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Errors in young children's decisions about traffic gaps: Experiments with roadside simulations

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Young children's vulnerability as pedestrians has often been attributed to deficiencies in their decision making about vehicle approach times. Some studies have found a preponderance of risky decisions below the age of eight years. In contrast, studies using a closer simulation of road crossing, known as the pretend road, have found a preponderance of overcautious decisions in young children: traffic gaps of adequate size were frequently rejected (missed opportunities). However, the pretend road has potentially distorting characteristics which may account for this divergent pattern of findings. The experiments reported below show that new simulations that eradicate distortions nevertheless validate the pattern of results produced with the pretend road. Differences between adults and young children were pronounced for missed opportunities, but not for risky decisions. Subsidiary analyses suggest that the risky decisions of the youngest children may have arisen through lapses in attention, rather than deficits in timing. These findings run contrary to the view that attributes young children's pedestrian vulnerability to perceptuo-motor deficiency.

The ability to make safe road-crossing decisions in relation to available traffic gaps rests on the individual's capacity to use temporal information. There is a long-standing schism between Gibsonian and Piagetian theories on how and when this capacity develops, with the latter theory leading to the prediction that young children are hazardous as pedestrians because of deficits in their conception of time. To date, direct tests of the hypothesis that young children are prone to making dangerous decisions about traffic gaps have yielded conflicting results. One problem endemic to research in this area relates to the nature of the tasks used to assess children's ability. It has long been recognized that several different tasks may equally seem to satisfy the logical criteria required to demonstrate a given competence, yet produce divergent results (Donaldson, 1978). The aim of the present paper is to identify the methodological shortcomings of previous studies which may have led previous investigators to distort young children's difficulties, and to provide new evidence based on tasks that most closely simulate the natural context of crossing the road.

Piaget's (1969) theory predicts that young children make hazardous decisions about vehicle approach times because they are unable to appreciate the inter-relationships among duration, velocity and distance, until around the age of 10 years. This forms a part of Piaget's general theory of the concrete operations stage (Piaget & Inhelder, 1969), during which children become adept at considering two or more variables simultaneously in their decision making (e.g. velocity and distance jointly determine arrival time). Prior to this attainment, children will tend to focus on only one salient variable (typically, distance) in anticipating relative arrival times of two objects.

Some authors (Cross, 1988; Cross & Mehegan, 1988; Kenchington, Alderson & Whiting, 1977) concur with Piaget's theory in accounting for young children's (five to nine years) overrepresentation in pedestrian accident statistics (Road Accidents Great Britain, 1988). Accident statistics have for a long time shown that young children in this age range have a serious pedestrian accident rate which is four times that of adults. When the relatively low traffic exposure of young children is taken into account, the disparity in accident rates is even more pronounced (Hillman, Adams & Whitelegg, 1990; Routledge, Repetto-Wright & Howarth, 1974).

According to the ecological theory of visual perception (Gibson, 1979), temporal information can be extracted directly according to specific optical principles, hence obviating the need for higher-order cognition of the sort discussed by Piaget. A central premiss of the ecological theory is that in order to survive, animals require speedy access to cues about their own movement and the motion of other bodies in relation to themselves; evolution has equipped each species with sensory apparatus that allows for such rapid and direct extraction of temporal information for ecologically salient features of the environment. One example of this is the specification of time-to-collision of an approaching object (Lee, 1976). As an object approaches a viewer, its retinal image dilates at a rate which varies inversely with time-to-collision. Consistent with this, research has demonstrated that human adults can anticipate collision time from expanding images in the absence of distance information (McLeod & Ross, 1983; Schiff & Detwiler, 1979).

In the ecological view, the developmental task rests on the child gaining sufficient experience of the world in motion, so that the directly specified temporal information can be calibrated to the requirements of different kinds of action. Some calibrations occur very early in development, as evidenced by four-month-olds' ability to engage in accurate anticipatory reaching for moving objects (von Hofsten, 1980, 1983).

