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The influence of demographic factors, processing speed and short-term memory on Iranian children's pedestrian skills

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ABSTRACT

Objectives: Young children, children from lower socioeconomic status and boys have the highest risk of pedestrian injury. This study examined the relationship between cognition and specific pedestrian skills of these groups of children in Iran.
Methods: 180 Iranian children aged 7 and 11 years from lower- and higher-socioeconomic status backgrounds participated in the study. A task to identify safe and dangerous road crossing sites and to plan a safe route to cross a road was administered to measure pedestrian skills. Coding and Digit Span subscales of WISC-R were administered to assess processing speed and short-term memory.
Results: Identifying safe/dangerous road crossing-sites and safe route-construction abilities increased with age. Boys scored higher than girls when identifying road crossing sites but did not differ to girls in route-construction. Lower socioeconomic status children scored higher than higher socioeconomic status children on the route-construction task. Girls from lower socioeconomic status backgrounds scored lowest on the identifying safe/dangerous sites task and girls from higher socioeconomic status backgrounds scored lowest on the route construction task. Speed of processing was a significant predictor for identifying crossing sites and socioeconomic status was a significant predictor for route-construction.
Conclusions: Pedestrian skills are complex and influenced by age, gender, socioeconomic status and cognitive development. Results are discussed in relation to child pedestrian safety research in Iran and road safety education for children.

1. Introduction

Road traffic injuries (RTI) comprise almost 30% of all injury deaths amongst children globally (World Health Organization, 2009). The types of road traffic injuries that affect children are predominantly pedestrian injuries and disproportionately higher injury rates are found for boys and for children from low income households (Backett and Johnston, 1997; WHO, 2008). The majority of research studies on factors associated with children's road traffic injuries have been carried out in high income countries. There is a scarcity of research on child road users in low to middle income countries where the majority of the world's children live.

In Iran, road traffic poses a significant threat to health (Karbakhsh et al., 2008; Rezapur-Shahkolai et al., 2009). The rate of RTI in Iran is very much higher than the worldwide rate reported by WHO (2009), particularly for children (Global Burden of Diseases, 2010; Naghavi et al., 2009). In the city of Tehran, Roudsari et al. (2006) found that RTI comprised 50% of all unintentional fatal injuries for children aged less than 15 years. This is considerably higher than the global rate of 30% reported by the WHO (2008). Boys were reported to have higher rates of deaths and injuries than girls, up to 2.2 times as many (Karbakhsh et al., 2008; Rezapur-Shahkolai et al., 2009; Zargar et al., 2003). The majority of child RTIs were pedestrians (Karbakhsh et al., 2008; Roudsari et al., 2006). When compared to global trends, similar demographic factors affect Iranian children's RTI statistics but the rates appear to be higher. Research on child pedestrian experiences and capabilities in Iran is scarce and there are several gaps in information needed to aid the development of prevention programmes (Tabibi et al., 2010).

1.1. Environmental context

Children in Iran face a dangerous traffic environment. Road traffic is dense in urban areas and pedestrian crossing facilities are scarce. The few pedestrian crossing facilities that exist are used infrequently and inappropriately. Consequently most Iranian parents who can afford it send their children to school by school bus

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services or by family car. In Mashhad, the second largest city in Iran, Shafabakhsh et al. (2008) found that only half of school aged children walk or cycle to and from school. However, a considerable number of children play on the streets because most live in flats or houses without gardens or in areas without playgrounds/playing fields (Soori, 2006). So streets are the most available place for children to play, particularly children in low income areas.

Research has consistently shown that children living in low-income areas have higher pedestrian injury rates and are more at risk for pedestrian injuries than children living in more economically advantaged areas (Collins and Kearns, 2005; Hasselberg et al., 2001; Reimers and Laflamme, 2005). Although reasons for such discrepancies have mainly been related to environmental differences (e.g., traffic density, lack of safe play areas, etc.), it is unclear whether educational and behavioural factors related to socioeconomic status might also be important (White et al., 1999). Also, there is a lack of information about social factors relevant to child pedestrian injury risk in Iran. One of the few studies to consider socioeconomic factors in relation to children's RTI in Iran compared RT injured children aged 6–9 years with a matched control group (Hadadi et al., 2007). The study found that RT injured children had mothers with lower levels of education than the matched control group. They also found that RT injured children and the matched controls differed with respect to parental supervision. Injured children's parents allowed their children to play outdoors and walk to school unsupervised more frequently than parents of the control group.

