Causal Relations Between Mothers' and Children's Beliefs About Math Ability: A Structural Equation Model

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Abstract

The expectancy-value model of achievement motivation (Eccles et al., 1983) posits that parents' beliefs about their children's abilities and values influence children's ability perceptions and values, which in turn influence children's motivation and performance. In this study, we examine (1) the extent to which parents' beliefs about their children's abilities influence their children's own ability beliefs, (2) the possibility that children's beliefs, in turn, affect their parents' beliefs, and (3) the developmental patterns in the causal relations of parents' and children's beliefs about abilities.

Using the structural equation modeling technique, we found a modest influence of mothers' beliefs about their children's math ability on children's beliefs about their own math ability among elementary and junior high school students. This influence vanishes by the time children reach high school. Additionaly, we found very little sign of the reverse impact of children's beliefs on mothers' beliefs at any age level. Stability and change in the ability beliefs are discussed in a developmental context. Also presented are gender and cohort differences in the causal relations of math ability beliefs.

In recent theoretical discussions of aspects of children's motivation (e.g., Eccles, et al., 1983; Nicholls, 1990; Schunk, 1991; Wigfield & Eccles, 1992) researchers have focused on children's achievement beliefs as key mediators of children's motivation and performance in achievement settings. Beliefs about ability take a prominent role in different theories of achievement motivation, including attribution theory (Weiner, 1979, 1985), expectancy-value theory (Eccles, et al., 1983; Wigfield & Eccles, 1992), and self-worth theory (Covington, 1984), as well as in more general models of self-concept such as those of Harter (1983, 1985, 1990) and Marsh and his colleagues (Marsh, 1989, 1990; Marsh & Shavelson, 1985). Ability beliefs refer to children's evaluations of their competence in different areas, and researchers have examined these beliefs in several different activity domains, such as academics, sports, social, and other domains. These beliefs are central to motivation theory because they relate to children's performance in different domains (see Eccles et al., 1983; Wigfield & Eccles, 1992), and because children often strive to maintain high beliefs about ability as a way to maintain self-esteem (see Covington, 1984).

As discussed in more detail by both Eccles (1984a,b) and Wigfield and Eccles (1992), ability-related constructs received a great deal of attention in work on achievement motivation done in the 1970s and 1980s. One reason for this focus on ability-related constructs was the dominance of cognitive paradigms in psychology during the 1970s and 1980s, a dominance that extended to motivation theory (see Weiner, 1990). Beliefs about one's ability, efficacy, and explanations for one's achievement outcomes generally can be categorized as cognitive motivational constructs. Cognitive motivational theorists such as Bandura (1977) and Weiner (1979, 1985) characterize individuals as trying to understand their achievement outcomes and to develop clear ideas about their ability and efficacy, in order to choose rationally the achievement activities in which they will engage. Another reason for the dominance of these constructs is their success in predicting various achievement outcomes (see Bandura, 1992; Weiner, 1985).

One central issue regarding children's ability-related beliefs concerns the role parents play in socializing those beliefs. Over the past several years researchers studying parent socialization practices have become increasingly interested in parents' beliefs about their children (e.g., Bacon & Ashmore, 1986; Eccles, et al., 1983; Goodnow, 1985; Goodnow & Collins, 1990; Sigel, 1985, 1986). Sigel (1985) defined parents' beliefs as constructions of reality that usually are based on parents' knowledge of their children. However, he also noted that these beliefs may or may not be supported by factual evidence, and are subject to change. He argued that parents' beliefs provide a guide to their activities with their children. Similarly, Bacon and Ashmore (1986) posited that parents' beliefs mediate between children's behavior and parents' responses to that behavior; they argued that to understand parents' interactions with their children we must understand their beliefs. They have proposed a model of these parental beliefs to describe how parents' beliefs mediate between children's activities and parental socialization practices. In the model, children's activities or behavior are said to activate parents' beliefs. The beliefs then lead parents to behave toward their children in different ways; hence their role as mediators. The critical beliefs serving this mediating role include background factors such as the parents' perceptions of the child's attributes, and parents' affective and cognitive structures, such as their goals for the child, affective belief systems, and skills in handling the child.

Goodnow (1985, 1988) also stated that parents' beliefs (ideas, in her terminology) likely relate to how they interact with their children; however, she has proposed that parents' ideas about children are interesting irrespective of whether they relate to parents' actual behaviors. In this sense parents' ideas are important instances of adults' social cognition (Goodnow, Knight, & Cashmore, 1986), and likely serve as general guides to parents' orientation to child rearing. In their recent essay on parents' ideas about children, Goodnow and Collins (1990) discussed how the relations between parents' ideas and their behaviors toward children often are complex, and that relations between the two can be difficult to determine (see also Sigel, 1986). They also suggested that parents' ideas about children come from their experiences with children, but also from the shared cultural knowledge coming from the group to which the parents belong. They discussed different aspects of the quality of parents' ideas that need to be further assessed in developmental research, including the accuracy of the ideas, how differentiated they are, how they are shared or not shared between mothers and fathers, and how they are connected or organized.

Although some researchers have focused on broad, general ideas about children and child rearing, other researchers have focused on parents' more specific beliefs. One area that has received fairly extensive study is parents' beliefs about children's abilities (see Miller, 1988, for a review). This work shows that parents are reasonably accurate at estimating their children's general abilities, though they tend to underestimate what infants can do and overestimate what their elementary school-aged children can do (Miller, 1986). Some studies show that there are individual differences in parents' accuracy, however. Mothers appear to be somewhat more accurate than fathers in estimating their children's abilities (see Bird, 1985; Miller, 1987). Phillips (1987) showed that certain parents believe their children are relatively incompetent despite the fact their children were performing well in school, whereas other parents accurately perceived their children's competence.

Parents' beliefs about their children's abilities have been shown to influence children's performance in school; hence these beliefs not only relate to parents' behavior but also to their children's behavior. For instance, Hess, Holloway, Dickson, & Price (1984) showed that mothers' expectations for their children's academic performance predicted their children's reading readiness scores. In an important longitudinal study of relations between parents' expectations for school performance and children's achievement outcomes during the first two years of school, Alexander and Entwisle (1988) found that parents' expectations for their children's performance had a strong influence on children's performance during the first year of school, and (at least for white parents) continued to have an influence during the second year of school. However, children's performance on school tests related to parents' subsequent expectations for their children, suggesting that the relations between parents' expectations and children's performance is bidirectional.

