

With Two Exits of Different Widths, Heading for the Nearer One Loses More Time the More People There Are

— with many people the best boundary moves to the point that divides by width, and the ratio of the two rules' times approaches a value set by the widths alone —the separator is whether people are divided by distance or by exit width — [Paper 979]

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— *From thinking to syncing.* —

Abstract

Widening the exit speeds evacuation only when there are many people; with few, the walking distance sets the time (Paper 895). Which exit people head for, the choice of exit, was not included there. With the walking speed of 1.3 m/s and exit flow of 1.3 persons/(m s) of Paper 895, this paper places exits at both ends of a 100 m corridor and compares the time for the last person to leave under a rule of heading for the nearer exit and under the best choice of boundary. No new theorem or law is claimed. First, with few people the two rules take almost the same time: with 60 people, averaged over 20 arrangements, the best time was **0.994959** (widths 1 to 3) to **0.995980** (1 to 2) of the time heading for the nearer exit, staying in this range for all three width ratios (Section 3). Second, the more people, the more time heading for the nearer exit loses: for widths 1 to 3 the mean ratio was **0.994959**, **0.674894** and **0.497270** for 60, 200 and 600 people (Section 3). Third, with many people the ratio approaches a value set by the widths alone: if only queueing sets the time, the ratio is twice the narrow width over the sum of widths, **0.666667** for 1 to 2 and **0.500000** for 1 to 3. The means for 600 people, **0.662493** and **0.497270**, differed from these by -0.004173 and -0.002730 (Section 4). Fourth, with many people the best boundary moves to the point dividing by width: for 600 people the mean best boundary was **33.398** m for 1 to 2 (width point 33.333 m) and **25.274** m for 1 to 3 (25.000 m). For 200 people at 1 to 3 it was **32.862** m, between the width point and the middle (Section 4). Fifth, the separator is whether people are divided by distance or by exit width: with 60 people, the middle boundary dividing by walking distance took almost the same time as the best. With 600 people, a boundary within 1 m of the point dividing by exit width was best (Section 5). **Keywords:** evacuation, exit choice, queueing, exit width, evacuation time, corridor.

Scope of this paper (scope note): No new theorem or law is claimed: that evacuation time splits into walking time and time through exits, that people crowding to the nearest exit lengthen its queue and slow the whole, and that dividing people according to what each exit can pass speeds evacuation, are all known in evacuation calculations. These are set values: the walking speed of 1.3 m/s and exit flow of 1.3 persons/(m s) are the model values of Paper 895; the 100 m corridor, exits at both ends, uniformly placed people, widths of 1 m and 1, 2, 3 m, 60, 200 and 600 people and 20 arrangements are set here. They correspond to no building or code. Human movement is not included: pushing, poor visibility from smoke, time before starting to walk, people choosing exits for themselves, and switching exits on the way are not included. The boundary is set from outside. No signage is recommended, which rule should guide people is not treated. Only the times of the two rules are compared. Relation to earlier papers: Paper 895, in its scope note, did not include smoke or human movement, leaving out poor visibility from smoke, pushing, the choice of exit and time before starting to walk; this paper sits in the seat of the choice of exit (no earlier occupant). Paper 895 showed that widening the exit speeds evacuation only when there are many people, and that with few the walking distance sets the time. Here the change in time from how people are divided between two exits of different widths is counted. What is added: comparing the two rules over 20 arrangements for three numbers of people and three width ratios, deriving the ratio when only queueing matters from the widths and comparing it with 600 people, measuring that the best boundary moves to the width point, checking the queue formula against person-by-person queueing, and placing the separator on “divided by distance, or by width”.

1. Notation and the Question

Setting: exits A and B are at 0 m and 100 m of a 100 m corridor, with widths $w_A = 1$ m and $w_B = 1, 2, 3$ m. People are placed uniformly at random along the corridor. The walking speed is $v = 1.3$ m/s and the exit flow is $q = 1.3$ persons/s per metre of width (Paper 895). If the n people heading for one exit arrive at times $a_1 \leq \dots \leq a_n$, the last one leaves at

$$T = \max_k \left(a_k + \frac{n - k + 1}{q w} \right)$$

which agreed within 10^{-9} with person-by-person queueing for four random sets. People left of a boundary x go to A and those right of it to B, and the total time is the larger T of the two exits. Heading for the nearer exit is $x = 50$ m; the best rule tries every midpoint between neighbouring people and both ends and takes the x with the shortest time. For 60, 200 and 600 people, 20 arrangements were made (random seeds 97900 to 97919).

Question: how much time does heading for the nearer exit lose against the best boundary, and how does that change with the number of people and the width ratio?

2. One Arrangement

Computation 2.1: for the first single arrangement made, the time heading for the nearer exit and the best time.

people	widths	nearer (s)	best (s)	best boundary (m)	ratio
60	1 to 3	38.085	38.085	50.585	1.000000
200	1 to 1	80.235	77.158	47.792	0.961651
200	1 to 2	80.235	54.081	33.009	0.674035
200	1 to 3	80.235	52.543	31.841	0.654861
600	1 to 1	235.588	231.026	51.034	0.980637
600	1 to 2	226.411	154.103	35.490	0.680635
600	1 to 3	226.411	115.642	26.793	0.510760

With 60 people all three width ratios gave 38.085 s, the two rules being the same. This is shorter than the 38.462 s to walk from the middle, 50 m, to an exit.

