sibling age discrepancy is much larger for MPA absent olders than for youngers). Unfortunately, the demographics and responses for the two MPA absent groups differ in ways that confound attempts to assess how similar they are (for each measure, there are too few MPA absent olders to draw reliable inferences). Thus the more conservative route was to restrict MPA absent analyses about beliefs to the large sample of youngers with older siblings, for whom reliable tests can be conducted (see also SI#7).

For youngers detecting olders, do beliefs matter? The subjects' consciously held beliefs about a sibling's degree of kinship (i.e., whether the subject reports the sib was full, half, or step/adoptive) are highly correlated with duration of coresidence with that sibling (across studies: .64 - .71). Nevertheless, coresidence duration predicted the outcome measures better than subjects' consciously held beliefs about their degree of relatedness. Controlling for beliefs, coresidence duration continues to significantly predict all three sexual aversion measures (partial *r*s: moral opposition: $r = .33$, $P = .02$ (.025), N=38; sexual disgust (rank): $r = .25$, $P = .005$ (.006), N=103); sexual disgust (Likert; men): $r = .17$, $P = .03$ (.04), N=131) and marginally predicts altruism ($r = .12$, $P = .06$ (.075), N=162). In contrast, when coresidence is controlled for, the subject's beliefs about kinship fail to correlate with any of the three sexual aversion measures (*partial r*s -.16, .08, .08, ns); only altruism shows an effect of belief independent of coresidence for this group of subjects (*partial* r=.29, $P = 9\text{x}10^{-5}$ (10^{-4})).

A critical test about the power of beliefs can be constructed by seeing what happens when explicit beliefs about kinship are pitted against a conflicting output from the kin detection system. This test can be conducted using subjects with older step and adoptive siblings: these subjects believe their siblings are not biologically related to them, yet are in a group where coresidence should matter (given the model proposed). Two samples yielded enough subject-and-older step/adoptive sibling pairs to conduct an analysis. When subjects believe their siblings are not blood kin, coresidence still robustly correlates with altruism toward that sibling and disgust at imagining sexual contact with that sibling (altruism: $r = .38$, $P = .04$ (.05), N = 22; sexual disgust (Likert; men): $r = .47$, $P = .03$ (.038), N = 16. Sexual disgust (rank) has only 8 relevant sib pairs; $r = .22$). (Similar effect sizes are found for the small sample of olders with younger step/adoptive siblings (altruism $r = .43$ (N=7, $P = .16$ (.20)); sexual disgust (Likert; men) $r = .40$ (N = 11, $P = .13$ (.16); the other measures had only 2 and 4 relevant pairs)). In short, when subjects believe their elder sibling is step or adoptive, *coresidence trumps beliefs about kinship*, indicating that when beliefs conflict with the kin detection system, the criteria used by the kin detection system prevail.

For olders detecting younger siblings, do beliefs matter? Beliefs about a younger sibling's degree of kinship did not significantly correlate with three of the four outcome variables (.11 < *r*s < .15); it correlated only with sexual disgust (rank) ($r = .18$, $P = .016$ (.02)).

It is perhaps worth noting that, for populations like ours, reported kinship reflects genetic kinship in 95-98% of cases.[44,45] Thus the beliefs variable indexes both genetic relatedness and subjects' beliefs about it.

Supplemental Information #7. A pattern similar to that shown in Figure 2 (see text) emerges if we compute the effects of coresidence for younger subjects detecting older siblings versus older subjects detecting younger siblings (instead of for MPA absent versus MPA present, as in Fig 2). Figure S7 presents this different way of organizing the data, showing that, as predicted, relatedness is computed differently for older versus younger siblings. Coresidence duration significantly predicts altruism and sexual aversion measures for youngers detecting olders. In contrast, for olders detecting youngers, coresidence fails to significantly predict any of the sexual aversion measures. Coresidence continues to predict altruism (although not once MPA has been controlled for, see Fig. 3), but the effect size is significantly lower than that found for youngers detecting olders.

