

ARTICLE

Revisiting goodness of fit in the cultural context: Moving forward from post hoc explanations

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Abstract

The goodness-of-fit model, which proposes that developmental outcomes result from combinations of environmental and children's factors, has contributed substantially to the recognition of person $\times$ environment processes. However, which pattern of person $\times$ environment interactions characterizes this model remains unclear, making it difficult to test or compare with other models (e.g., the differential-susceptibility model). In this article, we offer solutions for these issues. We propose that a contrastive effect pattern best summarizes both goodness of fit and poor-ness of fit. We outline methodological considerations that help determine whether a person $\times$ environment interaction supports the goodness-of-fit model. We then discuss how person $\times$ environment interactions can be culturally specific, an issue aligned with the goodness-of-fit model but not other models. We illustrate cultural specificities in socialization-by-temperament interactions with evidence from different sociocultural groups. These theoretical and methodological refinements help clarify how person $\times$ environment interactions can be interpreted and predicted by the goodness-of-fit model.

KEYWORDS

cultural specificities, goodness of fit, socialization-by-temperament interactions

Half a century after its development, the goodness-of-fit model has thrived, as indexed by more than 6000 citations of the original work in 1977 by Thomas and Chess.¹ This model suggests that interactions of environmental and children's factors help foretell individual differences in development over and above the additive effects of environmental and children's factors alone (Sanson et al., 2004). Goodness of fit represents “the consonance between organism and environment, showing that the organism's own capacities, characteristics, and styles of behaving are in accord with the properties of the environment and its expectations and demands” (Chess &

Thomas, 1999, p. 3). In contrast, poor-ness of fit represents “the discrepancies and dissonances between the capacities of the organism and environmental opportunities and demands” (Chess & Thomas, 1999, p. 3). Optimal development follows from goodness of fit, while suboptimal or pathological functioning results from poor-ness of fit (Chess & Thomas, 1999; Windle & Lerner, 1986).

The initial concepts of goodness of fit and poor-ness of fit grew out of the New York Longitudinal Study and a study with Puerto Rican working-class families, in which Thomas and Chess (1977) measured temperamental characteristics of young children and analyzed

Abbreviation: RSA, respiratory sinus arrhythmia.

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how the children fit in their environments. These studies showed that children's temperament, parental practices, and cultural norms jointly determine whether a child develops problem behaviors. The goodness-of-fit thinking provided foundations for later prominent theories, including the diathesis-stress model (vulnerable children are hindered more by stressful environments than are resilient children; Sameroff, 1983), the differential-susceptibility model (susceptible children do better in positive environments but worse in negative ones than nonsusceptible children; Belsky et al., 2007), and the vantage-sensitivity model (sensitive children benefit more from supportive environments than resistant children; Pluess & Belsky, 2013).

Compared with these other models, the goodness-of-fit model is more comprehensive and flexible, so the match/mismatch between multiple elements in an individual's developmental environment (e.g., parents' personality, expectations, parenting behaviors) and multiple aspects of individual differences (e.g., children's temperament, performance, behaviors) can be examined (Chess & Thomas, 1991).² Although goodness of fit and poorness of fit could be studied in a variety of domains, the goodness-of-fit model and other models are commonly applied to socialization-by-temperament interaction effects on children's competence and adjustment. However, it remains unclear which patterns of such interactions characterize the goodness-of-fit model. This model is too general in its prediction and lacks clear operationalization.

With the rise of other models with well-defined patterns to characterize such interactions (see Figure 1a–c), the goodness-of-fit model has been more or less marginalized. In recent literature, researchers returned to this model only to interpret results in a post hoc manner when their data failed to support other models (e.g., Suor et al., 2019), rather than using the goodness-of-fit model to construct testable hypotheses to compare with other models. In this article, we discuss how researchers can formulate and test the goodness-of-fit model to further enhance understanding of person $\times$ environment processes. We argue that the goodness-of-fit model provides at least two important additional perspectives on how variations in the environmental context combine with individual differences in children's characteristics that are not included in other person $\times$ environment models.

