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Collective behavior in road crossing pedestrians: the role of social information

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Social information use is common in a wide range of group-living animals, notably in humans. We investigated social information use by pedestrians in a potentially dangerous scenario: at a road crossing. To judge a safe gap in traffic, pedestrians can use social information, such as the crossing behavior of others, and follow others across the road. We tested if pedestrians followed others in this scenario by analyzing pedestrian starting position and crossing order. First, we found that neighbors of a crossing pedestrian tended to cross before other waiting pedestrians and that this tendency was significantly higher in observed pedestrians than in a null model: a simulation in which pedestrians did not follow each other. Also, by fitting the null model, we found that on average a person was 1.5–2.5 times more likely to cross if their neighbor had started to cross. Second, we found that males tended to follow others more than females. Third, we observed that some individuals started to cross and then returned to the roadside. These individuals were more frequently found in groups and tended to start to cross relatively later than other pedestrians. These observations suggest that some of these individuals made incorrect decisions about the timing of their crossing and that this was due to social information use. Finally, we propose that the relatively small benefit of a reduced waiting time came at the cost of an increased risk of injury, making the beneficial value of social information use questionable in this context. *Key words:* group behavior, human, pedestrian, sex, simulation, social information. *[Behav Ecol 21:1236–1242 (2010)]*

Animals in groups can use information directly from their environment, but also from social sources, to behave in an adaptive manner (Dall et al. 2005). Social information includes the position in a group, movement (e.g., velocity, acceleration and alignment), behavior (e.g., feeding or vigilance), state (e.g., nutritional, informational, and dominance), and morphology (e.g., body size and coloration) of other individuals (Krause and Ruxton 2002). This information can be used by individuals to respond to the behavior of their neighbors, for instance, to move closer to together to, or align with, other group members (Aoki 1982; Couzin and Krause 2003). Movements toward conspecifics can reduce individual predation risk, which has been theoretically demonstrated in the selfish herd model by Hamilton (1971), and empirical evidence for this theory has been reviewed by Krause (1994). Individual alignment with conspecifics has been shown to increase foraging returns for three-spined sticklebacks *Gasterosteus aculeatus* (Ward et al. 2008). Furthermore, these interindividual interactions can theoretically cause complex and potentially adaptive self-organized collective patterns (Parrish and Edelstein-Keshet 1999) such as activity synchrony (Conradt and Roper 2000; Rands et al. 2003) and effective conflict resolution (Couzin et al. 2005).

Humans have been empirically demonstrated to respond to a wide range of social information derived from the behavior of others. They respond to signals, that is, behavior performed for the purpose of information transmission, for instance, vocalizations (Cherry 1978), and also inadvertent social cues, that is, behavior that is not necessarily performed for the purpose of information transmission such as gaze following and facial expressions (Langton et al. 2000). An individual can gain functionally important information from the behavior of others (Cherry 1978), but social information use, in some animals, has also been empirically demonstrated to be disadvantageous (Giraldeau et al. 2002). We investigated a scenario in humans where social information use may have been disadvantageous and potentially dangerous; road crossing by pedestrians.

Road crossing is a daily necessity for all of us but also a potentially dangerous activity. In 2007 alone, 646 pedestrians were killed and 29 545 injured in road accidents in the UK (Allen et al. 2008). At road crossings, pedestrians attempt to cross the road safely (i.e., when they perceive a safe gap in traffic) but also quickly. However, if the street light at a crossing is red for pedestrians, then a quick crossing is no longer safely possible which results in a trade-off between speed and risk. Individuals that are willing to accept a higher risk will cross even when the light is red, whereas others may decide to wait (Schmidt and Färbar 2009).