3. Means over 20 Arrangements

Computation 3.1: ratio of times (best over nearer) and the best boundary.

people	widths	mean ratio	min and max ratio	mean boundary (m)	min and max boundary (m)
60	1 to 1	0.995728	0.963705 and 1.000000	49.994	48.471 and 51.169
60	1 to 2	0.995980	0.962986 and 1.000000	49.380	46.876 and 50.974
60	1 to 3	0.994959	0.962986 and 1.000000	49.380	46.876 and 50.974
200	1 to 1	0.960589	0.870442 and 1.000000	50.085	44.342 and 56.267
200	1 to 2	0.694901	0.638604 and 0.789772	33.849	30.194 and 40.109
200	1 to 3	0.674894	0.625249 and 0.740598	32.862	29.825 and 37.235
600	1 to 1	0.979916	0.943416 and 1.000000	49.706	47.867 and 52.444
600	1 to 2	0.662493	0.629064 and 0.694669	33.398	30.826 and 35.961
600	1 to 3	0.497270	0.472005 and 0.521186	25.274	22.465 and 28.177

Observation 3.2

the more people, the more time heading for the nearer exit loses. For widths 1 to 3 the mean ratio fell as 0.994959, 0.674894 and 0.497270 for 60, 200 and 600 people: with 60 people the mean ratio stayed between 0.994959 and 0.995980 whatever the width ratio. The 60-person mean boundary was the same 49.380 m for 1 to 2 and 1 to 3 (when several boundaries gave the shortest time, the smallest was taken).

Observation 3.3

even with equal widths the best is faster than the nearer rule, depending on the arrangement. For widths 1 to 1 the mean ratio was 0.960589 for 200 people and 0.979916 for 600. This comes from moving the boundary away from 50 m, with a minimum of 0.870442 (200 people).

4. The Value Set by Widths and the Best Boundary

Computation 4.1: if only queueing sets the time, heading for the nearer exit sends half the people to the narrow exit A, taking $(N/2)/(qw_A)$, while the best equalises the two queues at $N/(q(w_A + w_B))$, so the ratio is

$$\frac{2w_A}{w_A + w_B}$$

which is 1.000000, 0.666667 and 0.500000 for 1 to 1, 1 to 2 and 1 to 3. The means for 600 people differed from these by -0.020084 , -0.004173 and -0.002730 .

Observation 4.2

with many people the best boundary moves to the point dividing by width. The width point is $100w_A/(w_A + w_B)$ m, 33.333 m for 1 to 2 and 25.000 m for 1 to 3: the mean best boundaries for 600 people were 33.398 m and 25.274 m, both within 1 m. For 200 people at 1 to 3, 32.862 m lay between the width point 25.000 m and the middle 50 m.

5. The Separator

Observation 5.1

the separator is whether people are divided by distance or by exit width. With 60 people, the best time was on average 0.994959 to 0.995980 of the time with the middle boundary that equalises walking distance: with 600 people a boundary within 1 m of the point dividing people by width became best, and for 200 people at 1 to 3 the boundary fell between the two points. Which of the two terms of T , the arrival time a_k or the queue term $(n - k + 1)/(qw)$, is larger was not measured term by term here.

Observation 5.2

what is not said. Pushing, smoke, time before starting to walk, people choosing exits for themselves, switching exits on the way, and which rule should guide people are not treated. What is shown is how, in one corridor model, the ratio of times between heading for the nearer exit and the best boundary changes with the number of people and the width ratio.

6. Roll Call and Closing

1. the queue formula (Section 1): agrees with person-by-person queueing.
2. mean ratio **0.994959** to 0.995980 for 60 people (Computation 3.1): the two rules are almost the same.
3. 0.994959, 0.674894, **0.497270** at 1 to 3 (Computation 3.1): more people, more loss.

4. the ratio approaches twice the narrow width over the sum (Computation 4.1): difference -0.002730 for 600 people.
5. boundaries **33.398 m** and **25.274 m** (Observation 4.2): moved to the width point.
6. divided by distance, or by width (Observation 5.1): the separator; the scope note of Paper 895.

Closing: With two exits of different widths, heading for the nearer one loses more time the more people there are. With the walking speed and exit flow of Paper 895 and exits at both ends of a 100 m corridor, the best time was on average 0.994959 to 0.995980 of the nearer-exit time for 60 people, but for widths 1 to 3 it was 0.674894 for 200 people and 0.497270 for 600: for 600 people the ratio was close to the queue-only value of twice the narrow width over the sum of widths, and the mean best boundary was within 1 m of the width point (33.398 m and 25.274 m). The separator is whether people are divided by distance or by exit width. Placed among the earlier papers: to the walking time and queueing that Paper 895 counted for one exit, the choice of exit that Paper 895 did not include was added. To be honest. This is one corridor without pushing or smoke, with the boundary set from outside and only times compared. How much heading for the nearer exit loses with the number of people and the width ratio, and no further.

References

1. Yamagishi, Y. (2026). *Widening the Exit Speeds Evacuation Only When There Are Many People; With Few, the Walking Distance Sets the Time* [Paper 895]. YOI: <https://www.yamagishiyuuki.com/yoi/895>
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