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A Person-Oriented Approach to Diary Data: Children's Temperamental Negative Emotionality Increases Susceptibility to Emotion Transmission in Father-Child Dyads

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Abstract: The notion that some individuals are more prone to emotion transmission than others has prompted the need for a person-oriented approach to emotion transmission in parent-child dyads. The present study applied a person-oriented analysis to examine the patterns of emotion transmission that can be identified in the diary data of father-child dyads, and the extent to which children with high levels of temperamental negative emotionality are particularly susceptible to emotion transmission within the family. Mothers of 149 first grade children (age 6 to 7) completed questionnaires concerning their child's temperament. Mothers and fathers maintained diary questionnaires (for a total of 7 days) concerning their child's negative daily emotions, and fathers (n = 116) maintained diary questionnaires concerning their own negative daily emotions. Results of variable-oriented analyses with prospective change multilevel modeling showed, first, that emotions were, on average, not significantly transmitted in a father-child interaction. However, the person-oriented approach using multilevel mixture regression identified four qualitatively different patterns in the transmission of emotions. These results showed that the higher the level of a child's temperamental negative emotionality, the more typical it was for the father-child dyad in their daily life to show interaction patterns wherein the father's negative emotions were transmitted to the child.

Keywords: multilevel regression mixture model, diary data, emotions, emotional transmission, temperament, negative emotionality, differential susceptibility, biological sensitivity to context

According to the emotion transmission paradigm, emotions within families – particularly negative ones – tend to spread and affect the family atmosphere and the interaction between family members (e.g., Almeida, Wethington, & Chandler, 1999; Larson & Almeida, 1999). It has been suggested, however, that there are individual differences in emotion transmission, with some individuals being more prone to emotion transmission than others (Larson & Almeida, 1999; Repetti & Wood, 1997). Although it has been suggested that, in general, some children are more vulnerable to environmental effects than others due to their temperamental features (Belsky & Pluess, 2009), the role of a child's temperament in emotion transmission has thus far not been investigated. The present study focused on one aspect of this issue, the extent to which the negative daily emotions of fathers and children are transmitted in the father-child dyad, and the extent to which children's temperamental negative emotionality influences these associations.

A Person-oriented Approach to Daily Emotion Transmissions

The notion that some individuals are more prone to emo-

tion transmission than others (Larson & Almeida, 1999; Repetti & Wood, 1997) has prompted the need for a person-oriented approach to emotion transmission between partners. Previous studies using a person-oriented approach have typically focused on examining different groups of individuals that differ in the pattern of values they show in relation to some criteria variables (Bergman & Magnusson, 1991; Bergman, Magnusson, & El Khouri, 2003). The key idea of this approach is to focus on individuals rather than the associations between variables at the population level, and by doing so, to concentrate on the holistic nature of individual functioning (Magnusson, 1995; Magnusson & Stattin, 2006). In addition to identifying groups of individuals who evidence different patterns of values in some criteria variables, the person-oriented analysis provides some additional benefits, including information about the proportion of the sample belonging to certain identified groups, and what factors predict membership in different groups. The present study expands previous person-oriented research by focusing on identifying *patterns of transmission* between dyads of partners rather than patterns of individual characteristics. To examine patterns of emotion transmission that occur from one day to another over the course of one week, diary data for father-child dyads were used. To complement the person-oriented analysis of transmission patterns in father-child dyads, variable oriented multilevel modeling was also used. Within-level analysis (cf. analyzing variation within dyads from one day to another) in such circumstances can be interpreted to lie between variable- and person-oriented analyses.

The results were analyzed in the context of multilevel modeling in which variation in the children's and fathers' negative emotions across the seven days were divided into between- (between individuals) and within-person (between days) variations. First, a variable-oriented approach was used by applying the prospective change model (Larson & Almeida, 1999) with a random slope (random regression coefficient model) to examine (i) whether fathers' emotions on a given day would predict changes in their children's emotions from one given day to the next day, (ii) whether children's emotions on a given day would predict changes in their fathers' emotions from a given day to the next day, and (iii) whether there are individual differences in emotion transmission (i.e., a statistically significant variation in the regression slopes from father's emotions to child's emotions and vice versa). Then, children's temperamental negative emotionality was used to predict individual variations in the strength of emotion transmission and the overall emotion levels of children and their fathers.

Second, the person-oriented approach was used to identify different patterns of emotion transmission from one day to another in father-child dyads by applying a multilevel regression mixture analysis (Asparouhov & Muthén, 2008; Muthén & Asparouhov, 2009). In this analysis, qualitatively different patterns of emotion transmission in father-child daily interactions were identified in terms of the unobserved within-level heterogeneity in emotion transmission. The *typicality* of a certain pattern of daily interaction (i.e., emotion transmission) in the child-father dyad was then predicted by the child's level of temperamental negative emotionality.

One important difference between the two approaches used is that in the multilevel random regression coefficient model (variable-oriented approach), the strength of emotion transmission is assumed to vary from one father-child dyad to another, but to be constant from one day-to-day sequence to another within each dyad. In turn, in the multilevel mixture regression model (person-oriented approach), emotion transmission is allowed to vary from one day-to-day sequence to another *within* the dyad. In the latter case, some father-child dyads may have a higher probability of showing a certain kind of interaction pattern in daily life more frequently than other father-child dyads. In other words, although a father-child dyad may have a high probability of showing a certain kind of interaction pattern in daily life, the interaction pattern is not necessarily the same during each day-to-day sequence. In the present study, we assumed that in families where the child's temperament is characterized by a high level of negative emotionality, the probability of a day-to-day interaction pattern in which the father's negative emotions are transmitted to the child is higher than in other families.

One objective of the present study was to compare the results of the person-oriented and variable-oriented analyses to see whether these analyses produced similar results and whether the person-oriented analyses provided a complementary understanding of the emotion transmission in father-child dyads.

Emotion Transmission in a Family

The term "*crossover"* or *"transmission"* has typically been used as a label for the transmission of emotions from one individual to another (Bolger et al., 1989; Larson & Almeida, 1999; Nelson et al., 2009; Repetti et al., 2009). Emotion transmission in a family occurs when emotions from one family member's immediate daily experiences show a consistent, predictive relationship to subsequent emotions or behaviors in another family member (Larson & Almeida, 1999). There is some evidence to suggest that in the context of a family, emotions are more likely to be transmitted from parents to children than vice versa (Almeida et al., 1999; Downey et al., 1999; Larson & Gillman, 1999). Moreover, fathers' emotions have been shown to have the most impact on other family members (for a review, see Larson & Almeida, 1999), although some studies have also reported different results (Larson & Richards, 1994a, 1994b).

There is also some evidence that individual characteristics may impact emotional transmission (Larson & Almeida, 1999; Repetti & Wood, 1997), and that the process of emotion transmission is not similar for all parent-child dyads.