Stevenson and Newman (1986) also reported that parents' expectations influenced children's school performance during the later elementary school years.

Eccles and her colleagues (Eccles, 1984a, 1984b; Eccles et al., 1983; Eccles et al., in print; Wigfield & Eccles, 1992) have proposed a comprehensive expectancy-value model of children's achievement behavior that posits an important role for parents' beliefs in determining children's academic performance and motivation. In the model, parents' beliefs about their children's abilities and values are proposed to influence children's ability perceptions and values, which in turn influence children's performance and motivation. In empirical tests of the links between parents' beliefs and children's beliefs and behavior, Parsons, Adler, & Kaczala (1982) found that parents' beliefs about their 5th through 11th grade children's competencies had a stronger influence on children's own beliefs than did either parents' role modeling of different activities or children's own grades in school. Results also showed that parents of sons thought math was more important for their children than did parents of daughters. Eccles et al. (1983) found that the influence of parents' beliefs about the difficulty of math for their children and its importance on 5th through 12th grade students' beliefs was mediated through students' perceptions of those beliefs. For instance, parents' perceptions of the importance of math related to students' perceptions of their parents aspirations for them, which in turn related to students' valuing of math. Eccles et al.(1983) also found that mothers' perceptions of the difficulty of math for their children had a stronger impact on children's beliefs than did fathers' beliefs about difficulty.

It is clear that while many researchers have extensively studied the influence of parents on children's achievement-related beliefs, few of them have attempted to test empirically whether children do in turn influence their parents' beliefs about their own abilities and values. What is far less studied is whether the influence, between parents' and children's beliefs about abilities and values, whether unidirectional or bidirectional, changes over time as children pass through various levels of schooling.

In the present study we build on earlier work on relations between parents' beliefs about their children's ability and children's beliefs about their own ability in several important ways. First, we take advantage of a longitudinal design to tackle the complex task of causal inference. The longitudinal design is based on two-wave repeated measurement of two latent constructs (i.e., mothers' beliefs about their children's math ability, and children's beliefs about their own math ability) with multiple indicators. It is generally accepted that longitudinal designs have more leverage over cross-sectional designs in establishing strong cases for causality in developmental research (Schaie & Hertzog, 1982). Second, we take advantage of sophisticated techniques using LISREL program that have been suggested as a way to deal effectively with potential problems arising from longitudinal data analyses (Biddle & Marlin, 1987). Third, we examine age differences in the socialization of ability beliefs by comparing different age groups within a sample. And we replicate the age comparisons over a number of study samples of children at their distinct developmental stages (e.g., elementary school aged children, early adolescents in middle grade schools, and adolescents in high school). By doing so, we take a snapshot of developmental patterns of the parent and child socialization of math ability over wide cross-sections of age groups. Fourth, we explore cohort differences in these relations by examining different samples of early adolescents; two of the datasets we used include fifth and sixth graders born at different times. And fifth, we probe gender differences in these longitudinal patterns.

Sample and Methods

The data used in the present study come from three major longitudinal projects conducted under the direction of Jacquelynne Eccles to study the development and socialization of children's and adolescents' achievement-related beliefs concerning different school subjects. Data for Study 1 were collected in 1979 and 1980 from approximately 380 5th through 12th graders and their mothers.[1] Data for Study 2 were collected in 1983 and 1984 from approximately 950 5th and 6th graders, and their mothers. These two datasets allow for cohort comparisons, since they both include 5th and 6th grade children, but the children were in fifth and sixth grade at different time points. Data for Study 3 were collected in 1987 to 1990 from approximately 300 first, second, and fourth grade children, and their mothers.

In each study mothers and children completed questionnaires that included items assessing a variety of achievement-related beliefs and attitudes about different academic activities We focus in this study on mothers' beliefs about their children's ability in mathematics, and children's own math ability beliefs. Table 1 illustrates the question items and corresponding variable names used in this study. The items assessing mothers' beliefs about children's ability varied slightly across the three studies, but were similar to one another; hence the constructs included in the analyses are quite similar.[2] The same three items assessing math ability beliefs were asked of children in each study. In the first two studies children and their mothers completed questionnaires once each year over a two year period. In Study 3 children and their mothers completed questionnaires once each year over a three year period; data from the second and third year of this study are included in the present study.

The data were analyzed with the use of LISREL program (Jöreskog & Sörbom, 1989). We used the techniques of LISREL because they are arguably superior to other conventional techniques (e.g., ordinary least squares regression analysis) to deal effectively with complex problems that may arise from the longitudinal data (Biddle & Marlin, 1987). LISREL combines two major component models: the first component, structural equation model, allows researchers to tackle causal inference, and the second component, the measurement model, allows researchers to address measurement error issues involving longitudinal data with fallible measures. More specifically, the measurement model of LISREL allows investigators to test predicted relations of manifest variables with latent constructs (in this study, math ability beliefs). Furthermore, the measurement model of LISREL permits investigators to test various assumptions about alternative factor structures so that they can select a best fitting model for the given data. Figure 1 shows, in part, the measurement model component of the basic LISREL model used in this study. It involves two latent variables (depicted by circles in Figure 1) observed over two occasions of measurement, one for mothers' beliefs about children's math ability, and the other for children's beliefs about their own math ability. Each latent variable is assumed to be measured by multiple indicators (depicted by rectangular boxes in Figure 1) in the model.

The structural equation model component of LISREL, on which we will concentrate in this study, allows theorists to test conceptual connections among a set of latent factors (Alwin, 1988). The structural equation modeling component of the basic LISREL model shown in Figure 1 illustrate how our latent factors are interrelated over time. In an effort to address causal issues in specific, we adopted a basic LISREL model incorporating both auto-regression analysis and cross-lag regression analysis. First, the basic feature of auto-regression is that each variable causes itself over time. These auto-regressive coefficients (represented by $\beta 1$ and $\beta 2$ in Figure 1) are presumed to provide information about the stability or change of an individual variable over time. The auto-regression analysis has been argued to be an optimal modeling technique for studying stability and change in developmental applications (Jöreskog, 1979). Second, cross-lag regression analysis provides the most crucial information about the predicted causal relations in the socialization of math ability beliefs. Cross-lag regression analysis of latent variables with their multiple indicators is suggested to be an appropriate technique to address causality issues (Rogosa, 1979). By regressing an effect variable on its causal antecedent variable, a coefficient is generated that estimates the magnitude of causal influence, partialed for auto-regression effect. By examining the relative sizes of cross-lag regression coefficients (represented by $\beta 3$ and $\beta 4$ in Figure 1), one can test the compatibility of data with alternative causal predictions (i.e., the direction of causality and the magnitude of causal effects) regarding the relations between the ability beliefs held by mothers and children. In addition, by using the multiple group analysis approach of the LISREL program (Alwin & Jackson, 1981), we tested various assumptions about the equalities or differences between age groups as well as between gender groups. Using the same approach, we were able to obtain parameter estimates for multiple groups simultaneously.