1.2. Developmental factors

Although data on the rates of child road traffic injury is continuing to be accumulated, human factors that contribute to children's disproportionate pedestrian injury risk are still not thoroughly understood. Pedestrians require a range of fundamental road skills in order to interact safely with traffic. Comprehensive lists of the components of the cognitive skills required to cross a road safely have been provided by previous authors (e.g., Barton and Schwebel, 2007a; Thomson and Whelan, 1997). Foremost amongst these is the ability to perceive danger when crossing or deciding to cross roads. Age trends in the ability to identify safe and dangerous road crossing sites and to select a safe route to get to a given destination have been studied in a range of countries, including Scotland (Ampofo-Boateng and Thomson, 1991), England (Pfeffer, 2005; Tabibi and Pfeffer, 2003, 2007), Norway (Fyhri et al., 2004), USA (Barton and Schwebel, 2007a) and Iran (Tabibi, 2010). The consistent results are that young children up to age 10 years fail to anticipate potential danger inherent in different crossing sites in order to take appropriate actions. No differences in road hazard perception have been found between boys and girls, despite the high representation of boys in injury statistics (Granié, 2007).

Several researchers have concluded that the perception of road danger depends on cognitive development and that this may impose limitations to what children can actually do when negotiating traffic environments. From an information processing approach for development the role of inhibition skills, attention switching skills, concentration, cognitive efficiency, visual search strategies, short-term memory and information processing speed have all been noted (Barton and Morrongiello, 2011; Dunbar et al., 2001; Schwebel et al., 2011; Tabibi and Pfeffer, 2003, 2007; Vinje, 1981; Whitebread and Neilson, 2000). However, few studies have examined the interaction of several factors concurrently (Barton and Schwebel, 2007a,b; Morrongiello and Schwebel, 2008; Barton et al., 2011).

The present paper investigates the role of processing speed and short-term memory on children's pedestrian skills. Developmental studies have indicated that children's information processing speed and retention of information in working memory both increase as children develop and that these changes underlie changes in reasoning and problem solving (Fry and Hale, 2000; Kail, 2007). Amongst cognitive developmental theories Case's theory considers both developmental and individual differences in cognition and argues that development comes about as the result of maturational factors and experience. Case attributes developmental differences to processing efficiency (Case, 1985, 1987, 1993; Case et al., 1996; Morra et al., 2009). According to Case, the amount of mental effort needed to execute a cognitive process decreases with age. Two spaces independently contribute to mental effort; storage space and operating space. Storage space is the capacity available for storing information in short-term memory. Operating space is the capacity that can be allocated to the execution of intellectual operations. It is reflected by the time taken to execute a cognitive skill (speed of processing). Faster processing allows for more information to be taken in. With maturation and experience, the amount of operating space required for executing a cognitive process declines and thus efficiency increases. According to Case, the rate at which processing efficiency increases differs amongst individuals. He attributed this individual difference to either biological or cultural–experiential factors (Case, 1985, 1987, 1993). Applying this to pedestrian skills, Case' theory would predict that pedestrian skills will improve with increased processing speed and increased short-term memory.

1.3. Research aims

The current study therefore aimed to examine road safety awareness of a sample of Iranian children. This will add to the scant research literature on child road users in Iran and children in low to middle income countries generally. Also, the study aimed to examine the effects of demographic variables (age, gender and socioeconomic status) on Iranian children's pedestrian skills. Finally the relationship between specific pedestrian skills and measures of cognition (processing speed and short-term memory capacity, as measured by the WISC) was investigated.

