Quantitative chemical sensing by bacterial chemotaxis in microfluidic chips

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Table S1. Model parameters

Description	Symbol	Value	Units	Source
Geometry				
Height (*z*-direction)				
- channel	h	14	μm	experimental
- filter		0.25	μm	
Cell channel				
- width	$L_{Y,3}$	0.6	mm	experimental
- length	$L_{X,3}$	11.5	mm	
Source and sink channels				experimental
- width	$L_{Y,1}$, $L_{Y,2}$	1	mm	
- length	$L_{X,1}$, $L_{X,2}$	9	mm	
Inlet/outlet channels				experimental
- width	$L_{X,i}$	0.26	mm	
- length	$L_{Y,i}$	2	mm	
Filters				experimental
- width	$L_{X,f}$	5	μm	
- length	$L_{Y,f}$	100	μm	
Filter spacing	L_f	30	μm	experimental
Flow				
Water viscosity (at 20°C)	μ	0.001	Pa s	-
Water density	ρ	1000	kg m^{-3}	-
Flow rate source/sink channels inlet	$F_{in,l}$	0.25	μL min^{-1}	experimental
Flow rate cell channel inlet	$F_{in,m}$	0.003	μL min^{-1}	experimental
Solutes				
Diffusion coefficient[a]				
- rhodamine B	D_S	3.6×10^{-10}	m^2 s^{-1}	(Culbertson *et al.*, 2002) (Ma *et al.*, 2005)
- serine		8.9×10^{-10}		
Serine concentration in inflow	$c_{S,i}$	1, 5, 10, 20	μmol L^{-1}	experimental
Maximum serine uptake rate	v_{max}	338	nmol $mmol^{-1}$ min^{-1}	(Kayahara *et al.*, 1992)
Michaelis-Menten half-saturation coefficient	K_m	6	μmol L^{-1}	(Kayahara *et al.*, 1992)
Cells				
Motility coefficient	D_X	1×10^{-11}	m^2 s^{-1}	estimated
Maximum chemotaxis coefficient	$D_{ch,0}$	2×10^{-7}	m^5 s^{-1} mol^{-1}	estimated
Cell concentration in inflow	c_X	10	mmol L^{-1}	experimental
Maximum cell density	$c_{X,max}$	$10\times c_X$	mmol L^{-1}	estimated