Several studies have attempted to assess children's performance in the laboratory on time-estimation tasks that mimic aspects of road crossing. Two studies involved presenting subjects with film sequences of an approaching vehicle, with the film terminating at various time intervals from the designated crossing point. The subjects' task was to press a response key to indicate the arrival time of the vehicle. In one study, children aged seven and ten and adults performed similarly in terms of risky judgements (overestimating arrival time), but typically, arrival times were *underestimated* by subjects, especially the youngest (Vinje, 1982*a*). A similar tendency toward underestimation was also obtained in a study that included five- to six-year-olds (Hoffmann, Payne & Prescott, 1980). This suggests that young children are likely to be overcautious in their decisions about traffic gaps.

However, such studies do not address road-crossing decisions as such. A potential problem for younger children is calibrating perceived time-to-arrival of a vehicle in terms of crossing time. One study employed the film format mentioned above, with subjects having to indicate the point at which the vehicle had got just too close for a safe crossing. Over 88 per cent of seven-year-olds' decisions were for intervals too short for the filmed pedestrian to deal with (< 4 s) (Vinje, 1982*b*). However, over 21 per cent of adult responses also fell into this category. When the experiment was repeated, with new samples, at the roadside, the risky decisions fell to 71 per cent for the seven-year-olds and increased to 46 per cent for adults. Indicating the precise moment at which an interval becomes unsafe is apparently difficult. However, it is also unnecessary in the real world.

Another roadside study found that seven-year-olds nominated over 60 per cent of short gaps (< 8 s) as safe, and over 16 per cent of long gaps as unsafe (van Schagen, 1988). Following practice and feedback trials, these errors dropped to just under 36 and 6 per cent, respectively. One problem with this study is that the 8 s threshold seems far too long given that the task related only to a single lane of traffic. Hence, the effects of training may be due to the children recalibrating intervals to suit the experimental requirements.

One approach to assessing calibration has been proposed by Lee and colleagues (Lee, Young & McLaughlin, 1984; Young & Lee, 1987). Children are asked to cross a 'pretend road' that lies parallel to a main road, imagining each vehicle has a counterpart on the pretend road. The findings were that five-year-olds rejected 45 per cent of gaps of adequate duration (missed opportunities) and on 9 per cent of all crossing trials, accepted traffic gaps that were shorter than crossing time (tight fits). However, even adults committed tight fits on 7 per cent of crossing trials, though their missed opportunities constituted only 10 per cent of adequate gaps (Young & Lee, 1987). This pattern of findings diverges radically from the previously cited findings of Vinje (1982*b*) and van Schagen (1988). The findings of Young & Lee may suggest that young children are not as accurate as adults in using temporal information, but are largely able to compensate for this by spontaneously setting a wider safety margin in gap acceptance. The availability of such a strategy runs contrary to the view that emerges from the Vinje and van Schagen studies.

The advantage of the pretend road as an assessment task is that it does not impose arbitrary 'safe' intervals on children, but rather, allows for natural calibration of traffic gaps with crossing time. However, the pretend road has some potentially distorting characteristics. The child has a different perspective on the road from that normally available, and is required to coordinate events that are spatially displaced with respect to the locus of action. This could have two opposite consequences. First, the pretend road may be a more complex task than crossing the real road, and hence would underestimate children's ability as road-users. Second, the pretend road involves the child focusing on a space that is twice the width of the actual road (actual road width plus width of parallel footpath; see Fig. 1). It is possible that children use