That is, some individuals' emotions may be more influential to others' emotions and some individuals may be more prone to being influenced by others' emotions. For example, according to the diatheses stress and differential susceptibility models (Belsky & Pluess, 2009), temperamentally difficult (Martin & Bridger, 1999; Thomas & Chess, 1977) children are generally more vulnerable than other children to environmental effects. One characteristic of a difficult temperament that might be assumed to make a child especially prone to the influence of parental emotions is negative emotionality, i.e., the biological tendency of a child to intensive negative emotional reactions (Martin & Bridger, 1999; Thomas & Chess, 1977; see also Fabes, Hanish, Martin, & Eisenberg, 2002). Children showing a high level of temperamental negative emotionality are easily upset, become angry, and are often difficult to soothe, whereas children showing a low level of negative emotionality are quiet, calm, and subdued in their emotional expression.

Aims and Hypotheses

Although it has been suggested that there are individual differences in the process of emotion transmission within a family (Larson & Almeida, 1999; Repetti & Wood, 1997), studies have not yet examined the role of children's temperament as a predictor (moderator) of such individual differences. Consequently, the present study aims to examine whether there is individual variation in emotion transmission from a father to a child and vice versa, and whether a child's temperamental negative emotionality predicts this variation. More specifically, our aim is to examine whether children's temperamental negative emotionality has an impact on the extent to which a father's negative emotions are transferred to their child's negative emotions in day-to-day interactions, and on the extent to which the child's daily negative emotions are transferred to their father's negative emotions.

We applied both variable-oriented and person-oriented techniques to answer our research questions. Following the notion of differential susceptible and diatheses stress theories (Belsky & Pluess, 2009), we assumed that children with high temperamental negative emotionality are more prone than other children to experience negative emotions from their fathers in daily life. Moreover, we expected that *qualitatively different patterns of emotion transmission* could be identified in day-to-day father-child interactions, and that the typicality of these patterns could be predicted by the child's temperamental negative emotionality. In particular, it was assumed that the pattern of day-to-day interaction in which the father's negative emotions are transmitted to the child's negative emotions is more typical for those children who show a high level of temperamental negative emotionality than it is for other children. From the methodological point of view, our study is one of the first to apply person-oriented analysis to examine transactional patterns between partners within dyads over several days.

Method

Participants

The study sample initially consisted of 153 first grade children (79 girls, 74 boys; Age M = 7.5 years, SD=3.61 months) in regular classrooms and their mothers (N = 153) and fathers (N = 118). The schools participating in the study were situated in three mid-sized towns in Finland. One student from each classroom was randomly selected to participate in the study. The participating families were fairly representative of the general Finnish population. A total of 52% of the mothers and 31% of the fathers had completed at least a senior high-school education, 47% of the mothers and 66% of the fathers had completed a junior high-school education (comprehensive school), and 1.0% of the mothers and 3.0% of the fathers had not completed a junior high-school education. A total of 78% of the families were nuclear families (67 married, 11 cohabiting parents), 12% were blended families, and 10% were single-parent families. The number of children per family ranged from one to ten (M = 2.39, SD = 1.03).

Both of the children's parents or legal guardians were asked to respond to a mailed questionnaire concerning the child's temperament in the Fall (October) of the child's first grade. At the same time, both parents were asked to individually complete a structured diary questionnaire concerning their own and their child's emotions over seven successive days. In the present study, the focus is on the fathers' and children's negative emotions, and, thus, mothers' negative emotions are not examined in this context. However, mother-ratings of children's temperaments and children's daily emotions were used in the analyses. Information concerning each child's mother-rated temperament was available for 149 children. Information concerning children's negative daily emotions was available for 150 children (a total of 1,016 days) and for fathers' negative emotions from 116 fathers (a total of 727 days).

Measurements

Children's negative daily emotions. Children's emotions were assessed by the Daily Emotion Scale (DES; see Aunola, Tolvanen, Viljaranta, & Nurmi, 2013). During each day, parents rated statements concerning their children's daily emotions (11 items; e.g. "*My child was angry today*,"; "*My child was sad today*."; "*My child felt distressed today."*) on a 5-point Likert scale (1 = *not at all*; 5 = *very much*). The mean score for the children's negative daily emotions (8 items) on a particular day was calculated by combining the reports from mothers and fathers. The Cronbach's alpha reliabilities for children's negative emotions, calculated separately on each of the seven days, were on average .78 (range .74–.81).

Fathers' negative daily emotions. Fathers' daily emotions were measured using a scale identical to that used to

measure children's emotions. During each day, fathers rated statements concerning their daily emotions (11 items; e.g. "*I was angry today*"; "*I was sad today*"; "*I felt distressed today"*) on a 5-point Likert scale (1 = *not at all*; 5 = *very much*). The mean score for fathers' negative daily emotions (8 items) on a particular day was calculated. The Cronbach's alpha reliabilities for fathers' negative emotions, calculated separately on each of the seven days, were on average .82 (range .79–.85).

Temperamental negative emotionality. Children's temperament was assessed using mother ratings. Mothers rated their child's temperament on a 5-point Likert scale (1 = *not at all true*; 5 = *very true*) using the Temperament Assessment Battery for Children—Revised (TABC-R; Martin & Bridger, 1999). A subscale of negative emotionality consisted of seven items (e.g., *When taken away from an enjoyable activity, the child tends to protest strongly*; *When the child becomes angry, it is difficult to sidetrack him/her*). The Cronbach's alpha reliability for the mother-rated temperamental negative emotionality was .84. The correlation of mother-reported negative emotionality with father-reported negative emotionality was .65 ($p < .001$).

Analytic Strategy

In the present study, we used both variable-oriented and person-oriented approaches to examine our research questions. All analyses were conducted using multilevel modelling in which the variation in children's and fathers' negative emotions was divided into between- and within-person variations.

A variable-oriented approach to emotion transmission in the family. In the variable-oriented approach, the prospective change model (Larson & Almeida, 1999) was first utilized to examine the extent to which fathers' emotions on a given day (x_{t-1}) would predict (with a regression coefficient β) changes in their children's emotions from a given day (y_{t-1}) to the next day (y_t), and vice versa. Then, the prospective change model with a random slope was utilized to investigate the extent to which there are individual differences in the emotion transmission from fathers to children. In this analysis, the unobserved heterogeneity in emotion transmission from fathers to children was captured by a continuous, between-level latent variable, that is, a random slope. As a next step, children's temperamental negative emotionality was used as a between-level variable (Z) to predict the random variation (β_{2i}) in emotion transmission from fathers to their children, and the overall emotion levels of children and their fathers.

The tested model to investigate the extent to which there are individual differences in the emotion transmission from fathers to children is presented in Figure 1.