a) corrected for 20 °C

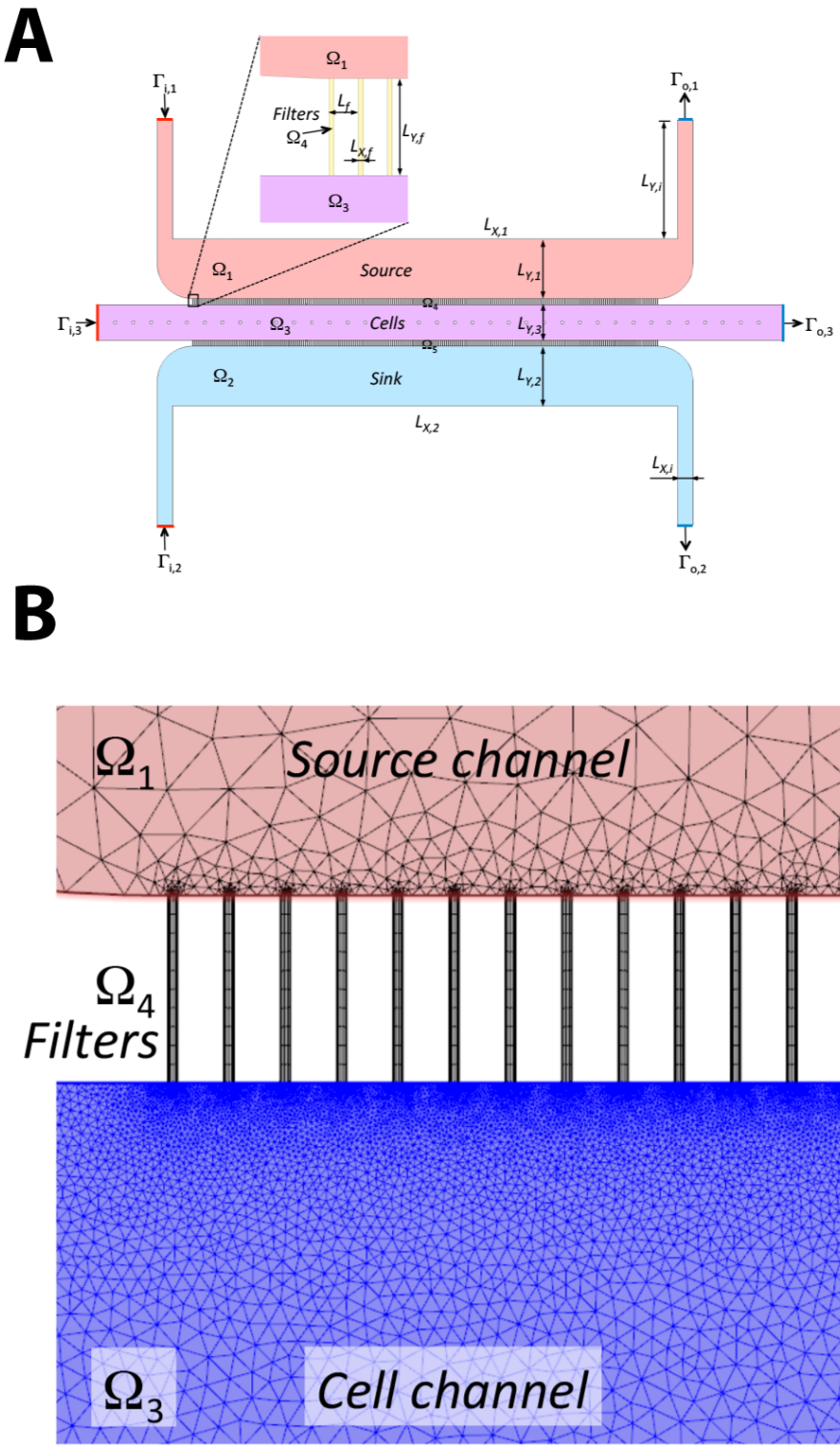

Figure S1. **(A)** Model geometry, dimensions, domains and boundaries. Ω_1: Source domain (fed with chemoattractant solution), Ω_2: Sink domain (fed with water), Ω_3: Cells domain (fed with a suspension of cells), Ω_4 and Ω_5: Filter domains (separate the cells from source and sink channels). $\Gamma_{i,1}$, $\Gamma_{i,2}$, $\Gamma_{i,3}$: Inflows, $\Gamma_{o,1}$, $\Gamma_{o,2}$, $\Gamma_{o,3}$: Outflows. The geometry dimensions are listed in Table S1. **(B)** Finite element mesh detail in the neighborhood of the filter region.

