

## Longitudinal and Concurrent Relations among Temperament, Ability Estimation, and Injury Proneness

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This study examined longitudinal and concurrent relations between temperament, ability estimation, and injury proneness. Longitudinal assessments of Inhibitory Control were collected through a behavioral battery at toddler (33 months) and preschool ages (46 months). Parent-reported measures of Inhibitory Control and Extraversion also were obtained at those ages. At school age (76 months), children participated in a set of tasks to assess overestimation and underestimation of physical abilities. Parents provided reports of children's temperament and injury history at school age. Results showed that children who were high on Extraversion and low on Inhibitory Control as toddlers and preschoolers tended to overestimate their physical abilities and to have more unintentional injuries at age 6. Children low on Extraversion and high on Inhibitory Control tended to underestimate their physical abilities. Implications for injury prevention are discussed.

### INTRODUCTION

Unintentional injuries are the leading cause of death in children under age 18 (National Safety Council, 1997; Rodriguez & Brown, 1990). Approximately 22,000 children and adolescents die each year as a result of drownings, poisonings, electrocutions, falls, pedestrian injuries, bicycle collisions, and choking on foreign objects. Not surprisingly, the alarming statistics on childhood injuries have led to a national emphasis on the reduction of unintentional childhood injuries.<sup>1</sup> Before injury prevention programs can be effectively designed and implemented, however, a better understanding of the underlying causes of childhood injuries is warranted. Recently, researchers have responded to this concern by examining some of the psychological factors that may play a role in childhood injuries (e.g., Farmer & Peterson, 1995; Plumert & Schwebel, 1997; Pulkkinen, 1995).

### Temperament

One factor frequently implicated as a contributor to injury risk is children's temperament. Temperament is defined as a set of individual differences ex-

pressed as generally stable behavioral tendencies throughout infancy and childhood, and into adulthood. Temperament reflects both reactivity to external stimuli as well as internal self-regulation (Goldsmith et al., 1987). Conceptually, temperament is viewed as a mediator of the child's experience (Rothbart & Bates, 1998). That is, temperamental characteristics such as activity level, approach tendencies, and inhibitory control may lead children to seek out some environments and avoid others (Scarr & McCartney, 1983). In terms of unintentional injuries, highly extraverted children may seek out new and unfamiliar activities and hence may be more prone to injure themselves. Thus, one model of the underlying cause of unintentional injuries is that temperament mediates the types of experiences children seek out. These experiences, in turn, put children at greater or lesser risk of injury.

Several studies support this model of unintentional injuries. Although injury researchers often refer to clinically oriented behavior patterns and personality rather than temperament, much of the psychological literature on unintentional injuries can be extended to suggest certain temperamental traits are predictive of children's injury history (see Carey, 1989; Chess & Thomas, 1989). Numerous cross-sectional studies suggest, for example, that children who are impulsive, active, and sensation-seeking are more injury-prone (e.g., Jaquess & Finney, 1994; Langley, McGee, Silva, & Williams, 1983; Manheimer & Mellinger, 1967; see also Plumert & Schwebel, 1997, who ground their work in temperament theory rather than personality).

In an early study of childhood injuries, Manheimer and Mellinger (1967) selected nearly 9,000 children

<sup>1</sup> Among the conceptual debates that have arisen in the psychological literature on injuries is terminology. Injuries such as cuts, bruises, and broken bones that are not intentionally caused were traditionally called "accidental injuries." However, use of the term "accidental" implies that the causes are unpredictable and without explanation. Researchers recognized the paradox in finding individual differences that predicted "accidents" and began to use other terminology such as "unintentional injuries" and "injury proneness" to minimize the emphasis on accidental causes of injuries (Matheny, 1988; Roberts & Brooks, 1987). The present article adopts this terminology.

aged 4 through 18 who varied in personal injury history. Through maternal interviews, they concluded that children with many injuries were more extraverted, daring, and aggressive. Likewise, Plumert and Schwebel (1997) found that 8-year-olds whose parents described them as highly active, impulsive, and undercontrolled had more severe day-to-day injuries.

Two sets of longitudinal studies have also found a link between temperament and unintentional injuries (Bijur, Golding, Haslum, & Kurzon, 1988; Bijur, Stewart-Brown, & Butler, 1986; Pulkkinen, 1995). Bijur and colleagues (Bijur et al., 1986, 1988) studied over 10,000 children at age 5 and again at age 10. Results suggest that high activity and aggression levels were concurrently and prospectively related to injury history. Pulkkinen (1995) examined a cohort of Finnish individuals at ages 8, 14, and 27. Among boys, she found that peer- and teacher-rated aggression at ages 8 and 14 predicted injury history at age 27. Noncompliance and disobedience in childhood and adolescence also predicted injury history. Among girls, no temperamental traits were consistent predictors of adult injury history.

#### Overestimation of Physical Ability

A second factor that may play a role in childhood unintentional injuries is overestimation of physical ability. In daily life, children regularly confront situations where they must make judgments about their physical capabilities and limitations in relation to the demands of the situation. According to J. J. Gibson (1979), adaptive behavior within the environment depends upon perceiving affordances, or the fit between one's own physical characteristics and the properties of the environment in which actions take place. Although injuries are complex phenomena that undoubtedly have multiple root causes, errors in judging the relation between one's physical abilities and the demands of the situation may contribute to injury risk. For example, although some bicycle accidents occur when children fail to follow basic traffic laws such as stopping at a stop sign, others may occur when children overestimate their balancing ability while turning a sharp corner.

Several recent studies suggest that children tend to overestimate their physical abilities, particularly when the perceived consequences for doing so are not severe. For example, infants between 8 and 12 months consistently attempt to grab toys well beyond their reach (McKenzie, Skouteris, Day, Hartman, & Yonas, 1993). Adolph and her colleagues also found that toddlers attempted to ascend and descend slopes that were too steep to be traversed (Adolph, 1995; Adolph,

Eppler, & Gibson, 1993). Although the children were more cautious when descending than when ascending slopes, some "persisted in attempts to reach the summit . . . even when efforts resulted in sliding back down several times" (Adolph, 1995, p. 748).