2. Method

2.1. Participants

A total of 180 pupils including 89 Year 2 (mean age = 7.5 years, SD = 0.5, age range 6.8 to 8.9 years) and 91 Year 5 children (mean age = 11.5 years, SD = 0.5, age range 10.9 to 12.9) participated in the study. Pupils were recruited from four schools, two (lower socioeconomic status) situated within a socially lower income area in the city of Mashhad, in the north east of Iran, and the other two (higher socioeconomic status) within socially middle to higher income areas of the city. The distinction between the two areas of the city is supported by Yousofi's (2010) study of the socioeconomic status of 14 urban areas in the city of Mashhad using a sample of 17,510 families. Families living in the two selected areas of the present study, had the highest dissimilarity in terms of jobs, educational and income levels. Families from the higher socioeconomic area had completed compulsory education and a few years of higher education, and were employed in professional jobs (e.g., teachers, nurses, business professionals). The educational level of families living in the lower socioeconomic area was elementary school. They were workers or unemployed. The average annual incomes of the higher socioeconomic families were 2.5 times more than the annual income of those in the lower socioeconomic area.

Also, children attending the schools in the lower income area mostly lived in densely populated areas with limited space and high traffic density. Children spend more time playing outdoors

Table 1
Distribution of participants by age group, gender and socioeconomic status.

Socio-economic status	Year 2 children			Year 5 children			All children
	Boys	Girls	Subtotal	Boys	Girls	Subtotal	
Higher	20	23	43	20	23	43	86
Lower	23	23	46	23	25	48	94
Total	43	46	89	43	48	91	180

than children from the higher income areas. Children attending the schools in the upper income area mostly live in houses with yards. The distribution of participants is presented in Table 1.

2.2. Measures

2.2.1. Pedestrian tasks

The task was in two parts, a recognition task and a route-construction task. Both were based on previous research (Ampofo-Boateng and Thomson, 1991; Barton and Schwebel, 2007a) and used stimuli that were derived from Tabibi and Pfeffer's (2003) study, modified to be appropriate to the traffic situation in Iran. Previous authors have found that such methods compare well with simulations of pedestrian tasks on real roads and have been used for children's pedestrian skills training (Ampofo-Boateng and Thomson, 1991; Ampofo-Boateng et al., 1993; Fyhri et al., 2004). Testing was carried out by a trained research assistant and the first author. Inter-coder reliability of $r = 0.87$ ($p < 0.001$) was obtained using Pearson correlation on a randomly selected sample of 30% of responses.

The recognition task aimed to assess children's ability to identify safe and dangerous road crossing sites. Ten coloured A4 size drawings of 4 safe and 6 dangerous road-crossing sites were used. The dangerous road crossing sites were a blind-bend, a complex junction, a roundabout, a three-lane free-way, the brow of a road-bridge and a straight road with parked cars. Designated safe crossing sites were a 'zebra' crossing, a traffic light on red, a pedestrian footbridge and a pedestrian underpass. A straight road with a clear view and no vehicles present was used for a practice trial. Children were asked to say whether the crossing site is safe or dangerous and to give a reason for their choice. One point was given for a correct response in identifying safe and dangerous crossing sites (maximum possible score = 10). For reasoning responses a score of one point was given if an element of danger was noted. For example, for crossing at a blind bend with an obstructed view, one point was given for responses such as "not being seen" or "the driver can't see". Overall scores ranged between 0 and 20.

The route-construction task was designed to assess the ability to choose a safe route to a given destination. In this task A4 sized drawings of three crossing sites were presented. These were a complex four-way junction, a roundabout with traffic emerging from several directions and a steep road with restricted visibility. Two criteria governed the choice of drawings: first, there was no ambiguity as to which route was safe or dangerous and second; there were only four possible routes to take in each one. A small toy doll was placed in a set location and the child was asked to take the doll to a specified destination. There were five trials altogether. Two trials used the complex junction (two different starting points with one destination), two trials used the steep road (one starting point and two different destinations), and one trial used the roundabout (one starting point with one destination). The instructions were "You will see some pictures of roads. There is a toy doll standing on a pavement, wanting to go to this place (the place was indicated to the child). To get there it has to cross the road. I would like you to walk the toy along a route you think would be safe so that it can get to where it wants to". Responses on each trial were scored on a four-point scale (from 1 = very unsafe to 4 = safest) based on criteria such as the length of time spent on the road, visibility and the number of junctions to take into account. For example, a score of 4 (safest) was assigned if the child chose to cross the road by the shortest route straight across the road (thus spending less time on the road) and where the view of oncoming traffic was good. A score of 1 was assigned when the child chose a diagonal route across the road rather than straight (thus spending more time on the road) and where the view of the road was restricted (such as by the brow of a hill or parked cars) or where there were multiple road junctions to be considered. Scores ranged between 5 and 20.

