

Journal of Consulting and Clinical Psychology

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Online First Publication, January 11, 2016. <http://dx.doi.org/10.1037/a0039937>

CITATION

Nix, R. L., Bierman, K. L., Heinrichs, B. S., Gest, S. D., Welsh, J. A., & Domitrovich, C. E. (2016, January 11). The Randomized Controlled Trial of Head Start REDI: Sustained Effects on Developmental Trajectories of Social-Emotional Functioning . *Journal of Consulting and Clinical Psychology*. Advance online publication. <http://dx.doi.org/10.1037/a0039937>

The Randomized Controlled Trial of Head Start REDI: Sustained Effects on Developmental Trajectories of Social–Emotional Functioning

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Objective: This study assessed the sustained effects of Head Start REDI (Research-based, Developmentally Informed), a randomized controlled preschool preventive intervention, on children’s developmental trajectories of social–emotional functioning into elementary school. **Method:** Twenty-five Head Start centers with 44 classrooms were randomly assigned to deliver Head Start REDI or Head Start as usual. Head Start REDI featured an integrated language-emergent literacy and social-emotional skills curriculum and enhanced support for positive teaching practices. The 356 4-year-old children (54% girls; 25% African American; 17% Latino; 70% living in poverty) in those centers and classrooms were followed for 5 years (from preschool through third grade; 91% retention rate). Each year, teachers rated multiple domains of social–emotional functioning. Person-oriented latent class growth models were used to identify the different developmental trajectories of social–emotional functioning that children followed. **Results:** Tests of proportions revealed that children who had been in the Head Start REDI intervention were statistically significantly more likely than children in the control condition to follow the most optimal developmental trajectories of social competence, aggressive–oppositional behavior, learning engagement, attention problems, student–teacher closeness, and peer rejection (odds ratio = 1.60–1.93). **Conclusions:** These findings suggest that enriching Head Start with evidence-based curriculum components and teaching practices can have long-lasting benefits for children’s social–emotional functioning. These findings elucidate how high-quality preschool experiences promote core competencies that are critical to the school success of children living in poverty.

What is the public health significance of this article?

When children participated in the enriched preschool program Head Start REDI, they were more likely to follow optimal developmental trajectories of social–emotional functioning through third grade. Ensuring that all children living in poverty have access to high-quality preschool may be one of the more effective means of reducing disparities in school readiness and increasing the likelihood of lifelong success.

Keywords: school readiness, early intervention, social–emotional learning, developmental trajectories

Supplemental materials: <http://dx.doi.org/10.1037/a0039937.supp>

This study tested the long-lasting effects of Head Start REDI (research-based, developmentally informed), a preventive intervention that enriched the Head Start curriculum and provided teachers with professional development support (Bierman, Domitrovich, et al., 2008). At the end of preschool, children who had been in the randomly assigned Head Start REDI

intervention classrooms demonstrated clear advantages over children who had been in Head Start “as usual” control classrooms in terms of language-emergent literacy skills and social–emotional functioning. Some of the intervention effects on language-emergent literacy skills had faded by the first follow-up assessment, when children were in kindergarten, but

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This project was supported by National Institute of Child Health and Human Development Grant HD046064. We thank Nilam Ram, the REDI research

team and clinical staff members, our Head Start partners, and all of the teachers and children who made this study possible. Celene E. Domitrovich is an author of the Preschool PATHS curriculum, has a royalty agreement with Channing Bete, Inc., and receives income from PATHS Training, LLC. All potential conflicts of interest have been reviewed and managed by the Individual Conflict of Interest Committee at Penn State.

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most of the effects on social–emotional functioning were still evident, especially when children matriculated at higher risk elementary schools (Bierman et al., 2014). This study examined whether Head Start REDI had sustained effects on children’s developmental trajectories of social–emotional functioning through third grade, 4 years after children participated in the enriched preschool curriculum.

Changing Lives With High-Quality Preschool

The purpose of Head Start is to promote the school readiness of children living in poverty through comprehensive, high-quality early education services. By nurturing children’s cognitive and social–emotional skills in preschool, Head Start seeks to place children on more positive developmental trajectories as they enter elementary school, enhancing their capacity to benefit from later educational experiences. The possibility that high-quality preschool can have lasting benefits is evident from model programs, such as the Abecedarian and the High/Scope Perry Preschool studies, which improved high school graduation rates and adult employment (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002; Schweinhart et al., 2005). This possibility is also evident from more universal programs: Children who attend Head Start, compared to their siblings who do not attend Head Start, exhibit better well-being in young adulthood, as reflected in a summary index of high school graduation, college attendance, unemployment, crime, adolescent parenthood, single-parent status, and physical health (Deming, 2009).

Positive preschool effects on adult adjustment have emerged despite evidence that positive preschool effects on academic test scores often fade during elementary school (Deming, 2009; Schweinhart et al., 2005). These findings highlight the importance of high-quality preschool on social–emotional functioning. Preschool enrichments that promote lasting gains in social–emotional functioning may contribute in critical ways to the positive school adaptation and long-term adjustment of children growing up in poverty (Heckman, 2006).

Domains of Social–Emotional Functioning and School Success

The key domains of social–emotional functioning associated with school adaptation and long-term adjustment include social behavior (e.g., social competence and control of aggressive–oppositional impulses), learning behavior (e.g., active and curious learning engagement and the ability to focus attention), and positive interpersonal relationships with teachers and peers (Boivin & Bierman, 2014; La Paro & Pianta, 2000). These skill domains are interdependent developmentally. For example, growth in social competence, such as cooperation and negotiation skills, promotes the capacity to manage conflict peacefully and thereby reduces aggression and fosters positive peer interactions (Bierman, 2004; Greenberg, 2006). Children who are more socially competent also show heightened learning engagement in the classroom and tend to form more positive relationships with teachers (Buhs, Ladd, & Herald, 2006; Hughes & Kwok, 2006). Conversely, children who exhibit elevated aggressive–oppositional behavior and attention problems in the classroom are more likely to become embroiled in

conflict with teachers and tend to struggle socially with peers (Denham & Burton, 2003).