As noted, the three most frequently tested person $\times$ environment models are the diathesis-stress, differential-susceptibility, and vantage-sensitivity models. These models have boundary conditions regarding what person $\times$ environment interactions can be explained. They commonly assume that environmental benefits or risks are usually conferred for children with a particular level

of a characteristic, namely those with a particular diathesis, susceptibility, or sensitivity factor. But less susceptible individuals are either unresponsive or less responsive to the same environmental influences (Zhang et al., 2021).

At least two situations at odds with this pattern can be accommodated by the goodness-of-fit model. First, children with both high and low levels of a characteristic may be affected by an environmental factor, but the impacts occur in opposite directions. For example, in studies of primarily North American or Western European children, controlling parenting predicted more externalizing behaviors for highly self-regulated children but fewer externalizing behaviors for less self-regulated children (see Kiff et al., 2011, for a review). In contrast, in studies with similar samples, autonomy-supporting parenting predicted fewer externalizing behaviors for highly self-regulated children but more externalizing behaviors for less self-regulated children (see Lengua et al., 2019, for a review). This situation illustrates a pattern of person $\times$ environment interactions with the potential to characterize the goodness-of-fit model. This is because this model recognizes that an environmental factor could have both positive and negative effects and the matching/mismatching level of children's characteristics may change, instead of being static, when children encounter different environments (Chess & Thomas, 1999).

Second, the way children with a certain level of a characteristic are influenced by an environmental factor may depend on the sociocultural background of these children. For example, in one study, negative family relations predicted more conduct problems for European American adolescents with low effortful control but not for their peers with high effortful control, whereas the pattern was opposite for Latino/a adolescents: Negative family relations predicted more conduct problems for Latino/a adolescents with high effortful control but not for their peers with low effortful control (Loukas & Roalson, 2006). This situation highlights cultural specificities in person $\times$ environment interactions, an issue acknowledged by the goodness-of-fit theory (Chess & Thomas, 1991), but not by the other models.

Next, we summarize methods to test the goodness-of-fit model. We then introduce patterns of expected interactions that capture both goodness of fit and poorness of fit. Then we discuss how our operationalization could be used in empirical investigations. Finally, we elaborate on cultural specificities in socialization-by-temperament interactions and illustrate how goodness-of-fit thinking could advance this knowledge.

METHODS TO TEST THE GOODNESS-OF-FIT MODEL

Both person-centered and variable-centered methods have been used to test the goodness-of-fit model. The person-centered method was originally adopted to describe

²To be consistent with other models, we focus on testing children's factors as the moderator, although either children's factors or environmental factors could be the moderator in the goodness-of-fit model.