Children were also asked how they travel to school. The main interest was whether children walked to school or take other forms of transport (e.g., car, school bus). Children were also asked whether they are allowed to go out by themselves to play or to buy something from the shop on an ordinal scale from 1 = never to 5 = everyday.

2.2.2. Digit Span memory subscale of Wechsler Intelligence Scale for Children-Revised (WISC-R, 1974)

This measures short-term memory and has two parts, direct memory and reversed memory. In this task the child listens to a series of numbers and is then asked to recall them in order or reverse order. According to McGrew (1994) the Digit Span of WISC is a strong measure of short-term memory. That is the ability to hold information in immediate awareness and then use it within a few seconds (Woodcock, 1992, cited in McGrew, 1994).

2.2.3. Coding subscale of Wechsler Intelligence Scale for Children-Revised (WISC-R, 1974)

This test was used to measure speed of processing. As Miller (2007) indicated anytime a test requires the examiner to record completion time, speed of processing is indirectly being measured. According to McGrew (1994) Coding in WISC is a strong measure of processing speed. That is the ability to rapidly perform automatic cognitive tasks (Woodcock, 1992, cited in McGrew, 1994). The child is asked to copy symbols that are paired with geometric shapes or numbers. The task is timed and bonuses are given for speed.

It should be noted that the WISC-R was the version of this test available with norms established for Iranian children, including norms for these two subscales (Shahim, 1994). The two subscales used are unchanged in new versions of WISC, including WISC-fourth edition (2003).

2.3. Procedure

The research was approved by the research committee of the Education and Psychology Faculty of Ferdowsi University of Mashhad, also by the education authority and the schools. The education authorities and schools were provided with the details of the materials used, the method of administration and the estimated time required for each participant. They were also assured of the confidentiality and anonymity of the results. Children's verbal consent was also obtained.

All tasks were piloted to ensure that the task was understandable to the participants and to establish coding reliability.

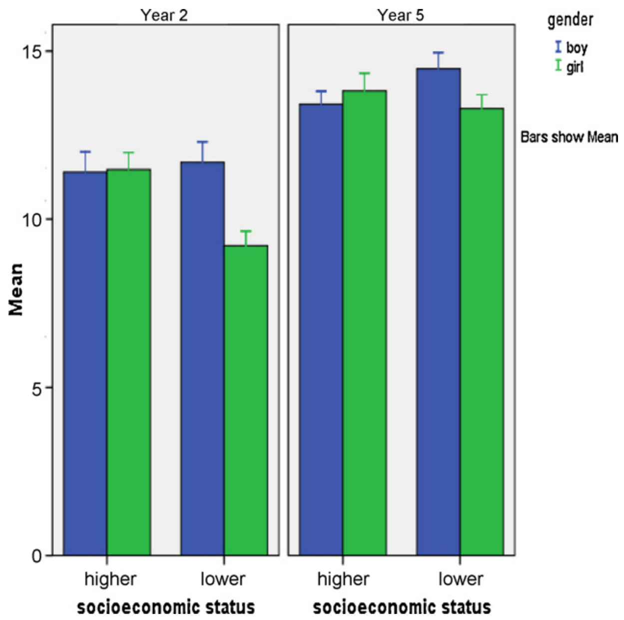

Fig. 1. Mean scores for the perception of safe and dangerous road crossing sites task (maximum possible score = 20) by age, gender and 'socioeconomic status'.