Results

LISREL analyses started with a series of tests of various measurement models to select a best fitting model for each study sample. Table 2 presents goodness of fit information for the different models tested separately for each of the three study samples. Model selection process started first with a within-sample null model (M0) in which there were no constraints imposed either over time or across groups within a study sample. As the χ^2/df goodness of fit index indicates, there was substantial lack of fit between the model and the data. Second, M1 allowed errors of the same measured variables to be correlated over time. As the changes in df and χ^2 from M0 to M1 indicate, the improvement of model fit was significant ($p < .001$) for all three study samples. Third, M2 added a stationary factor structure constraint, which means that factor loadings of each measured variables on the corresponding latent variable do not change over time. This assumption about the stationary factor structure was supported. We continued with this model fitting process to achieve as parsimonious a model as possible, while at the same time retaining as good a fit of model to data as possible. As Table 2 shows, however, other additional, more constraining assumptions such as equal error variance and covariance over time were not upheld in the ensuing tests. Therefore, M2 model with correlated errors and stationary factor structure assumptions was selected as the base model for the following multiple group analysis. Figure 2 illustrates the parameter specifications (λ s and θs) used for the base measurement model.

Next, we used LISREL to do multiple group comparisons (Alwin & Jackson, 1981; Jöreskog, 1979). This approach allowed us to test various assumptions about the equalities or differences, first between age groups within each Study samples, and then between gender groups. As a starting point, the constraints of equal factor patterns between age groups and genders were imposed on the first model (M.gr.1 and M.sx.1 for each Study). We applied similar model selection process as stated above to identify the final LISREL measurement model to be used to estimate the regression parameters of interest. As Table 3 shows, in Studies 2 and 3, the assumption of invariant factor loadings across grades was retained for the final model (M.gr.2). However, in Study 1, the same assumption was rejected ($p < .02$). The dissimilar factor loadings of 9th to 12th graders from those of 5th and 6th graders may have resulted from developmental changes in the math ability beliefs. Therefore, in Study 1, M.gr.1 model was used as the final model to estimate causal parameters separately for two different age groups. Finally, it is interesting to note that there are more in common between gender groups than between age groups in terms of the factor structures of math ability beliefs. Table 4 shows that additional equality assumptions like equal measurement errors for girls and boys were upheld for two of the three study samples. However, because assumptions about the equality between genders varied across studies, we decided to apply M.sx.2 uniformly across all studies as our final model for parameter estimations.[3]

<u>Age Differences</u>

Convergent findings across all three study samples showed that mothers' beliefs about their children's math ability were consistently more stable over time than were those of the children. LISREL estimates of stability in Table 5 reveal the difference between mothers and children. The auto-regression coefficients for mothers from Year 1 to Year 2 (β_1) averaged .69, ranging from .60 to .81, which means that, overall, mothers' beliefs were fairly stable, but yet were subject to substantial change over the interval of a year. In contrast, the auto-regression coefficients for children (β_2) averaged .46, ranging from .22 to .61, which means that change is a rule rather an exception in children's math ability perception over the interval of a year, particularly among the youngest children. Children's ability beliefs showed a developmental pattern of increasing stability: namely, they were very unstable in the early elementary school years, and somewhat more stable by high school years. The synchronous factor correlations (ψ_{21}) between mothers' and children's beliefs at Year 1 also got stronger across the age groups. This means that the mothers' and children's ability beliefs have more in common as children get older and have had more experience with school math. The factor correlation coefficients for mothers and first and second grade children averaged .25, for fourth through sixth grade children and their mothers .58, and for the high school students and their mothers, .62 (not shown in Tables).

A close look at the relative sizes of two causal effects shown in Table 6 reveals very crucial information about the role of mothers in the socialization of children's ability beliefs. We found modest but significant positive causal influences of mothers' beliefs about children's math ability on children's own ability beliefs for second to sixth graders, even in the midst of fluctuating ability beliefs on both parts. The cross-lag regression effects of mothers' beliefs Year 1 on children's beliefs Year 2 (β_3) averaged .25 (ranging from .23 to .28) for second to sixth graders. Little evidence of parental influence was observed for the youngest children, i.e., non-significant β_3 of .18 for the 1st graders. Interestingly, by the time children reached high school mother's influence on children's ability beliefs is again non-significant. Additionaly, we found very little sign of reverse impact of children's beliefs on mothers' beliefs at any age level. All of the causal effects of children's beliefs Year 1 on mothers' beliefs Year 2 (β_4) failed to reach the significance level (α=.05) with the singular exception of sixth graders in Study 2. [4]

Figure 3 summarizes a couple of developmental pattern in the causal relations between mothers' and children's math ability beliefs. First, the stability of children's math ability beliefs increases with age, and finally it approaches the level of mothers' by high school years. Second, the divergence of β_2 from β_3 illustrates that, as the stability of children's ability beliefs increases, the influence of mothers' beliefs on children's beliefs decreases.

Cohort Differences

The comparison of the fifth and sixth graders of Study 1 with the same age children in Study 2 revealed no cohort difference in the stability of both mothers' and children's math beliefs (see Tables 5 & 6). Surprisingly, however, there are some dissimilarities between the two cohorts with respect to the causal influences, which is rather odd and difficult to interpret. For one thing, unlike the young adolescents of Study 2, the counterparts of Study 1 were not affected by their mothers with respect to their beliefs about math ability. A few explanations may help interpret these unexpected findings. First, the disparity is due to the fact that two cohorts are drawn from two different populations. Second, the divergent findings may result from the fact that the parents' measures used in two studies were not identical (see Table 1). Third, sample size made a difference in showing the statistical significance. For another, as mentioned above, the sixth graders of Study 2 showed some peculiar deviation from the general pattern of the lack of child-to-mother influence.