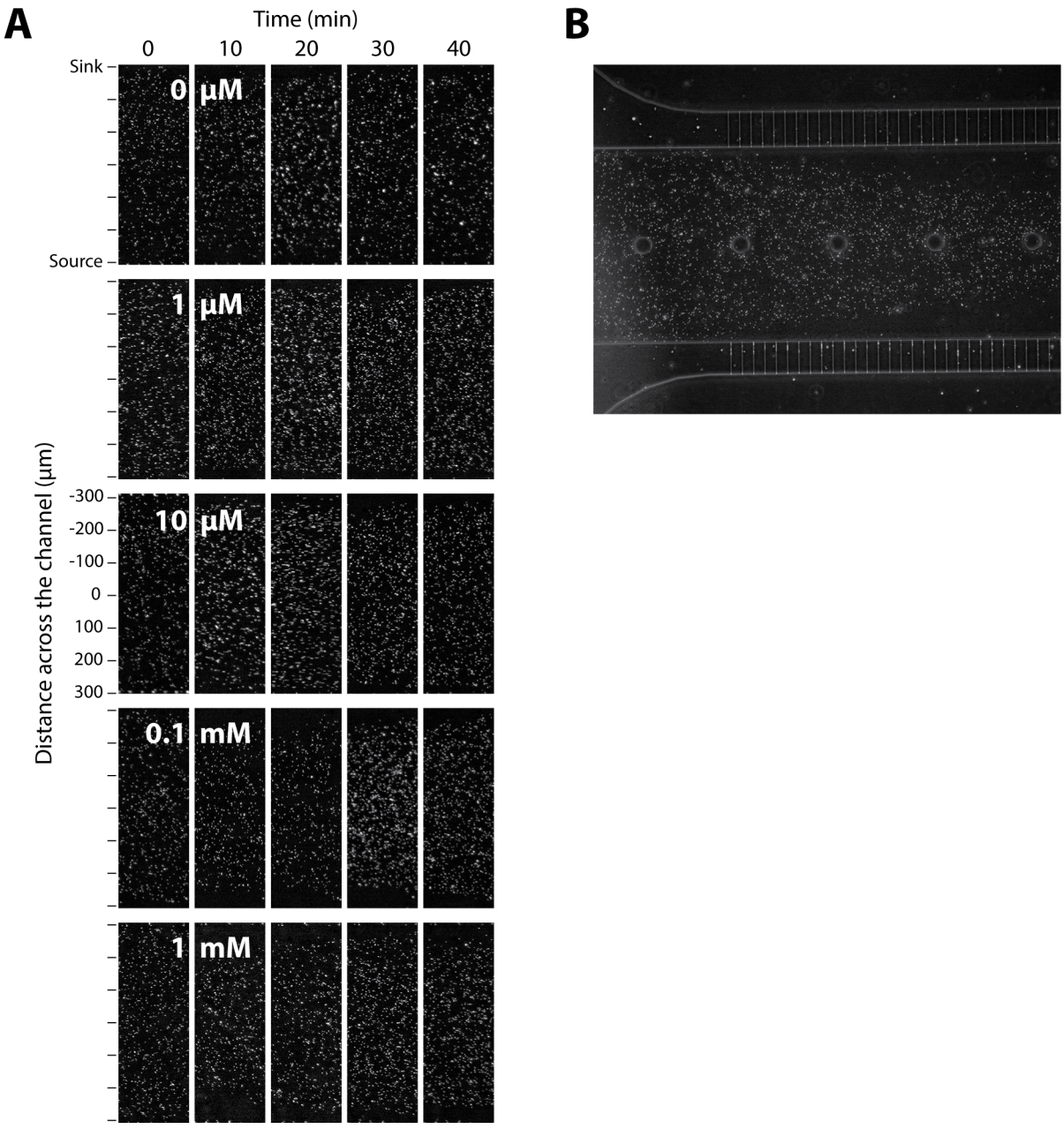

Figure S2: Non-chemotactic cell distribution of *E. coli* Δ*fliC*-mcherry toward serine. (A) Images showing the distribution of Δ*fliC*-mcherry at the same location over time (0 - 40 min) as a function of the indicated serine concentration. Top is sink channel, bottom is source channel. (B) Distribution of *E. coli* Δ*fliC*-mcherry cells along the channel, showing the slight concentration of non-swimming cells towards the middle of the observation channel as a result of inflow from the side channels.