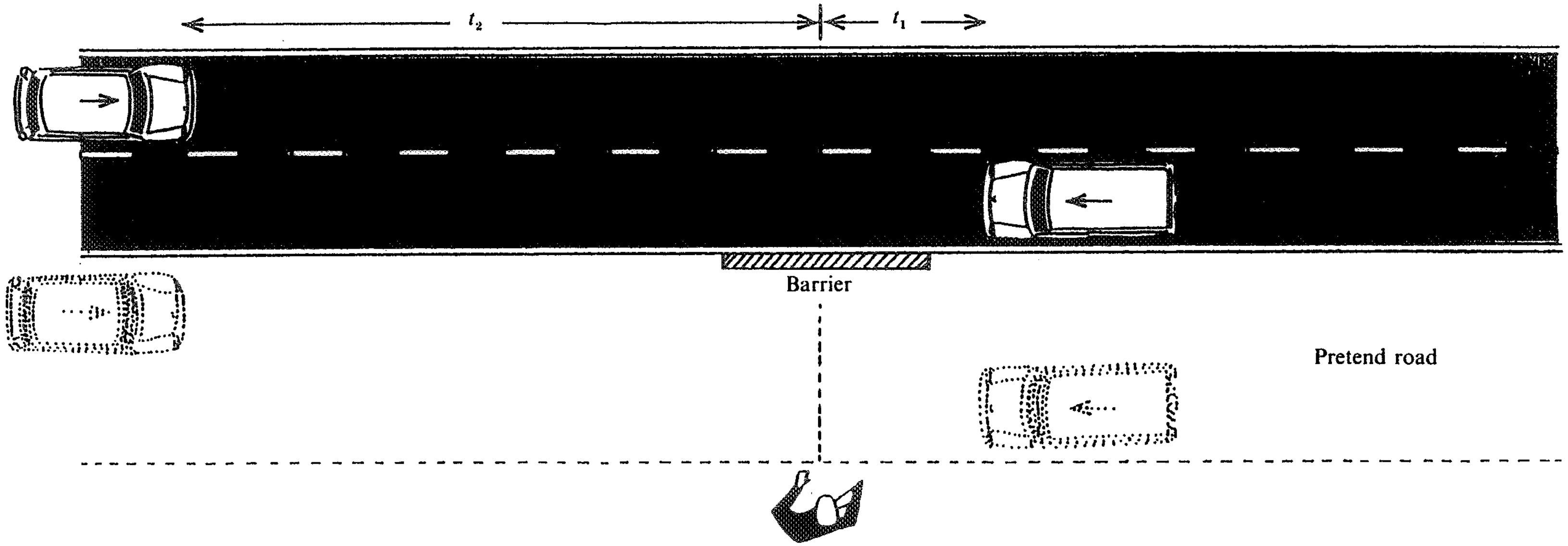

Figure 1. The pretend road task. If the subject crosses after the nearside car has passed, but before the farside car has passed, the traffic gap size will be a little less than $t_2 - t_1$.

this double width as a criterion for the appropriateness of traffic gaps. This would result in behaviour that overestimates the incidence of missed opportunities (a subjectively 'small' gap in terms of two road widths is objectively a 'large' gap in terms of one road width) and underestimates the incidence of tight fits (a gap that is 'small' in terms of two road widths is objectively larger in terms of one road width). The net effect of this 'double width' criterion would be for the pretend road to overestimate children's safe practice.

In order to obtain a valid portrayal of error patterns produced by young children, it is necessary to devise an assessment task that is free of the methodological problems of previous tasks. The studies reported below were devised with this aim. The first two experiments compared young children's performance on the pretend road with their performance on new simulation tasks. The comparisons enabled us to determine whether the pretend road underestimates children's capacities (producing more missed opportunities and more tight fits) or overestimates children's safe practice (producing more missed opportunities and fewer tight fits). The final experiment compared young children with adults on one of the new tasks, to establish whether young children make predominantly dangerous errors (as claimed by Vinje and van Schagen) or predominantly overcautious errors (as claimed by Young & Lee) relative to adults.

EXPERIMENT 1

Method

Subjects

Subjects were recruited from Primary 1 classes in a school in central Edinburgh. Eight boys and seven girls were randomly selected from a larger pool of over 30 children whose parents had given written consent. The remaining children took part in a different study on road safety that focused on issues not relevant to the current paper. The ages of the current sample ranged between five years, one month and five years, 11 months, with a median of five years, five months.

Tasks, apparatus and data recording

Two road-crossing simulations were used, both situated near a busy two-lane road of 9 m width, with a speed limit of 30 mph (48 km/h). The pretend road task (Lee *et al.*, 1984) involved the child crossing a path of 9 m width that ran adjacent to the road, whilst in effect transposing traffic from the real road to the pretend road (see Fig. 1).

The two-step task involved the child standing approximately 60 cm from the edge of the kerb, and indicating her/his decision to cross the road by taking two steps toward the kerb, and imagining that s/he was continuing to traverse the remainder of the road once the protective barrier mounted on the kerb had been reached. On this particular task, the child had a similar perspective on the road to that normally afforded the pedestrian. Both tasks enabled the child to retract a decision to cross, provided that this was corrected within two steps.