These social–emotional skills may improve children’s school adjustment because they increase behavioral compliance to the demands of school and thereby extend the amount of time children spend on task during instructional periods (Buhs et al., 2006). Prior research has demonstrated unique links between learning engagement and attention control in elementary school and positive change in academic achievement (Hughes & Kwok, 2006; McClelland, Acock, & Morrison, 2006). These noncognitive factors also may reflect and promote more positive emotional experiences at school and enhance motivation for learning. That is, children who identify with the goals of their schools and believe they are an integral part of a positive community of learners appear more committed to persevere in effortful learning tasks and to strive for success (Farrington et al., 2012). In addition, positive teacher and peer relationships promote school bonding, which is linked with attendance, high school graduation, and future employment (Hawkins, Guo, Hill, Battin-Pearson, & Abbott, 2001).

In these ways, improved social–emotional functioning may enhance educational attainment. Providing corroborative support to this developmental research, a recent meta-analysis demonstrated that preventive interventions designed to improve children’s social–emotional functioning contributed significantly to behavioral adjustment, constructive learning engagement, positive interpersonal relationships, and school success (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011).

Social–Emotional Functioning and Children Living in Poverty

When children, like those in Head Start, are growing up under conditions of adversity, promoting social–emotional functioning may be critical to fostering readiness for self-directed learning. Poverty often increases children’s exposure to multiple stressors, including family instability, crowded living conditions, and community violence. Hence, it may be especially important for these children to learn to understand and manage their feelings and to develop interpersonal relationships that provide emotional support (Denham & Burton, 2003; Greenberg, 2006). Because children living in poverty are more likely to attend lower quality schools with classmates who are also struggling, social–emotional functioning may be even more important to school success than it is for most children (Georges, Brooks-Gunn, & Malone, 2012).

Unfortunately, children growing up in poverty are particularly likely to exhibit significant deficits in social–emotional functioning at school entry. Over 40% of low-income children demonstrate delays in social competence and learning engagement at school entry, and over 20% exhibit high rates of aggressive–oppositional behavior (Kaiser, Hancock, Cai, Foster, & Hester, 2000). Thus, preschool experiences that promote social–emotional functioning may be especially important in placing low-income children on adaptive developmental trajectories that ultimately result in educational, employment, and personal benefits (Denham & Burton, 2003).

The Effects of Preventive Interventions on Children's Developmental Trajectories

Although the purported goal of many preschool interventions is to change children's developmental trajectories, very few evaluations actually assess developmental trajectories as outcomes. Instead, most evaluations examine intervention–control group differences at the end of treatment to document initial impact and again at some later point in time to determine whether effects have been sustained. Although informative, these kinds of evaluations provide little information about developmental trajectories and the ways in which early intervention may have changed the course of children's adaptation over time.

Person-oriented latent class growth models, which can simultaneously estimate multiple shapes of developmental trajectories, are particularly appropriate for the study of social–emotional functioning (Nagin & Tremblay, 1999). Unlike vocabulary and many academic skills, which tend to grow in a cumulative fashion for all children, social–emotional functioning can improve, get worse, or remain relatively stable over time for different subgroups of children. In recent years, person-oriented latent growth models have been used to document changes in developmental trajectories that occur as a result of intervention (Stulz, Thase, Klein, Manber, & Crits-Christoph, 2010). For example, Lacourse et al. (2002) found that adolescents who had participated in a preventive intervention as young children were significantly more likely to follow a low–stable developmental trajectory of antisocial behaviors and significantly less likely to follow a high–stable developmental trajectory.

The Present Study

The present study sought to determine whether the Head Start REDI program, an intervention delivered during preschool, changed children's developmental trajectories of social–emotional functioning. The initial evaluation of REDI (Bierman, Domitrovich, et al., 2008) indicated that the program had a positive impact at the end of preschool, reflected in significant intervention–control group differences on measures of vocabulary ($d = .15, p < .05$), phonological sensitivity ($d = .35-.39, p < .01$), print awareness ($d = .16, p < .10$), emotion knowledge and social problem-solving skills ($d = .21-.35, p < .05$), teacher ratings of aggression ($d = -.28, p < .05$), and observer ratings of learning engagement ($d = .29, p < .05$). A subsequent evaluation of REDI (Bierman et al., 2014) examined what happened after children transitioned to kindergarten. Significant intervention effects remained on phonemic decoding ($d = .27, p < .05$), social problem-solving skills ($d = .38, p < .01$), teacher ratings of aggression ($d = -.26, p < .05$), and teacher ratings of learning engagement ($d = .27, p < .05$); in addition, new intervention effects emerged on teacher ratings of social competence and attention problems when children matriculated at higher risk elementary schools.

To extend the evaluation of Head Start REDI, the present study used person-oriented latent class growth models to examine children's developmental trajectories in multiple domains of social–emotional functioning, including social competence, aggressive–oppositional behavior, learning engagement, attention problems, student–teacher closeness, and peer rejection. These developmental trajectories spanned the 5-year period in which children tran-

sitioned into kindergarten and adapted to elementary school (e.g., end of preschool, kindergarten, first grade, second grade, and third grade). Compared to assessments of intervention–control group differences at single points in time, these latent class growth models may enhance power to more accurately detect the sustained effects of REDI by fitting models across multiple years, which reduces the error associated with an individual teacher's idiosyncratic perspective on behavior and enhances the capacity to estimate missing data. More importantly, as opposed to traditional variable-centered analyses, these latent class growth models are specifically designed to capture heterogeneity in developmental trajectories. That is, they can show how early preschool experiences might set in place small positive perturbations that consolidate over time and account for the long-term effects on life success evident for some model preschool programs (Campbell et al., 2002; Schweinhart et al., 2005).

Although the exact shape of the developmental trajectories could not be forecast *a priori*, postintervention results suggested that children from Head Start REDI would start elementary school with better levels of social–emotional functioning than children in the control group (Bierman, Domitrovich, et al., 2008). It was hypothesized that Head Start REDI children would continue to follow developmental trajectories reflecting more positive adaptation over time.

Method

This study was conducted with the approval of the Internal Review Board of Pennsylvania State University. Signed consent was obtained from all parents and teachers.

Participants

This study included 356 children (58% European American, 25% African American, 17% Latino; 54% girls, 46% boys) who attended Head Start in three Pennsylvania counties. Reflecting the eligibility requirements of Head Start, 70% of the children came from families living in poverty, with an average income-to-needs ratio of .88. About 31% of primary caregivers had dropped out of high school, and 40% were single parents.

