The Roles of Age, Gender, Inhibitory Control, and Parental Supervision in Children's Pedestrian Safety

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Objective Thousands of American children are injured or killed each year as pedestrians, but behavioral factors in pedestrian injury etiology remain poorly understood. We examined the roles of children's individual differences (age, gender, and inhibitory control) and parental supervision in children's pedestrian behaviors. **Methods** Using the pretend road method, a sample of 85 children and 26 adults crossed a pretend crosswalk set adjacent to a real road. Safety of crossing the pretend road was determined based on actual traffic on the real road. Adults also crossed the real road. **Results** Adults' behavior on the real road paralleled that on the pretend road, supporting validity of the method. On the pretend road, younger children, boys, and children with less behavioral control engaged in riskier pedestrian behaviors. Children with less behavioral control responded more noticeably to increases in parental supervision. **Conclusion** Results are discussed in relation to children's development and injury prevention.

Key words inhibitory control; injury etiology; parental supervision; pedestrian injuries; unintentional injuries.

Each year approximately 15,000 American children under the age of 10 are injured as pedestrians, and more than 320 are killed (National Center for Injury Prevention and Control, 2005). In the United States alone, children's pedestrian injuries result in an estimated annual loss of $11.7 billion dollars in injury-related expenses (National Safety Council, 2001).

In spite of the tremendous public health and financial cost, behavioral factors that contribute to the etiology of pedestrian injuries remain poorly understood. The present study examines two independent but related questions concerning the etiology of children's pedestrian injury. First, we consider the roles of age, gender, and inhibitory control as individual differences influencing children's pedestrian behaviors. Second, we investigate the role of parental supervision in influencing children's pedestrian behaviors.

Individual Difference Factors

Age as a Risk Factor for Pedestrian Injury

Children aged 5–9 years are at high risk for pediatric pedestrian injuries (Assailly, 1997), probably due to the confluence of developing mobility and underdeveloped cognition. In middle childhood, children begin to display mobility and independence that motivate them to explore and seek pedestrian environments without adult supervision. In fact, most parents state that they are comfortable allowing their children to cross neighborhood streets and parking lots independently by age 6 or 7 (Wills et al., 1997). However, children in middle childhood, especially those aged 5 and 6, are not yet cognitively capable of simultaneously handling the several tasks required for safe pedestrian activity (Whitebread & Neilson, 2000). To cross a street safely, children must identify safe crossing gaps in traffic by attending to the speed, acceleration/deceleration, and distance of moving vehicles in at least two directions, judging the speed with which they can propel themselves across the span of the roadway, and recognizing and coping with visual occlusions such as parked cars, bushes, or curves and inclines on the roadway. The present study compares the ability of 5- and 6-year-olds to that of 7- and 8-year-olds and of adults to handle the multiple cognitive demands of safe pedestrian behavior.

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Gender as a Risk Factor for Pedestrian Injury

Epidemiological research repeatedly implicates male gender as a risk factor for pedestrian injury (e.g., Assailly, 1997). Several explanations have been offered to explain the gender disparity in injury rates. First, boys tend to have more impulsive, undercontrolled behavioral styles that lead to risk for unintentional injury (Schwebel & Barton, 2006). Second, boys are more likely to attribute injuries to bad luck, and girls to their own behavior and decisions, leading boys to repeat injury risk behaviors more often than girls (Morrongiello, 1997). Third, societal expectations and gender role socialization influence pedestrian injury risk (Morrongiello & Hogg, 2004). Boys are expected and permitted to take greater risks, to approach physical hazards more quickly and fearlessly, and to consider ''accidents'' to be bad luck more often than girls (Morrongiello & Rennie, 1998).

Inhibitory Control as a Risk Factor for Pedestrian Injury

Inhibitory control, defined as the child's capacity to inhibit impulses when faced with novel or desirable stimuli, or when instructed to do so by a superior (Rothbart, Ahadi, & Hershey, 1994) is also a risk factor of interest for pedestrian injury. Uninhibited children typically have strong urges to cross a street quickly to chase a lost toy or return home. Although most school-age children have been repeatedly instructed by adults to be careful near busy streets, there is great risk for a lapse in inhibition of impulses.

