How much additional space is required around a person walking with a trolley bag or baby stroller?

Ryuzo Ohno, Izumi Kaneko

Tokyo Institute of Technology, Japan

Context

The “New Barrier-Free Law,” was enacted in Japan in 2006, and it promotes mobility and accessibility for the aged and physically disabled. One side effect of this and as steps and obstructions have been removed from public spaces, the number of people walking around with a trolley bag or baby stroller has rapidly increased. To avert collision, surrounding pedestrians tend to keep more space around such people, impeding traffic flow in crowded situations and even causing accidents in the worst cases.

Purpose

This study quantitatively examines the behavior of pedestrians moving close to a person with a trolley bag or baby stroller. The data will prove useful in estimating how much extra space is needed for those with such gear, for example in a railroad station or other transport facility.

The data obtained

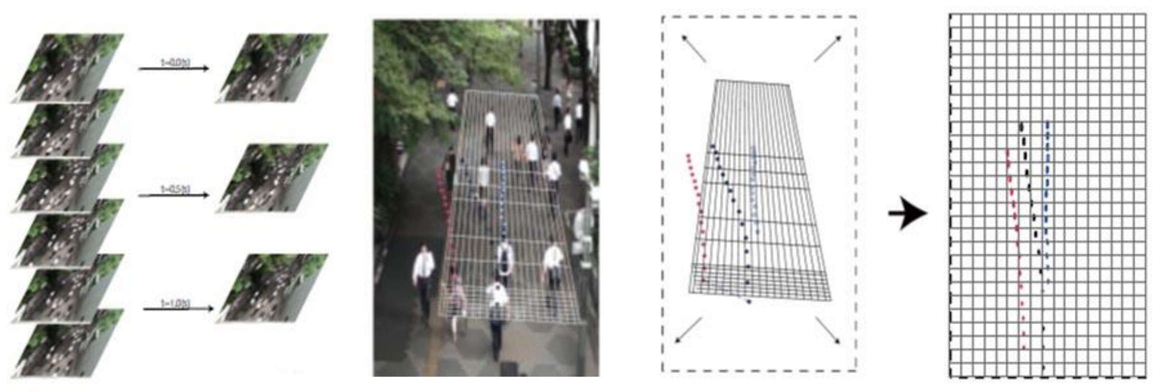
As shown in table 1, the experiment yielded data for a total of 360 pedestrians.

Table 1: Number of recorded pedestrian cases

	Test walker	Parallel against flow	parallel along with flow	Perpendicularly across flow
N	Carrying nothing	39	17	38
S	Pushing baby stroller	30	17	41
LB	Drawing a large trolley bag	40	10	36
SB	Drawing a small trolley bag	45	10	37

Procedure of analysis

To obtain the pedestrian trace, the video was processed in three steps.



Step 1: Still photo images were picked up from the video every 0.5 seconds apart.

Step 2: The pedestrian’s head position was marked on a plane with 20cm x 20cm grid lines perspectively drawn over the photo at a height of 1.6 m.

Step 3: The plane was converted to orthogonal projection to obtain the correct trace.

Figure 3: Obtaining the pedestrian trace

Result 1 _2

Figure 5 compares the size of the evasive area when the test walker moved against pedestrian flow while pushing a baby stroller (S) versus while carrying nothing (N). The average values of W and L were found to be about 0.3 m and 3 m greater respectively for S than for N.