Gender Differences

We found some gender differences in the stability of the mothers' beliefs about their children's math ability. LISREL estimates in Table 7 reveal these differences. For example, mothers of early adolescent girls (grades 5 & 6) maintained their beliefs about their daughters' ability more consistently over a year than mothers of early adolescent sons (β_1.girls= .66 vs. β_1.boys= .49). But, there was no difference in the relations between Year 1 and Year 2 beliefs for mothers of sons or daughters at elementary school levels (β_1.girls=.73 vs. β_1.boys=.76). Next, when we examined the stability of individual differences in children's own math ability perception, we found that boys' beliefs were somewhat less changeable than girls' beliefs both among young elementary school students (β_2.boys=.43 vs. β_2.girls=.31) as well as among the middle school students (β_2.boys=.55 vs. β_2.girls=.46).

As was the case for the age comparisons, the gender comparisons of cross-lagged effects show that, for both boys and girls, mothers' Year 1 beliefs influenced children's Year 2 beliefs rather than the reverse, although the coefficients were not significant in the high school group (see Table 8). The one interesting exception to this pattern was for the fifth and sixth graders in Study 2. Their cross-lagged regression coefficients (β_3=.28) suggested that mothers' beliefs have a modest and significant influence on girls' but not on boys' math ability beliefs. Also, boys' ability beliefs but not girls' ability beliefs had a significantly positive effect (β_4=.25) on their mothers' beliefs about their math ability (see Note 4).

Discussion

These results provide important new information about the nature of relations between mothers' beliefs about their children's ability and children's own ability beliefs at different stages in children's development. With few exceptions (Alexander & Entwisle, 1988), most studies of relations between parents' and children's beliefs have been cross-sectional. Our longitudinal, multiple-cohort study allows us to make stronger inferences about the nature of the causal direction between parents' (in this case, mothers') beliefs about their children and children's own beliefs. Our results support the view that, during the elementary and middle grades school years, mothers' beliefs about their children's ability influence children's own ability beliefs more than children's beliefs about their ability influence mothers' beliefs. In terms of socialization theory, our results support the idea that the causal direction between mothers' and children' beliefs about ability (at least in math domain) seems to be unidirectional rather than bidirectional.

A logical next step this study might take would be to extend this line of causal modeling to other domains of interest (e.g., reading or sports) or other achievement related beliefs (e.g., values). Researchers also need to assess more directly some of the processes by which parents' beliefs about children's ability actually do influence children's own beliefs (see Eccles et al., in press; Eccles et at., 1991). What kinds of messages do parents give to their children about their ability? How do different parents react to and talk to their children about both high and low marks on children's report cards? How do children of different ages interpret that feedback? Assessing these kinds of communications between parents and children of different ages would give us a better understanding of the relations between parents' and children's beliefs about children's ability.

It also would be interesting to explore how parents' beliefs about their children's abilities are formed. How do parents interpret children's achievement outcomes, such as their marks on individual tests and assignments, and their quarterly grades? Alexander and Entwisle (1988) found that parents' expectancies for their children's marks do change in response to the kinds of marks their children receive. Similarly, Eccles has repeatedly shown a strong linkage between parents' rating of their children's abilities and the children's grades (Parsons et al., 1982; Eccles, 1984b). Jacob and Eccles (1992) found that parents' perception of their children's abilities are affected by the parents' gender-role stereotypes. Furthermore, both Yee and Eccles (1988) and Eccles et al. (in press) found that parents' causal attributions for their children's performance also influence parents' perception of their children's abilities. Phillips (1991) has also done some intriguing work showing that some parents are quite accurate in their understanding of their children's ability, whereas others either under or over estimate their children's abilities. Phillips found that parents who under estimate their child's abilities have children who themselves doubt their own ability. These results are another indication of the kind of impact parents' beliefs about their children can have on their sense of ability.

Although our results do suggest that mothers' beliefs about children's ability causally influence children's own beliefs, the relations between mothers' and children's beliefs are not that strong, which means that there are other things influencing children's own beliefs. We find it especially interesting that by high school there no longer exist significant relations between parents' and children's beliefs. We interpret this finding to mean that by high school children's own beliefs are stable enough and are linked strongly enough to objective feedback that their parents no longer have much of an influence. In other word, children are now able to interpret the feedback directly while earlier they may have relied more on their parents' interpretations. Still another possibility is that the diminishing parental influence at adolescence could result from the "distancing" in parent-child relations that occurs at adolescence (see Steinberg, 1989); perhaps the adolescents in our study did not share much about their performance in school, so that their parents did not have very clear ideas about how they were doing. Parents' main information may come from the quarterly report cards their children receive, which might not be enough information for them to monitor closely how their children are doing in different school subjects. Particularly if their children are doing well in school, perhaps during high school parents do not monitor their performance that closely (see Epstein, 1990, for discussion of how parents' involvement in their children's schooling decreases during secondary school).

Our results also provide information about longitudinal relations in children's own beliefs at different ages, showing how those relations are stronger among older children. In the youngest children, auto-regression coefficients of their ability beliefs Year 1 to Year 2 are .22; for adolescents, the auto-regression coefficients are as high as .60 (refer to Table 5). These findings suggest that children's own beliefs become more stable as they proceed through elementary school, perhaps because children become increasingly sophisticated at processing the evaluative feedback they receive. As they receive more marks, test scores, and verbal feedback from teachers, children likely begin to have a clearer sense of their own abilities in different subject areas. Indeed, other researchers have found that as they get older children's beliefs about their ability relate more closely to their actual performance (Nicholls, 1979; Parsons & Ruble, 1978; Stipek, 1981). Our findings may be another indication of how children's beliefs become more "settled" as they proceed through school. It would be interesting to assess whether the increasingly strong correlation between children's beliefs about their math ability across a one-year period also means that more children have the sense that their ability is something they cannot change very much. Our correlational findings do not address that issue directly, but such a change in beliefs about the nature of ability could be a reason why the correlations are higher among older children. If children believe their ability is stable, the correlations between their ability beliefs may remain more consistent from one year to the next than if they believe their ability is quite changeable.