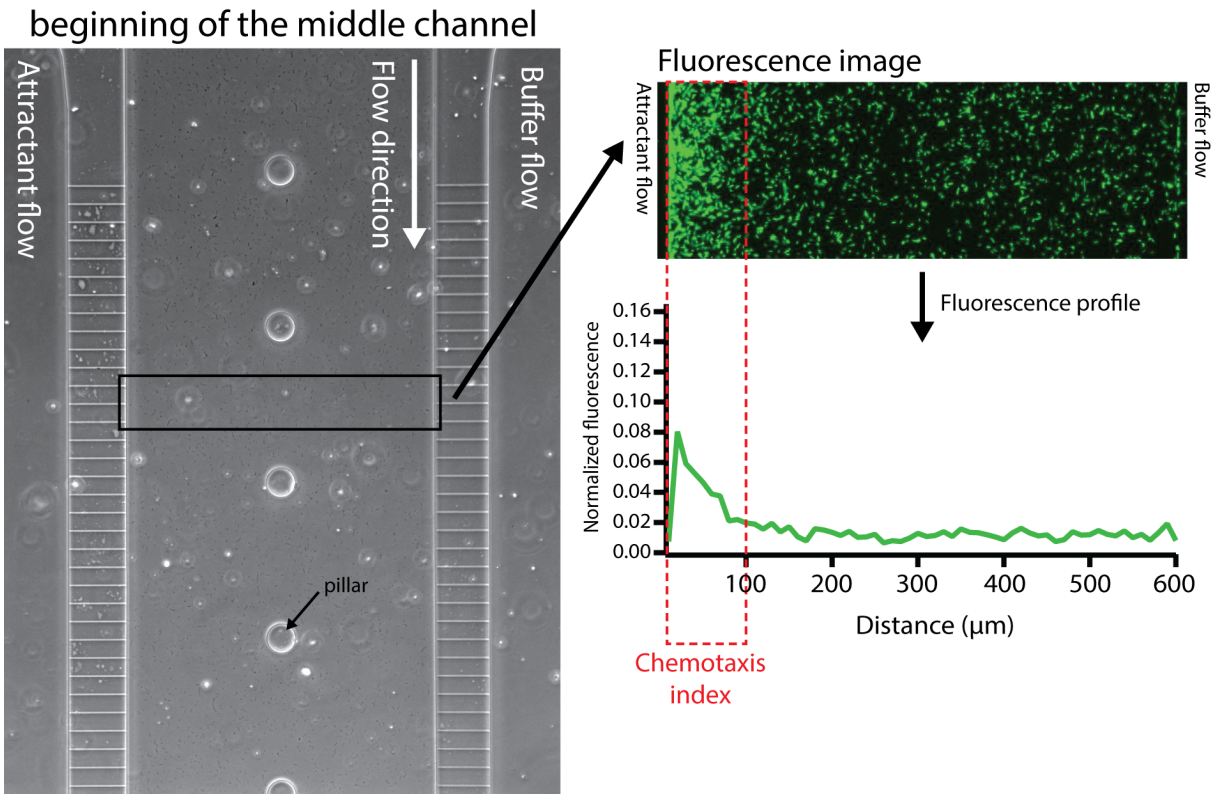

Figure S3: Chemotaxis index measurement setup. Chemotaxis response was quantified in a zone of 600 x 100 microns at a distance of 400 microns from the beginning of the filters. Fluorescence intensity profiles were extracted from the fluorescence images using ImageJ and normalized by the total fluorescence in the zone of measurement. The chemotaxis index was calculated as the proportion of fluorescence in the 100 µm segment closest to the source of attractant compared to the total fluorescence across the channel.

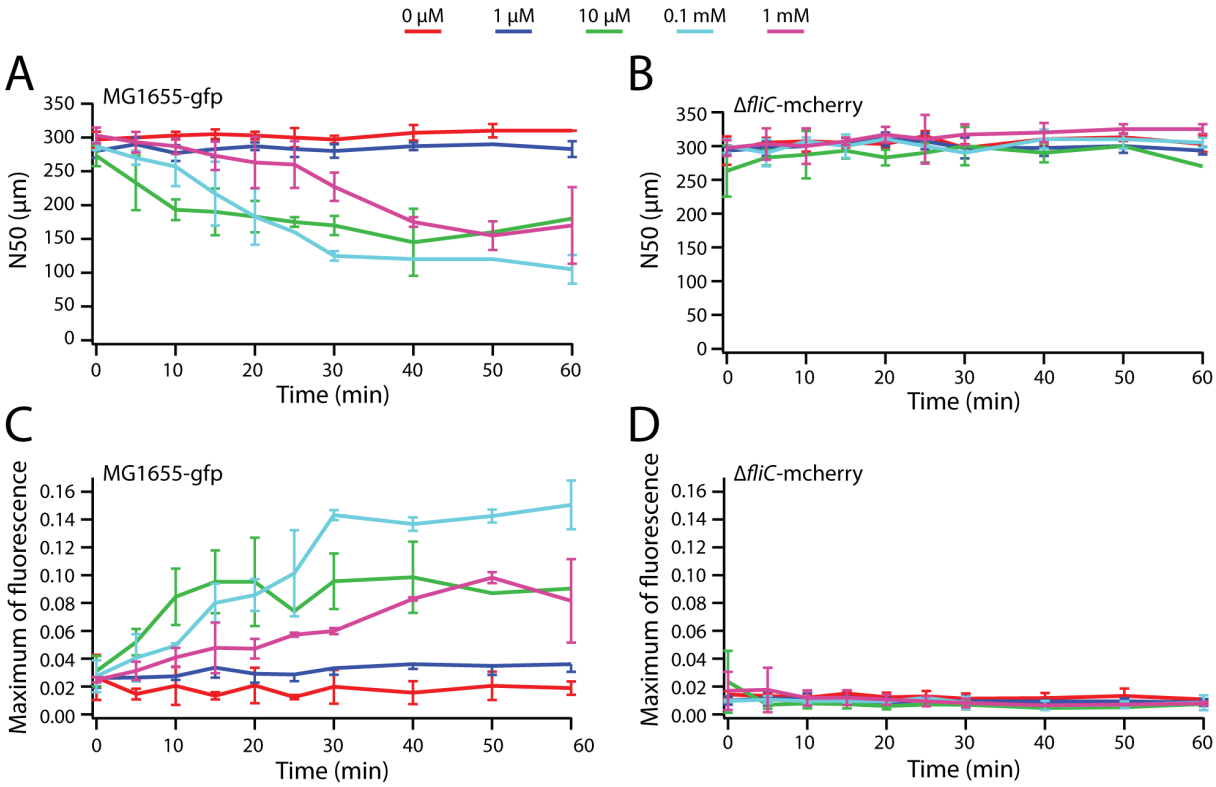

Figure S4: N50 chemotaxis value and normalized maximum of fluorescence. Chemotaxis response can be quantified with different parameters such as the *N50* representing the distance from the attractant channel that contains 50% of the cells for (A) MG1655-gfp and (B) Δ*fliC*-mcherry. The highest fluorescence intensity close to the pores of the attractant channel is represented for (C) MG1655-gfp and (D) Δ*fliC*-mcherry.