Tasks were administrated individually in school. The order of the administration of the tasks for all children was Coding, Digit Span, Recognition of safe and dangerous road crossing sites, then Pedestrian route-construction. The administration of the tasks took approximately 30–40 min for each child. The tasks for younger children were administered in two sessions.

3. Results

The effects of demographic variables (age group, gender and socioeconomic status) on each pedestrian task were analysed separately. Also, multiple regression was used to analyse the pedestrian task results with the cognitive tests (Digit Span, Coding) and age, gender and socioeconomic status as the predictor variables.

3.1. Perceptions of safe and dangerous road crossing sites

The overall mean score for this pedestrian task was 12.43 from a maximum possible score of 20. The number of children who completed all components of the task was 162. Fig. 1 shows the mean scores for boys and girls in each age and socioeconomic group. A three-way analysis of variance (ANOVA) was used to compare the main effects of age (2 levels), gender (2 levels), socioeconomic status (2 levels) and interactions between variables. The results of the ANOVA showed a statistically significant effect of age group ($F_{1,\,154}$ = 63.50, p < 0.001) with older children achieving higher scores (more correct responses) than younger children. A statistically significant effect of gender was also found ($F_{1,\,154}$ = 5.12, p < 0.025), with boys scoring higher than girls overall. No significant effect of socioeconomic status was found ($F_{1,\,154}$ = 1.06, p > 0.05). A two-way interaction emerged between socioeconomic status and gender ($F_{1,\,154}$ = 8.61, p < 0.004). Post hoc analyses showed that boys scored higher than girls in the lower SES group (p = 0.005) but not in the higher SES group. Girls in the lower socioeconomic status group scored lower than any other group. There was no significant three-way interaction.

Multiple regression was used to analyse the results for the perceptions of safe and dangerous road crossing sites test with the cognitive tests (Digit Span, Coding), age, gender and socioeconomic status as the predictor variables. Using the enter method, a significant model emerged ($F_{5,\,156}$ = 16.346, p < 0.001). Adjusted R square = .323. Significant variables are shown in Table 2. The Coding subscale of the WISC emerged as a significant predictor variable; however, the Digit Span subscale did not.

Table 2
Significant predictor variables for the perceptions of safe and dangerous road crossing sites task.

Predictor variable	Beta	p
Chronological age	.202	<0.023
Coding	.194	<0.008
Gender	.172	<0.015

Children's scores for the identification of road crossing sites as safe or dangerous were higher than their scores for the reasons it should be considered safe or dangerous. The mean score for the 'reasons' part of the task was 4.47 (from a maximum possible score of 10). Only 18 children scored 7 or higher and 22 children were unable to give an answer. The most popular reasons children gave for a road crossing site being safe were that it was recognised as a designated crossing site or had appropriately recognised signs (69.43% of answers given). Similarly, the most popular reasons children gave for a site being dangerous was that it was not recognised as a designated crossing site (36.11% of answers given). The presence or the absence of cars on the road was the second most popular reason given for deciding whether a road crossing site was safe (15.56%) or dangerous (15.60%). Other, less frequent, reasons given were the width of the road (3.75% for safe, 2.35% for dangerous), the complexity of the site (0.0% for safe, 10.15% for dangerous), speed (0.39% for safe, 8.75% for dangerous) and whether visibility was good (0.10% for safe, 2.51% for dangerous).

3.2. Pedestrian route-construction

The overall mean score for the pedestrian route construction task was 11.91 from a maximum possible score of 20; 170 children completed all components of the task. The mean scores for boys and girls in each age and socioeconomic status group can be found in Fig. 2. Due to the nonparametric nature of the data, a series of Mann Whitney U tests were used with Bonferroni corrections for multiple analyses. A statistically significant effect of age group was found (U = 2674, N_1 = 80, N_2 = 90, z = −2.901, p < 0.004) with older children achieving higher scores (safer responses) than younger children overall. No statistically significant effect of gender was found for this test. A significant effect of socioeconomic status was found (U = 2419, N_1 = 86, N_2 = 84, z = −3.731, p < 0.001). Children from the lower socioeconomic status group scored higher than children from the higher socioeconomic status group overall. We also compared responses by socioeconomic status and gender for each age group separately. For the younger children, no significant effect of gender, socioeconomic status or interactions were found. For the older children, the higher socioeconomic status girls had significantly lower scores than the higher socioeconomic status boys (U = 112.50, N_1 = 20, N_2 = 23, z = −2.890, p < 0.004) and the lower socioeconomic status girls (U = 152.50, N_1 = 20, N_2 = 23, z = −2.654, p < 0.008).