Traffic gaps were measured by means of a rubber tube connected to two pressure switches mounted at either side of the road. The tube was placed across the road at a point corresponding to the child's crossing path (broken line in Fig. 1). The centre of the tube corresponding to the middle of the road was constricted by two adjacent knots to prevent air pressure from a passing vehicle on one side of the road activating the pressure switch at the opposite end of the tube. The two pressure switches were connected to a portable computer, which recorded the passage of vehicles on the near and far lanes.

The child's road crossing was also recorded on the computer by the experimenter pressing a key three times: when the child began to take her/his first step, reached the median line (a white chalk line at the centre of the pretend road), and arrived at the protective barrier. For the two-step task, the child's decision to cross was recorded as a single event: when the child initiated the first pace toward the protective barrier.

Procedure

Each child received six sessions: three on the pretend road and three on the two-step task. Each session took place on a separate day, and children were tested individually. The two tasks were presented in the same alternating sequence for each child: pretend road followed by two-step. This order enabled subjects to extrapolate a suitable range of road-crossing times from the pretend road task, for use on the two-step task. *Post hoc* counterbalancing for statistical purposes was achieved by selective aggregation of sessions: for half the sample (randomly assigned), pretend road sessions 1 and 2 were compared with two-step sessions 1 and 2 (any potential practice effect favouring two-step); for the other half, pretend road sessions 2 and 3 were compared with two-step sessions 1 and 2 (any potential practice effect favouring pretend road).

Prior to the initial sessions on the pretend road and two-step, children were given practice on the tasks. Also, the experimenter modelled the task for the child, and provided a running commentary whilst performing the task with the child. It was explained to children that their subsequent independent performance would be rewarded with a prize. Each child received a book token at the end of the study.

All test sessions were preceded by the experimenter explaining to the child that safety and efficiency were important: s/he should cross as soon as it was safe, and not waste time at the kerb. The children were also told to establish the safety of their crossing for themselves, by referring to the position of traffic on the road. The experimenter only provided corrective feedback if the child committed a tight fit owing to a glaring failure to look in the appropriate lane.

Each test session comprised approximately six road-crossing trials. A trial was initiated by the experimenter when approaching vehicles in either lane were too close for the child to cross safely. The child was allowed to cross whenever s/he decided it was appropriate.

Measures

From recordings of the passage of vehicles and the child's road crossing, two error measures were calculated:

1. *Tight fit*: A 'crossing' where the child would not have succeeded in crossing a given lane before the arrival of a vehicle on that lane. This definition encompasses situations that would have resulted in a direct collision between vehicle and pedestrian, as well as 'narrow escapes'. This definition will tend to overestimate the incidence of 'accidents'. The measure used for analysis was the proportion of all 'crossings' that were tight fits.

2. *Mixed opportunity*: A rejected gap equal to or greater than 1.5 × the child's mean crossing time. This definition coincides well with the amount of time used up by children when accepting a gap. Typically, crossing was initiated around 2.5 s after a gap became available, which is approximately half the time required to cross the road. The measure used for analysis was the proportion of all gaps of sufficient size that were rejected.

The incidence of tight fits and missed opportunities was computed for each child, across test sessions. These comprised the two error measures. For the two-step task, measures were derived by incorporating each child's mean crossing time on the pretend road. This practice is likely to have inflated the apparent incidence of tight fits on the two-step task, since the child will not have the option of accelerating her/his walking pace when the demand arose.

Results and discussion

A summary of children's performance on the two tasks is provided in Table 1. Children had a significantly higher incidence of missed opportunities on the pretend road task than on the two-step task ($t(14) = 1.74, p = .05$, one-tailed). The incidence of tight fits was also higher on the pretend road task than on the two-step task, but the difference was not statistically significant.

Table 1. Incidence of tight fits and missed opportunities committed by five-year-olds on the pretend road and two-step tasks

	Tight fits		Missed opportunities	
	Pretend road	Two-step	Pretend road	Two-step
Median	.17	.09	.43	.27
Mean	.20	.13	.42	.31
Range	0–.58	0–.38	.11–.67	0–.67
Proportion zero	.40	.33	0	.07

These results refute the possibility, discussed above, that the pretend road may overestimate how safely children behave, because they make crossing judgements based on a double-width criterion (width of real road plus width of pretend road). The two-step task eliminated the possibility of a double-width criterion and yet the children performed better on this task than on the pretend road.