Children were recruited at the beginning of their last year in preschool and represented 86% of the eligible population in 25 Head Start centers with 44 classrooms. The children were followed as they transitioned to 33 school districts, 82 elementary schools, and 202 classrooms in kindergarten and even more districts, schools, and classrooms in first, second, and third grades. As summarized in Table 1, developmental trajectories were estimated for the 325 children (91% of the original sample) who had data from at least 3 of the 5 years included in this study (Nagin, 2005). At baseline, there were no statistically significant differences on any of the study outcomes between children who did and did not have data from at least 3 years.

The Head Start REDI Intervention

At the start of the study, the 25 Head Start centers were stratified on location, number of hours per day in program, and student demographic characteristics and were randomly assigned to the REDI intervention or usual practice conditions; all classrooms

Table 1
Participant Flow Through Study

Randomization	25 Head Start centers including 44 classrooms	
Assessed for eligibility	<i>N</i> = 412 4-year-old children	
Excluded	Withdrew from Head Start: <i>N</i> = 19 Had sibling in study: <i>N</i> = 2 Parent could not be contacted: <i>N</i> = 21 Parent declined to participate: <i>N</i> = 14 Total: <i>N</i> = 56	
Initial participants in study	Head Start REDI	Head Start as usual
	12 Head Start centers 22 classrooms <i>N</i> = 192 children	13 Head Start centers 22 classrooms <i>N</i> = 164 children
Lost to follow-up	Moved: <i>N</i> = 7 Unable to locate: <i>N</i> = 11 Medical problems: <i>N</i> = 1 Refused: <i>N</i> = 4 Total: <i>N</i> = 23	Moved: <i>N</i> = 5 Unable to locate: <i>N</i> = 2 Refused: <i>N</i> = 1 Total: <i>N</i> = 8
Analyzed	<i>N</i> = 169	<i>N</i> = 156

Note. REDI = research-based, developmentally informed.

within a center were assigned to the same condition. The intervention lasted 1 academic year and included 4 evidence-based components targeting language-emergent literacy skills and social-emotional functioning. REDI also provided teachers with extensive professional development support.

REDI included dialogic reading (Wasik, Bond, & Hindman, 2006; Whitehurst et al., 1994), in which teachers used scripted questions and toy props to actively engage children in read-aloud sessions designed to improve understanding of narrative, grammatical syntax, and vocabulary. REDI provided a series of sound games that exposed children at a developmentally appropriate pace to phonological skills, including listening, rhyming, alliteration, and segmenting words (Adams, Foorman, Lundberg, & Beeler, 1998). REDI also provided sequenced activities for an alphabet center, in which children could see, manipulate, and memorize individual letters (Lonigan, Farver, Phillips, & Clancy-Menchetti, 2011). To strengthen children's social-emotional skills, REDI implemented the Preschool PATHS (Promoting Alternative Thinking Strategies) curriculum (Domitrovich, Greenberg, Kusche, & Cortes, 2005), which promotes social competencies (e.g., prosocial behavior and being a good friend), emotion regulation (e.g., recognizing emotions in oneself and others), and control of aggressive impulses (e.g., self-calming and conflict resolution skills).

To ensure that teachers could competently deliver the curriculum and take advantage of ongoing opportunities to help children generalize skills, REDI provided 4 days of in-service workshops delivered by certified program trainers and weekly coaching delivered by master teachers and supervised by REDI personnel. Professional development support included instruction on new lessons as well as mentoring in positive classroom management practices, emotion coaching, and language use. REDI staff members spent an average of 3 hr/week in the classroom and 1 hr/week meeting with teachers.

Assessments of implementation quality documented moderate to strong fidelity. Teachers reported completing 87% of daily

dialogic reading activities, 86% of thrice-weekly sound games, 84% of daily alphabet center activities, and 88% of twice-weekly Preschool PATHS lessons. REDI staff members made monthly ratings of implementation quality and fidelity, which had means of 4.39–4.70, out of 5, across intervention components. Observations by research staff members blind to study condition documented moderate to large intervention-control group differences in the quality of teacher language use and classroom management practices, including supportive emotional climate and positive discipline (Domitrovich et al., 2009).

Measures

Outcomes for this study were based on ratings completed by 6 different teachers over 5 years. Ratings from lead and assistant teachers were collected at the end of Head Start, after the REDI intervention had been implemented, and averaged together. Ratings from kindergarten and first-, second-, and third-grade teachers were collected in the late spring of each academic year.

Social behavior. Social competence was assessed with 13 items representing prosocial behavior and emotion regulation from the Social Competence Scale (Conduct Problems Prevention Research Group, 1995). Sample items were "Shares with others" and "Controls temper when there is a disagreement." All items were rated on a 6-point Likert scale, with response options ranging from *almost never* to *almost always* ($\alpha = .94-.95$ within each of the 5 assessment periods).

Aggressive-oppositional behavior was assessed with 7 items from the Authority Acceptance subscale of the Teacher Observation of Classroom Adaptation—Revised (Werthamer-Larsson, Kellam, & Wheeler, 1991). Sample items were "Fights with other children" and "Ignores or refuses to obey adults." All items were rated on a 6-point Likert scale, with response options ranging from *almost never* to *almost always* ($\alpha = .89-.93$).

Learning behaviors. Learning engagement was assessed with 8 items developed for Head Start REDI. Sample items were "This

Table 2
Means and Standard Deviations of Study Variables Across 5 Years

	Head Start (N = 343)	Kindergarten (N = 321)	First grade (N = 322)	Second grade (N = 302)	Third grade (N = 288)
Social competence					
Intervention	4.15 (.82)*	4.31 (1.01)**	4.14 (.96)	4.30 (.96)**	4.15 (.96)
Control	3.98 (.88)	4.02 (.98)	4.04 (.99)	4.03 (.97)	4.08 (.99)
Aggressive-oppositional behavior					
Intervention	1.91 (.84)*	1.74 (.85)**	1.88 (.85)	1.82 (.83)†	1.89 (.81)
Control	2.07 (.89)	1.96 (.83)	1.95 (.85)	1.99 (.91)	1.95 (.85)
Learning engagement					
Intervention	5.08 (.86)	4.76 (1.11)**	4.60 (1.10)	4.76 (.99)*	4.62 (.99)
Control	4.97 (.90)	4.49 (1.11)	4.57 (.99)	4.51 (1.03)	4.57 (1.04)
Attention problems					
Intervention	.70 (.68)	.91 (.82)	1.00 (.84)	.93 (.77)	.89 (.79)
Control	.73 (.66)	1.02 (.80)	1.06 (.79)	1.03 (.79)	.97 (.85)
Student-teacher closeness					
Intervention	4.41 (.54)†	4.22 (.70)	4.23 (.71)	4.23 (.64)***	4.02 (.70)
Control	4.32 (.50)	4.13 (.64)	4.15 (.65)	3.92 (.76)	3.89 (.82)
Peer rejection					
Intervention	1.57 (.62)	1.51 (.70)	1.67 (.76)	1.63 (.65)**	1.82 (.81)
Control	1.61 (.65)	1.60 (.63)	1.69 (.73)	1.87 (.75)	1.86 (.82)