The within-person model (Level 1) can be expressed as

$$y_{it} = \tau_{yi} + \beta_1 \times y_{i,t-1} + \beta_{2i} \times x_{i,t-1} + \varepsilon_{yit},\ \varepsilon_{yit} \sim N(0, \sigma^2_{\varepsilon_y});$$

$$x_{it} = \tau_{xi} + \beta_3 \times x_{i,t-1} + \beta_4 \times y_{i,t-1} + \varepsilon_{xit},\ \varepsilon_{xit} \sim N(0, \sigma^2_{\varepsilon_x})$$

so that x_{t-1} and y_{t-1} covariance is

$\text{COV}(x_{t-1}, y_{t-1}) = \sigma^W_{xy}$ and the residual terms covariance is

$\text{COV}(\varepsilon_y, \varepsilon_x) = \sigma_{e_{xy}}$.

The between-person model (Level 2) can be expressed as

$$\beta_{2i} = \alpha_\beta + \gamma_1 \times z_i + \zeta_{\beta_2 i},\ \zeta_{\beta i} \sim N(0, \sigma^2_{\beta_2});$$

$$\tau_{yi} = \alpha_y + \gamma_2 \times z_i + \zeta_{yi},\ \zeta_{yi} \sim N(0, \sigma^2_y);$$

$$\tau_{xi} = \alpha_x + \gamma_3 \times z_i + \zeta_{xi},\ \zeta_{xi} \sim N(0, \sigma^2_x)$$

so that the residual terms ζ_y, ζ_x are allowed to correlate with each other $\text{COV}(\zeta_y, \zeta_x) = \sigma^B_{yx}$.

To be able to build the model, values for successive days (t-1, t) were arranged as separate variables: y_{t-1}, x_{t-1}, y_t, x_t. Furthermore, y_{t-1} and x_{t-1} were group mean centered, with variations only at the within level.

In a similar manner, the prospective change model with a random slope was utilized to examine the extent to which there are individual differences in emotion transmission from children to fathers. In this analysis, the unobserved heterogeneity in emotion transmission from children to fathers was captured by a continuous between-level latent variable. However, because there was no statistically significant individual variation in the regression slope for the transfer of children's negative emotions to fathers' negative emotions, the role of temperamental negative emotionality was not considered as a moderator in emotion transmission from children to fathers.

A person-oriented approach to emotion transmission in the family. In the person-oriented approach we used multilevel regression mixture analysis (Muthén & Asparouhov, 2009; Asparouhov & Muthén, 2008). In this analysis, unobserved heterogeneity in emotion transmission from fathers to children was captured by a categorical latent variable, that is, latent class. By estimating a between-level class variable on the basis of within-level emotion transmission (regression from fathers' emotions on a given day to children's emotions on the next day), it was possible to examine whether there were naturally occurring homogeneous patterns of day-to-day interactions that differed according to the emotion transmission from fathers to children. The *typicality* of certain patterns of day-to-day interaction to the individual child-father dyad (i.e., latent class) was predicted at the between-level by the child's level of temperamental negative emotionality using multinomial logistic regression. Because the initial analyses showed that there

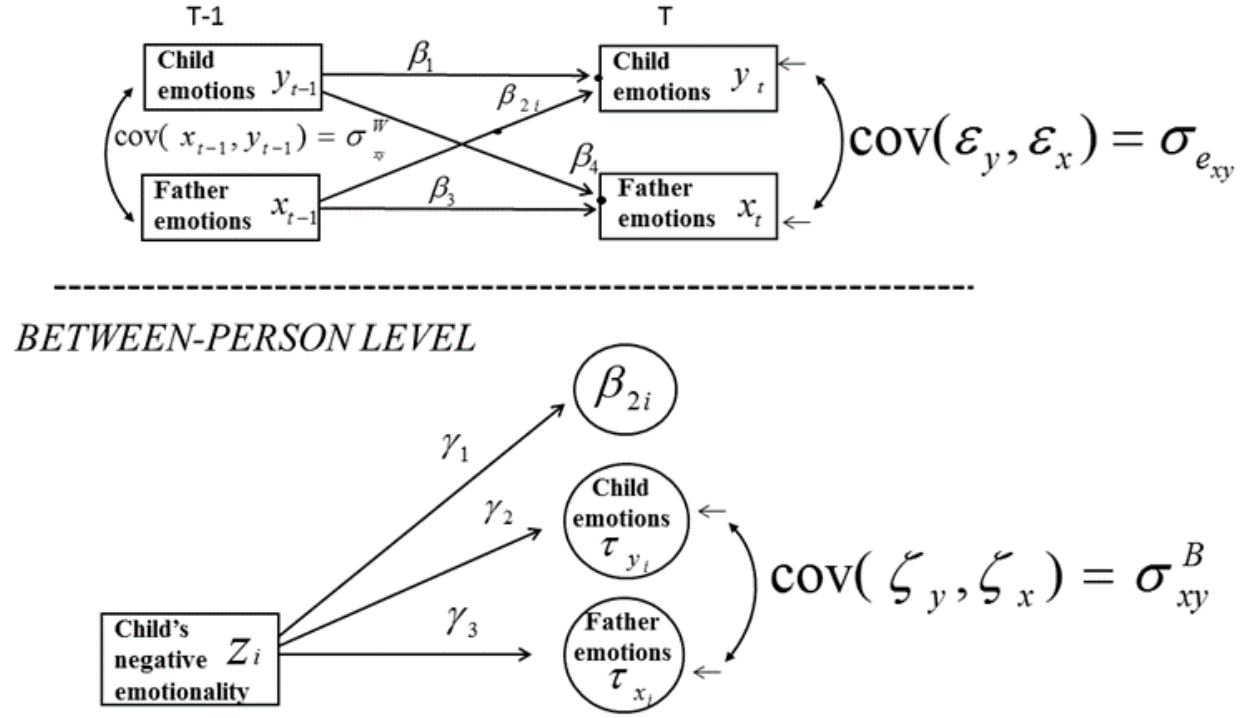

Figure 1. Schematic model (variable-oriented approach)

was no statistically significant individual variation in emotion transmission from children to fathers (variable-oriented approach) and that emotion transmission from children to fathers did not differentiate any latent classes (person-oriented approach), we report regression mixture analyses using only the emotion transmission from fathers to children (i.e., regression coefficient from fathers' negative emotions at t-1 to children's negative emotions at t) as the classification criteria. The tested model is presented in Figure 2. The within-person model (Level 1) can be expressed as

$$y_{it} = \tau_{yi}^{(k)} + \beta_1 \times y_{i,t-1} + \beta_2^{(k)} \times x_{i,t-1} + \varepsilon_{yit},\ \varepsilon_{yit} \sim N(0, \sigma^2_{\varepsilon_y}),$$

$$x_{it} = \tau_{xi} + \beta_3 \times x_{i,t-1} + \beta_4 \times y_{i,t-1} + \varepsilon_{xit},\ \varepsilon_{xit} \sim N(0, \sigma^2_{\varepsilon_x}),$$

so that x_{t-1} and y_{t-1} covariance is

$\text{cov}(x_{t-1}, y_{t-1}) = \sigma^W_{xy}$ and the residual term's covariance is $\text{cov}(\varepsilon_y, \varepsilon_x) = \sigma_{e_{xy}}$.