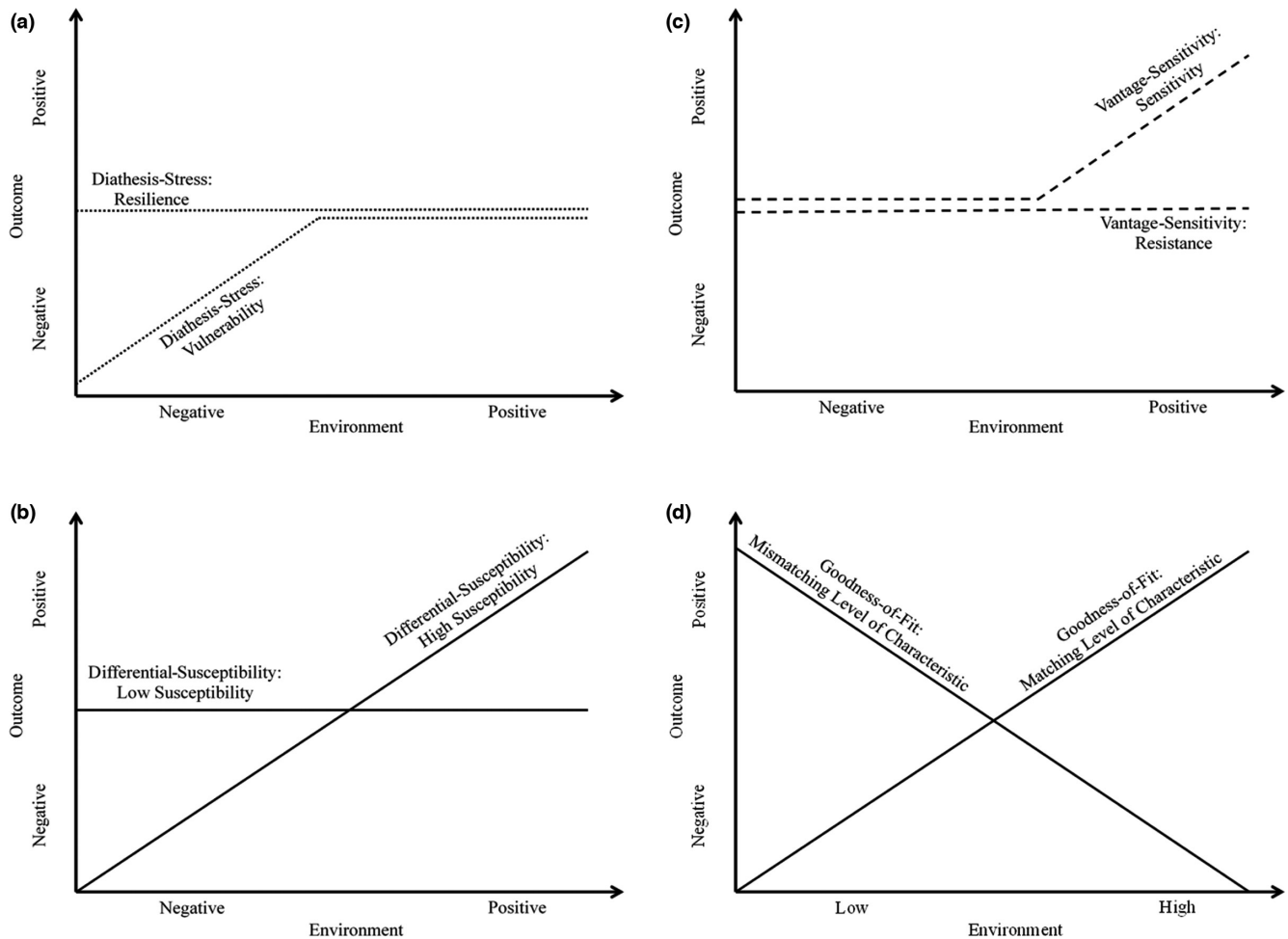


FIGURE 1 Graphical illustrations of the diathesis-stress model (a), the differential-susceptibility model (b), the vantage-sensitivity model (c), and the goodness-of-fit model (d). *Note:* The differential-susceptibility model (b) partly overlaps with the diathesis-stress model (a) in the quadrant showing the negative environment and negative outcome, and with the vantage-sensitivity model (c) in the quadrant showing the positive environment and positive outcome. a–c present the strong versions of these models, which assume that less sensitive/susceptible individuals are not responsive to the influences of environment (Zhang et al., 2021). For the goodness-of-fit model (d), environmental factors should no longer be seen as absolutely positive or negative because the same environmental factor can be beneficial for some children and detrimental for other children, depending on the level of children’s characteristics

children’s temperament clusters and their fit (or a lack thereof) with parental practices (Thomas & Chess, 1977). Typically, researchers classify temperament or personality profiles and analyze whether a match/mismatch exists between socialization factors and each subgroup of children based on group differences in associations between socialization factors and children’s outcomes. For example, in one U.S. study of mainly European American (non-Hispanic) middle-class children, for inhibited, fearful children, maternal responsiveness predicted better conscience, while for exuberant, impulsive children, responsiveness did not predict conscience (Augustine & Stifter, 2019).

Variable-centered methods comprise two approaches: expectation-behavior matching and behaviors matching. Regarding the expectation-behavior matching approach, discrepancies between the expected levels of characteristics and the actual levels of characteristics are treated as goodness-of-fit indices and used to predict children’s outcomes (Windle & Lerner, 1986). For example, U.S.

mothers of mainly African American and European American children in Head Start rated their expectations for their children’s temperament and the actual levels of temperament, and the correlation of these two ratings (a goodness-of-fit index) predicted children’s social skills, with a better fit predicting better social skills (Churchill, 2003). Regarding the behaviors matching approach, interactions of socialization factors and children’s characteristics are investigated as predictors of children’s competence (e.g., Suor et al., 2019) and social adjustment (e.g., Leerkes et al., 2009). For instance, authoritarian parenting in a sample of relatively highly educated European American families predicted higher social competence for children with low temperamental reactivity, but this type of parenting predicted lower social competence for their counterparts with high reactivity (Gagnon et al., 2014).