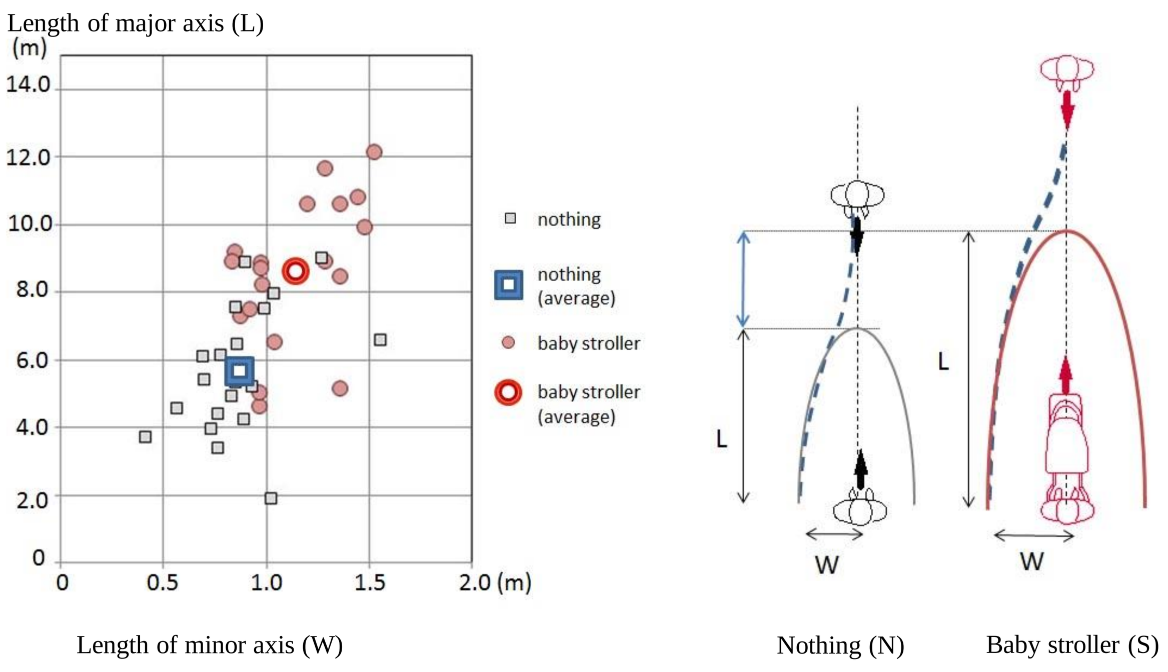


Figure 5: Size of evasive area when the test walker pushed a baby stroller (S) while moving against pedestrian flow

Result 1 _3

Figure 6 compares the size of the evasive area when the test walker moved along with pedestrian flow while pulling a small/large trolley bag (SB/LB) versus while carrying nothing (N). The average value of W was nearly the same in all three cases, while the average value of L was about 1.4 m greater for LB than for N. L did not differ between SB and N, suggesting that approaching pedestrians failed to notice the small bag.

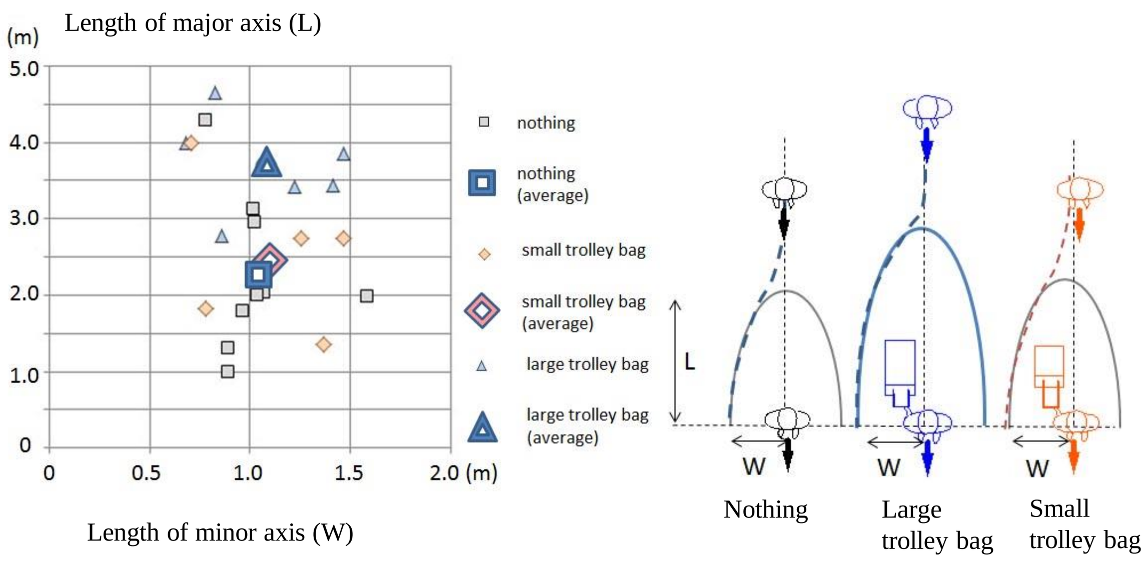


Figure 6: Size of evasive area when the test walker pulled a small/large trolley bag while moving along with pedestrian flow