Children's inhibitory control is linked to general risk for unintentional injury in several studies (e.g., Schwebel & Bounds, 2003; Schwebel & Plumert, 1999), but empirical research examining links between inhibitory control and injury in pedestrian settings is sparse. One study compared a group of children aged 5–12 years who were injured in pedestrian injuries to a matched control group (Christoffel et al., 1996). Pedestrian-injured cases did not differ from the matched controls on measures of inhibitory control impulsivity or sociability. The two groups also did not differ on clinical measures of hyperactivity, aggression, or inattention. A second study found conflicting results. It compared children aged 5–15 years injured as pedestrians or bicyclists with those injured in other settings (e.g., motor vehicle crashes, falls, or athletic injuries; Pless, Taylor, & Arsenault, 1995). Children injured as pedestrians or bicyclists were less able to inhibit their behavior in a computerized delayed response task than the controls injured in other settings.

The Role of Supervision

Parental supervision is among the most effective behavioral techniques for reducing pediatric injury risk (Morrongiello, 2005). Supervision, defined as the parent's physical proximity to the child and readiness to intervene (Morrongiello, 2005), likely influences children's pedestrian safety in at least two ways. First, a supervising adult can physically or verbally intervene when a child begins to behave in a dangerous way in a pedestrian environment. The efficacy of such interventions seems rather obvious—a parent holding a young child's hand can readily restrain the child if he or she begins to cross a street in front of an oncoming car—and has been demonstrated indirectly through empirical work in both home environments (Morrongiello, Ondejko, & Littlejohn, 2004) and pedestrian settings (Wills et al., 1997). However, the level of supervision intensity necessary to create a safe situation is unclear. Morrongiello (2005) suggested supervision is more effective as proximity to the child increases. Clearly holding a child's hand is safer than being absent, but is merely standing near a child—out of reach for physical contact—sufficient to prevent injury? Is watching a child through an automobile or home window—but being out of verbal contact—an effective or partially effective approach to supervision? The present study tested these questions by measuring children's pedestrian safety under four intensity levels of parent supervision.

Second, supervision may influence pedestrian behavior as a moderator of the link between inhibitory control and injury risk (Schwebel & Barton, 2005). Empiricists have long-recognized the link between children's inhibitory control and injury risk (e.g., Manheimer & Mellinger, 1967), but only recently have theorists considered the process through which inhibitory control might influence that risk (Schwebel & Barton, 2005, 2006). One hypothesis is that supervision causes undercontrolled children to judge their abilities more cautiously (Schwebel & Bounds, 2003). In other words, children tend to overestimate their physical abilities (Plumert, 1995), and impulsive children do so more than nonimpulsive children (Schwebel & Plumert, 1999). A recent laboratory study suggested that one way to reduce children's tendency toward overestimation of ability is to intensify parental supervision while children make

judgments about ability (Schwebel & Bounds, 2003). In that study, undercontrolled children judged their ability to complete basic physical reaching and stepping tasks more cautiously with a parent silently present in the room than when a parent was absent. The present study sought to extend this finding in the more ecologically valid setting of a pedestrian setting: Would undercontrolled children judge their ability to cross streets more cautiously when supervised?

The Present Study: Measurement Issues and Hypotheses

To assess the roles of development, gender, inhibitory control, and supervision on child pedestrian safety, children completed the pretend road technique (Lee, Young, & McLaughlin, 1984). The pretend road technique involves placement of a pretend wooden crosswalk, constructed at the same dimensions as an actual crosswalk, adjacent to a real road with real traffic. Participants watch real traffic on the real road and use that information to identify an appropriate traffic gap within which they can cross the pretend crosswalk. The pretend road technique offers the visual, aural, and motor stimulation of an actual crossing without placing children at risk of injury. Previous work using the pretend road technique suggests it is readily understood by children and adults and is crossed in a manner similar to that of real road crossings among adult samples, who can ethically be placed on real roads (Lee et al., 1984). Other work offers convergent validity of the pretend road with other methods (Demetre et al., 1992).