We focus on the behaviors matching approach because of its predominant use in the literature and its flexibility in overcoming some of the limits of the other approaches.

The behaviors matching approach makes comparisons with other models easier because the other models focus on how conditional associations between socialization factors and children's outcomes change with the increasing or decreasing value of children's characteristics. Person-centered methods may find different temperament or personality profiles in different cultures, making it difficult to compare the patterns of person $\times$ environment interactions between cultures; this is less of a problem with the behaviors matching approach.

As noted, due to a lack of predefined patterns of interactions that characterize the goodness-of-fit model, this model was mostly used as post hoc explanations for simple slope results found "unexpectedly" (e.g., Gagnon et al., 2014; Suor et al., 2019), rather than as a theoretical base for generating priori hypotheses. To address this issue, two directions are critical for refining this model: (1) clarifying what pattern of person $\times$ environment interactions is aligned with the goodness-of-fit conceptualization (and different from others), and (2) clarifying specificities of environmental factors and children's factors in a given sociocultural context when generating hypotheses.

EXAMINING PERSON $\times$ ENVIRONMENT INTERACTIONS USING THE GOODNESS-OF-FIT MODEL

To identify how to operationalize the goodness-of-fit model, we return to the original goodness-of-fit theory (Chess & Thomas, 1991, 1999), which posited that problem behaviors occur for some children because their characteristics do not keep step with opportunities and stresses parents create. In contrast, other children learn from the same opportunities or successfully challenge themselves to deal with the same stresses. In this sense, the same environmental factor may match the needs of some children but mismatch those of others. This developmental phenomenon is manifested as a contrastive effect (Belsky et al., 2007). Graphically, the pattern of a contrastive effect can be clearly distinguished from the patterns of interactions that support other models (see Figure 1). Corresponding to the goodness-of-fit model, a contrastive effect shows that children both high and low on a particular characteristic respond significantly to the influence of an environmental factor, but in reverse directions.

The contrastive effect indicates the coexistence of goodness of fit and poorness of fit. This phenomenon is not rare in the literature on socialization-by-temperament interactions. For example, the controlling parenting-by-self-regulation and autonomy support-by-self-regulation interactions mentioned earlier (Kiff et al., 2011; Lengua et al., 2019) are consistent with the contrastive effect pattern. Several studies conducted in the United States with families of diverse cultural and socioeconomic backgrounds have found this effect. Maternal

sensitivity to distress predicted less dysregulation for infants with high reactivity but more dysregulation for infants with low reactivity, and sensitivity to nondistress predicted more dysregulation for infants with high reactivity but less dysregulation for infants with low reactivity (Leerkes et al., 2009). Similarly, negative parenting was associated with more aggressive and rule-breaking behaviors for highly reactive adolescents but with fewer aggressive and rule-breaking behaviors for less reactive adolescents (Tung et al., 2019). The contrastive effect has also been found for positive developmental outcomes. In a study of preterm or low-birthweight children from mainly European American families, maternal flexibility was positively related to cognitive competence for temperamentally difficult children but negatively related to cognitive competence for temperamentally easy children (Dilworth-Bart et al., 2012). In another study, sibling conflicts in low-income, mainly African American and European American families were associated with higher social skills for children with low negative emotionality but lower social skills for children with high negative emotionality (Morgan et al., 2012).

Together, this body of literature attests that goodness of fit and poorness of fit indeed coexist in many cases of the combinations between environmental factors and children's factors. This suggests that the contrastive effect is a likely option to characterize the person $\times$ environment interaction in support of the goodness-of-fit model. Such evidence challenges a mindset that conditional associations between environmental factors and children's outcomes are always either positive or negative and that they vary only in strengths depending on the level of children's characteristics.

METHODOLOGICAL CONSIDERATIONS FOR TESTING THE GOODNESS-OF-FIT MODEL

To test the goodness-of-fit model against other models, many features of conventional methods to probe person $\times$ environment interactions remain useful, although several methodological considerations deserve attention. First, because every individual has unique characteristics and may go through unique pathways to adapt to their context (Hill, 2021), some environmental factors may, by nature, be both favorable and unfavorable. However, many studies automatically label any environmental factors as beneficial or detrimental for everyone. Researchers should consider whether the association between an environmental factor and a children's outcome could be positive for some children and negative for others.