The regression equation for y_{it} is now dependent on latent class k =1, 2,…, K. In the between-level, the notation $c_{it} = k$ means that observation y_{it} is in class k.

The between-person model (Level 2) can be expressed as

$$p(c_{it} = k \mid z_i) = \frac{e^{\alpha_k + \gamma_k \times z_i}}{\sum_{k=1}^{K} e^{\alpha_k + \gamma_k \times z_i}}, \text{ so that}$$

$$e^{\alpha_K + \gamma_K \times z_i} = 1$$

in which $p(c_{it} = k \mid z_i)$ is the conditional probability that observation y_{it} is in class k depending on z, which is a multinomial regression between the latent class and z,

$$\tau_{yi}^{(k)} = \alpha_y^{(k)} + \gamma_2 \times z_i + \zeta_{yi},\ \zeta_{yi} \sim N(0, \sigma^2_y),$$

$$\tau_{xi} = \alpha_x + \gamma_3 \times z_i + \zeta_{xi},\ \zeta_{xi} \sim N(0, \sigma^2_x);$$

so that the residual terms ζ_y, ζ_x are allowed to correlate with each other $\text{cov}(\zeta_y, \zeta_x) = \sigma^B_{yx}$.

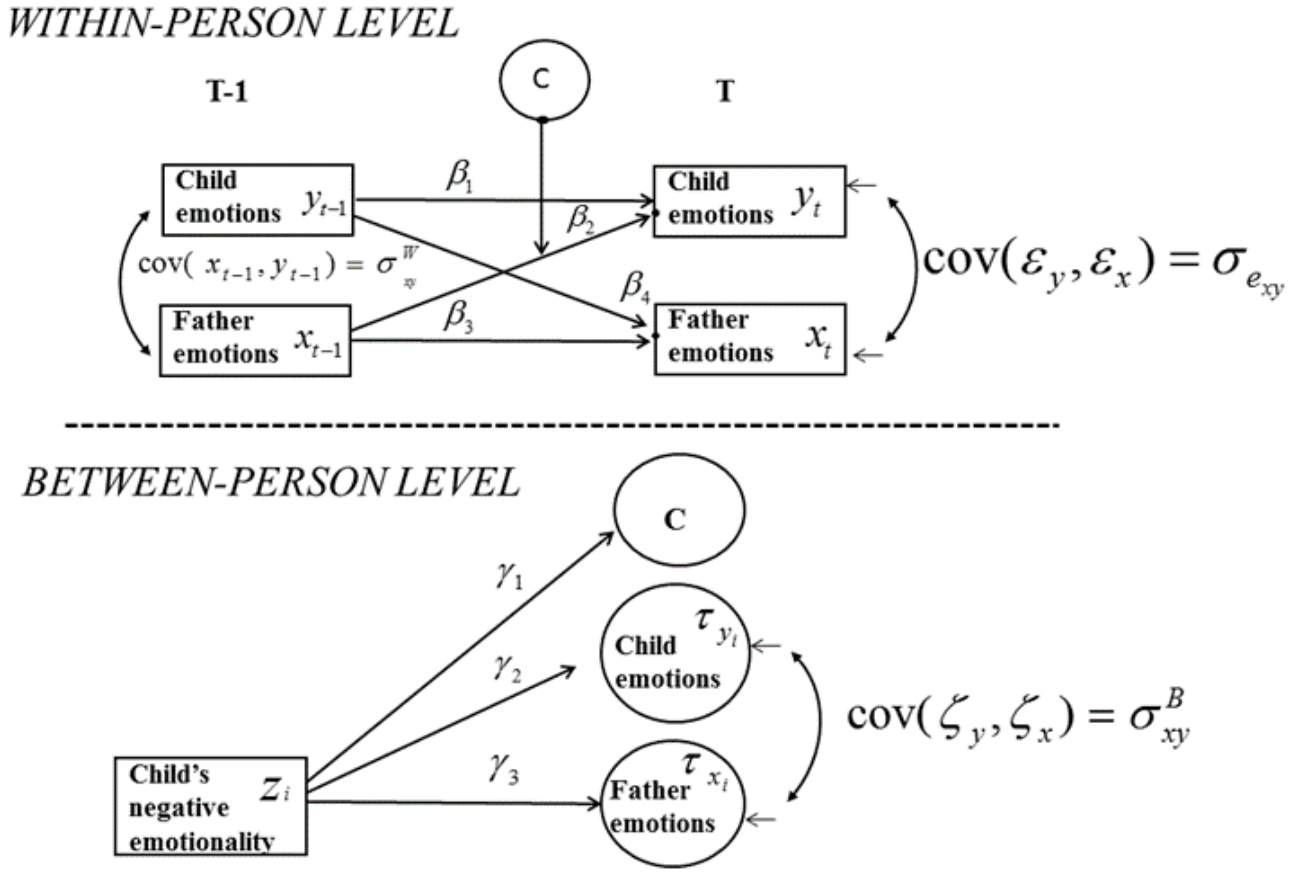

Figure 2. Schematic model (person-oriented approach)

To identify different patterns of day-to-day interaction within father-child dyads, we tested models with different numbers of latent classes. In these analyses, the latent classes were formed on the basis of the within-level regression from fathers' emotions (t-1) to children's emotions (t), so that each class defined a different pattern of the regression path. All other regression paths and covariances were estimated as being equal across the latent classes. Three different criteria (see Muthén, 2001a, 2001b, 2003; Tolvanen, 2007) were used to decide on the number of latent classes: (a) the fit of the model as evaluated by the Bayesian information criterion (BIC; Schwartz, 1978) statistics (the lower the BIC value, the better the model) and the Bootstrapped likelihood ratio (BLRT) test of fit (comparing solutions with different numbers of latent classes; a low p- value (.05) indicates that the k-1 class model has to be rejected in favor of a model with at least k classes); (b) the classification quality that can be determined by examining the posterior probabilities and entropy values (entropy values range from zero to one, with values close to one indicating a clear classification), and (c) the usefulness and interpretativeness of the latent classes in practice (e.g., the number of days in each class).

All the analyses were carried out using the Mplus statistical package (Version 7.0; L.K. Muthén & Muthén, 1998–2012). Using the missing data method in models allowed all observations in the dataset to be used to estimate the parameters in the models. Because some of the variables were initially skewed, the parameters of the models were estimated using the MLR estimator. Scripts of Mplus input code for the analyses are presented as Appendix.