In the present study, 85 children and 26 adults engaged in the pretend road technique by crossing a pretend road situated adjacent to a bi-directional, two-lane suburban thoroughfare with moderately heavy traffic. Adults were recruited to demonstrate validity of the pretend road environment: they crossed both the pretend road and the real road, and behavior in the two settings was compared. Children crossed the pretend road under varying levels of supervision intensity. We had two primary aims. First, we examined how age, gender, and inhibitory control were related to pedestrian safety when children were unsupervised. We hypothesized younger children, boys, and undercontrolled children would take more risks than their older, female, and more controlled counterparts. Second, we tested how increasing intensity of supervision might influence children's safety. We expected children, and in particular undercontrolled children, to display more caution with increasing intensity of parental supervision.

Method

Participants

Ninety-one children aged 5–8 years were recruited from community advertisements and a laboratory database of families interested in child safety research. Two children withdrew because they were fearful of crossing the pretend road without a parent nearby and four children were excluded due to incomplete data. Data from the remaining 85 children (17 age 5, 20 age 6, 16 age 7, 32 age 8; average age = 7.21 years, $SD = 1.25$) are presented. Gender and ethnic distribution of the child sample was diverse (53% male, 47% female; 53% Caucasian, 37% African-American, 4% Asian-American, 6% other ethnicities). The sample included individuals from a relatively wide range of socioeconomic status (median household income for child sample = $60,000; median household income in the area = $38,230; US Census Bureau, 2006).

Twenty-six adult participants were recruited from undergraduate psychology classes. Average age of adult participants was 22.24 years ($SD = 5.13$; range = 19–37). Gender and ethnic distribution was diverse (38% male, 62% female; 46% Caucasian, 46% African-American, 4% Asian-American, 4% other ethnicities). Median household income for families of adult participants was $20,000, reflecting the fact that most students have modest income.

All study protocols were approved by the university's ethics board. Adults and children's parents provided signed informed consent to participate in the study; children provided assent, as developmentally appropriate. Children's families received modest financial compensation for their time, and adults received credit as one option to complete course requirements.

Inhibitory Control Measure

The Inhibitory Control scale of the Child Behavior Questionnaire (CBQ; Rothbart et al., 1994) assessed inhibitory control ($M = 4.83$, $SD = 0.92$). The scale has good psychometric properties ($\alpha = .85$ in this study; see also, Rothbart, Ahadi, Hershey, & Fisher, 2001).

Pedestrian Safety Procedure

The task

The pretend road technique was used to measure participants' pedestrian behaviors (Lee et al., 1984). A wooden pretend crosswalk matching the dimensions

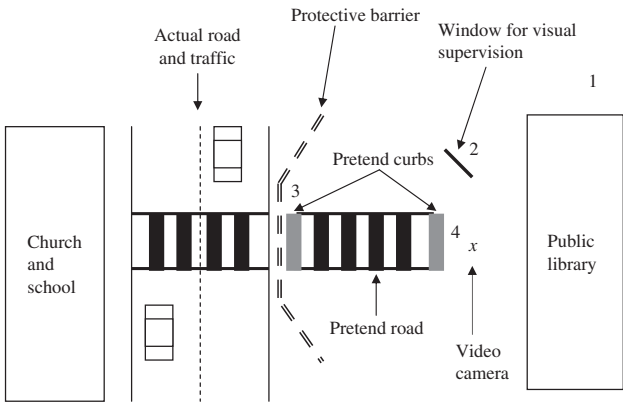

Figure 1. Diagram of the pretend road. Numbers indicate parent's position in each supervision intensity.

of a nearby real crosswalk was placed in a grassy area perpendicular to the two-lane, bi-directional real road in a suburban neighborhood (Fig. 1). Note that in the region of the United States where this study took place, vehicles do not typically yield to pedestrians waiting at a crosswalk with no traffic signal. To prevent children from entering the real road, the experimental area was cordoned from the real road using traffic sawhorses and yellow ''caution'' tape.

The real crosswalk connected a public library to a church and school, and was at a location where children frequently crossed the street unsupervised. The road had a posted speed limit of 30 miles per hour (MPH), and traffic generally traveled between 25 and 35 MPH. Traffic lights regulated traffic within a half-mile of the experimental site in both directions, but the pretend and real crosswalks were in unregulated locations. During experimental sessions, the average traffic volume was 11.13 vehicles per minute, a level associated with relatively high risk for pedestrian injury (Roberts, Norton, Jackson, Dunn, & Hassall, 1995). The *SD* of traffic volume was 2.30 vehicles per minute, suggesting relative consistency across participants.