Note. The first point of measurement is the postintervention assessment at the end of the Head Start year. Statistically significant intervention-control group differences are indicated with asterisks.

† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

child seems enthusiastic about learning new things” and “This child is careful with her/his work.” All items were rated on a 6-point Likert scale, with response options ranging from *almost never* to *almost always* ($\alpha = .94-.96$).

Attention problems were assessed with 8 items from the Inattentive-Impulsive subscale of the ADHD Rating Scale (DuPaul, 1991). Sample items were “Is easily distracted” and “Has trouble following directions.” All items were rated on a 4-point Likert scale, with response options ranging from *not at all* to *very much* ($\alpha = .93-.96$).

Interpersonal relationships. Student-teacher closeness was assessed with 8 items from the Student-Teacher Relationship Scale (Pianta, 2001). Sample items were “This child values her/his relationship with me” and “This child openly shares her/his feelings and experiences with me.” All items were rated on a 5-point

Likert scale, with response options ranging from *definitely does not apply* to *definitely applies* ($\alpha = .88-.91$).

Peer rejection was assessed with 3 items from the Excluded by Peers subscale of the Child Behavior Scale (Ladd & Profilet, 1996). The items were “Is disliked by classmates,” “Is left out or ignored by classmates,” and “Is teased or picked on by classmates.” All items were rated on a 6-point Likert scale, with response options ranging from *almost never* to *almost always* ($\alpha = .76-.83$).

Results

Means and standard deviations for each outcome at each assessment period by study condition are presented in Table 2. Skewness was always smaller than 1.32, and kurtosis was always smaller

Table 3
Correlations Among Variables at Beginning and End of Study

	1	2	3	4	5	6	7	8	9	10	11
End of Head Start											
1. Social competence											
2. Aggressive behavior	-.78										
3. Learning engagement	.73	-.56									
4. Attention problems	-.71	.68	-.80								
5. Student-teacher closeness	.51	-.35	.64	-.47							
6. Peer rejection	-.54	.54	-.51	.49	-.43						
End of third grade											
7. Social competence	.34	-.39	.24	-.37	.19	-.19					
8. Aggressive behavior	-.27	.39	-.16	.27	-.13	.10	-.81				
9. Learning engagement	.31	-.32	.34	-.39	.25	-.11	.65	-.58			
10. Attention problems	-.31	.30	-.33	.41	-.19	.07	-.61	.58	-.80		
11. Student-teacher closeness	.14	-.13	.12	-.09	.18	-.09	.39	-.30	.44	-.30	
12. Peer rejection	-.25	.22	-.18	.26	-.25	.16	-.64	.57	-.44	.40	-.25

Note. Correlations with an absolute value greater than .11 are statistically significant, $p < .05$.

than 1.95. In each case, the mean for the children who received the Head Start REDI intervention was more favorable than the mean for children from the control condition. *T*-tests revealed scattered differences that were statistically significant at the end of Head Start, in kindergarten, and in second grade.

Correlations among outcomes at the beginning and end of the study are presented in Table 3. These correlations demonstrate discriminant validity in teachers' perceptions of the different domains of social-emotional functioning within an assessment period ($|r| = .25-.81, p < .001$). The correlations also show modest stability in different teachers' perceptions of the same domain of social-emotional functioning over time ($r = .16-.39, p < .001$).

Preliminary analyses suggested that it was unnecessary to account for the nesting of children in Head Start classrooms. Intra-class correlation coefficients across study outcomes were negligible ($M = .003$) by third grade.

Plan for Analyses

Latent class growth models were estimated with *Proc Traj* (Jones, Nagin, & Roeder, 2001) in SAS. For each outcome, 5 models with 2 to 6 developmental trajectories were compared. Each developmental trajectory was specified with an intercept and linear, quadratic, and cubic growth terms. The Bayesian Information Criterion (BIC) was used to identify the model and the corresponding number of developmental trajectories that best captured the heterogeneity in the sample. These BIC values are listed in Table 4. In this study, there was a large enough difference between the BICs of the best-fitting and next-best-fitting models to constitute strong evidence in favor of the best-fitting model for social competence, aggressive-oppositional behavior, attention problems, student-teacher closeness, and peer rejection, according to Jeffreys' Scale of Evidence (Wasserman, 2000); there was moderate evidence in favor of the best-fitting model for learning engagement. For each outcome, the model with the best BIC was then refined by trimming nonsignificant parameters (Nagin, 2005).¹

In these latent class growth models, each child has a posterior probability of belonging to each developmental trajectory, and the sum of those probabilities equals 1.00. For each outcome, children were assigned to the developmental trajectory they most likely followed. This step introduces little error, as long as average posterior probabilities and odds of correct classification are high. Average posterior probabilities, which should be above .70 for each developmental trajectory, is one measure of model fit and indicates that children who were assigned to a particular developmental trajectory had a high likelihood of following that trajectory and a low likelihood of following any other trajectory (Nagin, 2005). Odds of correct classification, which should be above 5.00 for each developmental trajectory, is another measure of model fit and represents a ratio of the likelihood that children follow a particular developmental trajectory based on the average posterior probability, compared to the likelihood that children would follow that trajectory based on the population base rate alone (Nagin, 2005).