Multiple regression was used to analyse the pedestrian route construction task results with the cognitive tests (Digit Span, Coding) and age, gender and socioeconomic status as the predictor variables. Using the enter method, a significant model emerged ($F_{5,\,164}$ = 4.627, p < 0.001). Adjusted R square = .097. The only significant predictor variable was socioeconomic status (Beta = .261, p < 0.002). Scores on the WISC did not predict scores on the route construction task.

The number of children who reported that they regularly walk to school is shown in Table 3. Significantly more lower

Table 3
Number of children who reported that they walk to school.

	7-Year-old	11-Year-old	Boys	Girls	Higher socioeconomic status	Lower socioeconomic status
Walk to school	45	55	48	52	11	89
Do not walk to school	44	36	38	42	75	05
$\chi^2(1)$	1.78		0.004		121.98	
p	>0.05		>0.05		<0.001	

socioeconomic status than higher socioeconomic status children reported that they walked to school. There were no other statistically significant group differences. Children's self-report rates of being allowed out by themselves to play or buy something from the shop were compared by age group, gender and socioeconomic status using a series of Mann Whitney U tests. Older children were more frequently allowed out by themselves than younger children (11 year-olds Median = 3, modal response = more than once a week; 7-year-old median = 2, modal response = never; $z = -4.92$, $p < 0.001$). Boys were more frequently allowed out than girls (boys median = 3, modal response = everyday; girls median = 2, modal response = never; $z = -3.46$, $p < 0.001$). The higher socioeconomic status children reported that they were less frequently allowed out than the lower socioeconomic status children (higher socioeconomic status median = 2, modal response = never; lower socioeconomic status median = 3, modal response = more than once a week; $z = -2.65$, $p < 0.008$).

4. Discussion

Children's scores on the two pedestrian tasks used in this study were low. The overall mean score for perception of safe and dangerous road crossing sites was only 12.43 from a maximum possible score of 20. Also, for the pedestrian route construction task, overall scores were low with an overall mean score of 11.91 out of a maximum possible score of 20. The mean scores for the older children were considerably lower than Iranian adult scores from previous studies (Tabibi, 2010). More detailed task analyses showed that children were able to recognise a safe or dangerous road crossing site when shown. However, they were less capable at showing that they understood why such sites were safe or dangerous or that they could construct a safe route to cross the road. This supports previous findings that children's competence in one aspect of pedestrian skills does not necessarily indicate competence in other aspects (Islam and Pfeffer, 1999). It also supports findings that children often have difficulties with generalising and applying their safety knowledge (Zeekyk et al., 2001). The most common reasons children gave for judging a site as safe or dangerous were similar to the reasons children gave in other cultural settings (Ampofo-Boateng and Thomson, 1991; Hill et al., 2000; Pfeffer, 2005). Children relied on knowledge they may have been taught (such as how to recognise a designated crossing site) and on perceptually salient features such as the presence or the absence of cars on the road. These similar findings in different cultural settings may suggest underlying developmental processes such as the inability to decentre (Demetre, 1997), visual search (Whitebread and Neilson, 2000) or general cognitive skills (Thomson, 1996). Further research is needed to reach firm conclusions on this aspect.

As expected, older children demonstrated more road safety awareness than younger children on both pedestrian tasks. This supports well-established findings of similar research carried out in other countries (Ampofo-Boateng and Thomson, 1991; Pfeffer, 2005; Fyhri et al., 2004). Older children were more aware of the dangers inherent in crossing sites, such as limited visibility, predicting speed, and road complexity. They also reported more experience of walking to school and of being allowed out than younger children. Their developed cognitive skills or experiences with traffic may have improved their awareness of dangers and safe route-taking abilities.