The means, standard deviations and correlations between the study variables are presented in Table 1 (within-level statistics below the diagonal and between-level statistics above the diagonal).

Table 1
Means (M), Standard Deviations (SD), and Correlations between Study Variables in the Within- (below the diagonal; N = 1009–1016 days) and Between- (above the diagonal; N = 118–145 individuals) Data Levels

	1.	2.	3.	4.	5.	*M*	*SD*
1. Fathers' negative emotions, T	1.000	0.765	-	-	0.246	1.507	0.594
2. Children's negative emotions, T	0.191	1.000	-	-	0.365	1.381	0.438
3. Fathers' negative emotions, T-1[w]	0.114	0.030	1.000	-	-	-	0.452
4. Children's negative emotions, T-1[w]	0.021	-0.077	0.227	1.000	-	-	0.329
5. Child's negative emotionality[b]	-	-	-	-	1.000	0.000	0.762

Note. [b] Between-level variable (grand-mean centered); [w] Within-level variable (group-mean centered)

Results

Variable-oriented Approach to Emotion Transmission

First, a multilevel prospective change model was estimated to examine the extent to which fathers' negative emotions on a particular day would predict children's negative emotions the next day, and the extent to which children's negative emotions on a particular day would predict fathers' negative emotions the next day, after controlling for the level of children's or fathers' negative emotions on the previous day. The results showed that, at the whole sample level, fathers' negative emotions did not predict children's negative emotions (*standardized estimate* = .051, p = .357) and children's negative emotions did not predict fathers' negative emotions (*standardized estimate* = -.006, p = .922). These results suggest that one partner's negative emotions were not transmitted to other partner's negative emotions.

Next, prospective change models with a random slope were run to examine the extent to which there is individual variation in emotion transmission from fathers to children and from children to fathers. The results showed, first, that the variance of the tested random slope from fathers' emotions to children's emotions was statistically significant (*unstandardized estimate* = .097, *s.e.* = .021, p < .001), suggesting that emotion transmission from fathers to children is not a universal phenomenon, but rather varies from one dyad to another. Second, the variance of the random slope from children's emotions to fathers' emotions was not statistically significant (*unstandardized estimate* = 0.132, *s.e.* = .082, p = .109), suggesting that while children's negative emotions are not transmitted to their fathers at the level of the whole sample, there is no individual variation in this parameter either.

Finally, because individual variation in emotion transmission from fathers to children was found, children's temperamental negative emotionality was added to the model as a between-level variable in order to predict this individual variation, as well as the level of children's and fathers' negative emotions.

The results showed (Figure 3), first, a statistically significant prediction of the overall level of both children's and fathers' negative emotions from children's temperamental negative emotionality: the higher the level of children's temperamental negative emotionality, the higher the level of children's and fathers' negative emotions in daily life. Second, children's temperamental negative emotionality also predicted a random slope from fathers' emotions to children's emotions, i.e., an individual variation in emotion transmission. A visual representation of the moderating role played by a child's temperamental negative emotionality in the transmission of paternal negative emotions (i.e., cross-level interaction) is presented in Figure 4.

The results show (Figure 4) that among children displaying a low level of temperamental negative emotionality, fathers' negative emotions $_{(t-1)}$ were not transmitted to children $_{(t)}$, i.e., fathers' negative emotions on a particular day did not predict children's subsequent negative emotions on the following day. In turn, among children showing a high level of temperamental negative emotionality, fathers' negative emotions $_{(t-1)}$ were transmitted to their children $_{(t)}$, i.e., the higher the level of fathers' negative emotions on a particular day, the higher the level of children's negative emotions the following day.

Overall, the results suggest that among children with high temperamental negative emotionality, fathers' negative emotions on a particular day are transmitted to children's high negative emotions the next day. Among children showing low temperamental negative emotionality, this kind of transmission is not evident.

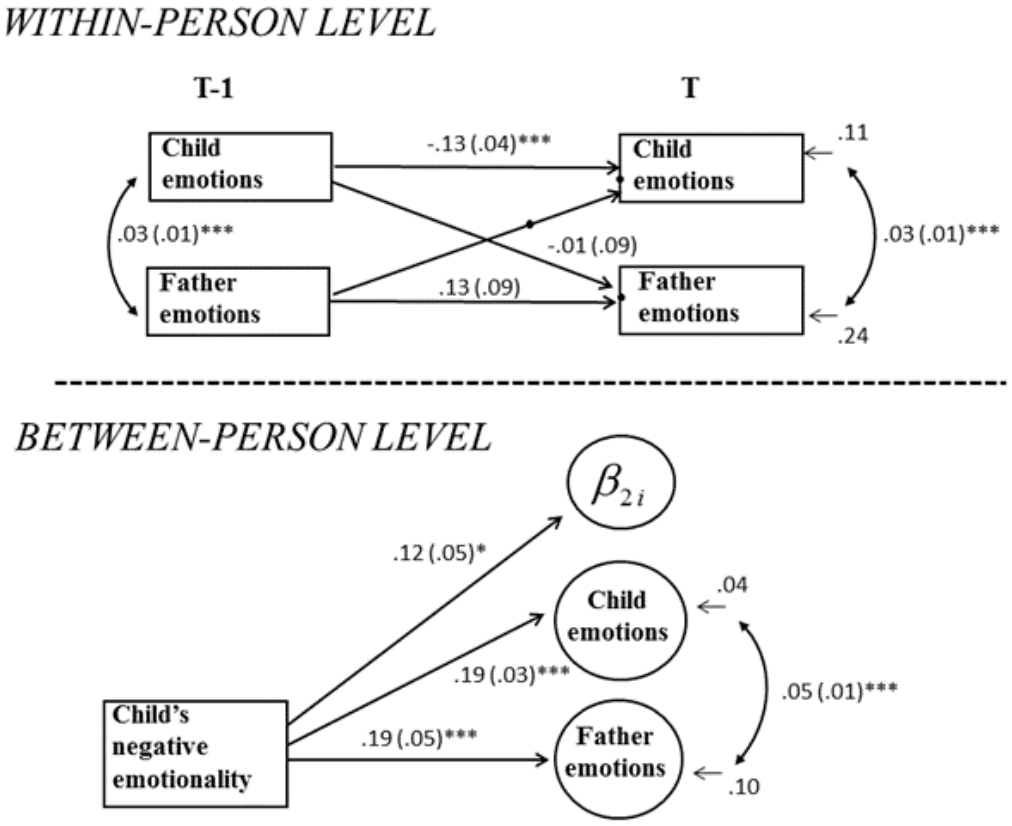

Figure 3. Results of the variable-oriented random slope model : Unstandardized coefficients (standard errors in parentheses). *Note.* *** $p < .001$