The test of the intervention effect was based on the proportion of children in each developmental trajectory who had been in Head Start REDI versus Head Start as usual. Because children's assignment to study condition occurred as part of a randomized con-

trolled design, statistically significant differences in proportions represent an intervention effect and indicate that Head Start REDI changed the likelihood that children followed a particular developmental trajectory. The magnitude of the differences in proportions is presented as the odds that children from Head Start REDI followed a particular developmental trajectory compared to the odds that children from Head Start as usual followed the same developmental trajectory; the statistical significance of the differences was calculated with a 2-proportion *z*-test. Although girls were more likely to follow optimal developmental trajectories in all domains, and indicators of risk, such as low family socioeconomic status, predicted worse developmental trajectories, tests of the robustness of intervention effects across child sex, race or ethnicity, and socioeconomic status revealed few statistically significant differences that formed no consistent pattern.

Developmental Trajectories of Each Domain of Social-Emotional Functioning

Results of the analyses are summarized in Table 5 and Figures 1-6.

Social behavior. As depicted in Figure 1, children followed 3 developmental trajectories of social competence:

1. Twenty-seven percent of children followed a high-increasing trajectory (specified with an intercept, a linear growth term, and a quadratic growth term), reflecting high scores at the end of Head Start, small improvements at the transition to elementary school, and little change after that.
2. Fifty percent of children followed a moderate-stable trajectory (specified with an intercept only), reflecting moderate scores at the end of Head Start and stability through the end of third grade.
3. Twenty-two percent of children followed a low-stable trajectory (specified with an intercept only), reflecting low initial scores at the end of Head Start that did not vary through the end of third grade.

Average posterior probabilities were high, .84-.89, as were odds of correct classification, 5.15-27.93. Significant intervention effects, based on a 2-proportion *z*-test, revealed that children who participated in the Head Start REDI intervention compared to children from Head Start as usual were more likely to follow the high-increasing developmental trajectory (33% vs. 21%, $p < .05$, odds ratio [*OR*] = 1.80) and less likely to follow the low-stable developmental trajectory (18% vs. 28%, $p < .05$, *OR* = .57).

As depicted in Figure 2, children followed 3 developmental trajectories of aggressive-oppositional behavior: (1) a low-

¹ These latent class growth models are based on classic taxonomic theory and posit that children in the sample are heterogeneous in terms of the developmental trajectories they follow but homogeneous within each developmental trajectory. These models rely on classes to account for all meaningful variance within the sample and specify no within-class variance of intercept or slope parameters. Growth mixture models, which allow within-class variance of intercept and slope parameters, produced a similar pattern of results. For comparison, the results from growth mixture models are presented in the online supplemental materials (see the first page of the article for the link).

Table 4
Bayesian Information Criterion for 2- to 6-Group Models

	2 groups	3 groups	4 groups	5 groups	6 groups
Social competence	-1,992.06	-1,976.88	-1,988.93	-2,002.65	-2,017.25
Aggressive-oppositional behavior	-1,924.57	-1,905.35	-1,907.88	-1,917.56	-1,923.74
Learning engagement	-2,136.03	-2,108.31	-2,104.28	-2,106.09	-2,115.12
Attention problems	-1,774.55	-1,751.55	-1,754.95	-1,766.79	-1,767.17
Student-teacher closeness	-1,668.39	-1,664.66	-1,670.93	-1,681.89	-1,695.13
Peer rejection	-1,868.32	-1,875.89	-1,887.98	-1,901.28	-1,914.66

Note. In *Proc Traj*, the Bayesian Information Criterion is not multiplied by -2; thus, larger values indicate better fit (Jones et al., 2001; Schwarz, 1978).

decreasing trajectory, (2) a moderate-stable trajectory, and (3) a high-stable trajectory. Average posterior probabilities were high, as were odds of correct classification. Once again, there were 2 statistically significant intervention effects: Children from Head Start REDI were more likely to follow the low-decreasing developmental trajectory of aggressive-oppositional behavior than children from Head Start as usual (53% vs. 37%, $p < .01$, $OR = 1.88$), and they were less likely to follow the moderate-stable trajectory (36% vs. 47%, $p < .05$, $OR = .63$).

Learning behaviors. As depicted in Figure 3, children followed 4 developmental trajectories of learning engagement: (1) a high-stable trajectory, (2) a high-decreasing trajectory, (3) a low-variable trajectory, and (4) a moderate-decreasing trajectory. Average posterior probabilities and odds of correct classification were high. Children who had been in Head Start REDI compared to children from Head Start as usual were more likely to follow the

high-stable developmental trajectory of learning engagement (43% vs. 29%, $p < .01$, $OR = 1.93$) and less likely to follow the high-decreasing developmental trajectory (46% vs. 56%, $p < .05$, $OR = .65$).

As depicted in Figure 4, children followed 3 developmental trajectories of attention problems: (1) a low-stable trajectory, (2) a moderate-increasing trajectory, and (3) a high-increasing trajectory. Once again, average posterior probabilities and odds of correct classification were high. Children who had been in Head Start REDI compared to children from Head Start as usual were more likely to follow the most optimal low-stable developmental trajectory (36% vs. 26%, $p < .05$, $OR = 1.60$).

Interpersonal relationships. As depicted in Figure 5, children followed 3 developmental trajectories of student-teacher closeness: (1) a high-stable trajectory, (2) a high-decreasing trajectory, and (3) a moderate-decreasing trajectory. Average poste-

Table 5
Developmental Trajectory Fit Statistics and Prevalence Rates

	Model fit statistics		Prevalence rates		Treatment effect size
	Average posterior probability	Odds of correct classification	Head Start REDI children	Head Start as usual children	Odds of being from REDI
Social competence					
1. High-increasing	.88	19.75	33%	21%	1.80*
2. Moderate-stable	.84	5.15	50%	51%	.94
3. Low-stable	.89	27.93	18%	28%	.57*
Aggressive-oppositional behavior					
1. Low-decreasing	.89	9.89	53%	37%	1.88**
2. Moderate-stable	.85	7.83	36%	47%	.63*
3. High-stable	.90	60.23	11%	15%	.70
Learning engagement					
1. High-stable	.91	17.98	43%	29%	1.93**
2. High-decreasing	.88	7.05	46%	56%	.65*
3. Moderate-decreasing	.85	57.30	8%	9%	.92
4. Low-variable	.89	194.18	3%	6%	.50
Attention problems					
1. Low-stable	.88	16.32	36%	26%	1.60*
2. Moderate-increasing	.83	5.73	43%	49%	.78
3. High-increasing	.90	28.50	22%	26%	.81
Student-teacher closeness					
1. High-stable	.83	5.51	54%	40%	1.72*
2. High-decreasing	.82	4.94	43%	54%	.62*
3. Moderate-decreasing	.92	276.00	4%	5%	.68
Peer rejection					
1. Low-variable	.88	3.78	72%	60%	1.66*
2. Moderate-increasing	.85	11.00	28%	40%	.60*

Note. REDI = research-based, developmentally informed.
* $p < .05$. ** $p < .01$.