The decision to cross by a pedestrian has been shown to be subject to a range of factors. Children in a simulated road crossing missed safe gaps in traffic in which to cross more often than adults (Demetre et al. 1992). In 2 studies of pedestrian crossings in Israel, males were more likely to cross when the pedestrian traffic light was red than females (Rosenbloom 2009); and Ultra-Orthodox pedestrians, in an Ultra-Orthodox setting, committed more road crossing violations than secular pedestrians (Rosenbloom et al. 2004). Furthermore, Bunghum et al. (2005) found that pedestrians were less vigilant if they were eating, drinking, talking, or wearing headphones than individuals who were not performing these activities. A pedestrian's crossing decision has also been shown to be influenced by their environment. Himanen and Kumala (1988) found that when a vehicle moved toward a road crossing, a pedestrian was more likely to continue to wait at a crossing

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(as opposed to starting to cross) if vehicles were moving at a relatively high speed, if the number of vehicles was relatively high, or if the crossing was relatively wide. Pedestrians may also be affected by the behavior of others at road crossings (Rosenbloom 2009).

To cross the road, pedestrians have 2 potential sources of information: social and nonsocial. Nonsocial information can be derived from oncoming vehicular traffic and also pedestrian street lights. Social information can be accessed from the behavior of other pedestrians crossing the road: If someone crosses the road, it may indicate that there is a gap in traffic sufficiently large to permit a safe crossing. However, social information use may not always be a reliable source of information with which to judge a safe gap in traffic: for instance, a gap in traffic used by one crossing pedestrian may no longer be safe for another following behind. Of key importance, children may be influenced to cross the road by social information before the arrival of a gap in traffic that is large enough to be safe for them (Tabibi and Pfeffer 2007).

Following by pedestrians, of others, is an indicator of social information use and has been studied in a number of investigations. Evidence from one previous study suggested that pedestrians follow others across the road, but it was unclear whether, or not, pedestrians were responding to the same nonsocial information, that is, a gap in traffic, as opposed to following one another (Yang et al. 2006). In another study that also suggested following, it was unclear whether or not the pedestrians in groups were familiar with one another, that is, whether or not they knew each other (Himanen and Kumala 1988). Clearly familiar individuals will cross together, whereas the focus of this investigation is on following between unfamiliar pedestrians. Finally, a further study found no evidence of following by pedestrians on crossings in Israel (Rosenbloom 2009). However, in Rosenbloom's study observers were not able to distinguish between pedestrians who were familiar with one another and those who were unfamiliar. In our study, we used video footage to determine whether or not pedestrians were familiar with others. Furthermore, Rosenbloom (2009) used a logistic regression model to analyze the behavior of pedestrians who crossed on a red light. In this model, they had 5 predicting variables for whether or not a focal pedestrian crossed the road, and one predicting variable was "Pedestrian (different to the focal individual) crossing during red-light phase." For a logistic regression, the sample size should equal at least 30 multiplied by the number of predicting variables. Therefore, the sample size required was at least 150, but their sample size was only 76. Therefore, their relatively small sample size may have accounted for why they did not find evidence for following in their study. In conclusion, there is not yet clear evidence for, or against, following between unfamiliar pedestrians at road crossings.

We investigated following behavior by road crossing pedestrians and how social information use may affect their decision making. First, to determine if pedestrians used social information from unfamiliar others, we tested if near neighbors of crossing pedestrians tended to cross before other waiting pedestrians. Second, in some cases, pedestrians lifted their foot but did not walk continuously across the road but instead lifted their foot, took one or more steps, and then aborted their crossing attempt (ACA). We tested 3 possible explanations for this behavior: 1) pedestrians may have stepped forward, and then stopped, to adjust their position so that their line of sight was less obstructed by other pedestrians. 2) Individuals may have stepped forward, and then stopped, to prepare themselves to cross. 3) Individuals may have aborted their crossing attempt because, after they stepped forward, they changed their decision from deciding to cross to deciding to wait. We found that the pedestrians that aborted their crossing attempt were likely to be changing their decision (i.e., explanation "3"). Therefore, we then tested the effect of the availability of social information on the number of individuals that changed their decision, that is, aborted their crossing. For this, we compared the frequency of individuals that aborted their crossing attempt between singletons (i.e., when no social cues available) and pedestrians in groups (i.e., when social cues were available).