Second, the goodness-of-fit model could be interpreted in a strict manner (Figure 2a) or a less strict manner (Figure 2b,c). In a strict manner, the goodness-of-fit model is supported when an interaction effect is consistent with the contrastive effect pattern—namely,

both goodness of fit and poorness of fit are shown in this interaction effect. Some children benefit from an environmental factor and show more competence (or less maladjustment), while others are hindered by the same environmental factor and show less competence (or more maladjustment).

In a less strict manner, an interaction effect delineates *either* goodness of fit *or* poorness of fit, but two or more interaction effects are complementary to support the contrastive effect pattern. Although researchers have been unable to distinguish the goodness-of-fit model from the vantage-sensitivity model or the diathesis-stress model based on a single interaction result, they can find support for the goodness-of-fit model when comparable interactions show that children with low and high levels of a characteristic respond reversely to the same environmental factor (see Figure 2b,c). Interaction effects are comparable when, for instance, environmental factors or children's factors are assessed using different methods,

a person $\times$ environment interaction is examined for the same outcome at different developmental phases, or the same person $\times$ environment interaction is investigated for different children's outcomes. In fact, cross-validating person $\times$ environment interactions is a requirement (i.e., a boundary condition of theory) to clarify the specificity of these models (Belsky et al., 2007). Researchers should be cautious about relying too much on findings drawn from one interaction effect and overlooking this requirement and an all-embracing pattern of results.

Third, researchers should use the Johnson–Neyman technique of regions of significance on moderators (Z) to discern whether a person $\times$ environment interaction is aligned with the contrastive effect (Finsaas & Goldstein, 2021). If a contrastive effect is not found and the goodness-of-fit model is not (yet) supported, other statistical methods (Del Giudice, 2017; Roisman et al., 2012) can be used to differentiate the diathesis-stress, vantage-sensitivity, and differential-susceptibility