Interestingly, in contrast to children's own beliefs, the longitudinal relations in mothers' beliefs about their children were similar for mothers of younger and older children. We had anticipated that among the mothers of younger children relations across year in their beliefs about their children's ability may be lower, because the mothers also may be in the process of forming their own beliefs about their child's ability in math during the early elementary school years. The fact that these relations are so similar for mothers of 2nd grade children and mothers of 10th graders suggest that mothers' beliefs about their child's ability are relatively consistent quite early on. This finding raises further questions about how parents' beliefs about their children's math ability are formed, what information they use in making their judgments, and when parents' beliefs become relatively firmly established.

In sum, our results extend those of earlier research by showing how mothers' and children's beliefs about children's math ability relate to each other over time, at different time points in development. Researchers should build on this work by examining how both parents and children develop their beliefs about ability, and how parents communicate their beliefs to children, thus influencing children's own ability beliefs.

Reference Notes

1 Due to their small sample size, seventh and eighth graders of Study 1 were not included in the age comparisons.

2 We believe that LISREL's analytic technique employing latent variables with multiple indicators is robust enough to handle any problems involving the non-identical but conceptually similar measures like ours.

3 Due to the unequal factor structure between 5th and 6th graders and 9th through 12th graders, we decided to examine gender differences in the latter age group only in Study 1.

4 This singular finding should not be ignored entirely as anomaly, since similar significant effect was found on fathers' data of the same sample. It is quite likely that its relatively large sample size of 6th graders (N=817) in Study 2 (compared to other samples, which ranges from 97 to 164) may have made it possible to reach rather divergent estimates.

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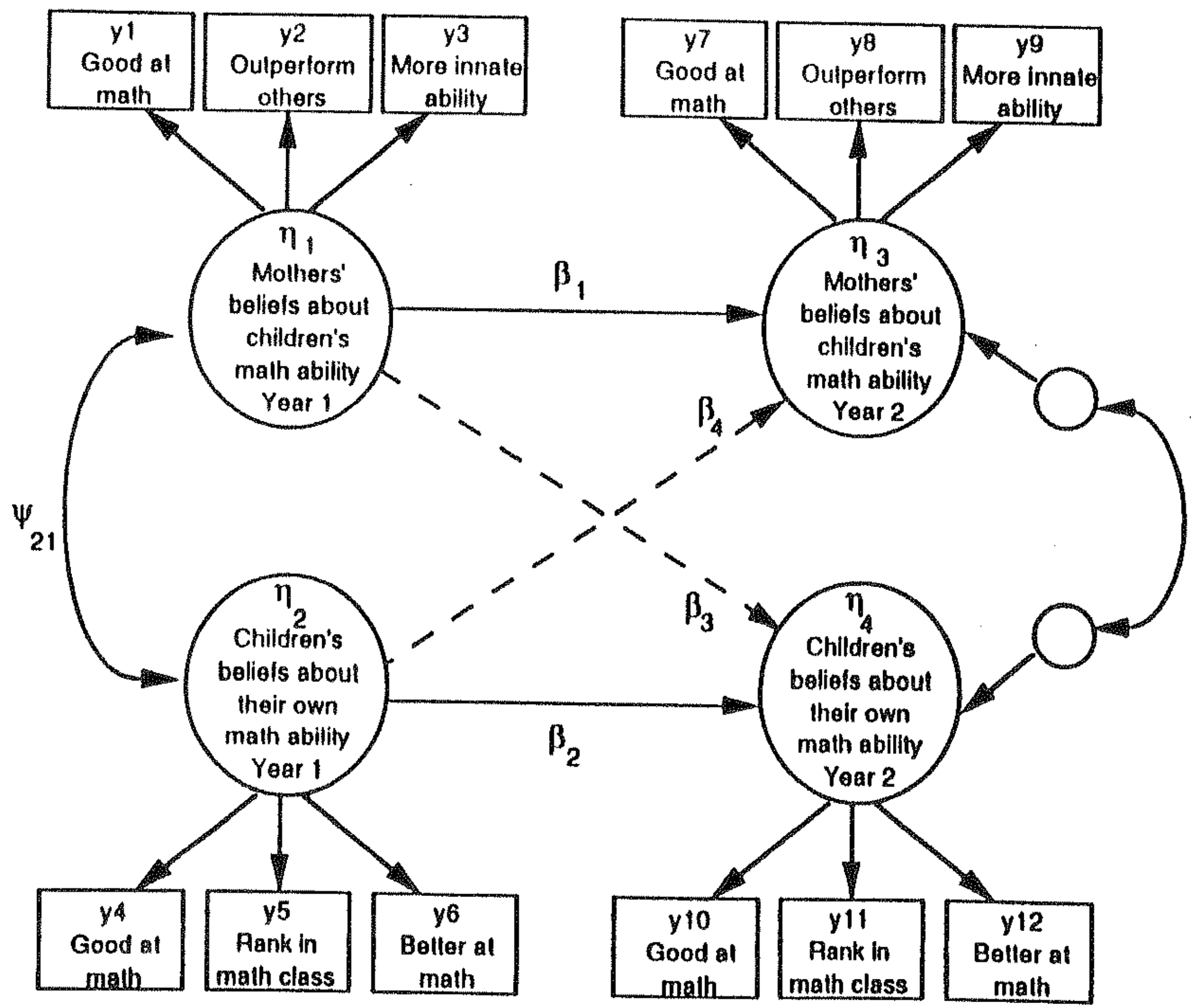
Table 1: Latent Variables and Measured Variables with Question Items Used in Three Longitudinal Studies

Latent Variables	Measured Variables with Their Question Items and Response Scales		
	Study 1	Study 2	Study 3
η1 Mothers' Beliefs about Children's Math Ability	y1 My child is 1. not at all good at math 7. very good at math y2 In comparison to other academic subjects, my child is 1. much worse in math than in other subjects 7. much better in math than in other subjects	y1 In general, I believe that my child is 1. not at all good at math 7. very good at math y2 How well is your child doing in math this year? 1. not at all well 7. very well	y1 How good is this child in math? 1. not at all good at math 7. very good at math y2 In comparison to other children, how would you evaluate this child's performance in math? 1. much worse 7. much better y3 In comparison to other children, how much innate ability or talent does this child have in math? 1. much worse 7. much better
η2 Children's Beliefs about Their Own Math Ability	y4 How good at math are you? 1. not at all good at math 7. very good at math y5 If you were to order all the students in your math class from the worst to the best in math, where would you put yourself? 1. one of the worst 4. in the middle 7. the best y6 Compared to most of your other school subjects, how good are you at math? 1. much worse 7. much better	y4 Same as Study 1 y5 Same as Study 1 y6 Same as Study 1	y4 Same as Study 1 y5 Same as Study 1 y6 Same as Study 1

Note:

1. Same variables are repeatedly measured at Year 2. See Figure 1 for the variable numbers of Year 2.
2. See Figure 1 to match the variable numbers and variable names with the LISREL notions.