It should be noted that the disparity between the incidence of missed opportunities and tight fits is even greater than would be inferred from the values in Table 1. To make these two measures directly comparable, incidence of tight fits would have to be defined as a proportion of all gaps shorter than 1.5 × crossing time. The overwhelming majority of available traffic gaps were shorter than this criterion. Thus, the baseline probability of committing a tight fit is considerably higher than the baseline probability of committing a missed opportunity. In the present studies, incidence of tight fits was defined as a proportion of crossing trials for the sake of computational convenience. Thus, the incidence measures reported in the present studies overestimate tight fits relative to missed opportunities.

No significant sex differences were found for either missed opportunities or tight fits on either the pretend road or the two-step task. There was no evidence for the errors being related: the rank-order correlation between incidence of missed opportunities and incidence of tight fits was non-significant for both tasks.

In testing children on the two-step task, two factors emerged which led to the task being modified for use in subsequent experiments. First, some of the tight fits committed by children seemed to have arisen because the children forgot to allow themselves sufficient time to 'cross' the remainder of the road, beyond the initial two steps. Second, children very rarely made use of the provision to reverse a decision by stepping back. Hence, an even simpler task was devised, which involved the child standing at the kerbside and calling out when s/he was ready to cross the road. The next experiment sought to replicate the pattern of findings from the present experiment with this modified task and a slightly older sample.

EXPERIMENT 2

Method

The procedure was identical to that used in the previous experiment, with the exception that the shout task was used as a substitute for the two-step task. In the shout task, children stood close to the kerb, behind a barrier, and signalled their readiness to cross by calling out 'Now!' rather than by taking two steps. Subjects were 24 children from Primary 2 classes, half of whom had participated in the previous experiment nine months previously. The sample comprised 14 girls and 10 boys. Ages ranged from five years, two months to six years, eight months, with a median of six years, two months.

Results and discussion

There were no differences in performance between the subsample that had participated in the first experiment and the subsample that was new to both tasks, hence their data were combined. The data are summarized in Table 2.

Table 2. Incidence of tight fits and missed opportunities committed by six-year-olds on the pretend road and shout tasks

	Tight fits		Missed opportunities	
	Pretend road	Shout	Pretend road	Shout
Median	0	0	.40	0
Mean	.07	.09	.39	.13
Range	0–.43	0–.44	0–.89	0–.50
Proportion zero	.74	.52	.17	.52

The incidence of missed opportunities was significantly less on the shout task than on the pretend road (Wilcoxon $T = 16$, $p < .0005$, one-tailed). The children committed very few tight fits on either task, and children's performance did not differ on the two tasks in this respect. Again, the results refute the notion that the pretend road task overestimates young children's capability, and seriously call into question the validity of Vinje (1982*b*) and van Schagen's (1988) results.

No significant sex differences were found for either tight fits or missed opportunities on either the pretend road or the shout task. There was no evidence of a relationship between errors: the rank-order correlation between tight fits and missed opportunities was non-significant for both tasks.

The children in the present experiment were only slightly older than those in the previous study, and yet, their performance on the shout task seems comparable to that of the adults reported by Young & Lee (1987), who were actually crossing this same stretch of road, or performing the pretend road task on this stretch of road.

The next experiment compares directly the performance of a new sample of five-year-olds with a sample of adults on the shout task.

EXPERIMENT 3

Method

Subjects

The sample of children comprised 25 pupils selected randomly from a larger pool of over 50 children attending Primary 1 classes. Ages ranged from four years, 10 months to six years, two months, with a median of five years, five months. There were 16 boys and nine girls in the sample. The adult sample of 23 comprised 10 first-year university students drawn randomly from a departmental subject pool, 10 research staff or graduate students, and three other volunteers. Ages ranged from 18 to 45 with a median of 23. There were 14 males and nine females.

Procedure

Each subject was given two sessions on the shout task, each session taking place on a separate day. Each session comprised approximately nine trials and each trial was initiated by the experimenter under the same conditions prevailing in the previous two experiments.

The subject was asked to stand close to the kerb, behind a barrier, and to shout 'Now' as soon as s/he felt able to cross the road safely at normal walking pace.