Third, we explored the effect of sex of pedestrians on their road crossing behavior. It has been shown that males tend to cross sooner than females (Rosenbloom 2009). In other words, males responded sooner to nonsocial stimuli than females. Therefore, we predicted that males will also respond sooner to social stimuli than females and will therefore be more likely to follow others across the road than females.

MATERIALS AND METHODS

Location and materials

Observations of pedestrians were made at a road crossing on Quebec street in one of the most populated cities in UK: Leeds (population: 715, 404). This crossing is 1 of the 2 main pedestrian crossings leading from the central train station into the city which means that a large volume of people, from a wide demographic, pass through this area daily. Observations were made between 08:00 AM and 09:00 AM when pedestrian volume was at its maximum from 01 September 2008 to 03 September 2008 and 18 December 2008 to 21 December 2008, using a video camera (Sony Digital Handycam DCR-PC100E) with a wide-angle lens. The camera was mounted on a tripod (height 2 m) and positioned 7 m behind the "near side" of the crossing (Figure 1). The road traffic was one-way, and we observed pedestrians crossing the road only from the near side to the far side of the crossing, which simplified filming the pedestrians (Figure 1). We analyzed the behavior of 365 pedestrians at the road crossing, of which 335 were in groups and 30 singletons.

Definition of a "pedestrian group"

A group comprised pedestrians that were directly adjacent to the road, at the crossing edge. Pedestrians behind the front row did not push past people in front of them to attempt to cross, and their view of the traffic was more likely to be obscured than people in the front row. Therefore, the crossing order of pedestrians behind the front row was likely to be dependent on the crossing order of the individuals in front.

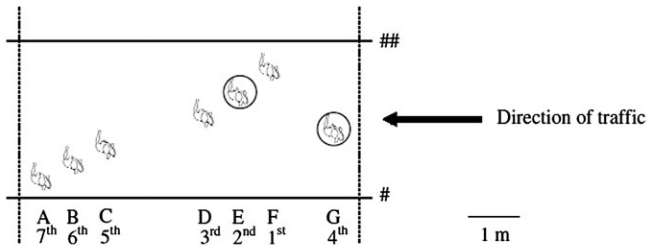


Figure 1
Schematic of pedestrians (A–G) at a road crossing on Quebec street, Leeds, UK. Pedestrians were observed crossing a one-way road from the near side (#), relative to the observer, to the far side (##) of the road, within the designated crossing area (—). We recorded the order that pedestrians began to cross the road (first to seventh) and their relative starting positions. In this example, pedestrian "F" was the first to cross, and their nearest neighbors were pedestrians "E" and "G" (○).

For simplicity, these pedestrians were not considered in the analysis, and there was no reason to suggest that their behavior confounded the relationship between crossing order and starting position of individuals in the front row.

We excluded observations where any group members were familiar with one another as these individuals were highly likely to assume close positions at the crossing and to commence crossing together. Individuals were considered to know one another, if they performed any of the following behaviors: 1) walked side by side to the crossing for 10 m prior to reaching the crossing, 2) walked side by side away from the crossing for 10 m, and 3) turned to face one another at the crossing or talked to each other.

Starting position and starting order

We recorded the crossing order and starting position (Figure 1) of each individual at the front row of the crossing. A pedestrian was considered to have started crossing from when they lifted their foot off the floor and then proceeded to walk continuously over the crossing. The starting position was recorded relative to the position of others and measured from the direction of the oncoming traffic.

To investigate interactions between people in the front row, we recorded the crossing order of the left and right neighbor of the first 3 individuals to start crossing, relative to their group members. Analysis of the neighbors of the remaining individuals to cross was unlikely to provide further evidence for the presence, or absence, of a relationship between crossing order and starting position because if there was a low number of individuals remaining at the crossing after others have crossed, their relative starting orders would have been closely similar. The neighbors of a crossing pedestrian were the individuals that commenced from the next occupied position to the left and right of the crosser.