Figure 1: Basic LISREL Model Showing both Measurement Model Component and Structural Equation Model Component



Note: 1. Auto-regression paths are depicted by solid lines with a single arrow, and their coefficients are β_1, β_2

2. Cross-lagged regression paths are depicted by dashed lines with a single arrow, and their coefficients are β_3, β_4

3. ψ_{12} is the synchronous factor correlation between mothers' and children's beliefs at Year 1.

4. For the sake of simplicity, the error terms of measurement model are not shown (see Figure 2).

5. Measured variables of Study 3 were presented here. See Table 1 for the variables of Studies 1 & 2.

Table 2: Tests of Goodness of Fit of Alternative Base Models in Three Longitudinal Studies ¶

Study 1

Model	Constraints	df	Chi-square	*p*	GFI	Chi-square/ df	Model Comparison	df change	Chi-square change	*p*
M0	no constraints	29	144.80	.000	.898	4.993				
M1	with correlated error terms	24	60.37	.000	.956	2.515	M0-M1	5	84.43	<.001
M2§	equal factor loadings over time	27	62.25	.000	.955	2.306	M2-M1	3	1.88	ns
M3	equal error var. & cov. over time	32	75.15	.000	.946	2.348	M3-M2	5	12.90	<.05
M4	equal factor var. & cov. over time	30	79.10	.000	.945	2.637	M4-M2	3	16.85	<.001

Study 2

Model	Constraints	df	Chi-square	*p*	GFI	Chi-square/ df	Model Comparison	df change	Chi-square change	*p*
M0	no constraints	29	230.95	.000	.956	7.964				
M1	with correlated error terms	24	59.25	.000	.987	2.469	M0-M1	5	171.70	<.001
M2§	equal factor loadings over time	27	62.36	.000	.987	2.310	M2-M1	3	3.11	ns
M3	equal error var. & cov. over time	32	170.34	.000	.965	5.323	M3-M2	5	107.98	<.001
M4	equal factor var. & cov. over time	30	92.27	.000	.981	3.076	M4-M2	3	29.91	<.001

Study 3

Model	Constraints	df	Chi-square	*p*	GFI	Chi-square/ df	Model Comparison	df change	Chi-square change	*p*
M0	no constraints	48	103.73	.000	.945	2.161				
M1	with correlated error terms	42	54.80	.088	.971	1.305	M0-M1	6	48.93	<.001
M2§	equal factor loadings over time	46	61.12	.067	.968	1.329	M2-M1	4	6.32	ns
M3	equal error var. & cov. over time	52	84.48	.003	.957	1.625	M3-M2	6	23.36	<.001
M4	equal factor var. & cov. over time	49	108.12	.000	.944	2.207	M4-M2	3	47.00	<.001

Note:

¶ Tests are based on the entire sample of each Study.

§ demotes the base model of choice.

GFI stands for Goodness of Fit Index.

Figure 2: The Base LISREL Model and its Parameters to be Estimated with Multiple Group Analyses in Study 3