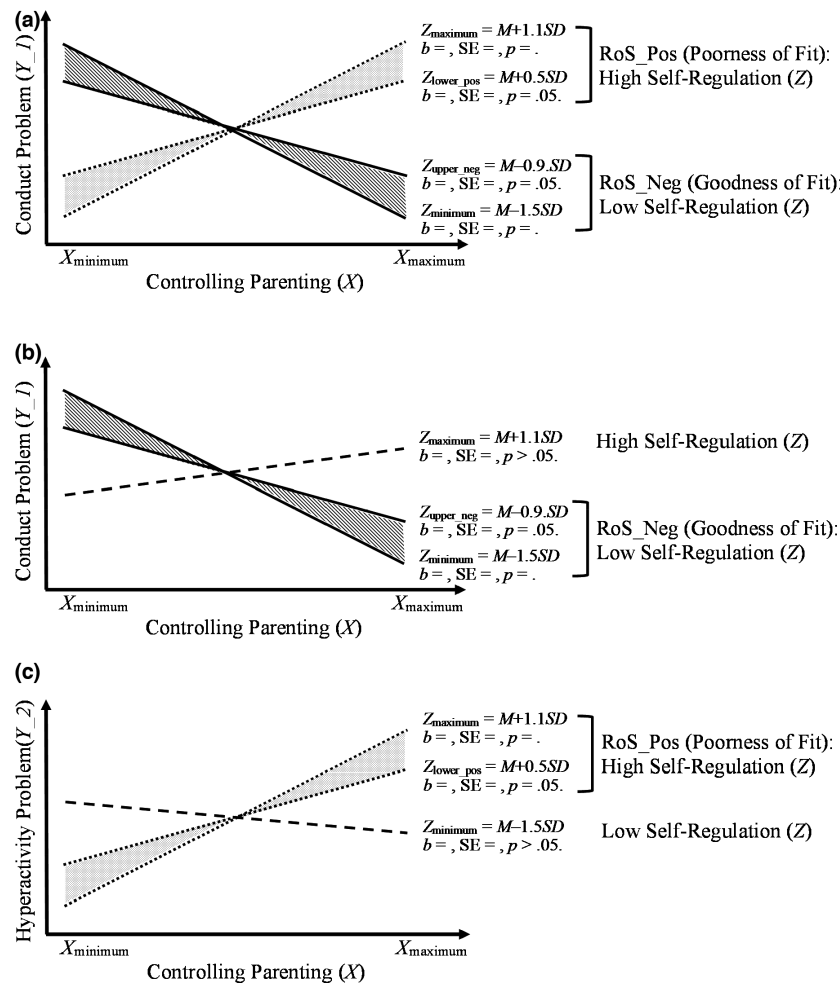


FIGURE 2 Examples for strict (a) and less strict (b, c) versions of the goodness-of-fit model. *Note:* *b*, unstandardized regression coefficient; Neg, negative associations; Pos, positive associations; RoS, region of significance; *SE*, standard error of regression coefficient. The solid line and diagonally striped area illustrate goodness of fit between controlling parenting (*X*) and low levels of children's self-regulation (*Z*). The dotted line and dot-shaded area illustrate poorness of fit between controlling parenting and high levels of children's self-regulation (*Z*). Dashed lines illustrate nonsignificant associations between controlling parenting and children's outcomes (conduct problem *Y*₁ and hyperactivity problem *Y*₂) for some children (see also figure 6 in Finsaas & Goldstein, 2021)

models. The regions-of-significance technique is most effective in differentiating the goodness-of-fit model from other models because other models are established on the statistical assumption that “the effect of the environment is amplified in high-susceptibility individuals but only attenuated (rather than reversed) in low-susceptibility ones” (Del Giudice, 2017, p. 1271). The regions of interest are within the minimum and maximum of predictors (environmental factors) and moderators (children’s factors; Finsaas & Goldstein, 2021). Researchers should plot all the plausible associations between an environmental factor (X) and a children’s outcome (Y) at all the observed levels of a children’s factor (Z), particularly by marking the upper (Z_{upper}) and lower (Z_{lower}) bounds for each region of significance (see Figure 2). Estimating the confidence intervals for such upper and lower bounds is important given imprecision in assessments and the possibly arbitrary meaning of values on measures used (McCabe et al., 2018).

SPECIFICITIES OF SOCIALIZATION AND CHILDREN’S CHARACTERISTICS IN SOCIOCULTURAL CONTEXTS

We now turn to the issue of cultural specificities. Culture-specific perceptions, interpretations, and normativeness in socialization factors and children’s characteristics and relevant two-way (culture $\times$ socialization or culture $\times$ temperament) interactions have been identified in the literature (Chen, 2018; Davidov, 2021). However, we know little about commonalities and specificities in person $\times$ environment processes and such three-way (culture $\times$ socialization $\times$ temperament) interactions need to be elucidated.

The same patterns of socialization-by-temperament interactions are sometimes shown across cultures. For example, similar to findings with children from Western cultures (Kiff et al., 2011; Lengua et al., 2019), less self-regulated young Chinese children benefitted from controlling parenting (Dong et al., 2022; Yu et al., 2018), while this type of parenting was unfavorable for highly self-regulated children (Dong et al., 2022), illustrating a contrastive effect for controlling parenting-by-self-regulation interactions. Moreover, the autonomy support-by-self-regulation interactions are consistent with the contrastive effect pattern, with highly self-regulated children benefitting from autonomy-supportive parenting, while less self-regulated children were hindered by this type of parenting (Dong et al., 2021, 2022; Ren et al., 2018).

However, patterns of socialization-by-temperament interactions are sometimes culturally specific. We mentioned one example earlier regarding the distinct moderation effects of effortful control on the association of negative family relations with conduct problems in European American and Latino/a adolescents (Loukas & Roalson, 2006).

Another example concerns the interaction effect between suppressive emotion socialization and baseline respiratory sinus arrhythmia (RSA) on problem behaviors.