Older children also sometimes misjudge the relation between their physical abilities and the demands of the situation. McKenzie and Forbes (1992), for example, found that 9- and 12-year-old boys overestimated the height of stairs they could climb. Plumert (1995; Plumert & Schwebel, 1997) found that 6- and 8-year-olds overestimated their reaching and stepping abilities, although the 8-year-old children judged more accurately than the 6-year-olds. Similarly, Palmer, Constantinople, Davis, and Silverman (1997) found that as children developed, they became better able to judge their reaching, jumping, and balancing abilities. By age 12, most children accurately judged their ability to jump long distances although they continued to overestimate their ability to walk across a balance beam. Finally, a study by Lee, Young, and McLaughlin (1984) of 5- to 9-year-old children's road-crossing behavior showed that the majority of children at all ages accepted traffic gaps that were too small on at least one occasion. In this study, children crossed a "pretend" road immediately adjacent to a real road and judged traffic gaps of actual passing automobiles. Even with this more realistic situation, about 75% of the 5-year-old children made at least one error in judgment that would have resulted in injury had they been crossing an actual road. Sixty-five percent of 7-year-olds and 58% of 9-year-olds made similar errors. Together, these studies suggest that children frequently overestimate their ability to successfully perform physical tasks that are actually beyond their ability.

Although little research has been conducted examining the links between ability estimation and injury proneness, two studies suggest that 6-year-olds who overestimate their abilities tend to have more unintentional injuries. In two independent samples, Plumert (1995) found that 6-year-olds' overestimation of ability in the laboratory was significantly correlated with the number of lifetime injuries they had experienced requiring medical attention. That correlation was not significant among 8-year-olds in either sample, however. Plumert and Schwebel (1997) examined more minor daily injuries among 6- and 8-year-olds as measured by a diary completed by children and their parents over a 2-week period. They found a significant correlation between overestimation of ability and average severity of injuries among 6-year-old boys, but not among 6-year-old girls or among 8-year-olds of either gender. Thus, it

appears that overestimation of ability may be a risk factor for unintentional injuries, particularly among younger children.

### Relations between Temperament and Ability Estimation

The studies reviewed above examine temperament and ability estimation as independent contributors to unintentional injuries. However, it seems likely that temperament and ability estimation are related. Children who are active and approach-oriented may be more likely to overestimate their physical abilities. Plumert and Schwebel (1997) have conducted the most comprehensive study that examines the relation between temperament and ability overestimation. In a cross-sectional design, 6- and 8-year-old children engaged in a behavioral task where they were asked to judge whether they could successfully complete physical tasks such as reaching for objects and stepping over targets. Parents completed a self-report measure of children's temperament. Plumert and Schwebel (1997) found that temperament was in fact related to children's estimations about their physical abilities. In particular, highly active and undercontrolled 6-year-olds were more likely to overestimate their physical abilities.

Studies of children's ability to judge the relation between their own physical characteristics and the demands of the situation have shown that when children make errors, they almost always overestimate rather than underestimate their abilities. Little is known about when and why children might underestimate their abilities. Paralleling previous findings that suggest temperament plays a role in overestimation of physical ability, it seems likely that temperament may play a role in children's underestimation of physical ability as well. Specifically, children who are particularly cautious and controlled may have less confidence in their ability and may underestimate their ability to complete physical tasks.

### Present Study

Taken together, previous work suggests that both temperamental characteristics and ability overestimation contribute to injury risk during childhood. Although temperament and ability overestimation may make independent contributions to injury risk, a more appealing hypothesis is that temperament and overestimation work together to create risk for injuries. Temperamental traits such as impulsivity, extraversion, and poor inhibitory control may put children at risk for injuries because these characteristics lead to

overestimation errors in children's judgment about their abilities. When judging whether it is safe to roller-skate down a steep hill, for instance, children need to stop and think before attempting descent. Highly impulsive and undercontrolled children may be prone to injury-causing errors in judgment because they judge quickly without careful consideration of the possible consequences of their actions. This model of unintentional injuries is supported by the fact that Plumert and Schwebel (1997) found that 6-year-olds rated as highly active, impulsive, and undercontrolled by their mothers also overestimated their physical abilities.

One way to address the issue of how temperamental characteristics, ability overestimation, and injury proneness are related is to look at concurrent relations among these three variables (Plumert & Schwebel, 1997). A second, more elegant technique is to investigate longitudinal relations among temperament, ability overestimation, and injury proneness. The primary goal of this study was to determine how temperament at a young age is related to later injury proneness and ability estimation. We also examined concurrent relations among temperament, ability overestimation, and injury proneness. Both behavioral and mother-reported temperament measures were used to assess longitudinal links between temperament, ability estimation, and injury proneness. Based on previous research (Plumert & Schwebel, 1997), we focused on temperamental characteristics of Extraversion and Inhibitory Control. According to Rothbart (Ahadi, Rothbart & Ye, 1993; Rothbart & Bates, 1998), Extraversion encompasses traits of approach, high intensity pleasure, smiling, activity level, impulsivity, and lack of shyness. Called Surgency in earlier publications (e.g., Ahadi et al., 1993; Plumert & Schwebel, 1997), children high on Extraversion tend to enjoy and display positive affect when faced with new or complex stimuli, have high energy levels, respond quickly to situations, and eagerly anticipate new and pleasurable activities. It seems reasonable to conjecture that children high on Extraversion may find themselves in dangerous, injury-producing situations due to their proclivity to impulsively engage in new, unfamiliar activities. Inhibitory Control designates children's capacity to plan and inhibit inappropriate approaches under new, uncertain, or directed situations. Children low on Inhibitory Control, it seems, may find themselves approaching dangerous situations without plan or direction, causing injury when they are unable to negotiate the environment to which they are exposed.