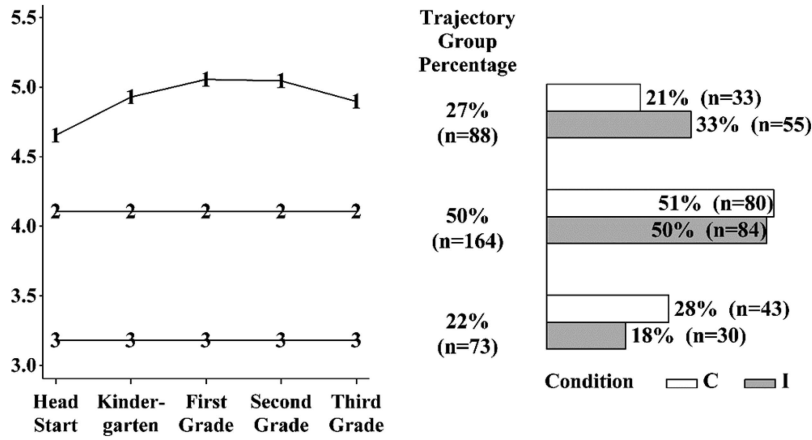


Figure 1. Developmental trajectories of social competence.

rior probabilities and odds of correct classification were high. In this case, children who had been in Head Start REDI compared to children from Head Start as usual were more likely to follow the high-stable developmental trajectory of student-teacher closeness (54% vs. 40%, $p < .05$, $OR = 1.72$) and less likely to follow the high-decreasing trajectory (43% vs. 54%, $p < .05$, $OR = .62$).

Finally, as depicted in Figure 6, children only followed 2 developmental trajectories of peer rejection: (1) a low-variable trajectory and (2) a moderate-increasing trajectory. Average posterior probabilities and odds of correct classification were high. Children who had been in Head Start REDI compared to children from Head Start as usual were more likely to follow the most optimal low-variable developmental trajectory of peer rejection (72% vs. 60%, $p < .05$, $OR = 1.66$) and less likely to follow the moderate-increasing trajectory (28% vs. 40%, $p < .05$, $OR = .60$).

Discussion

This study relied on a person-oriented approach to examine the effects of a preschool preventive intervention on children’s developmental trajectories of social-emotional functioning after the transition into elementary school. It did this in the context of a

randomized controlled trial, with a large and diverse sample of children growing up in poverty. The control group was composed of children who received Head Start as usual, which has been associated with numerous positive long-term outcomes in previous studies (Deming, 2009; Ludwig & Phillips, 2008). Even so, children who received Head Start REDI were still more likely to exhibit optimal developmental trajectories across multiple domains of social-emotional functioning. For example, the odds that a child who had attended Head Start REDI followed the most optimal developmental trajectory of social competence was 1.80 times the odds that a child who had attended Head Start as usual followed the most optimal developmental trajectory of social competence. The corresponding odds were 1.88 for the most optimal developmental trajectory of aggressive-oppositional behavior, 1.93 for learning engagement, 1.60 for attention problems, 1.72 for student-teacher closeness, and 1.66 for peer rejection. The magnitude of the benefit of being in Head Start REDI compared to Head Start as usual on children’s optimal developmental trajectories is comparable to the magnitude of the benefit of not smoking or maintaining a healthy weight on preventing heart attacks (Yusuf et al., 2004). Because these results come from a randomized

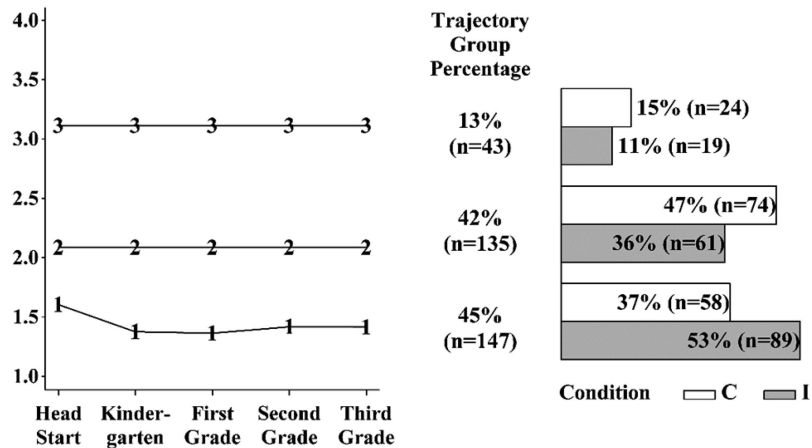


Figure 2. Developmental trajectories of aggressive-oppositional behavior.

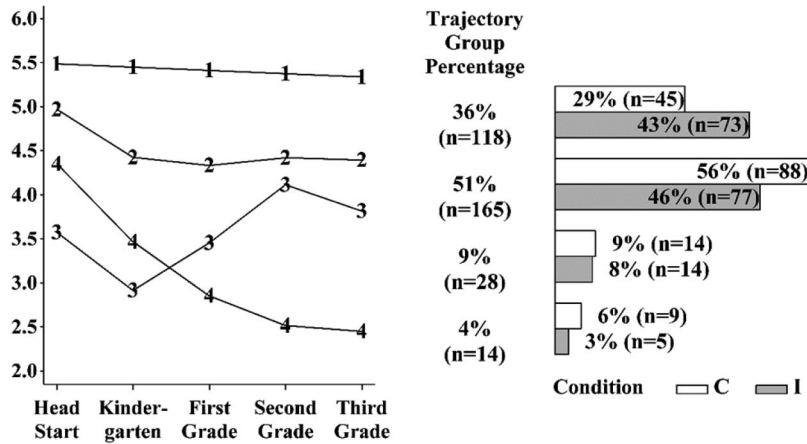


Figure 3. Developmental trajectories of learning engagement.

controlled trial and because prior analyses showed that children from intervention and control groups attended elementary schools of similar quality (based on observer ratings of teaching practices and state records of student achievement; Bierman et al., 2014), these differences can be interpreted as sustained effects of Head Start REDI.

