

In a Corridor, Picking One's Own Fastest Exit Matches the Best Boundary for Both the Last and the Mean Time

— with exits at both ends of a corridor, the equilibrium in which each person picks an exit by their own leaving time alone is unique in every arrangement, and agrees with both the boundary minimising the last person's time and the boundary minimising the mean —the separator is whether the person at the boundary makes others wait

— [Paper 992]

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Abstract

With two exits of different widths, heading for the nearer one loses more time the more people there are (Paper 979). There the boundary was set from outside, and people choosing exits for themselves were not included. In the corridor of Paper 979, this paper finds the equilibrium in which each person picks the exit that lets them out sooner, and compares the last person's time and the mean time with the best boundary of Paper 979, with heading for the nearer exit, and with the boundary minimising the mean. No new theorem or law is claimed. First, the equilibrium was unique in every arrangement: in all 180 arrangements of 60, 200 and 600 people, width ratios 1 to 1, 2 and 3, and 20 layouts each, there was exactly one boundary at which neither person beside it wanted to switch (Section 2). Second, the last person's time equalled that of the best boundary: in all 180 arrangements, the equilibrium's last-person time agreed with the best boundary of Paper 979 within a relative 10^{-12} (**115.641** s on average for 600 people at 1 to 3) (Section 2). Third, the mean time also equalled that of the boundary minimising the mean. It agreed in all 180 arrangements; for 600 people at 1 to 3 the mean was 78.014 s heading for the nearer exit and **58.085** s choosing for oneself (ratio **1.343110**) (Section 3). Fourth, the person at the boundary does not change others' leaving times: for an arrangement of 200 people, adding the boundary person to one queue left everyone else's leaving time unchanged in all 199 cases (difference 0). The boundary person arrives last at that exit and so joins the end of the queue (Section 4). Fifth, the separator is whether the person at the boundary makes others wait, because the boundary person makes no one wait, choosing by their own time alone did not worsen the total. This differs from the case where adding a road slows everyone down (Paper 631) (Section 5). **Keywords:** evacuation, exit choice, equilibrium, queueing, Wardrop's principle, corridor.

Scope of this paper (scope note): No new theorem or law is claimed: that the equilibrium where each person minimises their own time (Wardrop's first principle) and the choice that makes the whole best agree when one person's choice does not delay others is known in traffic assignment theory. These are set values: the 100 m corridor, exits at both ends, walking speed 1.3 m/s, exit flow 1.3 persons/(m s), widths, numbers of people and 20 layouts are the same model values as Paper 979, and correspond to no building. People are taken to know their times: each person is taken to know their own leaving time correctly. Mistaken information, following others, pushing and switching exits on the way are not included. The model is not extended: only exits at both ends of a corridor with queues leaving in order of arrival are treated. Corridors with exits partway along and wide rooms are not. Relation to earlier papers: Paper 979, in its scope note, did not include human movement, leaving out pushing, poor visibility from smoke, time before starting to walk, people choosing exits for themselves and switching exits on the way, with the boundary set from outside; this paper sits in the seat of people choosing exits for themselves (no earlier occupant). Paper 979 showed that with two exits of different widths heading for the nearer one loses more time the more people there are, and that the best boundary moves to the point dividing by width. Here, letting each person choose instead of setting the boundary from outside, where it settles is counted. Paper 631 showed that adding a road slows everyone down only when the number of cars lies in a certain range. Here a case where each person's choice agrees with the best for the whole is counted. What is added: searching all boundaries for equilibria in 180 arrangements, confirming that the equilibrium is unique and matches the best boundary, confirming that it also matches the boundary minimising the mean, confirming that the boundary person does not change others' leaving times, and placing the separator on "whether the boundary person makes others wait".

1. Notation and the Question

Corridor and queues: as in Paper 979, exits A (width 1 m) and B (width 1, 2 or 3 m) are at the ends of a 100 m corridor, and 60, 200 or 600 people are placed uniformly at random (the same 20 layouts as Paper 979). Walking speed is 1.3 m/s, exit flow 1.3 persons/s per metre of width, and each queue lets people out one at a time in order of arrival. Ordering people by distance from A, the boundary j means the first j go to A and the rest to B.

Equilibrium: at boundary j , if the last person heading for A (j -th) would not get out sooner by moving to B, and the first person heading for B ($j + 1$ -th) would not get out sooner by moving to A, neither wants to switch. All such j were found. Three boundaries are compared: heading for the nearer exit (50 m), the boundary minimising the last person's time (the best boundary of Paper 979), and the boundary minimising the mean of everyone's leaving time.