During the study, participants stood on the pretend curb facing the real road and were instructed to use traffic on the real road to decide when to cross the pretend road. Anecdotal evidence from this study and empirical evidence from previous work (Lee et al., 1984) suggest that children and adults understood the protocol without difficulty.

Experimental Conditions

Adults crossed both the pretend and real roads, using the marked crosswalk, five times. Order of crossing real and pretend roads was randomized across adult participants. Children crossed the pretend road five times under each of the four intensities of supervision (no supervision, visual supervision, partial supervision, and full supervision), for a total of 20 crossings. Intensity level was presented in random order across participants. In the no supervision condition, children's parents were completely out of view. In the visual supervision condition, the parents watched children through a nearby window. Neither verbal nor nonverbal communication between children and parents was permitted or possible during crossings in this condition. In the partial supervision condition, parents stood on the opposite side of the pretend road, and to the right of the pretend curb from the children's perspective. Communication was permitted, and most parents did so via shouting or hand and body signals. In the full supervision condition, parents crossed the pretend road with their children. Many parents held hands with their child during this condition; almost all used physical and verbal communication.

Thus, increases in intensity beyond the no supervision condition involved two key aspects of parent supervision, varying parental attentiveness and readiness to intervene (Morrongiello, 2005). Attentiveness increased across conditions in the form of parental observation and communication. Readiness to intervene increased through the physical presence and proximity of the parent.

Protocol

Participants were first asked to stand on the pretend curb. Following a cue to ''cross when you think it looks clear,'' participants began looking at traffic on the real road and crossed when they deemed it safe. After reaching the far side of the pretend road, participants walked back to the starting curb. All crossing behaviors were videotaped for subsequent coding using a camera with a wide-angle lens situated approximately five feet behind participants.

Measures

As detailed below, six pedestrian behaviors were measured: wait time, attention to traffic, missed opportunities, gap size, anticipations, and tight fits. Scores on each measure were calculated for each child within conditions of supervision intensity. Aggregates were created by averaging measures of time and common events (wait time, attention to traffic, gap size) and by summing uncommon events (missed opportunities, anticipations, tight fits).

''Wait time'' was calculated as the time in seconds that elapsed between the researcher's cue to cross when judged safe and both of the participants' feet leaving the curb. ''Attention to traffic'' was measured as the number of times participants looked left plus the number of times they looked right for oncoming traffic while waiting to cross. Variations in traffic flow were controlled for both the ''wait time'' and ''attention to traffic'' measures by dividing each score by traffic volume (vehicles per minute) during the participants' session. ''Missed opportunities'' were determined by timing all traffic gaps during a participant's session. Gaps not chosen that were greater than 1.5 times the participant's average cross time were considered missed opportunities (i.e., safe gaps not chosen). Due to positive skew, data were recoded as 0 (no missed opportunities) or 1 (missed one or more opportunities to cross in a condition). ''Gap sizes'' were calculated as the distance, in seconds, between moving vehicles that participants chose to cross within. Timing began when the last vehicle left the crosswalk before the participant began crossing, and ended with the arrival of the next vehicle in the crosswalk. ''Anticipations'' represented a participant's entering the near lane of traffic before a vehicle cleared the crosswalk on the far side of the road, in expectation of a safe crossing opportunity. ''Tight fits'' occurred when participants attempted to cross in a gap temporally smaller than their average crossing time. These were scored by counting the number of crossings participants made in a gap less than their average cross time within that condition. Many but not all of these crossings would have resulted in a collision on the real road. Because the pretend road technique lacks the precision to consistently identify instances when a vehicle would have hit the child, the present study replicates previous pretend road research (e.g., Demetre et al., 1992) and combines near and actual hits into a single measure of tight fits.