Result 2_2

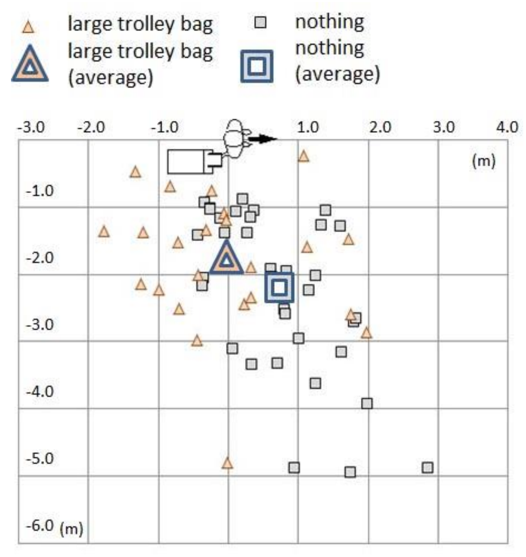


Figure 9: Starting points of evasive action when the test walker pulled a large trolley bag while cutting across pedestrian flow

As shown in figure 9, the starting point of evasive action when the test walker pulled a large trolley bag (LB) was located closer to and more behind him compared with when he carried nothing (N).

The difference was about 0.7 m between the average figures. Thus it seems that some pedestrians adjusted their route only after they came close to the bag.

Result 2_3

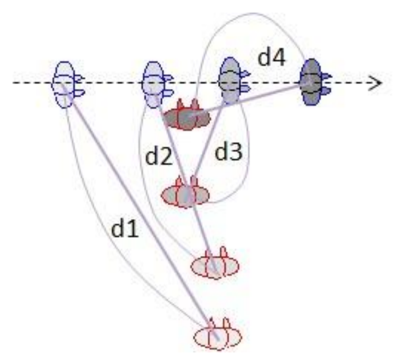


Figure 10: Identification of shortest distance between test walker and approaching pedestrian

To locate the end point of evasive action, we measured the distance between the test walker and the pedestrian at every 0.5 seconds (see fig. 10).

The end point was defined as the place of shortest distance between the two as they passed one another.

Method: Quasi-experiment

Figure 1: Experimental setting

The experiment was conducted on a street in a Tokyo business district during the morning commute, when pedestrian traffic largely flowed in one direction. The "test walker", a male assistant hired for the experiment, was asked to walk in three directions with respect to pedestrian flow—1) against, 2) along, and 3) across— while 1) carrying nothing (N), 2) pushing a baby stroller (S), 3) pulling a large trolley bag (LB), or 4) pulling a small trolley bag (SB), for a total of 12 experimental situations.

Experimental conditions

The movements of the surrounding passersby were recorded by a video camera set up above them on a pedestrian overpass.

The images were used to identify pedestrians whose movements were affected by the test walker and to extract their traces.

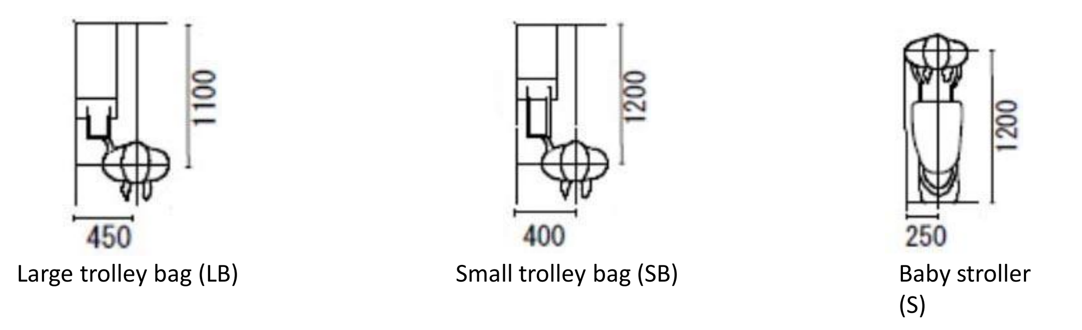
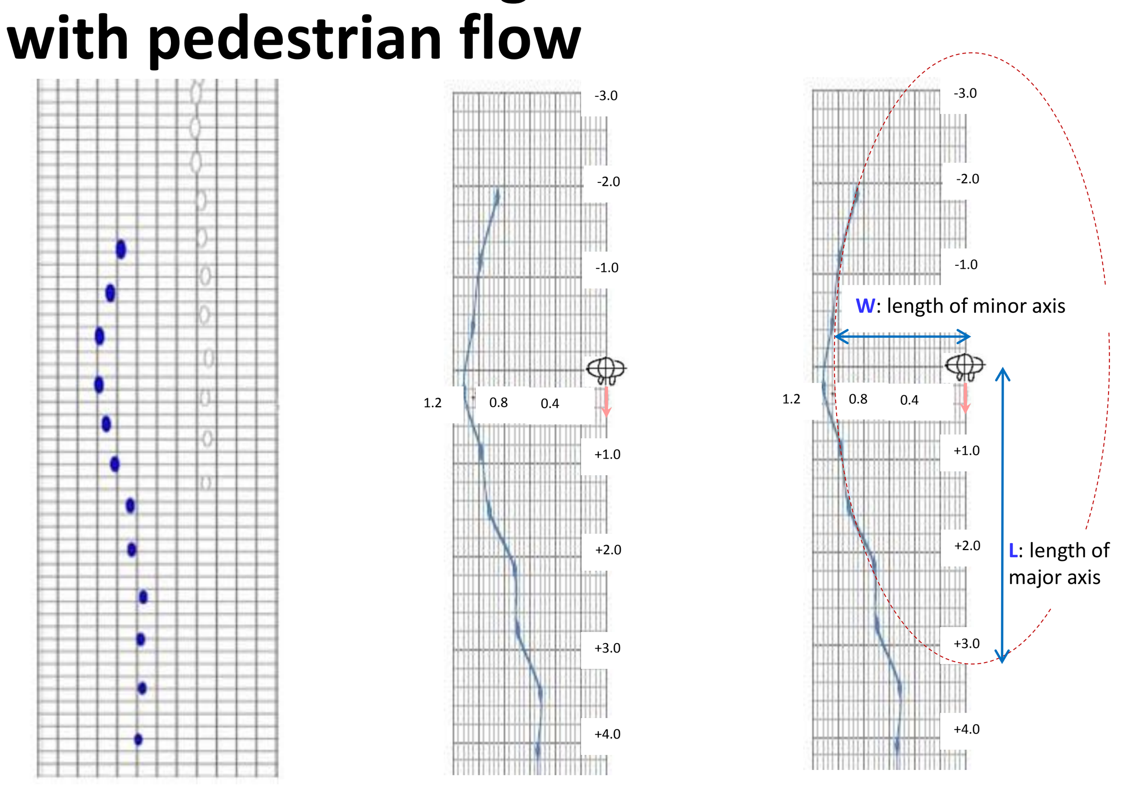