Gender differences were found for some aspects of the pedestrian skills tested but not others. Boys in the lower socioeconomic status group gave more correct responses to the perception of safe and dangerous road crossing sites task than girls, demonstrating more safety awareness for this aspect of the pedestrian skills. There were no overall gender differences for the ability to plan a safe route across the road, although for the older age group the higher socioeconomic status girls showed the least safe pedestrian route construction ability. These findings from the Iranian children differ to those of previous researchers who have reported few gender differences in similar tests of road safety awareness (Granié, 2007). They also differ from other studies with Iranian children (Tabibi, 2010) which did not investigate socioeconomic status as an independent variable. This may be indicative of cultural factors which affect children differently depending on their socioeconomic environment. For example, although there were no significant differences in the number of boys and girls who walked to school, boys reported more frequently being allowed out unaccompanied than girls to play or run errands and this gender difference was larger for the lower socioeconomic status children (higher socioeconomic status $p = 0.03$; lower socioeconomic status $p = 0.001$). Further research is needed to investigate the role

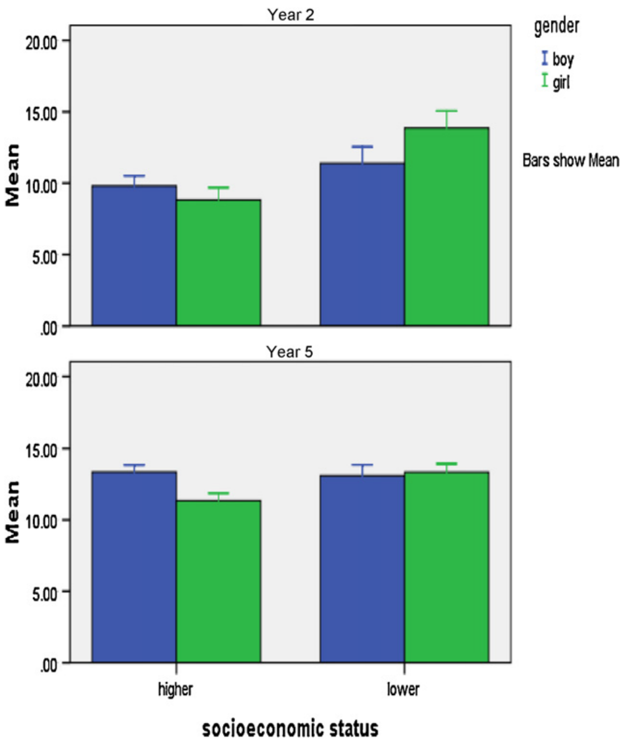

Fig. 2. Mean scores for the route construction task (maximum possible score = 20) by age, gender and 'socioeconomic status'.

of a range of cultural factors, including traffic experiences in the development of children's pedestrian skills.

Socioeconomic status did not affect responses to the perception of safe and dangerous road crossing sites task overall, however, the lower socioeconomic status girls showed the least road safety awareness of any of the comparison groups of children. Socioeconomic status affected the route construction responses with lower socioeconomic status children demonstrating safer routes across the road than the higher socioeconomic status children. This is in contrast to Barton and Schwebel's (2007a) research with American children. They found that higher socioeconomic status children scored higher on their pedestrian tasks than lower socioeconomic status children. Cultural differences are expected to be important here. Lower socioeconomic status Iranian children reported more experience of walking to school on a regular basis than higher socioeconomic status children who were more likely to be transported to school by car or school bus. They also reported more experience of playing out on the streets or running errands independent of adult supervision, supporting the findings of Hadadi et al. (2007).