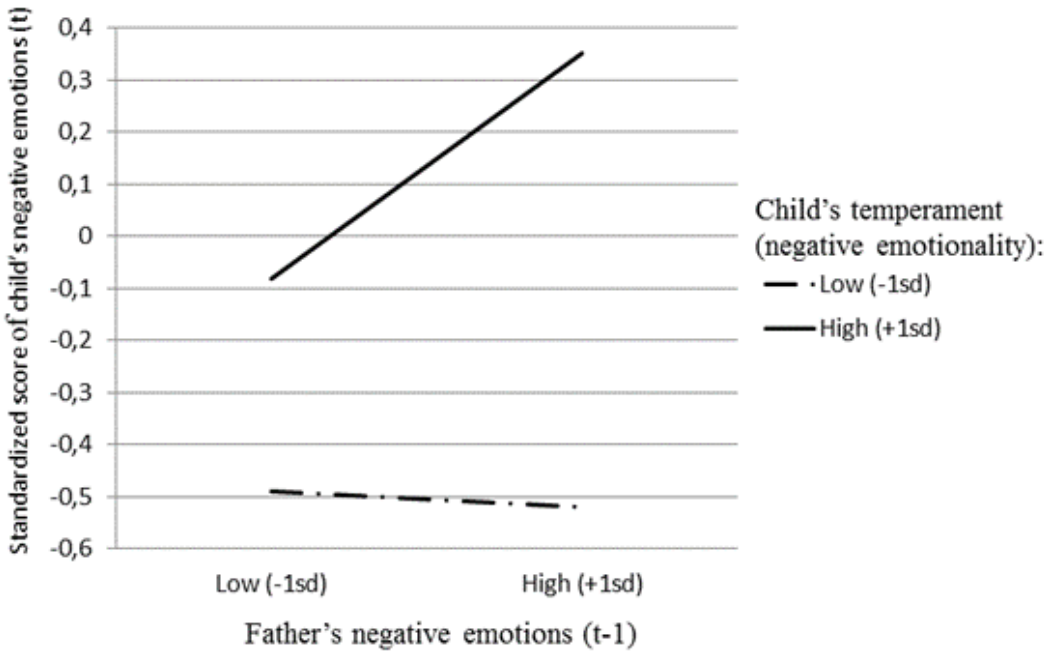

Figure 4. Fathers' negative emotions on the previous day (t-1) as predictors of children's negative emotions on the next day (t) as a function of children's negative emotionality

Person-oriented Approach to Emotion Transmission

Next, the person-oriented approach was applied to the data to examine different *patterns* of day-to-day emotion transmission, and the extent to which children's temperamental negative emotionality would predict the typicality of such patterns in daily life (latent class).

The fit indices for Regression Mixture Models with a different number of latent classes are presented in Table 2. The results showed that the BIC index supported a four-class solution. The fit of this solution was better than that of either the three-class or five-class solutions. Also, the BLRT test suggested that a four-class solution was better than a three-class solution, and that the five class-solution is no better than the four-class solution. Consequently, the four-class solution was selected as the final solution. The results of this final model, that is, the estimated values for the regression from fathers' emotions at t-1 to children's emotions at t, together with estimated class probabilities for each latent class are shown in Table 3.

Table 2

Model Fit Indices and Entropy for Regression Mixture Models and Tests for Different Numbers of Latent Classes (N = 1016 days)

Number of Classes	Log Likelihood	BIC*	BLRT	Entropy
1	-1587.715	3246.503	-	-
2	-1532.624	3162.504	$p < .001$	.935
3	-1520.727	3164.896	$p = .069$	.778
4	**-1495.696**	**3141.017**	$\mathbf{p = .030}$	**.821**
5	-1513.348	3202.507	$p = .235$	.846

Note. BIC* = Sample-size adjusted Bayesian Information Criterion. The smaller the BIC value, the better the fit of the model. BLRT= Bootstrapped Likelihood Ratio Test of Fit (compares solutions with different numbers of latent classes; significant values ($p < .05$) indicate that the k-1 class model has to be rejected in favor of a model with at least k classes). Entropy values range from 0 to 1, with values close to 1 indicating greater clarity in classification.

Table 3

The Results of the Final Four-Class Cluster Solution: Standardized Estimates for the Regression from Fathers' Emotions (T-1) to Children's Emotions (T) (β_2), and Estimated Class Probabilities and Class Sizes (n of Days) for Each Latent Class

	Standardized Estimate of β_2	*p*	Probability	*n* of days
Class				
Class 1: moderate transmission	.503	< .001	.823	140 (14%)
Class 2: no transmission	.015	.667	.912	750 (74%)
Class 3: reversed transmission	-.671	< .001	.839	77 (8%)
Class 4: strong transmission	.963	< .001	.939	42 (4%)
Whole data	.051	.397		

The first class consisted of 140 days. This class was typified by an interaction pattern where fathers' negative emotions were transmitted with moderate strength to children (i.e., fathers' negative emotions on the given day_{t-1} predicted an increased level of children's negative emotions on the following day_t). The second and biggest class consisted of 750 days. This class was typified by an interaction pattern in which emotions were not transmitted from fathers to children (i.e., fathers' negative emotions on the given day_{t-1} did not predict children's negative emotions on the following day_t). The third class consisted of 77 days, and was typified by an interaction pattern in which fathers' negative emotions on a particular day *negatively* predicted children's negative emotions on the next day (i.e., fathers' negative emotions on the given day_{t-1} predicted a decreased level of children's negative emotions on the following day_t). The fourth class consisted of 42 days. This class was typified by an interaction pattern wherein fathers' negative emotions were very strongly transmitted to their children's negative emotions (i.e., fathers' negative emotions on the given day_{t-1} predicted a strong increase in the level of children's negative emotions on the following day_t).

Next, the typicality of the day-to-day interaction patterns (latent class) for the child-father dyad was predicted by children's temperamental negative emotionality at the between-level of the data. The results are shown in Table 4.

Table 4
Child's Temperamental Negative Emotionality as a Predictor of Class Probability (Estimates and Standard Errors for Multivariate Logit Coefficients; Logit Coefficients Express the Relation between Temperamental Negative Emotionality and Class Membership in the Logit Scale)

	Estimate (logit coefficient)	*SE*	*p*
Class			
Class 4: strong transmission			
vs. 1 (moderate transmission)	0.899	0.779	.249
vs. 2 (no transmission)	2.001	0.732	**.006**
vs. 3 (reversed transmission)	1.569	0.816	**.055**
Class 3: reversed transmission			
vs. 1 (moderate transmission)	-0.670	0.694	.334
vs. 2 (no transmission)	0.432	0.504	.391
Class 2: no transmission			
vs. 1 (moderate transmission)	-1.103	0.512	**.031**

The estimates, that is, logit coefficients, express the relations between children's temperamental negative emotionality and latent classes in the logit scale. The results showed (Table 4) that the higher the child's level of temperamental negative emotionality, the more typical it was for the father-child dyad to show a pattern of strong emotion transmission (OR= 7.40) or a pattern of moderate emotion transmission (OR= 3.01) rather than a pattern of no emotion transmission. More specifically, the results suggest that a one-unit increase in child's temperamental negative emotionality was associated with an increase of 2.001 in the logit (log odds) of showing strong transmission, and with an increase of 1.103 in the logit of showing moderate transmission as compared to no transmission. The results showed further that the higher the child's level of temperamental negative emotionality, the marginally more typical ($p < .10$) it was to display a pattern of strong emotion transmission (OR= 4.80) as compared to a pattern of reversed transmission.