To make comparisons between groups of different sizes, we normalized the crossing order of each pedestrian (NCO_i) according to their group size, excluding individuals who have already crossed. For an individual i and its crossing order CO_i we define

$$NCO_i = (CO - 1)/\text{group size} \quad (1)$$

For example in Figure 1, the nearest neighbors of the first pedestrian to cross ("F") were pedestrians "E" and "G." They were second and fourth to cross, respectively, so their COs were 2 and 4, respectively, and their NCOs were 1/7 and 3/7, respectively. Note that for a large number of groups, the average NCO of the nearest neighbors of the first to cross will be 0.5 regardless of the group sizes, if the crossing orders are chosen at random (i.e., if all possible crossing orders of the nearest neighbors are equally probable). If the nearest neighbors of the first to cross tended to follow the crosser, and have a higher tendency than others in the group, then we would expect a mean NCO value less than 0.5.

Pedestrian simulation

To determine if the nearest neighbors of crossing pedestrians were crossing sooner than expected than if pedestrians crossed at random, we compared observed pedestrian waiting position and crossing order, to that in a simulation. In the simulation, the probability that a pedestrian crossed the road was independent of the crossing behavior of others. However, the position of an individual along the roadside may have affected the timing of their cross. Therefore, the probability that each simulated pedestrian crossed was calculated as a function of their relative waiting position from the oncoming traffic. To simulate the pedestrian starting order with respect to position, we calculated the probability that each individual started to cross, at each time step, depending on their position. For instance, if individuals standing closer to the traffic were more likely to cross before individuals further from the traffic; then, to mimic this in the simulation, agents starting to cross closer to the direction of traffic would have a higher probability of starting, at each time step, relative to individuals further from the traffic.

The first pedestrian in the group to cross after a vehicle had crossed had no other pedestrians to follow across the road. Therefore, we assumed that this individual was not adjusting their decision to cross based on the behavior of others. With this in mind, we used the position distribution of the observed lead pedestrians, normalized for group size, to generate the probability that an individual at each position would cross in the absence of interactions with other crossing pedestrians. If lead pedestrians started to cross from the position closest to the traffic, relative to other positions, then simulated individuals in this position would have had a higher probability of starting to cross, at each time step, than individuals at other positions. For further details of the simulation, see Supplementary Appendix A. In addition, we used the observed group size distribution in the simulation.

To determine the nature of following interactions between pedestrians, we also fitted the simulation model to the observed data by adjusting the probability an individual began to cross at the next time step as a function of the crossing behavior of their neighbors, that is, we added following behavior to pedestrians in the simulation. In the simulation, we increased the probability of an individual crossing after their neighbor had crossed by a factor of "F." We then compared the NCO of the simulated nearest neighbors with that of the observed pedestrians. We ran multiple simulations to test a range of "F" values.

Analysis

Data analysis and model programming were performed using "R" version 2.8.1 (R Core Development Team 2008).

We analyzed the observed mean NCO of the nearest neighbors of the first, second, and third pedestrians to cross by comparing them with the corresponding mean NCOs generated in the simulated null model. The observed mean NCO was considered to be significantly different to the model output if it was below the 2.5th or above the 97.5th percentile of the simulated mean NCO distribution ($\alpha = 0.05$).

We used this simulation to analyze pedestrian behavior because the probability that a pedestrian started to cross was affected by their position. The relationship between probability to cross and their position affected the NCO distribution in a way that could not be dealt with analytically.

To investigate the effect of pedestrian sex on followership, we analyzed the difference in observed mean NCO between males and females using a Monte Carlo difference test. In the analysis, we computed an observed test statistic and compared it to a distribution of test statistics generated by randomizations of the data. To compute the test statistic: for each observed pedestrian group, we used observations of the nearest neighbors of the first 3 individuals to cross. We then categorized the pedestrians by sex and calculated a group mean NCO for males and a group mean NCO for females. We then computed the sample mean of the groups for males and for females. The observed test statistic was the difference between the male sample mean NCO and the female sample mean NCO. To generate the randomized distribution: for each iteration, in each group for the 2 mean NCOs (for males and females), the sex labels were removed and reallocated at

