How the mesencephalic "locomotor region" recruits hindbrain neurons?

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Bernstein:

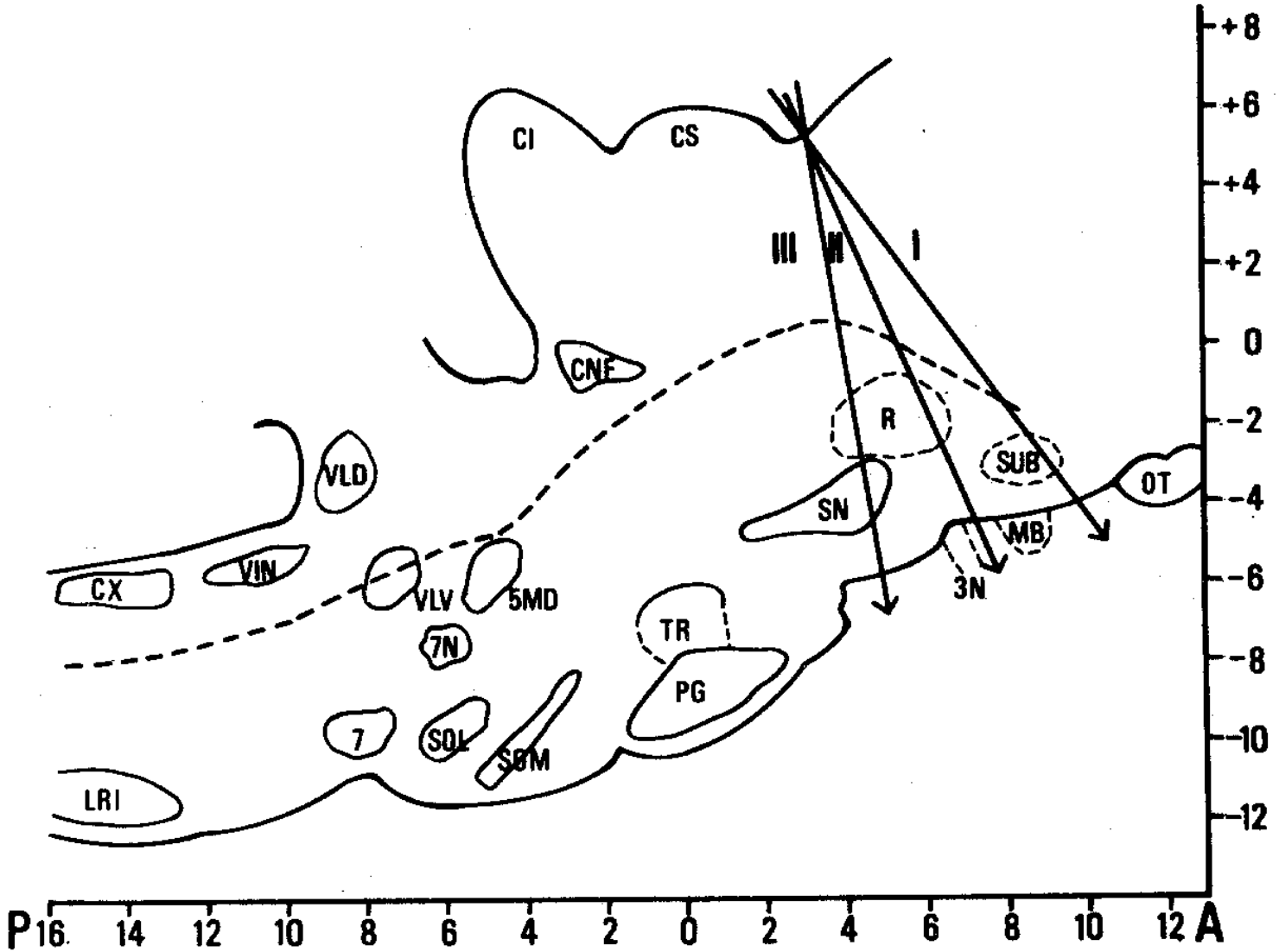
Coordination of movements comprises cardinal and appropriate reduction of the number of degrees of freedom. Different brain levels use distinct representations of world, body, tasks, and movements. Therefore, communication between levels needs translation.