Figure 2: Size and position of trolley bags and baby stroller

Result 1: Effect of test walker moving against and along with pedestrian flow

The position of the test walker was fixed on the trace at the origin so as to show the relative distance and direction between him and the pedestrian.



Pedestrian's head positions as recorded every 0.5 seconds

Pedestrian trace with test walker fixed at the origin

Lengths of minor axis (W) and major axis (L) of an ellipse fitted to the pedestrian trace

Figure 4: Obtaining the oval evasive area in cases where the test walker moved against or along with pedestrian flow

We postulated an oval evasive area around the test walker that was defined by two values: length of major axis (L) and length of minor axis (W).

L may be interpreted to indicate the starting point of evasive action as the pedestrian approached the test walker directly from the front or back.

W indicates the distance between the test walker and the pedestrian as they passed one another.

Result 1 _4

Figure 7 summarizes the results by showing the size of the evasive area in all experimental situations involving the test walker moving against or along with pedestrian flow. The data for these front and back evasive areas should prove useful in estimating the additional space necessary to maintain smooth flow in pedestrian traffic including people with a trolley bag or baby stroller.

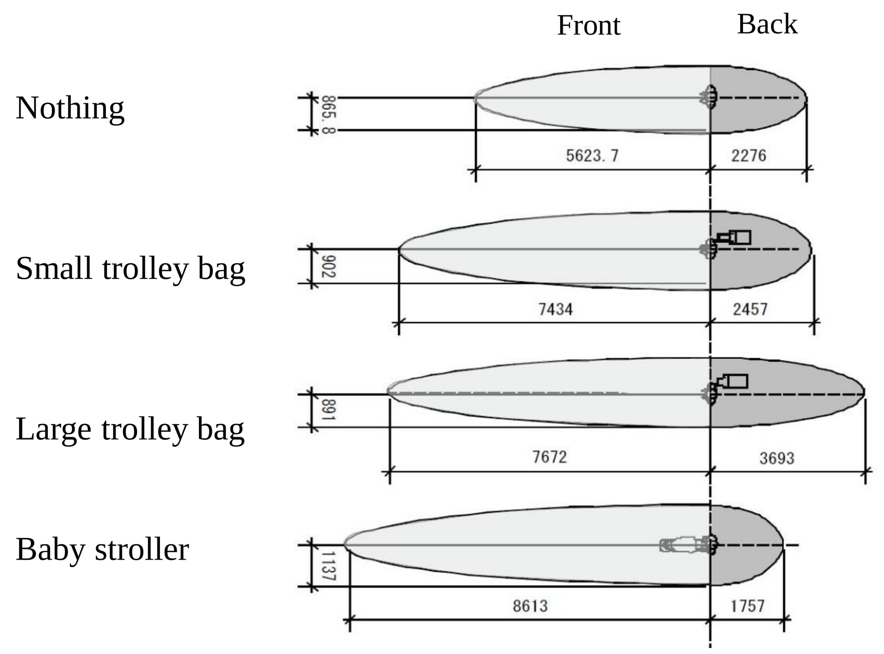
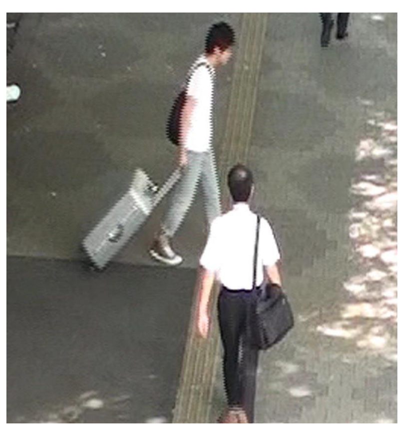