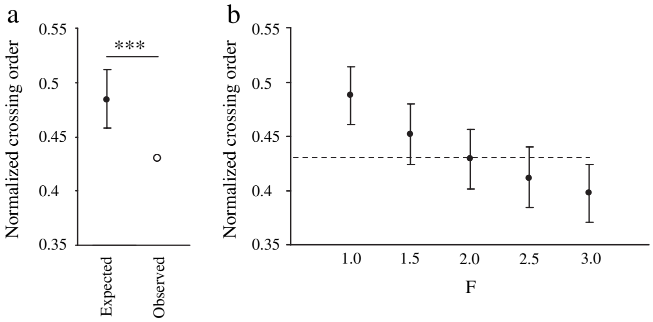


Figure 2
(a) Comparison of the mean observed (○; $N_{groups} = 50$) normalized crossing order (NCO) of neighbors of the first, second, and third pedestrians to cross, and the expected mean NCO generated by simulated pedestrians (●; $N_{groups} = 50$). We compared the observed mean NCO with the median expected mean NCO (1000 iterations, error bars: 97.5th and 2.5th percentiles). Significance is indicated by: $***P < 0.001$). (b) The effect of introducing following behavior to simulated pedestrian behavior. The simulated pedestrians at each time step either crossed or waited. The probability that an individual crossed was calculated as a function of their (A) position (relative to the position of others) and (B) whether their neighbors had begun to cross. If the neighbor of a focal individual crossed, the probability that the focal individual crossed was multiplied by "F." We increased the value of "F" incrementally to fit the model output to the observed mean NCO (– –). An F value of between 1.5 and 2.5 was sufficient to fit the model output to the observed data.

random. We then computed the test statistic for the sample. Ten thousand iterations were performed, which generated a distribution of test statistics. We then analyzed the observed test statistic by comparing it with the test statistics generated in the randomization.

We also analyzed pedestrian crossing order between males and females. In other words, we considered if males, or females, were more likely to be first to cross. We compared the observed frequency of males and females who were first in a group to cross, with an expected frequency calculated from the overall ratio of males to females who crossed the road during our observations, using a chi-squared test ($\alpha = 0.05$).

To investigate the possible explanations 1–3 for the behavior of ACA individuals (who aborted their crossing attempt), we used Monte Carlo difference tests ($\alpha = 0.05$). For 1), we expected a higher frequency of individuals further (relative to the position of others) from the oncoming traffic to make a single or multiple step and then stop. Therefore we compared pedestrian relative waiting position between ACA individuals and non-ACA individuals, that is, individuals that took one step and then walked without stopping across the road. For 2), we expected individuals who made a step in readiness to cross, to cross relatively earlier than other waiting pedestrians. Therefore we compared the NCO of ACA individuals, with an expected NCO if ACA individuals crossed at random relative to other group members. For 3), we expected ACA individuals to cross relatively later than other waiting pedestrians. Individuals who started to cross relatively later than others would have had a smaller gap in traffic in which to cross than those who crossed earlier. Also, the relatively smaller gap in traffic would have increased the likelihood that relatively late individuals changed their decision to cross and returned to the safety of the roadside.

To investigate the effect of the availability of social cues on the aborted crossing attempts, we compared the number of ACA individuals in groups, and as singletons, with that expected if ACA individuals were randomly allocated to the observed groups and singletons.

RESULTS

The observed mean NCO of neighbors of the first, second, and third pedestrians to cross was lower than the mean NCO of corresponding pedestrians in a simulation which indicated that there was an interaction between individuals (comparison to simulation: $N = 50$; $P < 0.001$; Figure 2a). To determine the effect size of this interaction, we fitted a model to the observed data and found that, when an individual crossed, the probability that their neighbor crossed increased by a factor of between 1.5 and 2.5 (± 0.25; Figure 2b).

The road in this study has a speed limit of 30 mph, and the estimated braking distance for a car moving at 30 mph is 23 m (Department for Transport—Driving Standards Agency 2007). Three of the 365 pedestrians crossed when at least one vehicle was within 25 ± 2.5 m of the crossing and traveling at approximately 30 mph when the pedestrian was crossing the lane of the car. Therefore, these pedestrians were likely to have been positioned within the braking distance of these cars. None of these pedestrians were the first in the group to cross.