Overall, the results found by using the person-oriented approach were in line with those found by using the variable-oriented approach. However, by using the person-oriented approach, it was possible to identify qualitatively different daily interaction patterns, which would not be found by using the variable-oriented approach – for example, the pattern wherein fathers' negative emotions on one day predicted children's *low* levels of negative emotions the next day.

Discussion

It has been suggested that some individuals are more prone to emotion transmission than others (Larson & Almeida, 1999; Repetti & Wood, 1997). The present study tested this idea by using a person-oriented analysis to investigate emotion transmission in father-child dyads over one week of daily interactions. The results of the variable-oriented, prospective change, multilevel modeling showed that, on average, negative emotions were not transmitted within the father-child dyads from one day to another. However, the person-oriented approach using multilevel mixture regression identified four patterns for the transmission of emotions. Moreover, children's temperamental negative emotionality predicted the likelihood of day-to-day interactions patterns showing fathers' negative emotions being transmitted to children, but reduced the likelihood of pattern in which fathers' emotions were not transmitted to children. The present study expands previous person-oriented research by focusing on identifying patterns of transmission between dyads of partners rather than patterns of individual characteristics. Moreover, the study examined patterns of emotion transmission from one day to another, over a one-week period by using diary data for father-child dyads. To complement person-oriented analysis, variable oriented, multilevel change modeling with a random slope was used. The results of person- and variable-oriented analyses were fairly similar, even though the person-oriented analysis identified one pattern of emotion transmission that could not be expected on the basis of the variable-oriented analysis.

It has been suggested that individuals vary in respect to whether they are affected by environmental experiences, and the degree to which this is so (Belsky & Pluess, 2009). The present study examined this hypothesis in the context of daily family life by testing whether emotion transmission from fathers to children, and from children to fathers, varies depending on a child's temperamental negative emotionality. Two different approaches were applied: the person-oriented approach and the variable-oriented approach.

The results of the person-oriented approach using multilevel regression mixture modeling identified four different patterns of emotion transmission: (a) the father's negative emotions were not transmitted to the child, (b) the father's negative emotions were moderately transmitted to the child, (c) the father's negative emotions were very strongly transmitted to the child, and (d) the father's negative emotions predicted the child's decreased subsequent negative emotions. Although the most typical pattern in daily life

was that in which fathers' emotions were not transmitted to their children (evident in 74% of days), there were two patterns (a combined 22% of days), where father's negative emotions were transmitted to the child. The results also showed that the higher the level of the child's temperamental negative emotionality, the more *typical* it was for the father-child dyad in their daily life to show day-to-day interaction patterns wherein the father's negative emotions were transmitted to the child as opposed to an interaction pattern in which the father's emotions were not transmitted to the child. In turn, the lower the level of a child's temperamental negative emotionality, the more typical it was for the father-child dyad to show an interaction pattern in which emotions were not transmitted from the father to the child as opposed to the patterns in which the father's negative emotions were either moderately or strongly transmitted to the child's negative emotions.

The results of variable-oriented methods using multilevel prospective change models with a random slope were in line with results gathered using the person-oriented approach in terms of the moderating role of children's temperamental negative emotionality: children varied in the extent to which they were affected by their fathers' negative daily emotions, and this variation was predicted by children's temperamental negative emotionality. Overall, in line with the Diatheses Stress and Differential Susceptibility models (Pluess & Belsky, 2009), and our hypothesis, the results of both the variable-oriented and person-oriented approaches showed that fathers' negative emotions on a particular day were more typically transmitted to children's negative emotions on the next day among children showing a high level of temperamental negative emotionality as compared to children with a low level of temperamental negative emotionality. These results may be due to the fact that children characterized by a high level of temperamental negative emotionality react to environmental stressors with heightened physiological reactivity (Belsky & Pluess, 2009; Pluess & Belsky, 2009). The results of the present study showing that fathers' negative emotions are transmitted to children, rather than vice versa, are consistent with the previous findings suggesting that emotions in a family context are more likely to be transmitted from parents to children than from children to parents (Almeida et al., 1999; Downey et al., 1999; Larson & Gillman, 1999).

Although the results of the person-oriented analyses were in line with those of the variable-oriented analyses, they provided a complementary understanding of emotion transmission. Namely, by using the person-oriented approach, it was possible to identify one day-to-day interaction pattern which could not be predicted on the basis of the variable-oriented approach, i.e., the pattern wherein fathers' negative emotions on a given day predicted *decreased* levels of negative emotions among children on the next day. Because children's temperamental negative emotionality was not found to predict the likelihood of showing this particular pattern in daily life, further studies are needed to explore possible antecedents. While the variable-oriented approach tested the assumption that the strength of emotion transmission is constant from one day to another within a dyad, the strength of the person-oriented analysis was its demonstration that the pattern of emotion transmission varied from one day-to-day sequence to another, and that each dyad varied in terms of the probability of showing a particular pattern in daily interactions.

In the variable-oriented multilevel regression analysis, the unobserved heterogeneity in relations between variables is expressed in terms of random intercepts and slopes, i.e., continuous latent variables that vary between clusters (i.e., individuals in the case of the present study). In turn, in the person-oriented approach, it is possible to consider unobserved heterogeneity that represents *qualitatively* different relationships between the variables under investigation (McLachlan & Peel, 2000; Muthén & Asparouhov, 2009). According to Muthén and Asparouhov (2009), the within-level heterogeneity in the form of latent classes can be mistaken for between-level heterogeneity in the form of the random effects that are used in conventional two-level regression analysis and, consequently, mixture models have an important role to play in multilevel regression analyses. Mixture models allow heterogeneity to be investigated more fully by more correctly attributing different portions of the heterogeneity to the different levels (Muthén & Asparouhov, 2009).

There are some limitations that should be taken into account before generalizing the results of the present study. First, diary data was only gathered over a one week-period. With a longer study period, it might be possible to find even greater variability in the patterns of emotion transmission. Second, only father-child dyads were investigated and other family members were not included in the analyses. It is, however, possible that emotion transmission may prove to be more a complex phenomenon if other partners, like mothers, are included in the analyses. The person-oriented approach will be valuable tool with which to analyze emotion transmission, even in the case of three partners. Third, because the children in the present study were quite young, parent-ratings of children's emotions were used rather than children's self-reports. To what degree parents' ratings of their children's emotions are consistent with the children's own ratings or with observational data is a matter of debate (Richters, 1992). The fact that both children's and fathers' negative emotions were measured by using parental ratings only should be taken account when interpreting the results. Finally, in the present study emotion transmission was investigated from one day to another. Because it is possible that emotion transmission occurs within shorter time period, further studies are needed to examine the transmission effect using more intensive measurements, for example, minutes within hours or hours within days.