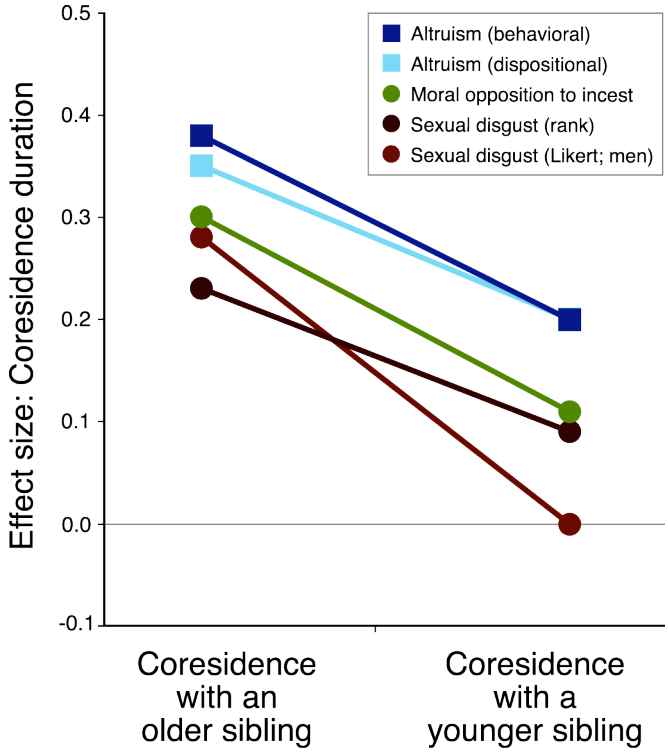

Figure S7. Coresidence duration effect sizes as a function of whether the subject is younger or older than his or her sibling.

Supplemental Information #8. For two instruments, altruism and sexual disgust (Likert; men), some subjects had more than one sibling; these subjects generate >1 data point (one for each subject-sibling pair). This raises a question of independence (though one that works against our hypothesis; any subject variable that predicts similarly for multiple subject-sibling pairs will tend to reduce the effects of coresidence). To address the independence issue, additional analyses were conducted for those instruments that collected information for more than one sibling pair per subject. (Moral opposition and sexual disgust (rank) only considered subjects with one opposite sex sibling, thus posing no problems of non-independence.) The following table displays the effect sizes between coresidence and the dependent measures for individuals with and without MPA for two samples: (i) all sibling pairs (as reported in the main text) and, (ii) for one randomly chosen sibling pair per subject (in parentheses). As data analyses show, when only one sibling pair is chosen per subject, the effect sizes remain unchanged.

Table S8. Non-independence: comparison of all sibling pairs and one sibling pair per subject

	MPA absent All sibling pairs* (one pair per subject)	**MPA present** All sibling pairs (one pair per subject)
Altruism N=287 (N=154)		
Composite	.41 (.43[a])	.00 (.18)
Behavioral	.34 (.34[b])	-.01 (.15)
Dispositional	.30 (.36[c])	.05 (.16)
	N=185 (N=103)	N=102 (N=51)
Sexual disgust (Likert; men) N=246 (N=191)	.24 (.27[d]) N=156 (N=116)	-.18 (-.17) N=90 (N=75)

* exact P values in text. [a]$P=10^{-6}$; [b]$P=10^{-4}$; [c]$P=10^{-5}$; [d]$P=10^{-3}$ (for directed *P* values, multiply by 1.25)

Supplemental Information #9. One-tailed versus directed tests. In the text, we report *P* values for both one-tailed and directed tests, because each has strengths the other lacks. One-tailed tests were designed to powerfully test *a priori* predictions about the direction of a relationship (e.g., that two variables will be positively correlated). They are particularly appropriate where one is testing a series of predictions tightly derived from a highly constrained prior theory (which is the case for most of our analyses.) If a relationship *does* occur in the direction opposite from that predicted, one rejects the hypothesis that there is a relationship in the predicted direction; however, the one-tailed test provides no measure of whether the *unpredicted* relationship is significant or just noise. (In the studies reported herein, we found no relationships in a direction opposite from that predicted.)

To address this problem, Rice and Gaines (1994) suggest using 'directed' tests as opposed to 'one-sided' tests. Directed tests allocate .04 of a total alpha of .05 to the predicted tail and .01 to the unpredicted tail, leaving open the possibility of finding a significant effect in the non-predicted direction. (This is achieved at the cost of lower power for finding predicted effects.) For those interested in what the results would be using directed tests, these are reported in parentheses after the one-tailed *P* values, in the form "(*P* = one-tailed (directed))". For the predicted tail, directed *P* = one-tailed *P* x 1.25).

Supplemental References

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45. MacIntyre, S. & Sooman, A. Non-paternity and prenatal genetic screening. *Lancet* **338**, 869–871 (1991).