Male nearest neighbors of crossing pedestrians tended to cross sooner than female nearest neighbors (Monte Carlo difference test: observed test statistic = 0.085; $N_{groups\ comprising\ a\ male} = 41$; $N_{groups\ comprising\ a\ female} = 48$; $P < 0.01$; Figure 3). However, males were not more likely to be the first to cross the road than females (chi-squared test: $N_{male\ observed} = 28$; $N_{male\ expected} = 23$; $N_{female\ observed} = 22$; $N_{female\ expected} = 27$; $\chi^2 = 0.953$, $P = 0.243$).

With regards to hypotheses 1–3: for 1), ACA individuals (who aborted their crossing attempt) did not tend to be positioned either at the closest or the furthest position from the oncoming traffic (Monte Carlo difference test: $N = 43$, $P = 0.996$; Figure 4a). For 2) and 3), ACA individuals tended to cross relatively later than other waiting pedestrians (Monte Carlo difference test: $N = 43$, $P < 0.001$; Figure 4b).

ACA individuals were significantly more frequent in groups than as singletons (Monte Carlo difference test: $N = 43$, $P = 0.030$; Figure 4c).

DISCUSSION

We found, and described, a potentially important factor that influenced the decision of the timing that pedestrians crossed a road, the behavior of other waiting pedestrians. By comparison with simulated pedestrian behavior, we found that observed pedestrians were 1.5–2.5 times more likely to cross, at each time step, if one of their neighbors had already begun to cross. These findings provide the first clear evidence that pedestrians followed others across the road and therefore used social information in this context.

In contrast, Rosenbloom (2009) found that pedestrians were not more likely to cross when the pedestrian light was red, if another individual had already begun to cross. The differences in findings between the studies are likely to be due to the analysis; in the Rosenbloom study, the sample size was insufficient for the analytical model.

There are many scenarios in which animals experience similar situations to the pedestrians in this study. For example, penguins on the edge of an ice floe that are about to reenter the water after a predation threat or a flock of swallows that is resting on a wire with some birds taking off (Krause and Ruxton 2002). All cases of 1D animal groups conform to the type of situation that we investigated here and should be amenable to the same analytic approach to detect elements of collective decision making in which group members copy the behavior of local neighbors.

We also found that male nearest neighbors of crossing pedestrians tended to cross sooner relative to other waiting

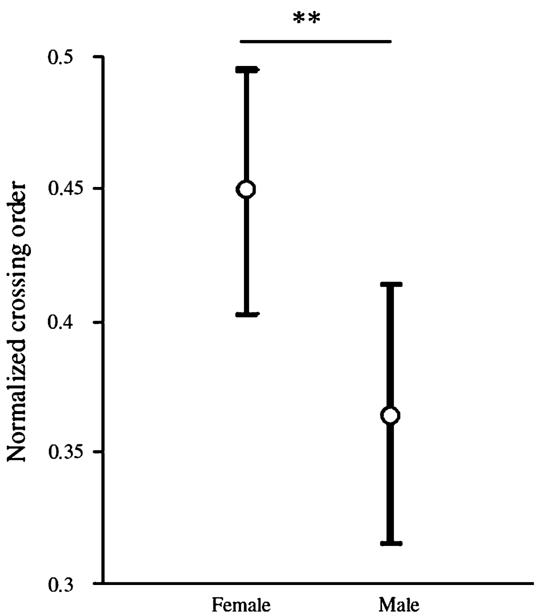


Figure 3
We compared the observed normalized crossing order between male and female neighbors of the first, second, and third pedestrians to cross the road. A significant difference was denoted by the following: $^{**}P < 0.01$).