Although the function of baseline RSA indexing children’s sensitivity to context is unlikely to change across cultures, the function of suppressive emotion socialization works differently for African Americans and European Americans, with relatively weak aversive influences for African Americans (Leerkes et al., 2015). Parents’ suppressive response to children’s negative emotional expressions can protect African American children from racial bias, whereas for European American children who need not worry about personal racial discrimination, the same practice might be seen as invalidating their emotional expressions. Correspondingly, suppressive emotion socialization predicted more internalizing behaviors, with the prediction varying only in strength rather than direction for European Canadian children with different levels of baseline RSA (Ugarte et al., 2021). Yet in African American families, while suppressive emotion socialization still predicted more internalizing behaviors for sensitive children (high baseline RSA), this type of parenting predicted fewer internalizing behaviors for less-sensitive children (low baseline RSA; Dunbar et al., 2021).

A third example concerns interaction effects between controlling parenting and shyness on problem behaviors. Shyness is a risk factor for problem behaviors in urban Chinese children, especially those with controlling parents (Bullock et al., 2018), comparable with the detrimental influence of such a combination in children from Western cultures (e.g., Finland; Zarra-Nezhad et al., 2014). However, we speculate that this pattern may not generalize to rural Chinese children.

Rural Chinese parents stress the values of traditional Chinese culture, including nonassertiveness, self-restraint, and family hierarchy (Chen, 2019). Their value systems differ from urban Chinese parents, who co-emphasize the values of Western, individualistic cultures, including taking social initiatives, self-expressiveness, and personal autonomy (Chen, 2019). Therefore, controlling parenting is acceptable among rural Chinese families because it is congruent with the values of parents’ authority and family hierarchy (Liu et al., 2020). This high normativeness of controlling parenting attenuates the strength of its aversive impacts (Lansford et al., 2005). Indeed, rural Chinese children view controlling parenting as more common and less harmful than do urban Chinese children (Helwig et al., 2014).

Moreover, shyness is seen as adaptive and benign among rural Chinese children because it corresponds with the expectations that these children and their parents hold for a socially mature, well-adjusted individual. Indeed, shyness is positively related to social adjustment among these children (Chen et al., 2011). Thus, it is reasonable to speculate that the controlling parenting-by-shyness interaction is unique for rural Chinese children. Shy children’s nonassertiveness matches parental expectations for

self-restraint, and controlling parenting effectively facilitates children's respect for parental authority and builds closer family bonding so children are protected against developing problem behaviors. In contrast, assertiveness in children who are not shy may be perceived by parents as hard to manage. Controlling parenting is ineffective in eliciting the optimal arousal in these children to self-correct misbehaviors. Rather, controlling parenting exacerbates conflicts in parent-child relationships and stimulates the emergence of problem behaviors.

These examples demonstrate that specifying the meanings of environmental factors and children's factors in a sociocultural context is important for generalizing hypotheses for interaction effects. For the field to move forward, more evidence is needed for cultural commonalities and specificities in person $\times$ environment processes. The goodness-of-fit theory can be applied to culture-specific patterns of person $\times$ environment interactions because it acknowledges culture as a context for how person $\times$ environment interactions might present (Chess & Thomas, 1991), whereas the diathesis-stress, differential-susceptibility, and vantage-sensitivity models do not anticipate culture-specific patterns of interactions.

CONCLUSIONS AND RECOMMENDATIONS FOR RESEARCH

In this article, we showed how the goodness-of-fit model is an important theoretical model that captures unique aspects of person $\times$ environment interactions not included in other popular models. We demonstrated the coexistence of goodness of fit and poorness of fit in various socialization-by-temperament interactions and proposed that a contrastive effect best summarizes this goodness-of-fit conceptualization. We also demonstrated how cultural specificities in environmental factors and children's factors modify person $\times$ environment processes. In doing so, we have identified common gaps in the research on person $\times$ environment interactions and how the goodness-of-fit model can be used to address those issues.

In closing, we call for more theoretical discussions on and empirical analyses of how environmental factors (mainly parenting) might differentially affect the development of specific children's outcomes. The so-called "unexpected" effects of adverse environments (yesterday's obstacles are today's opportunities; Frankenhuis & Nettle, 2020) and supportive environments (too much of a good thing may be bad; Segrin et al., 2015) are important for understanding a contrastive effect pattern. Moreover, researchers should conduct multigroup analyses with socialization-by-temperament interactions or test three-way culture $\times$ socialization $\times$ temperament interaction effects on diverse children's outcomes. Such research remains scarce but can help clarify whether the pattern of particular interaction effects is generalizable across groups and consistent across children's outcomes.

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