REDI Intervention Effects: Mechanisms of Action

Head Start REDI utilized multiple curriculum components and specific teaching practices to promote growth in both language-emergent literacy skills and social-emotional functioning. A core assumption of the intervention model was that this dual focus would promote synergistic gains across domains and that enhanced language-emergent literacy skills and academic readiness would enhance children’s social-emotional functioning, including self-regulation skills, at school entry (Nix, Bierman, Domitrovich, & Gill, 2013). To directly promote social-emotional functioning, children in the REDI program participated in Preschool PATHS lessons that taught them about the range of emotions people experience. Children learned to use “feeling faces” cards as a means of monitoring and sharing their own internal states and

noticing and attending to the internal states of their classmates. Through Preschool PATHS, children also learned developmentally appropriate strategies they could use to calm themselves down when upset, with the goal of enhancing intentional inhibitory control and the capacity for reflective social reasoning. Through role-plays, children practiced using their words to express their feelings, asserting their needs in an appropriate manner, and resolving problems through cooperation and compromise. In addition, REDI included an interactive dialogic reading program (Wasik et al., 2006), featuring books with themes that matched the weekly lessons of Preschool PATHS. Those books were scripted with specific questions for teachers to ask so that children would be encouraged to reflect on and discuss the characters’ feelings and motives and learn about cause-effect relations in characters’ reactions and behaviors.

To further reinforce what children were learning through the integrated curriculum components, REDI teachers received training and extensive coaching in the use of language expansion, positive classroom management strategies, specific praise, daily compliments, and *in vivo* scaffolding. REDI teachers explicitly articulated and modeled their own self-regulation practices as

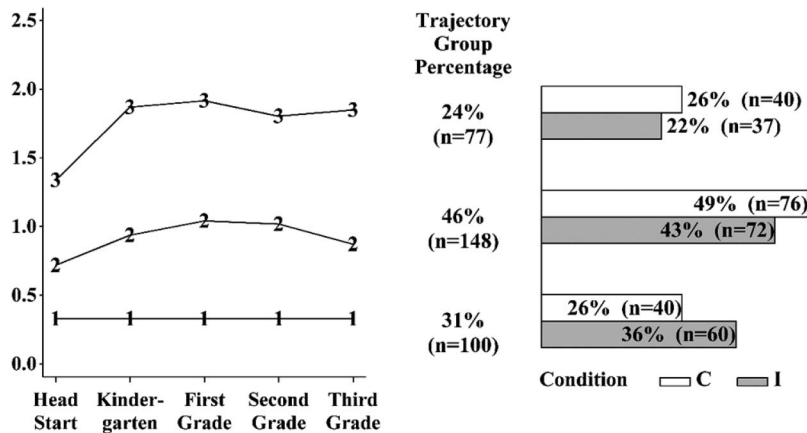


Figure 4. Developmental trajectories of attention problems.

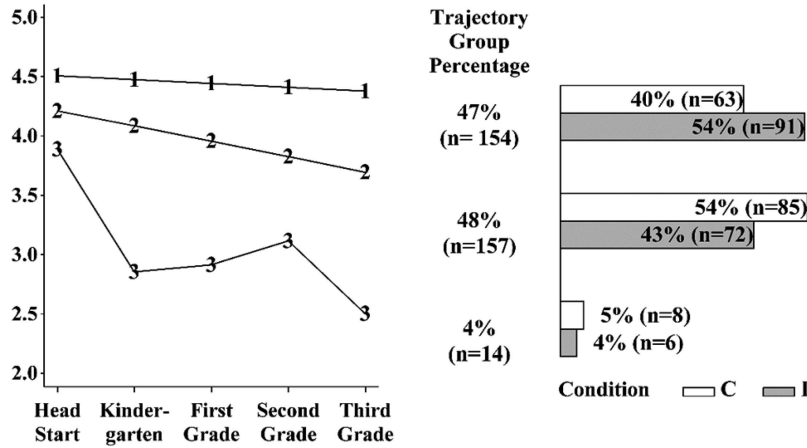


Figure 5. Developmental trajectories of student-teacher closeness.

opportunities arose; they labeled and reflected children’s emotions; and they used induction strategies to foster self-control.

A prior study evaluating the impact of Preschool PATHS in Head Start demonstrated significant intervention effects on children’s emotion knowledge and social competence (Domitrovich, Cortes, & Greenberg, 2007). By integrating Preschool PATHS with additional language-emergent literacy interventions and providing more extensive professional development to teachers, Head Start REDI likely increased its impact on academic outcomes and may have strengthened its effect on social-emotional functioning as well. Indeed, process analyses of Head Start REDI mechanisms suggested that preschool gains in language-emergent literacy skills and social-emotional functioning each made unique contributions to kindergarten adjustment, thereby documenting cross-domain synergy (Nix et al., 2013).

In this study, it is not possible to determine how specific intervention components contributed to the sustained effects. However, it appears that the multicomponent REDI intervention was able to promote a set of core social-emotional competencies when children were young that set them on more optimal developmental trajectories for years to come. Previous studies demonstrated that,

compared to the control group, children who received Head Start REDI were able to interact with their peers more effectively (Bierman, Domitrovich, et al., 2008); form better relationships with their teachers (Bierman et al., 2014); and pay attention, inhibit prepotent responses, and maintain behavioral organization in the face of academic challenge and frustration (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008). Just as it was the early gains in those core competencies that predicted children’s successful transition to kindergarten (Nix et al., 2013), it may be that those early gains also herald long-term adaptation to school.