Figure 7: Size of evasive area in all tested situations involving movement against (front) and along (back) pedestrian flow

Result 2: Effect of test walker moving across pedestrian flow



The cases in which the test walker cut across pedestrian flow required a different method of analysis from the one described before.

We defined the starting point of evasive action as the place where the pedestrian made the sharpest change of route.

Accordingly, the pedestrian's direction of movement was determined on the trace at every 0.5 seconds to identify where the largest change in angle occurred between two consecutive points (see fig. 8).

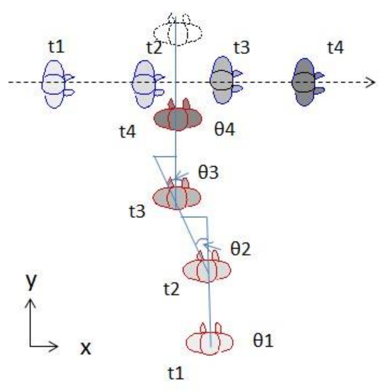


Figure 8: Starting point of evasive action as defined by the value of the angle (θ) of direction change

Result 2_4

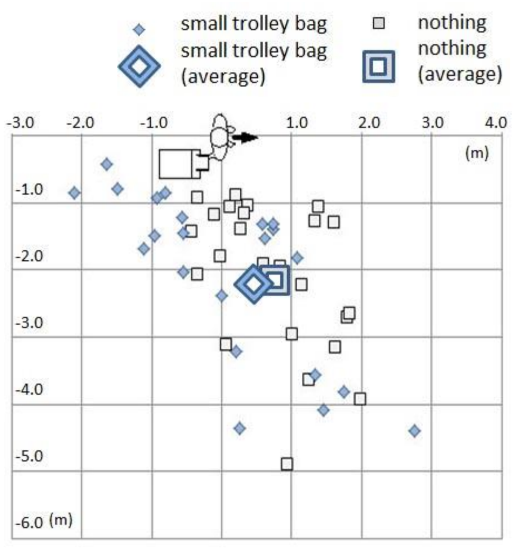


Figure 11: Starting points of evasive action when the test walker pulled a small trolley bag while cutting across pedestrian flow

Meanwhile, the starting points of evasive action when the test walker pulled a small trolley bag (SB) were nearly the same as for N. Here again, pedestrians apparently did not notice the small bag.

The average distance between the test walker and pedestrian at the end points of evasive action were 1.1 m when carrying nothing, 1.4 m when pushing a baby stroller, and 1.3 m when pulling a large or small bag.

In short, a roughly 20 cm (20%) wider space was required for the three situations in which the test walker carried something.

Conclusion

- When moving against pedestrian flow, a walker pushing a baby stroller requires a 53% longer evasive space in the front than while carrying nothing. A 36% and 32% longer space is required for someone pulling a large and small trolley bag, respectively.
- When moving along with pedestrian flow, a walker pulling a large bag requires a 62% longer evasive space in the back than while carrying nothing.
- When moving across pedestrian flow, a walker pushing a baby stroller requires a 27% larger evasive space than while carrying nothing. Someone pulling a large or small trolley bag requires about 20% larger evasive space.
- The above data can be used to estimate the extra room that needs to be allowed for people walking with a baby stroller or trolley bag in a public space.
- A small trolley bag, which many pedestrians often seem not to notice, may carry greater risk of accident.