Mother-reported measures of Extraversion and Inhibitory Control were available for the children in this

study when they were toddlers (33 months), preschoolers (46 months), and school-aged (75 months). Behavioral assessments of Inhibitory Control were available from toddler and preschool ages.

As in previous studies (Plumert, 1995; Plumert & Schwebel, 1997), ability estimation was assessed by asking children to judge whether they could perform four tasks of varying levels of difficulty before they attempted each activity. For example, children stood with hands at their sides, looked up at a toy on a shelf, and judged whether they could reach the toy by standing on their tiptoes. By comparing children's judgments with their actual ability to perform the tasks, overestimation and underestimation of ability was determined. Overestimation was inferred when participants judged that they could perform tasks that they actually were unable to perform. Underestimation was inferred when children judged they could *not* perform tasks that they actually could perform successfully. These tasks were completed at school age.

Finally, at school age, mothers reported their children's lifetime history of injuries requiring professional medical treatment at age 6. Although there is some concern that parents may have poor recall of their children's injuries (Harel et al., 1994; Peterson, Harbeck, & Moreno, 1993), such reports are widely used in the literature and provide a reasonable estimate of children's injury history.

We hypothesized that children rated high on Extraversion as toddlers and preschoolers would tend to overestimate their physical ability at age 6. We also predicted that those toddlers and preschoolers falling low on Inhibitory Control, as measured both through parent-report and a behavioral battery, would tend to overestimate their physical ability at age 6. Similarly, it seemed likely that those children whose parents rated them high on Extraversion and low on Inhibitory Control at age 6 also would overestimate their physical abilities. When considering underestimation of ability, we predicted that those children rated low on Extraversion and high on Inhibitory Control as toddlers and preschoolers, as well as at school age, would tend to underestimate their ability. Finally, we predicted children high on Extraversion and low on Inhibitory Control would have a history of more unintentional injuries.

## METHOD

### Participants

Participants originally were recruited as toddlers in response to advertisements in the community. All

were normally developing. A relatively broad socioeconomic range was represented in the sample; most were of European American background, although 7% identified themselves as minorities. The families came from an area including a college town, a small city, and rural farm communities in eastern Iowa.

Children were assessed at five time periods, although only data obtained at three time periods are reported in this study. To avoid confusion, they are referred to as the toddler-age, preschool-age, and school-age assessments. The toddler-age assessment took place both at children's homes and in the laboratory and lasted approximately 2½ hours ( $N = 103$ , 51 girls, 52 boys, *mean age* = 32.86 months, *SD* = 4.09). The preschool-age assessment was a 3½ hour laboratory session ( $N = 99$ , 49 girls, 50 boys, *mean age* = 46.01 months, *SD* = 2.62).

At age 6, all children originally recruited as toddlers who were eligible for the present study were sent a letter describing the goals of the school-age session. The letter explained that this study, not part of the original longitudinal battery of studies parents had agreed to join when their children were toddlers, was being conducted to examine the relations between children's temperament and injury proneness and that their participation was entirely voluntary. The letter was followed by a phone call inviting participation; 83% of those contacted agreed to participate ( $N = 59$ , 29 girls, 30 boys, *mean age* = 75.51 months, *SD* = 4.47). Thus, the final sample available at all three assessments was 59 children. Attrition, although larger than desirable, was due to a variety of factors. Accounting for most of the attrition were those children who moved away from the area ( $n = 20$ ), those who had participated in similar studies in our laboratory and thus knew the protocol and could not be included ( $n = 7$ ), and those who had discontinued participation in the longitudinal battery or who decided they did not want to participate in the school-age assessment ( $n = 14$ ). There was no indication that the sample at school age differed statistically from the original toddler-age sample based on demographic or temperament measures. At school age, children received two small gifts and \$10 for participating in the study.

### Procedure and Measures

*Temperament.* As toddlers and preschoolers, children participated in a behavioral battery that included tasks to assess functions and capacities most prototypical for Inhibitory Control (Rothbart 1989a, 1989b; Rothbart & Ahadi, 1994). Batteries included seven tasks at toddler age and 13 tasks at preschool

age; they are described in detail elsewhere (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). Briefly, the batteries provided multiple measures of the children's ability to demonstrate Inhibitory Control. The following general functions were assessed: slowing down motor activity, suppressing/initiating activity to a signal, delaying and lowering voice, and cognitive reflectivity (preschool age only). All tasks involved multiple trials.

At each time period, tasks in the behavioral batteries were moderately intercorrelated and had high internal consistency ( $\alpha$ s were .75 and .79, average item-total correlations were .42 and .45 at toddler and preschool ages, respectively). Therefore, tasks were standardized and aggregated to create a composite behavioral Inhibitory Control z-score. Among those children who participated in the school-age assessment, mean aggregated scores of the Behavioral Inhibitory Control battery were .05 ( $SD = .60$ ) and  $-.01$  ( $SD = .52$ ), at toddler and preschool ages.

Mothers also completed the Child Behavior Questionnaire (CBQ; Rothbart, Ahadi, & Hershey, 1994), a widely used measure of child temperament, at the toddler, preschool, and school ages. The CBQ is a 225-item instrument that asks parents to rate items on a 7-point Likert scale, ranging from extremely untrue of their child's behavior to extremely true of their child's behavior within the last 6 months. Previous research suggests good internal reliability (Cronbach's  $\alpha$ s for the 15 scales range from .67 to .94; Rothbart et al., 1994).