Removal of Outliers

Behavioral data were examined for outliers by trial prior to aggregation, with scores greater than 3 *SD* above or below the mean classified as outliers and removed (Plumert & Schwebel, 1997). For example, each child's waiting time was examined for each individual trial. Waiting times (divided by traffic volume) 3 *SD*s above or below the mean across all participants within that trial were removed. Within each pedestrian behavior, there were 20 trials and 85 participants for a total of 1700 data points. Data points removed within each variable never exceeded 3% (51 cells). Most of these instances occurred because children became inattentive while waiting to cross the street, and therefore represented off-task distraction rather than anomalous pedestrian behavior. Following outlier removal, the five trials within conditions were aggregated to form a single variable for each condition.

Interrater Reliability

Interrater reliability in coding pedestrian behavior was tested by having two researchers independently code 20% of the sample. Reliability for all measures was high (all $rs \geq .97$). Differences were resolved by using data from the primary coder, who coded all data.

Results

Analysis proceeded in four steps. First, adults' pedestrian behaviors on the pretend and real roads were compared to validate the methodology. Second, the roles of age, gender, and inhibitory control on children's unsupervised pedestrian safety were considered in independent analyses. Third, the role of supervision was considered in an independent analysis. Finally, the roles of age, gender, inhibitory control, and supervision were examined concurrently in a single multivariate analysis.

Validation with Adults: Pretend and Real Road Comparison

Adults' pedestrian behaviors on the pretend and real roads were compared in a repeated-measures MANOVA (detailed results available from the first author). A significant multivariate main effect was found, F (6, 20) = 3.31, $p < .05$, Wilks' lambda = .50, $\eta^2 = .50$. Just one significant univariate main effect emerged. Replicating previous work (Lee et al., 1984; Young & Lee, 1987), adults had significantly more tight fits on the pretend road than on the real road, suggesting most behavior by adults on the pretend road is comparable with that in real traffic.

The Role of Age in Children's Pedestrian Safety

Relations between age and unsupervised pedestrian behaviors were examined next. First, we correlated children's ages (in months) and all six unsupervised pedestrian behaviors. Significant relations were found between age and five of the six pedestrian behaviors. Wait times, attention to traffic, missed opportunities, and gap sizes were all positively related to age [r (85) = .30, .34, .36, and .37, respectively; all $ps < .01$]. Tight fits were negatively related to age, r (85) = −.35, $p < .01$. Anticipations were not related to age, r (85) = −.08, $p > .05$.

Second, a MANOVA was used to examine mean differences in pedestrian behaviors under no supervision between younger children (aged 5–6 years), older children (aged 7–8 years), and adults. A significant multivariate main effect was found, F (12, 202) = 3.23, $p < .01$, Wilks' lambda = .70, $\eta^2 = .16$. Significant univariate main effects were found for five of the six pedestrian behaviors (Table I). For attention to traffic, missed opportunities, gap sizes, and tight fits, the effect followed a similar pattern: younger children performed less safely than older children, but not significantly different from adults (who presumably were cognitively capable of somewhat riskier behaviors). For anticipations, a slightly different pattern emerged in which adults anticipated safe gaps significantly more often than younger and older children.

The Role of Gender in Children's Pedestrian Safety

Gender differences in all six unsupervised pedestrian behaviors were examined with a MANOVA. A significant multivariate main effect was found, F (6, 76) = 2.84, $p < .05$, Wilks' lambda = .82, $\eta^2 = .18$. Significant univariate results were found for four of the six pedestrian behaviors (Table I). Girls waited longer than boys and attended to traffic more than boys. Boys missed fewer opportunities to cross than girls, and engaged in more anticipations than girls. There were no significant gender differences in gap sizes or tight fits. Together, these results converge with epidemiological data that boys have more pedestrian injuries than girls—in this sample, the boys tended to behave in a riskier manner on the pretend road than did the girls.

The Role of Inhibitory Control in Children's Pedestrian Safety

We examined relations between children's inhibitory control and all six unsupervised pedestrian behaviors using Pearson correlations. Significant relations were found between inhibitory control and five of the six pedestrian behaviors (Table II). Children with greater inhibitory control waited longer, attended more to traffic, missed more opportunities, and chose larger gap sizes ($r = .36$, .38, .31, and .39, respectively; all ps $< .01$). Greater inhibitory control also was related to fewer tight fits ($r = -.22$, $p < .05$). These results parallel research in the broader child injury literature (e.g., Schwebel & Barton, 2006; Schwebel & Plumert, 1999): children with greater inhibitory control tended to behave more cautiously on the pretend road. Parenthetically, Table II also shows that most pedestrian measures were related at a statistically significant level to each other.