Overall, the present study provided new insights into individual differences in the process of emotion transmission between first-grade children and their fathers. From a

methodological point of view, the results highlight the fact that failing to take into account individual differences in emotion transmission may mask some interesting results concerning day-to-day parent-child interactions. The results of the present study showed that, although at the entire sample level, fathers' negative emotions were not transmitted to their children, there were individual differences in emotion transmission. Moreover, we were able to identify qualitatively different patterns of father-child interactions; patterns in which fathers' negative emotions were not only transmitted to their children's negative emotions but also, in some cases, to decreased levels of negative emotions.

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Appendix: *Mplus Input Scripts.*

```
TITLE:          Multilevel prospective change model (Model 1)
DATA:           FILE IS data.dat;
VARIABLE:       NAMES ARE id BFneg BCneg Fneg Cneg neg-
emo ;
USEVARIABLES ARE    BFneg BCneg Fneg Cneg ;
CLUSTER IS id;
MISSING ARE ALL (-999);

WITHIN ARE Cneg Fneg;

DEFINE: CENTER Cneg Fneg (groupmean);

ANALYSIS:
                TYPE=TWOLEVEL;
                STITERATIONS=20;
                ESTIMATOR=MLR;

MODEL:
%WITHIN%
BFneg ON Fneg;
BFneg ON Cneg;
BCneg ON Cneg;
BCneg ON Fneg;

BFneg WITH BCneg;
Fneg WITH Cneg;

%BETWEEN%
BFneg WITH BCneg;

OUTPUT: SAMP STAND MOD(4);

TITLE:          Multilevel prospective change model with random
slope (Model 2: random slope from fathers' emotions to children's
emotions)
DATA:           FILE IS data.dat;
VARIABLE:       NAMES ARE id BFneg BCneg Fneg Cneg neg-
emo;
USEVARIABLES ARE BFneg BCneg Fneg Cneg;
CLUSTER IS id;
MISSING ARE ALL (-999);

WITHIN ARE Cneg Fneg;

DEFINE: CENTER Cneg Fneg (groupmean);

ANALYSIS:
                TYPE=TWOLEVEL RANDOM;
                ESTIMATOR=MLR;
            STITERATIONS=20;
                ALGORITHM=INTEGRATION;
                INTEGRATION=MONTECARLO;

MODEL:
%WITHIN%
BFneg ON Fneg;
BFneg ON Cneg;
BCneg ON Cneg;
S|BCneg ON Fneg;

BFneg WITH BCneg;
Fneg WITH Cneg;

%BETWEEN%
BFneg WITH BCneg;

S;
[S];

OUTPUT: SAMP STAND MOD(4);


TITLE:          Multilevel prospective change model with random
slope (Model 3: random slope from children's emotions to fathers'
emotions)
DATA:           FILE IS data.dat;
VARIABLE:       NAMES ARE id BFneg BCneg Fneg Cneg neg-
emo ;
USEVARIABLES ARE    BFneg BCneg Fneg Cneg ;
CLUSTER IS id;
MISSING ARE ALL (-999);

WITHIN ARE Cneg Fneg;
```

```
DEFINE: CENTER Cneg Fneg (groupmean);

ANALYSIS:
        TYPE=TWOLEVEL RANDOM;
        ESTIMATOR=MLR;
        STITERATIONS=20;
    ALGORITHM=INTEGRATION;
        INTEGRATION=MONTECARLO;

MODEL:
%WITHIN%
BFneg ON Fneg;
S|BFneg ON Cneg;
BCneg ON Cneg;
BCneg ON Fneg;

BFneg WITH BCneg;
Fneg WITH Cneg;

%BETWEEN%
BFneg WITH BCneg;

S;
[S];

OUTPUT: SAMP STAND MOD(4);
TITLE:    Multilevel prospective change model with random slope (Model 4: child's negative emotionality as a predictor of random slope)
DATA:     FILE IS data.dat;
VARIABLE:    NAMES ARE id BFneg BCneg Fneg Cneg negemo;
USEVARIABLES ARE BFneg BCneg Fneg Cneg negemo;
CLUSTER IS id;
MISSING ARE ALL (-999);

WITHIN ARE Cneg Fneg;
BETWEEN ARE negemo;

DEFINE: CENTER Cneg Fneg (groupmean);
DEFINE: CENTER negemo (grandmean);

ANALYSIS:
        TYPE=TWOLEVEL RANDOM;
        ESTIMATOR=MLR;
    STITERATIONS=20;
        ALGORITHM=INTEGRATION;
        INTEGRATION=MONTECARLO;
  PROCESSORS=4;

MODEL:
%WITHIN%
BFneg ON Fneg;
BFneg ON Cneg;
BCneg ON Cneg;
S|BCneg ON Fneg;

BFneg WITH BCneg;
Fneg WITH Cneg;

%BETWEEN%

S;
[S];

S ON negemo;
BFneg BCneg ON negemo;

BFneg WITH BCneg;

OUTPUT: SAMP STAND MOD(4);


TITLE:    Multilevel mixture regression model - 4 class-solution (Model 5)
DATA:     FILE IS data.dat;
VARIABLE:    NAMES ARE id BFneg BCneg Fneg Cneg negemo;
USEVARIABLES ARE BFneg BCneg Fneg Cneg negemo;
CLUSTER IS id;
CLASSES = cb (4);
MISSING ARE ALL (-999);

WITHIN ARE Fneg Cneg;
BETWEEN ARE cb negemo;
DEFINE: CENTER Fneg Cneg (groupmean);
DEFINE: CENTER negemo (grandmean);

ANALYSIS:
        TYPE=TWOLEVEL MIXTURE;
        STARTS = 500 20;
        STITERATIONS=20;
        ESTIMATOR=MLR;
        PROCESSORS=4;

MODEL:

%WITHIN%
%OVERALL%

BFneg ON Fneg;
BFneg ON Cneg;
BCneg ON Cneg;
BCneg ON Fneg;
BFneg WITH BCneg;
Fneg WITH Cneg;

%cb#1%
BCneg ON Fneg;
%cb#2%
BCneg ON Fneg;
```

```
%cb#3%
BCneg ON Fneg;
%cb#4%
BCneg ON Fneg;

%BETWEEN%
%OVERALL%
```

```
BFneg WITH BCneg;
cb BFneg BCneg ON negemo;


OUTPUT: SAMP STAND MOD(4) TECH11    TECH14;
```