The CBQ has 15 scales that fall into three broad factors (Ahadi et al., 1993); internal reliability of the scales at school age was good (Cronbach's  $\alpha$ s ranged from .71 to .96). Reliability from the measurements at the other two ages was also good and is presented elsewhere (Kochanska et al., 1996). Based on previous research (Plumert & Schwebel, 1997), the CBQ measures of particular interest to the present study were the general factor labeled Extraversion and the Inhibitory Control scale. Extraversion includes loadings from the approach, high intensity pleasure, smiling, activity, impulsivity, and, negatively, shyness scales. This factor, sometimes called Surgency or Positive Affectivity, encompasses sensation-seeking, joyful, sociable, and impulsive behaviors. As expected based on a previous factor analysis (Ahadi et al., 1993), internal consistency of the six scales was high (Cronbach's  $\alpha = .65, .64,$  and  $.74$  for the toddler-, preschool-, and school-age measurements, respectively). The mean Extraversion score for the toddler-age CBQ was 5.04,  $SD = .62$ ; for preschool age,  $M = 5.00, SD = .58$ ; and for school age,  $M = 5.00, SD = .63$ . Table 1 shows scores on the individual scales and the aggregated Extraversion factor.

**Table 1** Means of CBQ Temperament Scales

Temperamental Characteristic	32 Months	46 Months	75 Months
Inhibitory Control	4.17 (.76)	4.51 (.63)	4.84 (.77)
Extraversion	5.04 (.62)	5.00 (.58)	5.00 (.63)
Approach	5.14 (.62)	5.20 (.60)	5.34 (.70)
High intensity pleasure	5.20 (.92)	5.07 (.94)	5.19 (.95)
Smiling	5.74 (.65)	5.72 (.61)	5.82 (.77)
Activity	5.15 (.68)	5.12 (.70)	4.55 (.80)
Impulsivity	4.76 (.81)	4.69 (.76)	4.62 (.85)
Shyness	3.77 (1.40)	3.81 (1.34)	3.51 (1.43)

Note: Standard deviations appear in parentheses.

The Inhibitory Control scale includes 13 items designed to measure the child's capacity to plan and to suppress inappropriate approach responses when cautioned or when confronted with novel or uncertain situations (Cronbach's  $\alpha = .74$ ; Rothbart et al., 1994). Means on the scale at toddler, preschool, and school ages were 4.17 ( $SD = .76$ ), 4.51 ( $SD = .63$ ), and 4.84 ( $SD = .77$ ), respectively (See Table 1). Internal consistency for the scale was high at each age level (Cronbach's  $\alpha = .78, .77,$  and  $.81$ , for the toddler, preschool and school ages, respectively).

*Estimation of physical ability.* At school age, children completed four tasks designed to measure their ability to judge their physical capabilities and limitations. A figure depicting the apparatus can be found in Plumert (1995). The vertical reach task involved removal of a small toy from a shelf while standing on tiptoes. The shelf was mounted on brackets that were attached to shelving strips on a wall and was adjustable in 1-in increments. The horizontal reach task involved reaching out from a squatting position to retrieve a small toy off a wooden block without touching hands or knees on the floor. Children performed the horizontal reach while squatting on a flat board with an edge on the front end to prevent them from moving closer to the toy. The stepping task involved stepping from behind one stick attached to the floor over a second, parallel stick. Children began the step by placing both feet against the edge of one stick. The clearance task involved moving under a wooden bar attached to two posts without knocking the bar down or putting hands or knees on the floor. Children began the clearance task by squatting next to the bar and placing both feet in a box marked by tape on the floor.

As in Plumert (1995), children completed four variations of each task: (1) the well-within version was 13% below the child's estimated maximum ability level; (2) the just-within version was at the child's es-

timated maximum ability level; (3) the just-beyond version was 8% beyond the child's estimated maximum ability level; and (4) the well-beyond version was 13% beyond the child's estimated maximum ability level. Each task was individually scaled for each child at 1-in increments using previously measured estimates of their maximum reaching, stepping, and crouching abilities. The tasks that were well within and just within the child's ability assessed underestimation tendencies. In other words, if children incorrectly judged they could not complete a task within their ability, they were underestimating their ability. The tasks that were just beyond and well beyond children's ability, conversely, measured overestimation tendencies. Children who inaccurately judged they could complete tasks that were actually beyond their ability were overestimating their ability.

Estimates of children's maximum levels of ability were obtained before the test trials in a separate room. The actions used to derive estimates of the children's maximum levels of ability were similar to, but not identical to, those used to perform the four tasks described above and are described in detail elsewhere (Plumert, 1995; Plumert & Schwebel, 1997). After threshold estimates were taken, one experimenter prepared the apparatus in the testing room while a second experimenter occupied children with a filler task. The filler task involved listening to several short vignettes and answering related questions. The vignettes were unrelated to the hypotheses of this study and results are presented elsewhere (Schwebel, Plumert, & Martin, 1997). Once the apparatus had been prepared, the experimenter led children into the testing room and gave instructions for the study. Children were told that they would be playing some games and were presented with \$8 of play money to use in the games. The experimenter explained that they were to position themselves for each task and decide whether or not they could complete the task. If they said yes, then they would be permitted to try the task. If successful, they would be rewarded with another dollar; if unsuccessful, however, they would have to pay the experimenter a dollar. If they said no, children were told that they would not win or lose any play money and they would not try the task. Finally, children were told they could use their play money at the end of all the games to buy prizes. After money had been counted at the end of all trials, children were asked to perform the trials they had judged they were unable to complete successfully. This manipulation maintained the integrity of the game during the test trials yet allowed the experimenter to determine whether tasks had been scaled correctly and to compare the accuracy of children's judgments with their actual abil-

ity. At the end, all children were allowed to choose two prizes.

The total of 16 test trials was divided into four trial blocks. Task difficulty was randomly determined across trial blocks with the stipulations that each child performed each task at each of the four difficulty levels (i.e., well-within, just-within, just-beyond, and well-beyond levels) and that each child completed each task once in each trial block. Between trial blocks, the vignette filler task was continued by one experimenter in a separate room while the second experimenter adjusted the apparatus. This ensured that children would not witness equipment adjustment and discover whether tasks might be easier or harder. All activity in the testing room was videotaped via a Panasonic camcorder through a one-way mirror to allow for later coding.