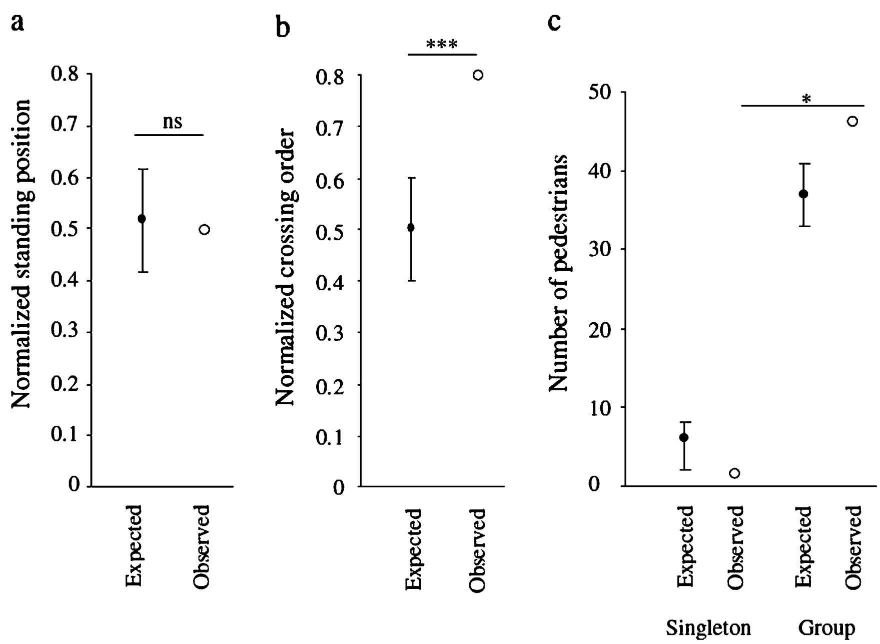
pedestrians than female nearest neighbors. A possible explanation may have been that males generally tended to cross before females but we did not find evidence for this. Therefore, our results suggest that, at road crossings, male pedestrians are more likely to respond to the behavior of others than females. To our knowledge, there are no other studies that investigate the effect of pedestrian sex on their following behavior.

We also found that some pedestrians made a single, or multiple steps, before crossing the road, but then aborted the crossing (so called ACA individuals). Moreover, in at least 4 groups, a pedestrian walked almost half way across the road and then backtracked to the safety of the roadside from where they had departed. We tested 3 possible explanations for this behavior (see Introduction). We found that individuals who waited in positions further from the oncoming traffic were no more likely to abort their crossing than individuals closer to the traffic. Therefore, it was unlikely that movement by pedestrians to adjust their line of view could account for the aborted crossings (i.e., explanation "1"). We also found that individuals who aborted their crossing were late to cross relative to those who did not abort their crossing. This indicates that explanation "2" was also an unlikely explanation, but does support explanation "3." Individuals who started to cross relatively later than others would have had a smaller gap in traffic in which to cross than those who crossed earlier. The relatively smaller gap in traffic would have reduced the likelihood to cross of relatively late individuals (in the same gap as others in their group). Also, the relatively smaller gap in traffic would have increased the likelihood that relatively late individuals changed their decision to cross and returned to the safety of the roadside. Therefore, from these results, the most likely explanation is that individuals tended to abort their crossing because they changed their decision about when to cross (i.e., explanation "3").

We also found that pedestrians in groups (that started relatively late) were more likely to abort their crossing than pedestrians who were waiting at the crossing alone (i.e., singletons). This finding indicates that the presence or behavior of others encouraged pedestrians to cross when the gap was not sufficiently large enough for a safe crossing. Furthermore, if an individual changes their decision during a cross, it implies that they are relatively uncertain about when to cross compared with individuals who did not change their mind. Therefore, this finding also indicates that the presence of social cues tended to make pedestrians more uncertain about the timing of their crossing.