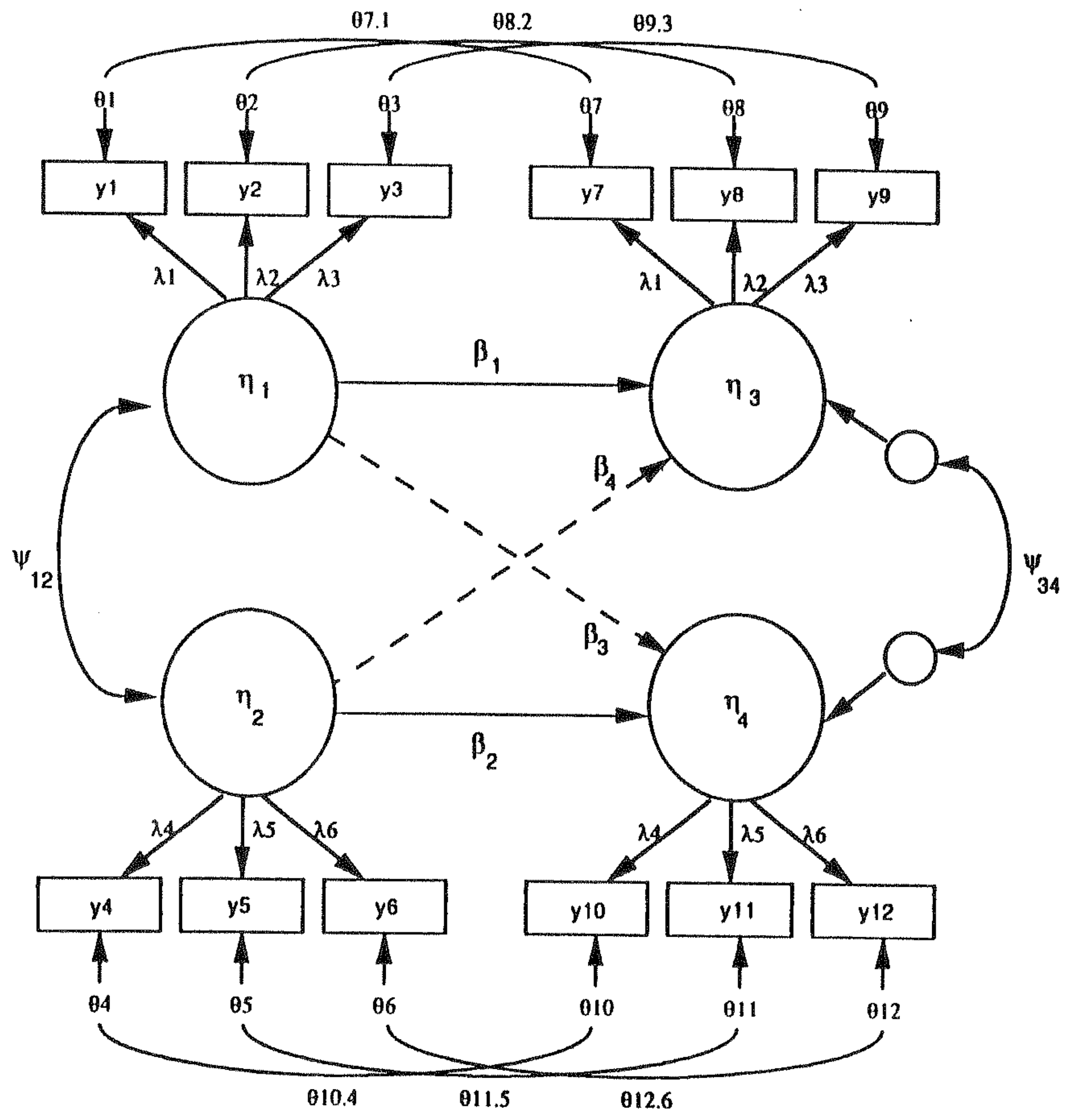


Table 3: Tests of Goodness of Fit of Alternative Multiple Age Group Models in Three Longitudinal Studies

Study 1

Model	Constraints	Chi-Square	df	*p*	GFI	Chi-square/ df	Comparison	Chi-Square change	df change	*p*
M.gr.1 †	Equal factor patterns across groups added to base model	88.24	54	.002	.943	1.634				
M.gr.2	Equal factor loadings across groups added to M.gr.1	99.50	57	.000	.935	1.746	M.gr.2-M.gr.1	11.26	3	<.02
M.gr.3	Equal errors across groups added to M.gr.2	116.84	72	.001	.929	1.623	M.gr.3-M.gr.2	17.34	15	ns

Study 2

Model	Constraints	Chi-Square	df	*p*	GFI	Chi-square/ df	Comparison	Chi-Square change	df change	*p*
M.gr.1	Equal factor patterns across groups added to base model	94.59	54	.001	.986	1.752				
M.gr.2 †	Equal factor loadings across groups added to M.gr.1	100.85	57	.000	.985	1.769	M.gr.2-M.gr.1	6.26	3	ns
M.gr.3	Equal errors across groups added to M.gr.2	193.23	72	.000	.970	2.684	M.gr.3-M.gr.2	92.38	15	<.001

Study 3

Model	Constraints	Chi-Square	df	*p*	GFI	Chi-square/ df	Comparison	Chi-Square change	df change	*p*
M.gr.1	Equal factor patterns across groups added to base model	171.04	138	.029	.919	1.239				
M.gr.2 †	Equal factor loadings across groups added to M.gr.1	180.71	146	.027	.917	1.238	M.gr.2-M.gr.1	9.67	8	ns
M.gr.3	Equal errors across groups added to M.gr.2	287.83	182	.000	.841	1.581	M.gr.3-M.gr.2	107.12	36	<.001

Note:

† demotes the final model of choice.

GFI stands for Goodness of Fit Index.

Table 4: Tests of Goodness of Fit of Alternative Multiple Gender Group Models in Three Longitudinal Studies

Study 1

Model	Constraints	Chi-Square	df	*p*	GFI	Chi-square/ df	Comparison	Chi-Square change	df change	*p*
M.sx.1	Equal factor patterns across groups added to base model	117.43	54	.000	.944	2.175				
M.sx.2 †	Equal factor loadings across groups added to M.sx.1	124.91	57	.000	.935	2.191	M.sx.2-M.sx.1	7.48	3	ns
M.sx.3	Equal errors across groups added to M.sx.2	147.49	72	.000	.926	2.048	M.sx.3-M.sx.2	22.58	15	ns
M.sx.4	Equal var. & cov. across groups added to M.sx.3	156.71	78	.000	.919	2.009	M.sx.4-M.sx.3	9.22	6	ns

Study 2

Model	Constraints	Chi-Square	df	*p*	GFI	Chi-square/ df	Comparison	Chi-Square change	df change	*p*
M.sx.1	Equal factor patterns across groups added to base model	94.51	54	.001	.985	1.750				
M.sx.2 †	Equal factor loadings across groups added to M.sx.1	100.03	57	.000	.984	1.755	M.sx.2-M.sx.1	5.52	3	ns
M.sx.3	Equal errors across groups added to M.sx.2	129.17	72	.000	.977	1.794	M.sx.3-M.sx.2	29.14	15	<.02
M.sx.4	Equal var. & cov. across groups added to M.sx.3	137.35	78	.000	.976	1.761	M.sx.4-M.sx.3	8.18	6	ns

Study 3

Model	Constraints	Chi-Square	df	*p*	GFI	Chi-square/ df	Comparison	Chi-Square change	df change	*p*
M.sx.1	Equal factor patterns across groups added to base model	120.53	92	.025	.945	1.310				
M.sx.2 †	Equal factor loadings across groups added to M.sx.1	127.22	96	.018	.943	1.325	M.sx.2-M.sx.1	6.69	4	ns
M.sx.3	Equal errors across groups added to M.sx.2	155.13	114	.006	.929	1.361	M.sx.3-M.sx.2	27.91	18	ns
M.sx.4	Equal var. & cov. across groups added to M.sx.3	168.86	120	.002	.921	1.407	M.sx.4-M.sx.3	13.73	6	<.05

Note:

† demotes the final model of choice.

GFI stands for Goodness of Fit Index.

Table 5: LISREL Estimates of Stability of Mothers' and Children's Beliefs: Auto-Regression Coefficients for Different Age Groups of Three Study Samples §

			Stability Measures	
			Mothers' Beliefs	Childrens' Beliefs
Sample ¶	Age Group	N	β1	β2
Study 3	1st grade	97	.71	.22 ns
	2nd grade	109	.81	.47
	4th grade	99	.71	.47
Study 2	5th grade	125	.59	.41
	6th grade	817	.60	.53
Study 1	5-6th grades	102	.70	.49
	9-12th grades	164	.71	.60

Table 6: LISREL Estimates of Causal Effects of Mothers' and Children's Beliefs: Cross-Lag Regression Coefficients for Different Age Groups of Three Study Samples §

			Causal Effects	
			Mother-to-Child	Child-to-Mother
Sample ¶	Age Group	N	β3	β4
Study 3	1st grade	97	.18 ns	.07 ns
	2nd grade	109	.28	.05 ns
	4th grade	99	.25	.13 ns
Study 2	5th grade	125	.24	.04 ns
	6th grade	817	.23	.17
Study 1	5-6th grades	102	.17 ns	.05 ns
	9-12th grades	164	.01 ns	.12 ns

Note:

§ LISREL estimates shown here are common metric completely standardized estimates.