Measures

Crossing-time measures from previous studies using this stretch of road (Young & Lee, 1987 and Expts 1 and 2 above) were used to produce an estimated crossing time in order to derive tight fit and missed opportunity data. The previous studies report median crossing times of the order of 5.2–5.5 s, with no differences between adults and five-year-old children. The use of both the lower-bound estimate of 5.2 s, and the upper-bound estimate of 5.5 s produced virtually identical values for tight fits and missed opportunities, and hence, only the latter are reported.

Results

The results for tight fits and missed opportunities are summarized in Table 3. Comparison of Tables 1 and 3 reveals that five-year-olds perform very similarly on the two-step and shout tasks, thereby lending validation to the estimation procedure used in the present study.

The incidence of missed opportunities was significantly higher for the children than for the adults ($U = 65$, $p < .00003$, one-tailed).[1] However, there was no significant difference between adults and children in the overall incidence of tight fits, though there was a tendency for more children than adults to commit at least one tight fit ($\chi^2(1) = 2$, $p < .10$, one-tailed).

No significant sex differences were found for either missed opportunities or tight fits at either age. The rank-order correlation between missed opportunities and tight fits was non-significant at both ages.

Further analyses were undertaken in an attempt to provide a more comprehensive characterization and explanation of these findings:

Systematic criterion for gap acceptance. Figure 2 provides a summary of gap acceptance

[1] The definition of a missed opportunity as 1.5 × crossing time may have exaggerated the conservative tendency of children, since on average, they take 2 s longer than adults to initiate a crossing. Thus, when adults make a decision to accept a given gap, this occurs 0.5 s after the gap has become available, whereas children take about 2.5 s. To compensate for this disparity, a new analysis was performed on the adult data, in which a missed opportunity was defined as 1.5 × crossing time − 2 s. This redefinition made virtually no difference to the data.

Table 3. Incidence of tight fits and missed opportunities committed by five-year-olds and adults on the shout task

	Tight fits		Missed opportunities	
	Children	Adults	Children	Adults
Median	.11	0	.25	0
Mean	.13	.08	.25	.01
Range	0–.38	0–.57	0–.55	0–.11
Proportion zero	.28	.52	.20	.87

decisions (for children and adults) and gap rejection decisions (children only). Differences between the adults and children can be seen in the size of gaps accepted, which were significantly larger (by 3.5 s on average) for the children (Mann–Whitney $U = 46$, $p < .001$). However, this difference may largely have been due to the fact that the children took 2 s longer on average than the adults to start crossing after the lead vehicle of a gap had passed. To eradicate the disparity in starting delays, the data were recomputed, subtracting each subject's mean starting delay from the mean gap measures. Analysis of these corrected measures also revealed that the gap sizes accepted by children were significantly larger than those accepted by adults (Mann–Whitney $U = 178.5$, $p < .03$). Furthermore, the size of gaps of adequate size accepted by children was significantly larger than rejected gaps (missed opportunities) (Wilcoxon $T = 31$, $p < .01$). Collectively, the findings indicate that the children's gap acceptance decisions were based on what would appear to be a systematically cautious criterion.

Locus of tight fits. The tendency toward more children than adults committing tight fits may have arisen for reasons extraneous to errors in gap judgement. One possibility is that younger children are more likely to be inattentive than adults on any given task.

One *post hoc* measure of inattention is how late in a session tight fits were committed. If children were committing tight fits because of inattentiveness, we would expect them to commit their first tight fit on a relatively late trial in the series, when they were tired or bored. In fact, the median trial on which the first tight fit was committed was the second trial for both children and adults.

A second *post hoc* measure of inattention is the lane in which a tight fit was committed. One would expect tight fits that arise from timing errors to occur predominantly on the farside lane, if the subject has underestimated the total amount of time required to cross the road. It seems reasonable to infer that tight fits occurring on the nearside lane are somewhat more likely to reflect lapses in attention, since the subject is less likely to underestimate crossing time to this degree. Analysis indicates that children commit a significantly greater proportion of their tight fits on the nearside lane (median = .50) than adults (median = 0), (Mann–Whitney $U = 54$, $p <$ .05). When nearside tight fits are eliminated, children and adults perform similarly:

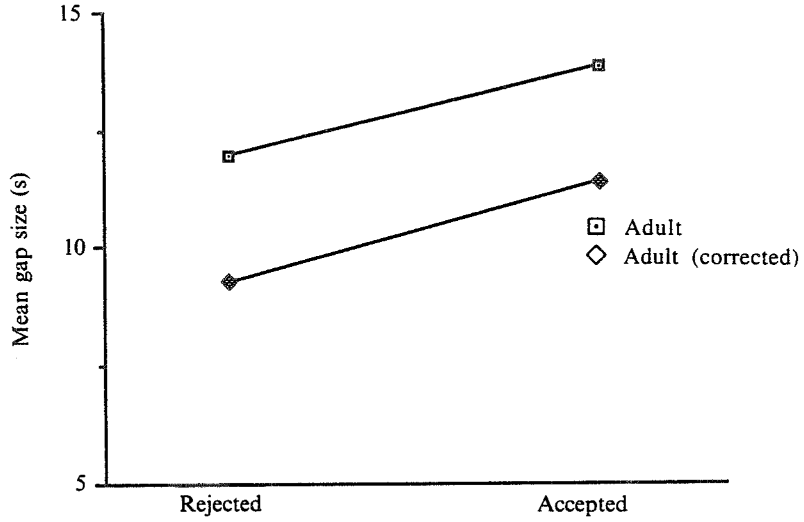

Figure 2. Mean gap size of rejected and accepted gaps. Starting delays were subtracted from gap sizes to yield corrected data points ⊡, Adult; ◇, adult (corrected); ⊡—⊡, children; ◈—◈, children (corrected).

median proportion of tight fits = .05 (children) and 0 (adults); proportion committing no tight fits = .48 (children) and .61 (adults).

Coordinating information from two lanes. Young & Lee (1987) found that children committed considerably fewer tight fits on the pretend road when a single lane was used. The median figure of 2 per cent was equal to that of adults. One possible interpretation of their findings is that children have particular problems in coordinating information from two different lanes. To test this possibility more directly using the current data, tight fits occurring during gaps that involved vehicles in both lanes were compared with tight fits occurring during gaps involving vehicles in only one lane. For five-year-olds, 45 per cent of tight fits occurred during dual-lane gaps, whereas 28 per cent were expected by chance (baseline probability of dual-lane gap acceptance). For adults, the respective figures were 45 and 39 per cent. Analysis reveals that the children committed significantly more tight fits on dual-lane crossings than would be expected by chance (t (17) = 2.5, $p < .05$), whereas adults did not. However, deviations from expected levels did not differ significantly between the two groups. One interesting side finding is that children appear to accept proportionately fewer dual-lane gaps than adults (t (27) = 2.04, $.10 > p > .05$). This suggests that children may strategically reject dual-lane gaps.

Discussion

The findings indicate that though five-year-olds missed considerably more opportunities than adults, statistically they were only marginally more likely to commit a tight fit. Ancillary analyses suggest that gap wastage by five-year-olds reflected a cautious criterion of gap acceptance, rather than a general inability to make appropriate decisions about gap size.

The asymmetry in the prevalence of tight fits and missed opportunities found both in the present experiment and in Expt 1 lends further support to this view: a general deficiency in timing judgement would have resulted in considerably more symmetry between tight fits and missed opportunities. The absence of significant correlations between these two measures in all three experiments may also be indicative of a dissociation between the two kinds of error.

The relatively high proportion of nearside tight fits committed by 5-year-olds may suggest that tight fits arose from lapses in attention or failures to orient appropriately, rather than through deficiencies in timing *per se*. The finding that the children committed more tight fits than expected by chance for dual-lane gaps lends further support to the notion that tight fits arose from deficiencies in skill or information processing that were not directly attributable to deficiencies in timing.

The general picture that emerges from these findings is that young children behave in a strategic manner, and in some measure, compensate for their deficiencies. Using a conservative criterion of gap acceptance and missing opportunities can compensate for a relative lack of precision in calibrating temporal information. Of course, the ability to use this strategy rests on the child possessing some fundamental ability to use temporal information. Selective rejection of dual-lane gaps seems a sensible way of dealing with situations that seem to cause children difficulties. However, the data do not provide unequivocal evidence that this selective behaviour is strategic in the full sense of the word.