To accurately assess children's estimation ability, incorrectly scaled tasks were removed from the data set prior to analysis. A task was deemed as correctly scaled if the child was able to perform a task that was at the well-within or just-within levels of difficulty, or was unable to perform a task that was at the just-beyond or well-beyond levels of difficulty. The mean number of correctly scaled tasks (out of 4) for the well-within, just-within, just-beyond, and well-beyond levels of task difficulty were 3.68, 3.03, 3.22, and 3.72, respectively. A one-way repeated measures analysis of variance (ANOVA) was conducted on those means and yielded a significant effect of difficulty level,  $F(3, 174) = 16.37, p < .001$ . Tukey's HSD follow-up tests revealed that significantly more tasks at the well-within and the well-beyond levels of difficulty were scaled correctly than either the just-within or just-beyond level of difficulty. There was no significant difference between the just-within and just-beyond levels or the well-within and well-beyond levels. As in previous studies (Plumert, 1995; Plumert & Schwebel, 1997), it was easier to scale tasks at the well-within and well-beyond levels than at the just-within and just-beyond levels.

After removal of incorrectly scaled tasks, four accuracy scores were computed based on the proportion of tasks that children judged correctly at each level of difficulty. These scores were calculated by dividing the number of correct judgments by the number of correctly scaled tasks at each level of difficulty. For the well-within, just-within, just-beyond, and well-beyond levels, respectively, the mean proportion of correct judgments was .95 ( $SD = .12$ ), .87 ( $SD = .25$ ), .42 ( $SD = .35$ ), and .52 ( $SD = .28$ ). A one-way repeated measures ANOVA was conducted to evaluate whether children's judgments at the four levels of task difficulty differed significantly,  $F(3, 174) = 57.18, p <$

.001. Tukey's HSD follow-up tests revealed that children made a greater proportion of correct judgments at the well-within and just-within levels of difficulty than at either the just-beyond or well-beyond levels of difficulty. There was no significant difference between either the well-within and just-within levels or the just-beyond and well-beyond levels.

Because there were no significant differences in accuracy of judgments about tasks well within and just within children's ability or in accuracy of judgments about tasks well beyond and just beyond children's ability, tasks were aggregated. A single *overestimation* score was created by computing the proportion of tasks well beyond and just beyond the child's ability that was correctly judged. The mean score on the overestimation measure was .47 ( $SD = .28$ ). Lower scores, therefore, represent more frequent overestimation of ability. Similarly, a single *underestimation* score was created by aggregating the proportion of tasks well within and just within the child's ability that was correctly judged. In this case, lower scores represent more frequent underestimation of ability. The mean score on the underestimation measure was .91 ( $SD = .17$ ). Based on previous research, it is not surprising that children exhibited more overestimation than underestimation of ability,  $t(58) = -8.83, p < .001$ .

*Unintentional injury history.* At school age, mothers completed a brief survey designed to measure injury proneness. The questionnaire simply asked for a report of all lifetime injuries children had experienced that required a visit to a doctor or hospital and the approximate age of the injury. The following injury categories were listed for mothers: animal bites, broken bones, bruises, burns, concussions, cuts/scrapes, dental injuries, heat exhaustion/dehydration, choking, near drowning, and joint injuries. An "other" category for other types of injuries not listed also was provided. The total number of lifetime injuries was summed for analysis. Mean number of injuries reported was 1.19 ( $SD = 1.22, range = 0-5$  injuries). Twenty-one of the children's parents (36%) reported no lifetime injuries requiring medical treatment, 17 (29%) reported one injury, 15 (25%) reported two injuries, and 6 families (10%) reported three or more injuries.

## RESULTS

Three primary issues were examined: (1) correlational links between longitudinal and concurrent *parent-reported* temperament and both estimation ability and injury history; (2) correlational links between longitudinal *behaviorally measured* temperament and both estimation ability and injury history; and (3) correlational links between estimation ability and in-

jury history. Regression analyses also were conducted to examine multivariate relations. Throughout all analyses, longitudinal and concurrent measures were examined separately.

Preliminary analyses that were conducted to evaluate the potential moderating effects of gender on all variables revealed just one significant difference, on school-age Inhibitory Control (male  $M = 4.64, SD = .80$ ; female  $M = 5.04, SD = .69$ )  $t(57) = 2.02, p < .05$ . Therefore, males and females were pooled in subsequent analyses. A separate set of analyses was run with participants divided by gender and revealed results similar to those presented.

Although all children were about age 6 at the school-age assessment ( $range = 67-86$  months), age was significantly related to several school-age measures. Therefore, age was controlled in analyses.

### Relations between Parent-Reported Temperament and Both Estimation Ability and Injury History

To assess the relations between parent-reported temperament and ability estimation and injury history, an age-partialled correlation matrix was created (see Table 2). Both Extraversion and Inhibitory Control measures are reported from toddler-, preschool-, and school-age sessions. These scores were correlated with children's ability overestimation and underestimation, and injury history as measured at school age.

As Table 2 shows, children rated high on Extraversion tended to overestimate their physical abilities. As measured by mother report, the correlation between Extraversion and ability overestimation was significant not only at school age, when ability estimation was assessed,  $r(56) = -.31, p < .05$ , but also at preschool age,  $r(56) = -.27, p < .05$ . In other words, children who enjoyed intense and novel stimuli and who were impulsive and active tended to overestimate their abilities. Furthermore, children low on Extraversion tended to underestimate their ability. This finding was true based on mother temperament report at toddler age,  $r(56) = .27, p < .05$ , preschool age,  $r(56) = .34, p < .01$ , and school age,  $r(56) = .41, p < .005$ .