Question: when each person picks an exit by their own leaving time alone, where does the boundary settle, and how bad is it for the total time?

2. Equilibrium and the Last Person's Time

Computation 2.1: last person's time (s, mean over 20 layouts).

people	widths	nearer exit	best boundary	own choice
60	1 to 1	39.075	38.897	38.897
60	1 to 3	38.668	38.464	38.464
200	1 to 1	80.734	77.454	77.454
200	1 to 2	77.299	53.560	53.560
200	1 to 3	77.299	52.047	52.047
600	1 to 1	235.773	230.976	230.976
600	1 to 2	232.703	154.064	154.064
600	1 to 3	232.703	115.641	115.641

In all 180 arrangements of 9 combinations of 3 numbers of people and 3 width ratios with 20 layouts, the equilibrium was unique and its last-person time agreed with that of the best boundary within a relative 10^{-12} (largest deviation 0).

3. Mean Time

Computation 3.1: mean of everyone's leaving time (s, mean over 20 layouts).

people	widths	nearer exit	own choice	nearer over own choice
60	1 to 1	20.005	19.999	1.000315
200	1 to 1	39.381	39.252	1.003283
200	1 to 2	30.240	27.318	1.106946
200	1 to 3	29.409	26.173	1.123655
600	1 to 1	115.999	115.915	1.000724
600	1 to 2	87.495	77.341	1.131291
600	1 to 3	78.014	58.085	1.343110

In all 180 arrangements, the equilibrium's mean time agreed with that of the boundary minimising the mean within a relative 10^{-12} . The last-person time at the mean-minimising boundary also equalled that of the best boundary in the 20-layout means of all 9 combinations (115.641 s for 600 people at 1 to 3).

4. The Person at the Boundary

Computation 4.1: for one arrangement of 200 people, raising the number heading for A from j to $j + 1$ changed the leaving times of the first j by at most 0 s for every $j = 1$ to 199.

Observation 4.2

the person at the boundary does not change others' leaving times. The boundary person is the farthest from their exit among those heading there, and arrives last: queues let people out in order of arrival, so that person joins the end of the queue and makes no one ahead wait. Moving the boundary by one person therefore changes only that person's own time.

5. The Separator

Observation 5.1

the separator is whether the person at the boundary makes others wait. If switching changes only the boundary person's own time, picking the sooner exit for oneself worsens neither the mean nor the last person's time: in 180 arrangements the equilibrium agreed with the best boundary for both last-person and mean time. Paper 631 showed that adding a road can slow everyone down for a certain range of car numbers. Here, in a model where one person's choice makes no one wait, no such worsening occurred.

Observation 5.2

what is not said. People not knowing their leaving time, following others, pushing, switching exits on the way, corridors with exits partway along or wide rooms, and real evacuation guidance are not treated. What is shown is that in one corridor with exits at both ends, the equilibrium of individual choices agrees with the best for the whole.

6. Roll Call and Closing

1. searching all boundaries for equilibria (Section 1): **180 arrangements.**
2. a unique equilibrium matching the best boundary for the last person (Computation 2.1): **115.641 s** for 600 people at 1 to 3.
3. the mean also matches its minimising boundary (Computation 3.1): **58.085 s.**
4. nearer over own choice **1.343110** (Computation 3.1): **faster than the nearer exit set from outside.**
5. the boundary person does not change others' times (Computation 4.1): **difference 0 in 199 cases.**
6. makes others wait, or not (Observation 5.1): **the separator; the scope note of Paper 979.**

Closing: In a corridor, picking one's own fastest exit matches the best boundary for both the last and the mean time. In 180 arrangements of the corridor of Paper 979, the equilibrium where each person picks the exit letting them out sooner was unique, with the last person's time matching the best boundary and the mean time matching the boundary minimising the mean: for 600 people at 1 to 3, the mean was 78.014 s heading for the nearer exit and 58.085 s choosing for oneself (ratio 1.343110). Adding the boundary person to a queue left others' leaving times unchanged. The separator is whether the person at the boundary makes others wait. Placed among the earlier papers: to the boundary Paper 979 set from outside, people choosing exits for themselves, which Paper 979 did not include,

were added, counting a case where, unlike the roads of Paper 631, no worsening occurs. To be honest. This compares equilibrium and best in one corridor model where each person knows their time correctly. What happens to the whole when people choose for themselves, and no further.

References

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