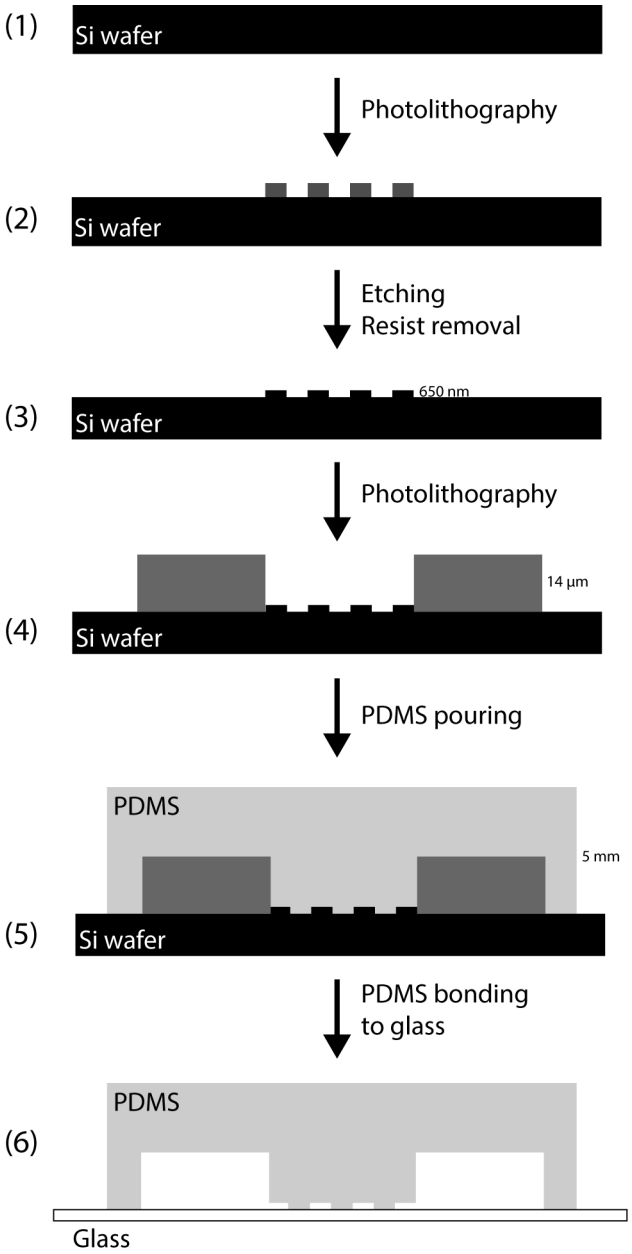

Figure S5: Microfluidic chip fabrication procedure

The fabrication procedure starts with a silicon wafer (1). A photolithography process produces a layer of resist at the filter position that protects this zone during the etching step (2). The etching results in the formation of the negative of the 650 nm high channels of the filters (3). A second step of photolithography produces the mold of thechannels with a resist layer of 14 microns high (4). This inverted mold is used multiple times to produce the PDMS chips, by pouring PDMS on it and let polymerize (5). Once polymerized, the PDMS is peeled off the inverted mold and, after punching holes for the inlets, is bonded to the glass slide by a plasma treatment (6).

Supplementary references

Culbertson, C.T., Jacobson, S.C., and Ramsey, J.M. (2002) Diffusion coefficient measurements in microfluidic devices. *Talanta* **56**: 365-373.

Kayahara, T., Thelen, P., Ogawa, W., Inaba, K., Tsuda, M., Goldberg, E.B., and Tsuchiya, T. (1992) Properties of recombinant cells capable of growing on serine without NhaB Na^+/H^+ antiporter in *Escherichia coli*. *J Bacteriol* **174**: 7482-7485.

Ma, Y., Zhu, C., Ma, P., and Yu, K.T. (2005) Studies on the diffusion coefficients of amino acids in aqueous solutions. *J Chem Eng Data* **50**: 1192-1196.