Mother-reported Inhibitory Control at preschool and school ages was not related to ability overestimation. However, mother-reported Inhibitory Control at preschool and school ages was significantly related to ability underestimation,  $r(56) = -.29, p < .05$ , and  $r(56) = -.25, p < .06$ , respectively. Therefore, children who were able to restrain approaches in novel situations were likely to underestimate their ability, but those whose parents reported poor Inhibitory Control were not particularly prone to overestimation of ability.

**Table 2** Correlations between Parent-Reported Temperament and Children's Estimation Ability and Injury History

	Extraversion			Inhibitory Control		
	32 Months	46 Months	75 Months	32 Months	46 Months	75 Months
Ability overestimation (75 months) <sup>a</sup>	-.21	-.27*	-.31*	.05	.05	.21
Ability underestimation (75 months) <sup>a</sup>	.27*	.34**	.41***	-.13	-.29*	-.25 <sup>+</sup>
Lifetime injuries (75 months)	.15	.17	.30*	-.17	-.16	-.34**

<sup>a</sup> Proportion judged correctly. Higher scores indicate more accurate judgment of ability.

<sup>+</sup>  $p < .10$ ; \*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .005$ . All two-tailed, controlled for age at school age, 56 *df*.

Table 2 also shows the correlations between mother-reported temperament and lifetime medically treated injuries. Unlike the relations with ability estimation, only concurrent, school-age temperament was related to medically treated injuries. Both children rated high on Extraversion,  $r(56) = .30$ ,  $p < .05$ , and those rated low on Inhibitory Control,  $r(56) = -.34$ ,  $p < .01$ , tended to have more injuries than peers without those traits.

#### Relations between Behaviorally Measured Temperament and both Estimation Ability and Injury History

Table 3 shows age-partialed correlations of behaviorally measured Inhibitory Control from the toddler- and preschool-age assessments with ability estimation and medical injury history measured during the school-age assessment. Unexpectedly, Inhibitory Control as measured at toddler age was a better predictor of ability estimation at age 6 than Inhibitory Control measured at preschool age. Inhibitory Control at toddler age was significantly related to ability overestimation,  $r(56) = .30$ ,  $p < .05$ , at school age. Thus, chil-

dren who had little capacity to suppress approach tendencies as toddlers were also more likely to inaccurately judge that they were capable of performing tasks beyond their ability as 6-year-olds.

Behaviorally measured Inhibitory Control at preschool age was related to lifetime injuries requiring medical treatment,  $r(56) = -.26$ ,  $p < .05$ . Thus, children who were less controlled in preschool had more unintentional injuries by age 6 than did their peers. The corresponding correlation based on Inhibitory Control at toddler age was in the predicted direction, but was not significant,  $r(56) = -.21$ ,  $p = .12$ .

#### Relations between Estimation Ability and Injury History

Despite the fact that estimation ability was correlated with temperamental characteristics and temperamental characteristics were correlated with injury proneness, there were no significant correlations between estimation ability and injury history. However, both overestimation of ability and underestimation of ability did correlate weakly with injury history in the expected direction,  $r(56) = -.12$ , *ns*, and  $r(56) = .18$ , *ns*, respectively.

**Table 3** Correlations of Inhibitory Control Behavioral Battery with Children's Ability Estimation and Injury History

	Inhibitory Control	
	32 Months	46 Months
Ability overestimation (75 months) <sup>a</sup>	.30*	.15
Ability underestimation (75 months) <sup>a</sup>	-.24 <sup>+</sup>	-.03
Lifetime injuries requiring medical treatment (75 months)	-.21	-.26*

<sup>a</sup> Proportion judged correctly. High scores indicate more accurate judgment of ability.

<sup>+</sup>  $p < .10$ ; \*  $p < .05$ . All two-tailed, controlled for age at school-age, 56 *df*.

#### Multivariate Analyses

Regression analyses were conducted to determine which factors best predicted estimation ability and injuries requiring medical treatment. To reduce the number of predictive variables, and because they correlated so highly with each other, temperamental measures from toddler and preschool ages were aggregated for the regression analyses. Correlations between the measures at the two ages were  $r(57) = .64$ ,  $r(57) = .76$ , and  $r(57) = .64$ , all  $ps < .001$  for mother-reported Extraversion, mother-reported Inhibitory Control, and behaviorally measured Inhibitory Control, respectively.



**Table 4** Summary of Hierarchical Regression Analyses for Predicting Ability Overestimation and Underestimation

Variable Entered	Ability Overestimation			Ability Underestimation		
	<i>B</i>	<i>SE B</i>	$\beta$	<i>B</i>	<i>SE B</i>	$\beta$
Step 1: Age						
Age	-.00	.01	-.01	.01	.00	.25 <sup>+</sup>
Step 2: Aggregated Longitudinal Temperament						
Behavioral Inhibitory Control	.17	.09	.29 <sup>+</sup>	-.02	.05	-.07
CBQ Inhibitory Control	-.08	.07	-.17	-.02	.04	-.08
CBQ Extraversion	-.13	.07	-.26 <sup>+</sup>	.08	.04	.26 <sup>+</sup>
Step 3: Concurrent Temperament						
CBQ Inhibitory control	.06	.06	.16	-.01	.04	-.06
CBQ Extraversion	-.12	.09	-.27	.09	.05	.33 <sup>+</sup>

Note: For ability overestimation,  $R^2 = .00$  for Step 1;  $R^2 = .13$  for Step 2; and  $R^2 = .19$  for Step 3. For ability underestimation,  $R^2 = .06$  for Step 1;  $R^2 = .17$  for Step 2; and  $R^2 = .23$  for Step 3.

<sup>+</sup>  $p < .10$ .