Table II. Relations between all Pedestrian Behaviors and Inhibitory Control

Variables	1	2	3	4	5	6	7
1. Inhibitory control	–	.36**	.38**	.31**	.39**	−.22*	−.10
2. Wait times		–	.91**	.61**	.38**	−.34**	−.29*
3. Attention			–	.58**	.43**	−.37**	−.26*
4. Missed opportunities				–	.33**	−.49**	−.24*
5. Gap sizes					–	−.59**	−.10
6. Tight fits						–	.17
7. Anticipations							–

$N = 85$.
*$p < .05$, **$p < .01$.

Table I. Means and *SD*s for Age and Gender Differences for all Pedestrian Behaviors

Behaviors	5–6-year-olds	7–8-year-olds	Adults	F	η^2
Wait times	1.33 (1.27)	1.97 (1.27)	1.57 (0.95)	2.75	.05
Attention to traffic	0.23 (0.21)[a]	0.35 (0.20)[b]	0.27 (0.10)	4.72**	.08
Missed opportunities	0.43 (0.50)[a]	0.77 (0.42)[b]	0.31 (0.47)	10.15**	.16
Gap sizes	11.50 (4.41)[a]	14.18 (4.34)[b]	11.85 (3.59)	4.25*	.07
Tight fits	1.53 (1.16)[a]	0.90 (0.97)[b]	1.65 (1.20)	5.74**	.10
Anticipations	0.46 (0.73)[a]	0.46 (0.74)[a]	1.12 (0.99)[b]	6.31**	.11
	Boys	**Girls**			
Wait times	1.26 (1.05)	2.18 (0.36)		11.06**	.12
Attention to traffic	0.25 (0.20)	0.36 (0.22)		5.33*	.06
Missed opportunities	0.51 (0.51)	0.75 (0.44)		5.39*	.06
Gap sizes	12.16 (4.91)	13.98 (3.95)		2.53	.03
Tight fits	1.30 (1.13)	1.03 (1.05)		1.51	.02
Anticipations	0.64 (0.86)	0.25 (0.49)		6.57**	.08

Ages 5–6, $n = 36$; ages 7–8, $n = 47$; adults, $n = 26$; boys, $n = 44$; girls, $n = 39$. Superscript alphabets indicate significant differences between age groups.
*$p < .05$, **$p < .01$.

The Role of Parental Supervision in Children's Pedestrian Safety

A repeated-measures MANOVA evaluated differences in pedestrian behaviors according to intensity of parent supervision (Table III). A significant multivariate main effect was found, F (18, 53) = 1.93, $p < .05$, Wilks' lambda = .61, $\eta^2 = .40$. Univariate tests indicated significant differences by supervision intensity for missed opportunities, tight fits, and anticipations. Post hoc testing was done using paired-samples t-tests with Cohen's d as an indicator of effect size. Children had more missed opportunities when fully supervised than when visually supervised ($d = .32$). Children had significantly more tight fits when unsupervised, visually supervised, and fully supervised, in comparison with partial supervision ($d = .44$, .31, and .36, respectively). For anticipations, there was a trend for a difference between partial and full supervision intensities ($d = .31$).

The Combined Roles of Age, Gender, Inhibitory Control, and Supervision

A final multivariate analysis was conducted. Inhibitory control was dichotomized using a median split (median score = 4.82; the two resulting groups were significantly different; greater behavioral control mean = 5.60; lower control mean = 4.05; t (83) = −14.09, $p < .01$). Supervision intensity (four levels) was examined in the context of a 2 (age) × 2 (gender) × 2 (inhibitory control) repeated-measures MANOVA. Two significant multivariate effects were found: inhibitory control, F (6, 62) = 2.76, $p < .05$, Wilks' lambda = .79, $\eta^2 = .21$; inhibitory control × supervision interaction, F (18, 50) = 1.96, $p < .05$, Wilks' lambda = .59, $\eta^2 = .41$.