The Value of a Person-Oriented Approach to Understanding REDI Intervention Effects

A strength of this study is that it relied on a person-oriented approach to examine intervention effects on children’s developmental trajectories. A sole focus on variable-centered main effects can ignore the more nuanced processes that underlie how children change over time (Haapasalo, Tremblay, Boulerice, & Vitaro, 2000). When analytic models are better aligned with predicted developmental models, they may better illuminate preventive in-

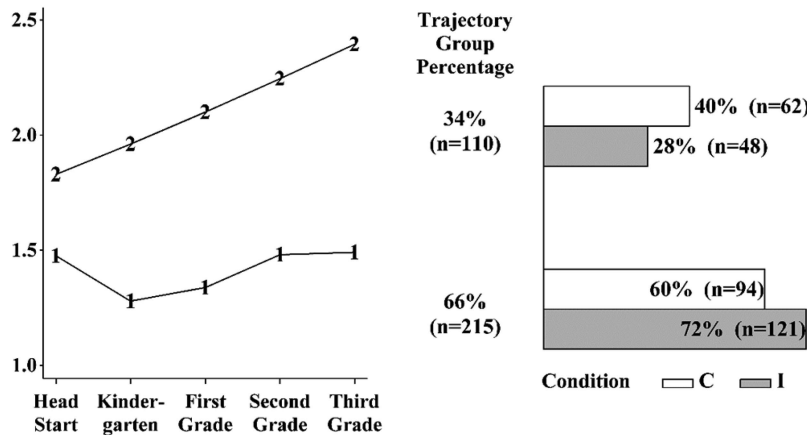


Figure 6. Developmental trajectories of peer rejection.

intervention effects and contribute more to our understanding of change. For example, in variable-centered analyses of the Multimodal Treatment Study of Children with Attention-Deficit/Hyperactivity Disorder, Jensen et al. (2007) reported no sustained intervention effects after 3 years. However, with a person-oriented approach, Swanson et al. (2007) found that children who were assigned to receive medication as part of the study were more likely to follow a developmental trajectory in which there was a rapid initial drop in symptoms and maintenance of those gains over time.

In this study, for every domain of social-emotional functioning at every assessment period, the mean of children from Head Start REDI was higher than the mean of children from Head Start as usual, and differences were statistically significant in 3 of 5 years (e.g., at the end of Head Start, kindergarten, and second grade). However, those variable-centered results poorly reflect the underlying processes of change across intervention conditions. By contrast, the latent class growth models extract unambiguous patterns revealing that children from Head Start REDI are always less likely than children from Head Start as usual to follow the non-optimal developmental trajectories in every domain of social-emotional functioning. Although only some of those differences in proportions are statistically significant, the differences accumulate so that children from Head Start REDI are always statistically significantly more likely to follow the most optimal developmental trajectory in each domain of social-emotional functioning.

In Head Start REDI, the latent class growth models highlight the importance of early change. When children ended preschool with high levels of competence or low levels of problem behaviors—regardless of whether they arrived at that point as a result of intervention or some other factor—they continued to do well or get better over time. In contrast, when children ended preschool with less optimal social-emotional functioning, they rarely improved on their own. Most likely, Head Start REDI achieved its sustained intervention effects by nudging children past a threshold of early social-emotional functioning after which self-perpetuating processes (like those described in the Introduction) were set in motion.

Findings like these from the Multimodal Treatment Study of Children with Attention-Deficit/Hyperactivity Disorder and Head Start REDI can emerge because person-oriented approaches take better advantage of longitudinal data than do variable-centered approaches and because latent class growth models do not treat small deviations from normal distributions as errors but rather as potential sources of information to be evaluated and tested (Shiyko, Ram, & Grimm, 2012). Latent class growth models are capable of capturing the different configurations of development across the range of social-emotional functioning, thereby enhancing the capacity to discern the impact of early preventive interventions like Head Start REDI on future growth.

Study Limitations

Despite its strengths, this study has limitations that warrant mention. First, this study could not identify *a priori* those children for whom the Head Start REDI intervention would be especially effective. For universal programs like Head Start REDI, in which all children in a classroom receive the preventive intervention regardless of need, it is not as important to know *which* children

will respond as it is to know that *some* children will respond. Nonetheless, these findings should be considered exploratory rather than confirmatory (Bloom & Michalopoulos, 2010). This same issue makes it impossible to tell whether the children who moved into a more optimal developmental trajectory in 1 domain of social-emotional functioning were the same children who moved into a more optimal developmental trajectory in another domain. If there were complete overlap, Head Start REDI would have improved the lives of about 10% of children in all 6 domains; if these changes were completely independent, Head Start REDI would have improved the lives of 78% of children in a single domain. Third, although tests of robustness of intervention effects across child sex, race or ethnicity, and family socioeconomic status were conducted and found to be inconsistent, those tests were underpowered. Fourth, this study only focused on social-emotional functioning. There were no constant measures of children's language-emergent literacy skills across the 5 years of the study. When developmental trajectories were modeled with fewer years of data, there were no significant intervention-control group differences. It seems likely that the wide range of positive effects on language-emergent literacy skills that were evident at the end of preschool (Bierman, Domitrovich, et al., 2008) faded out by early elementary school. Fifth, in terms of measurement, this study relied on teacher ratings only. Different teachers rated each child in this study across each of the 5 years of the study, thus reducing the effects of informant bias across years; however, the same teacher rated all 6 domains of social-emotional functioning within any single year. Finally, there are multiple ways to examine change over time (Ram & Grimm, 2007). The latent class growth models included in this study revealed theory-consistent intervention effects that were similar across all 6 outcomes. Although such predictive validity is one indicator of the appropriateness of a statistical model, study results can fluctuate depending on the assumptions that underlie different statistical models (Kreuter & Muthén, 2008).

Implications for Practice and Future Directions

The implications of this study are straightforward: Enhancing preschool education programs with multiple evidence-based curriculum components and supportive teaching practices can have long-lasting effects on children's social-emotional functioning. Children who received the Head Start REDI intervention rather than Head Start as usual were more likely to follow optimal developmental trajectories in social competence, aggressive-oppositional behavior, learning engagement, attention problems, student-teacher closeness, and peer rejection.

There is good reason to believe that these improvements in social-emotional functioning might translate to differences in long-term educational attainment and other indicators of positive adjustment, such as high school completion, employment outcomes, and personal satisfaction (Moffitt et al., 2011). During the period in which children are adapting to school, it appears that children who start out well continue to do well or improve over time. In contrast, children who struggle initially rarely get better on their own. Ensuring that all children living in poverty have access to high-quality preschool may be one of the more effective means of closing the gaps in school readiness and increasing the likelihood of lifelong success.

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Received June 13, 2013

Revision received June 18, 2015

Accepted September 9, 2015 ■