Two separate hierarchical regressions were conducted to predict overestimation and underestimation of ability (see Table 4). Age was entered first, followed by all three aggregated longitudinal temperament measures (mother-reported Extraversion, mother-reported Inhibitory Control, and behaviorally measured Inhibitory Control), and finally the two concurrent temperament measures (mother-reported Extraversion and Inhibitory Control) in the final step. The overall regression approached significance for overestimation of ability,  $F(6, 52) = 2.05$ ,  $p < .08$ ;  $R^2 = .19$ . The strongest predictors on the final step were the aggregated longitudinal measures of behavioral Inhibitory Control ( $\beta = .30$ ) and mother-reported Inhibitory Control, which surprisingly was a strong predictor in the negative direction ( $\beta = -.31$ ). The overall regression for underestimation of ability was significant,  $F(6, 52) = 2.58$ ,  $p < .05$ ;  $R^2 = .23$ . In this case, age and school-age Extraversion were the strongest predictors on the final step ( $\beta = .30$  and  $.33$ , respectively).

A Poisson regression was conducted to predict injuries requiring medical treatment, with injuries modeled in the Poisson distribution and a logarithmic curve used as the predictive curve. The following variables were entered: age, the three aggregated longitudinal temperament measures, the two concurrent temperament measures, and overestimation of ability (see Table 5). The strongest predictors were the aggregated longitudinal behavioral Inhibitory Control measure,  $\chi^2(1, N = 59) = 3.35$ ,  $p < .07$ , and school-age mother-reported Inhibitory Control,  $\chi^2(1, N = 59) = 3.07$ ,  $p < .08$ , and Extraversion,  $\chi^2(1, N = 59) = 2.27$ ,  $p < .14$ . A second regression equation was conducted using underestimation of ability as a predictor

rather than overestimation of ability (see Table 6). For this regression, the strongest predictors were the aggregated longitudinal behavioral Inhibitory Control measure,  $\chi^2(1, N = 59) = 3.11$ ,  $p < .08$ , and school-age mother-reported Inhibitory Control,  $\chi^2(1, N = 59) = 2.91$ ,  $p < .09$ , and Extraversion,  $\chi^2(1, N = 59) = 1.93$ ,  $p < .17$ .

## DISCUSSION

The results of this study demonstrate that Extraversion and Inhibitory Control are related to both estimation of physical ability and to unintentional injuries. This was true not only of concurrently measured temperament, but also of temperament measured sev-

**Table 5** Summary of Poisson Regression Analysis Predicting Injuries Requiring Medical Treatment with Temperament and Overestimation of Ability

Variable	Estimate	<i>SE</i>	$\chi^2$
Intercept	-7.26	3.13	5.38*
Age (75 months)	.03	.04	.72
Behavioral Inhibitory Control (aggregated 32 and 46 months)	-.62	.34	3.35 <sup>+</sup>
CBQ Inhibitory Control (aggregated 32 and 46 months)	.25	.28	.80
CBQ Extraversion (aggregated 32 and 46 months)	-.21	.32	.40
CBQ Inhibitory Control (75 months)	-.37	.21	3.07 <sup>+</sup>
CBQ Extraversion (75 months)	.48	.32	2.27
Overestimation of Ability (75 months)	.16	.47	.11

Note:  $\chi^2(1, N = 59)$ .

<sup>+</sup>  $p < .10$ ; \*  $p < .05$ .

**Table 6** Summary of Poisson Regression Analysis Predicting Injuries Requiring Medical Treatment with Temperament and Underestimation of Ability

Variable	Estimate	SE	$\chi^2$
Intercept	-6.99	3.03	5.32*
Age (75 months)	.03	.04	.53
Behavioral Inhibitory Control (aggregated 32 and 46 months)	-.56	.32	3.11 <sup>+</sup>
CBQ Inhibitory Control (aggregated 32 and 46 months)	.22	.27	.67
CBQ Extraversion (aggregated 32 and 46 months)	-.21	.32	.41
CBQ Inhibitory Control (75 months)	-.36	.21	2.91 <sup>+</sup>
CBQ Extraversion (75 months)	.45	.32	1.93
Underestimation of Ability (75 months)	.35	.97	.13

Note:  $\chi^2$  (1,  $N = 59$ ).

<sup>+</sup>  $p < .10$ ; \*  $p < .05$ .

eral years earlier. Children high on Extraversion and low on Inhibitory Control as toddlers and preschoolers tended to overestimate their physical abilities when they were age 6. In addition, toddlers and preschoolers low on Extraversion and high on Inhibitory Control tended to underestimate their physical abilities at age 6. Finally, children high on Extraversion and low on Inhibitory Control at age 6 tended to have more injuries in their history requiring medical treatment. Preschoolers who scored low on a behavioral battery of Inhibitory Control had significantly more lifetime injuries at age 6. Even though there were minor differences, it appears that the behaviorally measured Inhibitory Control scores displayed similar patterns of relations with both estimation of ability and with injury history, as did the parent-report measures of Inhibitory Control.

#### Mechanisms Linking Temperament, Ability Estimation, and Injury Proneness

Although even the longitudinal correlations observed here must be interpreted with caution, it appears that the relation between temperament and injury proneness may be mediated through other variables such as ability overestimation. We did not find that ability overestimation was related to injury proneness in this study, but other studies have found a link between the two (Plumert, 1995; Plumert & Schwebel, 1997). In two independent samples, Plumert (1995) reported a significant correlation between ability overestimation and injury proneness among 6-year-olds. Plumert and Schwebel (1997) replicated this finding among a sample of 6-year-old boys. These results suggest that ability overestimation may medi-

ate the relation between temperament and injury proneness. In other words, those children who are particularly approach-oriented, impulsive, and active are injured more frequently because they tend to overestimate their physical abilities. This overestimation of ability, in turn, leads to injuries.