GENERAL DISCUSSION

The findings from the three experiments are consistent in their general portrayal of errors in young children's decisions about traffic gaps. Relative to adults, children missed many more opportunities, but committed very few more tight fits. Indeed, the incidence of tight fits in six-year-olds in Expt 2 was almost identical to that of adults in Expt 3. These findings are diametrically opposed to the findings of Vinje (1982*b*) and van Schagen (1988), which used less natural assessment tasks.

Comparison of the new simulation tasks with Young & Lee's (1987) pretend road indicates some concordance in the pattern of errors diagnosed, especially for the youngest children. Though the pretend road overestimated the incidence of missed opportunities committed by children, it did not underestimate the incidence of tight fits. These results are encouraging because the pretend road is a potentially useful training medium for children who do have a serious timing problem. The pretend road allows a child to experience directly whether or not s/he has committed a tight fit, and this feedback could prove useful in helping children and adults with various neurological impairments attain calibrations for traffic. The new tasks (two-step and shout) do have the practical advantage of ease of use. They can be practised where there is no room for a pretend road, and thus are readily modifiable for various traffic situations, such as complex junctions.

These findings raise a number of issues concerning children's competence and limitations as pedestrians. To begin with, the findings suggest that in tasks in which appropriate calibration of traffic gaps is the crucial parameter, young children make relatively few dangerous decisions. This suggests that young children's over-representation in accident statistics cannot be attributed to a general developmental phenomenon regarding timing of the sort discussed by Piaget. It is of course possible that some children are selectively at risk for accidents because of certain perceptuo-motor deficits, which encompass calibration of traffic gaps. Identifying such populations and assessing the extent to which their numbers contribute to the overall accident rates of young children is clearly an issue in need of investigation.

Subsidiary analyses of data gathered in Expt 3 suggest that young children may have a more general problem in controlling attention. This problem has been discussed by previous investigators, as well as being a part of common wisdom (Older & Grayson, 1974; Sandels, 1975). Given that the tasks used in the present studies placed minimal extraneous demands on the children's attention, it is likely that due weight has not been given to this as a contributing factor to accidents.

While the present findings suggest that fewer tight fits occur than previously reported by Vinje and van Schagen, it nonetheless seems to be the case that both adults and children produce alarming rates of tight fits. As was indicated earlier, it was impossible to differentiate between tight fits that would have resulted in collisions from those that would have resulted in 'narrow escapes'. Clearly, direct collisions only account for some (unspecifiable) proportion of the tight fits reported. There was, however, no difference between the adults and the children in the lateness of subjects' arrival during tight fits. Moreover, the tasks used placed heavy demands on subjects, in that they were not allowed to divide their crossing in two by stopping at the median. It is also likely that drivers reduce speed on approaching a crossing pedestrian. Thus, in the real world, pedestrians may not need the level of accuracy required in the simulation tasks.

Could the behaviour of drivers have differentially affected the apparent performance of subjects on the simulation tasks? This seems very unlikely, given that subjects were visibly cordoned off from the road. While drivers may typically reduce speed when they see a child pedestrian standing at the kerb, this did not appear to occur more than very rarely while the present experiments were in progress.

The conservative tendencies of the children, as reflected in the incidence of missed opportunities, the use of a conservative criterion of gap acceptance, and selective reduction of dual-lane crossings all seem to point to strategic behaviour. It is conceivable that the use of such criteria may result in unnecessary delays in getting across a road, with attendant feelings of frustration and impulsive decisions. The only data presented here that address this issue concern the correlation between missed opportunities and tight fits. It will be recalled that in all three experiments, this correlation was non-significant. However, it is possible that under conditions in which the child is more motivated to cross the road, frustration and impulsiveness occasioned by delayed crossing may well result in dangerous behaviour. This is an important issue for future research, as it may well transpire that the present characterization of the young child as strategic and overcautious may prove to point to a major problem after all.

In conclusion, the findings suggest that children as young as five and six years of age were not markedly different from adults in their ability to make sensible decisions about traffic gaps. Though direct comparisons revealed the children to be generally less skilled than adults as road users, the children were able in some measure to compensate for their deficiencies. It would seem highly unlikely that young children's greater vulnerability as pedestrians can be directly attributed to a general developmental deficiency in the extraction of temporal information.

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