Although these are only two rather basic measures of children's road traffic experiences, they give a picture of differences in children's experiences that are worth further investigation. Experience as an important factor for awareness of danger has been noted for 5- to 6-year-old (Pfeffer, 2005), and 7- to 8-year-old children (Demetre and Gaffin, 1994; Hill et al., 2000). Hill et al. (2000) presented evidence indicating the sensitivity of experienced 7- to 8-year-old children and younger to dangers on the roads. It is also worth highlighting that child factors are difficult to consider in isolation. Children from lower socioeconomic status families are at a higher risk for road traffic injuries in Iran and other countries, regardless of how well they perform on measures of pedestrian skills. It may be difficult for children to implement their knowledge in a practical situation due to environmental factors, such as high traffic density and poor road crossing amenities, that are outside their control.

The cognitive test results showed a significant relationship between children's ability to identify safe/dangerous road crossing sites and the Coding subscale of the WISC which measures processing speed. Children with faster processing speed scored higher on this pedestrian task. This supports previous findings of the role of processing speed and cognitive efficiency in children's pedestrian judgements (Barton and Morrongiello, 2011). Based on Case's theory, operating space rather than storage space was important for efficient performance at identifying dangerous crossing sites. That is, speed of processing information is more important than the amount of information to be taken in. According to Case, experience should reduce the amount of operating space required for executing the cognitive tasks of identifying safe and dangerous pedestrian crossing sites and safe route taking, thus increasing efficiency. In our study, age, gender and processing speed were significant predictor variables for the perceptions of safe/dangerous crossing sites task. Also, age and gender were relevant to experience: older children and boys reported more experience with roads and scored highest on the perceptions of safe and dangerous crossing sites task. This aspect of the research needs further investigation, particularly regarding the type of experience that may be important and whether practice is more important than ad hoc informal learning experiences (Case, 1987). Case's theory does not explain the results of the route-construction task which were not related to processing speed or short-term memory. It may be the case that specific aspects of cognitive development are more important than others. For example, visual memory may be more important than the verbal memory tested in this study. Or social factors may play a more significant role than cognition. Also, the pedestrian skills measured in this research represent only part of the repertoire of skills required to negotiate traffic safely.

The present study is one of few studies to be conducted with Iranian children, a group very much under-represented in the child injury research literature. Also it is part of a growing body of research that investigates the effects of several variables and the interactions between them. However, we investigated only a limited selection of the many variables that may be important. Child temperament and attitudes to risk taking, parental supervision and road safety education practices, peer group influences are other equally important variables to be considered. Also, further studies of Iranian children's pedestrian safety skills using different types of pedestrian tasks are needed. The tasks used in our study were based on those used in similar studies in other countries, modified to suit the Iranian environment. More realistic tasks, such as high quality virtual reality pedestrian tasks would be ideal but have not yet been developed for Iranian settings. However, the results of Hill et al.'s (2000) study support our use of relatively simple stimuli. Hill et al. (2000) used simple line drawings and compared the results with those obtained from video stimuli. They found that children's scores were higher for the line drawings than the videos because the video stimuli included more irrelevant stimuli than their drawings. Also, the measures of Coding and Digit Span are typically used to tap into speed of processing and short-term memory. This does not mean that they are pure measures of speed and capacity. They also tap into other constructs such as visual-motor coordination, concentration, attentional capacity or motor speed. The use of two or more measures for each construct would have enhanced this study.

5. Conclusions

Age, gender and socioeconomic status affected Iranian children's responses to the pedestrian skills tests used. As expected, young children's performance was poor in both pedestrian tasks. The performance of girls from lower socioeconomic status schools was poor in identifying safe and dangerous crossing sites. Children from lower socioeconomic status schools performed relatively well in the route taking task. Also, cognitive tests measuring speed of processing were related to some aspects of these pedestrian skills. An increase in processing speed predicted a higher ability at identifying safe and dangerous crossing sites.

The implications of this study are that road safety educational programmes need to be tailored towards the socioeconomic environment of children as well as their cognitive development. Gender differences associated with socioeconomic factors need to be taken into consideration. Also, as all age groups showed difficulties in understanding the dangers inherent in different crossing sites, explicit training about these dangers is needed. In this regard, appropriate opportunities for children to safely experience traffic during road safety education would be beneficial.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.aap.2012.01.013.

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