Pedestrians who followed others across the road are at a relatively higher risk than those who did not for 2 reasons: 1) following individuals may experience conflicting social and

Figure 4
We analyzed pedestrians who took a single step, or multiple steps, into the road but then stopped their crossing (ACA individuals). In (a), (b), and (c), the observed values (○) were compared with expected values (●; error bars: 2.5th and 97.5th percentiles) generated by corresponding Monte Carlo simulations. We analyzed (a) ACA normalized standing position (NSP; $N_{groups} = 42$); (b) normalized crossing order (NCO; $N_{groups} = 42$); and (c) the observed frequency difference of ACA individuals in singletons and groups ($N_{\text{"ACA" individuals}} = 43$). NCO = order to cross/(group size + 1); NSP = relative position from the direction of traffic/(group size + 1). Significant differences were denoted by the following: $^{*}P < 0.05$; $^{***}P < 0.001$; no significant difference: ns).



nonsocial information which may cause uncertainty about when to cross. If an individual is uncertain, this confusion may be transmitted to the vehicle driver and both individuals may be more likely to panic and thus cause an accident. 2) Individuals that follow others may be more likely to have made incorrect decisions about the timing of the crossing. An incorrect decision in this case would be to step in front of a car within the braking zone of the vehicle and would be likely to cause injury to the pedestrian. Individuals that follow others may have made incorrect decisions because the gap in traffic is smaller for followers that for lead pedestrians. The fact that some individuals changed their decision while crossing and that they were more likely to change their decision if they were in a group suggests that they first copied the behavior of the others and then realized that they had made an incorrect decision and returned to the roadside from where they had left.

In 6 h, 3 people at this crossing, some of whom were likely to be following others, crossed within the braking distance of a car moving at the road speed limit: 30 mph (Department for Transport—Driving Standards Agency 2007) and were putting themselves at substantial risk. However, if individuals are aware that they are affected by the behavior of others, they may be less susceptible to this behavior and thus less at risk of an accident. Of key importance in this scenario is when children are crossing the road. Children are less effective at judging a safe gap in the road, than adults, and may also be more susceptible to follow others across the road (Tabibi and Pfeffer 2007).

Our findings suggest that social information use in this scenario was disadvantageous for pedestrians, and disadvantageous social information use has also been demonstrated in nonhuman animal groups (Giraldeau et al. 2002). A disadvantage to using social information is that it may tend to be of a lower quality than nonsocial information. In a pedestrian road crossing group of 2, social information, that is, the crossing behavior of the first pedestrian to cross, available to the second pedestrian to cross, was more likely to be incorrect than nonsocial information, that is, the distance of a vehicle because the vehicle would have been further from the crossing when the first pedestrian started to cross than when the second crossed. Therefore, in this scenario, if an individual used social information and disregarded nonsocial information, they would have been more likely to have attempted to cross in an unsafe gap in traffic than if they used only nonsocial information. In nonhuman animal groups, social information use been shown to be disadvantageous in a range of taxa (Laland 1996; Giraldeau et al. 2002), for instance, in the guppy *Poecilia reticulata* (Laland and Williams 1998).

An explanation for why a pedestrian would disregard nonsocial information for social information, even if social information was of low quality, is that social information use may have caused maladaptive informational cascades through the group. For example, 2 pedestrians may observe the advancing traffic and deem the road safe to cross. At the same time, a third pedestrian may observe the traffic and consider the road not safe to cross. However, they may also consider that the opinions of the other 2 outweighs their own opinion and therefore decide to cross, a dangerous decision in this scenario (Giraldeau et al. 2002). In nonhuman groups, maladaptive cascades have been demonstrated in mannikins *Lonchura punctulata* (Rieucau and Giraldeau 2009). Road crossing pedestrians may make a good model system for future research in informational cascades in animal groups. Maladaptive information cascades between pedestrians, such as following others across a road, may be common, should be researched, and the findings communicated to the public.

We showed that road crossing pedestrians were more likely to cross if their roadside neighbor had begun to cross and therefore that they used social information to determine the time at which they crossed the road. This may provide benefits to the individual in form of a reduced waiting time at the crossing but is likely to put them at a greater risk of an accident: a trade-off that road crossing pedestrians may not be aware of, but perhaps they should.

SUPPLEMENTARY MATERIAL

Supplementary material can be found at http://www.beheco.oxfordjournals.org/.

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