Univariate tests indicated inhibitory control was related to differences in three pedestrian behaviors. Children with less inhibitory control ($M = 1.48$) spent less time waiting than children with more control ($M = 2.06$), F (1, 67) = 6.25, $p < .05$, $\eta^2 = .09$. Children with less inhibitory control ($M = 0.25$) attended less to traffic than children with more control ($M = 0.34$), F (1, 67) = 5.56, $p < .05$, $\eta^2 = .08$. Finally, children with less inhibitory control ($M = 12.65$) chose smaller crossing gaps than children with more control ($M = 14.40$), F (1, 67) = 6.71, $p < .05$, $\eta^2 = .09$.

The interaction between inhibitory control and supervision intensity was relevant to one pedestrian behavior, gap sizes, F (3, 201) = 3.89, $p < .01$, $\eta^2 = .06$. Children with less inhibitory control chose significantly smaller gaps ($M = 10.81$, $SD = 3.68$) when unsupervised than children with more inhibitory control ($M = 15.16$, $SD = 4.31$), F (1, 83) = 24.97, $p < .01$. Gap sizes chosen were significantly larger among children with less inhibitory control when supervision intensity increased from no supervision ($M = 10.81$, $SD = 3.68$) to visual supervision ($M = 12.73$, $SD = 3.02$), t (41) = −2.62, $p < .01$ (detailed data and figure available from the first author).

Discussion

The roles of age, gender, inhibitory control, and supervision in children's pedestrian safety were studied using the pretend road technique. Like in previous works (Lee et al., 1984; Young & Lee, 1987), we found that adults behaved similarly on the pretend and actual roads, and concluded that the pretend road technique offers a valid measure of pedestrian behaviors. Our primary hypotheses were tested through independent and multivariate analyses of how age, gender, inhibitory control, and supervision contributed to children's pedestrian behaviors. All four factors played a role in safety independently, and inhibitory control played the strongest role in multivariate analysis. We also discovered an inhibitory control by supervision interaction for one measure of pedestrian safety. Below, we address the primary findings and discuss implications for pedestrian injury prevention.

Table III. Means and *SD*s for Comparisons between Intensities of Supervision

	Intensity of supervision					
Behaviors	No	Visual	Partial	Full	F	η^2
Wait times	1.69 (1.30)	1.73 (1.40)	1.72 (1.10)	2.07 (1.00)	2.34	.03
Attention to traffic	0.30 (0.21)	0.29 (0.18)	0.27 (0.17)	0.32 (0.15)	2.08	.03
Missed opportunities	0.62 (0.49)	0.54 (0.51)[a]	0.59 (0.50)	0.69 (0.46)[b]	2.91*	.04
Gap sizes	13.01 (4.55)	13.46 (4.13)	13.89 (4.38)	14.36 (4.39)	1.96	.03
Tight fits	1.17 (1.10)[b]	0.99 (1.17)[b]	0.67 (0.91)[a]	1.02 (1.06)[b]	3.00*	.04
Anticipations	0.46 (0.73)	0.33 (0.59)	0.30 (0.55)	0.49 (0.69)	2.79*	.04

$N = 85$. Superscript alphabets indicate significant differences in post hoc tests. Estimates of effect size are from the overall multivariate analysis.
*$p < .05$.

Consistent with epidemiological findings (e.g., Assaily, 1997), 5- and 6-year-old children tended to display the most dangerous pedestrian behaviors on the pretend road. Compared to 7- and 8-year-olds, younger children took more risks and had more tight fits that might have resulted in collisions. This finding corresponds to cognitive development research, suggesting children under age 7 or 8 may utilize inferior strategies to visually search pedestrian settings (Connelly, Conaglen, Parsonson, & Isler, 1998; Whitebread & Neilson, 2000). In particular, hearkening classic Piagetian theory, younger children are unable to decentrate—or focus on multiple parts of a problem—whereas older children can more successfully integrate information from multiple sources to handle pedestrian crossings. In other words, young children may tend to focus on the distance of a single impending vehicle when determining the safety of a crossing, whereas older children and especially adults are better able to consider simultaneously the speed, distance, and acceleration of multiple vehicles from multiple directions, as well as the speed with which they can physically cross the span of the road.