This hypothesis does not rule out the possibility, of course, that there are other mediating variables that also help explain the relation between temperament and injury proneness. For example, children's exposure to novel situations also may act as a mediating factor. Activity level and approach tendencies may be risk factors for unintentional injuries because these traits are related to the number of novel situations that children encounter. Novel situations may lead to injuries because such situations force children to react to potentially unforeseen, dangerous problems. The possibility that several variables might play mediating roles between temperament and injury proneness suggests that no single mediating variable may have a strong and consistent relation to injuries and could explain the present estimation results. Rather, a larger constellation of mediating variables may be necessary to explain the relation between temperament and injury proneness.

#### Underestimation of Ability

This study also revealed important links between temperament and underestimation of ability. Although children's overestimation of ability has been examined extensively in the cognitive development literature (e.g., Adolph, 1995; Adolph et al., 1993; Lee et al., 1984; McKenzie et al., 1993; McKenzie & Forbes, 1992; Plumert, 1995; Plumert & Schwebel, 1997), underestimation of ability has rarely been observed. Present results indicate that children rated high on Inhibitory Control and low on Extraversion tended to underestimate their physical abilities. Most studies of childhood injuries focus on the temperamental and cognitive traits of children who are highly injury-prone, but it may also be useful to consider possible protective factors of children who are particularly injury-free. Both temperamental characteristics such as low Extraversion and high Inhibitory Control as well as underestimation of ability may be such protective factors.

Although underestimation of ability may help the child avoid frequent unintentional injury, underestimation could have other, less positive consequences. Socially, children who underestimate their physical abilities may be left behind their peers. For example, imagine a group of boys running through a field, jumping over a creek, and arriving at a park to play

basketball. But suppose one boy reaches the creek and pauses. He looks at the creek and, underestimating his ability, decides he cannot successfully complete the jump. He must run an extra few hundred meters to a bridge over the creek that he can cross and then rejoin his peers for the game. The underestimator in this case may feel socially isolated, develop low self-esteem and, over time, may be taunted, ridiculed, and ultimately rejected by peers.

A second consequence of underestimation of ability is the reduced opportunity to practice physical skills. Children who underestimate their ability frequently will not attempt physical activities, causing less muscle development, less flexibility, and less balance. Such physical deficits may have negative social and physical consequences as the child develops. Development, particularly during childhood, encompasses the aspiration to try new things that may be beyond one's ability (Bjorklund & Green, 1992; Plumert, 1995). Although overestimation over repeated circumstances or in particularly dangerous situations may have injurious consequences, overestimation in relatively safe circumstances allows children to experiment, grow, and explore their environment. Clearly, this conundrum of overestimation and underestimation deserves more study and future research should concentrate not just on overestimation but also on underestimation of ability.

### Implications for Injury Prevention

Childhood injuries are among the few child health problems where annual mortality rates have decreased only slightly over the past several decades (National Safety Council, 1997). As national concern for prevention of unintentional injuries has grown, several strategies have been used to help prevent childhood injuries. Institution of laws such as the use of child safety seats in automobiles and major national safety initiatives such as the encouragement of the use of children's bicycle helmets have been beneficial. Teachers, parents, community leaders, and even children themselves have become more aware of environmental dangers. Nonetheless, children's injuries remain a crucial national health problem.

In considering the present data and its implications for intervention to prevent injuries, a first reaction may be to target individual children who score high in Extraversion or who tend to overestimate their ability. Temperament theory suggests that temperament is relatively stable throughout development (Caspi & Silva, 1995; Goldsmith et al., 1987) and, therefore, early temperament traits predicts later behavioral outcomes (e.g., Kochanska, Murray, & Coy, 1997). The present findings confirm these ideas and

imply that temperament in toddlerhood is related to injury history and estimation of ability several years later. Thus, interventions should be directed toward educating those children with vulnerable temperament patterns about safe behaviors. For example, children who are particularly extraverted are likely to enjoy riding their bicycles and therefore face dangerous situations such as railroad crossings. A combination of impulsive tendencies and frequent overestimation of ability may cause those children to incorrectly judge they can cross dangerous railroad crossings before the arrival of trains, accounting for the alarming statistics on children's accidents at railroad crossings. With proper training directed specifically toward children who ride bicycles across railroad tracks, and who are high in Extraversion and tend to overestimate their ability, many of these accidents could be prevented.

Although such interventions are necessary and useful, both parents and professionals—as well as the children themselves—may find it difficult to alter lifelong temperamental tendencies and cognitive strategies. Children high in Extraversion are likely to impulsively approach dangerous situations and overestimate their ability at railroad crossings and similar situations throughout their lives. In fact, these tendencies often serve such children well as they enter careers that require sensation-seeking traits. Intervention to teach cognitive awareness of temperamental tendencies, although valuable, may be ineffective in preventing all injuries.

Psychological understanding of the causes of injuries is also important to development of a second means of injury prevention. In collaboration with educationally oriented intervention, environmental manipulations must be designed and utilized to prevent behaviors that may cause injuries. Knowledge that impulsive, overestimating behaviors are factors in injuries can help identify appropriate interventions. Consider again dangerous railroad crossings. Over the past few decades, gates have been added to many railroad crossings. Rather than seeing just a flashing light when a train approaches, motorists (and child bicyclists) are blocked from crossing the tracks by a wooden gate that is lowered when a train is approaching and raised only after the train has safely passed the intersection. These gates provide a visual and physical impediment to impulsive, overestimating attempts to cross the tracks before the arrival of the train and are only a logical intervention with psychological knowledge that impulsivity and overestimation may cause injuries in dangerous situations such as railroad crossings.

Thus, both environmental interventions and edu-

cational interventions are essential means to prevent children's injuries. Each of those techniques depends on insight concerning the psychological contributors to injury proneness such as temperament and overestimation of ability. Continued research on the psychological factors related to injury proneness is imperative to achieving the goal of reducing the rate of childhood death and disability due to unintentional injuries just as the rate of death and disability from other children's health problems has been dramatically lowered over the past several decades.

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