¶ The presentation of the results is based on the age of children (i.e., from younges to oldest), rather than on the chronological order of the studies.

ns Not significant. All other coefficients are significant at least at $p<.05$ level.

Figure 3: Developmental Patterns in the Causal Relations between Mothers' and Children's Math Ability Beliefs

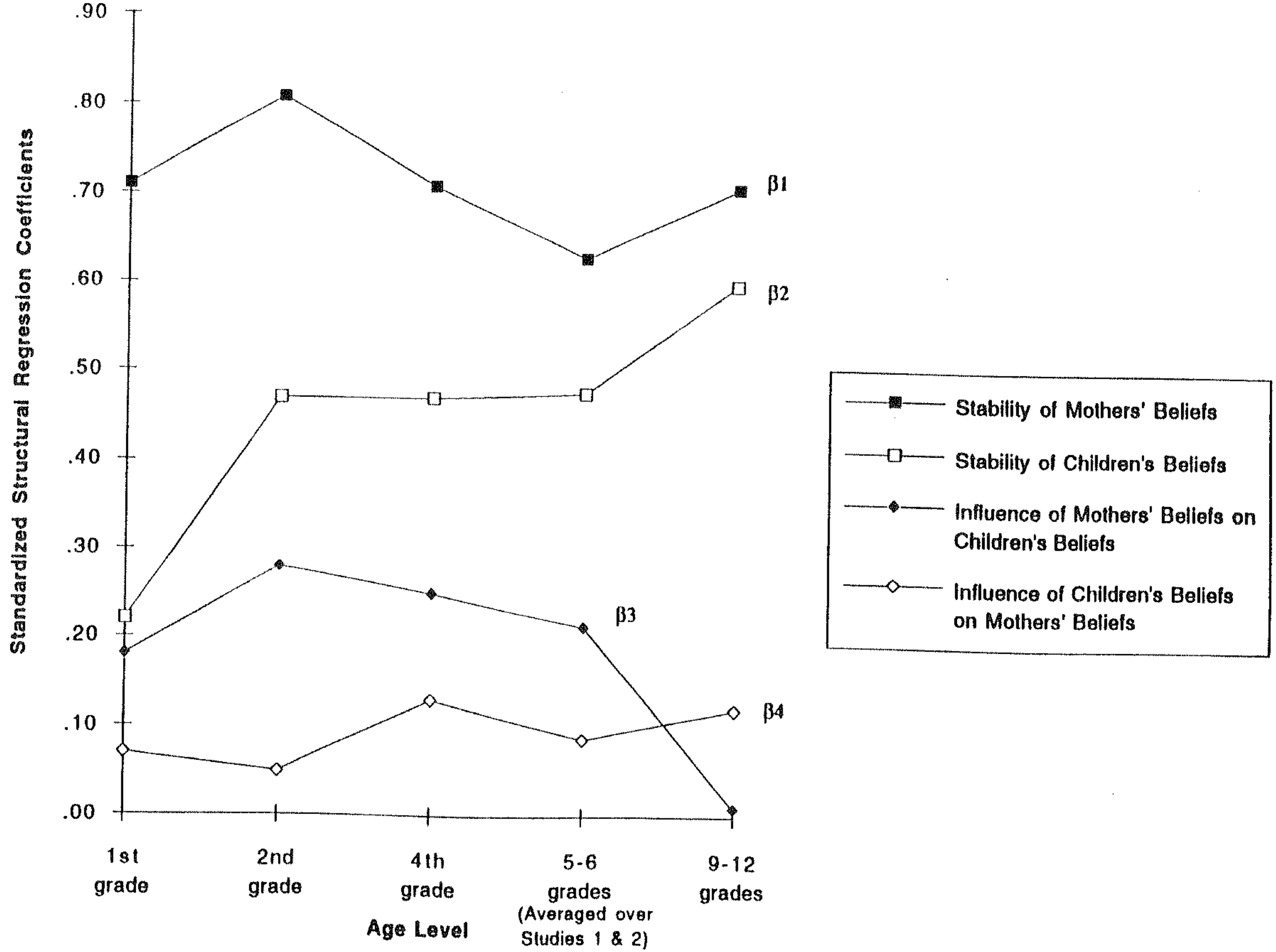


Table 7: LISREL Estimates of Stability of Mothers' and Children's Beliefs: Auto-Regression Coefficients for Girls and Boys of Three Study Samples §

				Stability Measures			
				Mothers' Beliefs $\beta 1$		Childrens' Beliefs $\beta 2$	
		N					
Sample ¶	Age Group	Girls	Boys	Girls	Boys	Girls	Boys
Study 3	Grades 1-2,4	155	150	.73	.76	.31	.43
Study 2	Grades 5-6	465	478	.66	.49	.46	.55
Study 1	Grades 9-12	185	193	†	.76	†	.47

Table 8: LISREL Estimates of Causal Effects of Mothers' and Children's Beliefs: Cross-Lag Regression Coefficients for Girls and Boys of Three Study Samples §

				Causal Effects			
				Mother-to-Child $\beta 3$		Child-to-Mother $\beta 4$	
		N					
Sample ¶	Age Group	Girls	Boys	Girls	Boys	Girls	Boys
Study 3	Grades 1-2,4	155	150	.29	.24	.11 ns	.04 ns
Study 2	Grades 5-6	465	478	.28	.09 ns	.06 ns	.25
Study 1	Grades 9-12	185	193	†	.06 ns	†	.11 ns

Note:

§ LISREL estimates shown here are common metric completely standardized estimates.

¶ The presentation of the results is based on the age of children (i.e., from youngest to oldest), rather than on the chronological order of the studies.

ns Not significant. All other coefficients are significant at least at $p<.05$ level.

† LISREL program failed to estimate the paremeters for girls in Study 1.