Interestingly, the young children's behavior on most measures was statistically similar to adults' behavior. This finding likely reflects the fact that adults have fully developed cognitive skills that permit safe risk-taking. That is, adults do not necessarily avoid engaging in all risky behaviors, but are perhaps better at taking calculated risks. Adults performed differently than both sets of children only on the measure of anticipating safe traffic gaps. Anticipations are the most cognitively complex of the tasks measured. Anticipating a safe gap in traffic requires sophisticated and simultaneous assessment of the speed, acceleration/deceleration, and distance of oncoming traffic in both directions—and anticipations result in serious penalty for miscalculation. Therefore, it is not surprising that adults might anticipate safe traffic gaps more often than either group of children.

Our findings on the roles of gender and inhibitory control on pedestrian safety were as expected. Consistent with epidemiological findings, girls were safer and more cautious pedestrians than boys. Research on the role of inhibitory control on children's pedestrian behavior is sparse and reliant primarily on cognitive measures of inhibitory control (e.g., Briem & Bengtsson, 2000; Pless et al., 1995), but the present findings—that uninhibited children take greater risks in pedestrian settings—are consistent with the broader child injury literature (Schwebel & Barton, 2006).

Perhaps the most unexpected results were those on the role of supervision on children's pedestrian safety. Children behaved somewhat more cautiously when supervised but crossing without a parent, but these results were weaker than hypothesized. The most consistent finding was increased risk-taking when children were fully supervised, a finding likely attributed to the fact that parents and not children decided when to cross in the full supervision condition.

We discovered an interaction between inhibitory control and supervision intensity related to selection of traffic gap size. When unsupervised, children with poor inhibitory control chose significantly smaller gap sizes than their counterparts with better inhibitory control. As supervision intensity increased, the disparity between children with high and low inhibitory controls diminished. Under full supervision, the two groups chose gap sizes that were essentially identical. This result replicates findings in a laboratory setting (Schwebel & Bounds, 2003) and suggests that children at greatest risk for unintentional injury—those with less behavioral control—are most influenced by parental supervision.

Limitations

Several limitations of the present research should be mentioned. First, children completed crossings on the pretend road as a proxy measure for crossings on a real street. Empirical data might be strengthened through comparison with children's behaviors exhibited while crossing a real street with a parent. Second, children's crossings were completed in response to traffic on the real road, which obviously contained some variability. Controlled traffic is difficult to arrange but might help isolate behavioral differences caused by variations in traffic flow. Third, the use of multiple measures might have strengthened the assessment of inhibitory control.

Implications for Pedestrian Injury Prevention

Temperament theorists have long recognized the importance of how individual differences interact with contextual environments to influence children's behavior (Wachs & Kohnstamm, 2001). The present results confirm these findings in an ecologically valid setting: individual differences in age, gender, and inhibitory control all influenced children's safety on the pretend road. Supervision played a more minor, but still relevant, role.

The findings might be used in a few ways to develop empirically driven injury prevention strategies. First, prevention efforts might target those children who are at greatest risk of injury—in particular, boys and undercontrolled children. Second, prevention efforts must consider the cognitive development of the target population. Combined with previous work, our results suggest that most 5- and 6-year-olds lack the cognitive complexity to become safe pedestrians. Children aged 7 and 8 years are more likely to be capable of handling the cognitive complexities of pedestrian safety and might therefore be the ideal target group for prevention efforts based on cognitive methods.

A third implication of our results concerns the finding that children with poor inhibitory control might be more susceptible to influences from parental supervision in their decision-making in pedestrian environments. Parental supervision has emerged in the literature as one of the strongest behavioral predictors of children's safety (e.g., Morrongiello, 2005), but the mechanisms through which supervision preserves children's safety remain poorly understood (Morrongiello, 2005; Schwebel & Barton, 2005). The present study suggests that the mere presence of a parent, especially with increased intensity of supervising an undercontrolled child, may cause children to behave more cautiously (Schwebel & Bounds, 2003). However, although closer supervision seems a common-sense method of injury prevention, many parents do not closely monitor their children's pedestrian behaviors (Gielen et al., 2004). Through more intensive and more adaptive supervision, parents might prevent pediatric injuries both directly through teaching, modeling, and intervening to prevent danger, and indirectly by tempering children's undercontrolled behavior patterns.

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