Gelfand and Tsetlin:

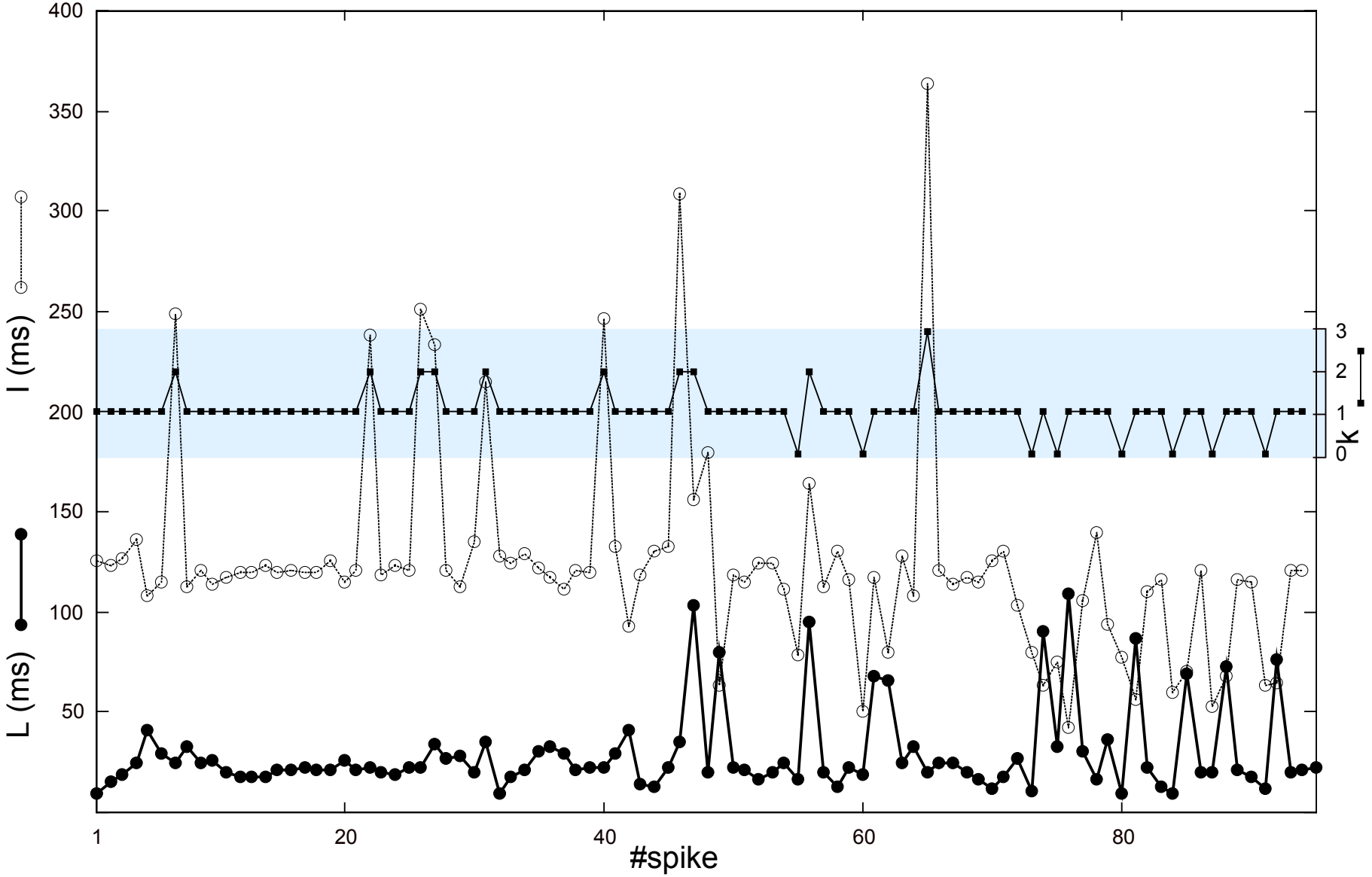
Elements of the control system, albeit relatively simple, act according to their particular aims (*e. g.* minimum of certain function). The elements of one level affect the interaction between elements of the other. This results in an appropriate population behavior of the latter. Alternative pathways for spinal reflexes discovered by Lundberg can be considered in this framework.

Brainstem control of locomotion. Hypothalamic and mesencephalic “locomotor regions” (*MLR*). Cortical induction of locomotion after transection of medullary pyramids. Pontine inhibitory region. Reticulospinal neurons. “Go there, I do not know where, and bring me that, I do not know what!” (Folk fairy tale). An uncertain component is a condition for the non-individual control.

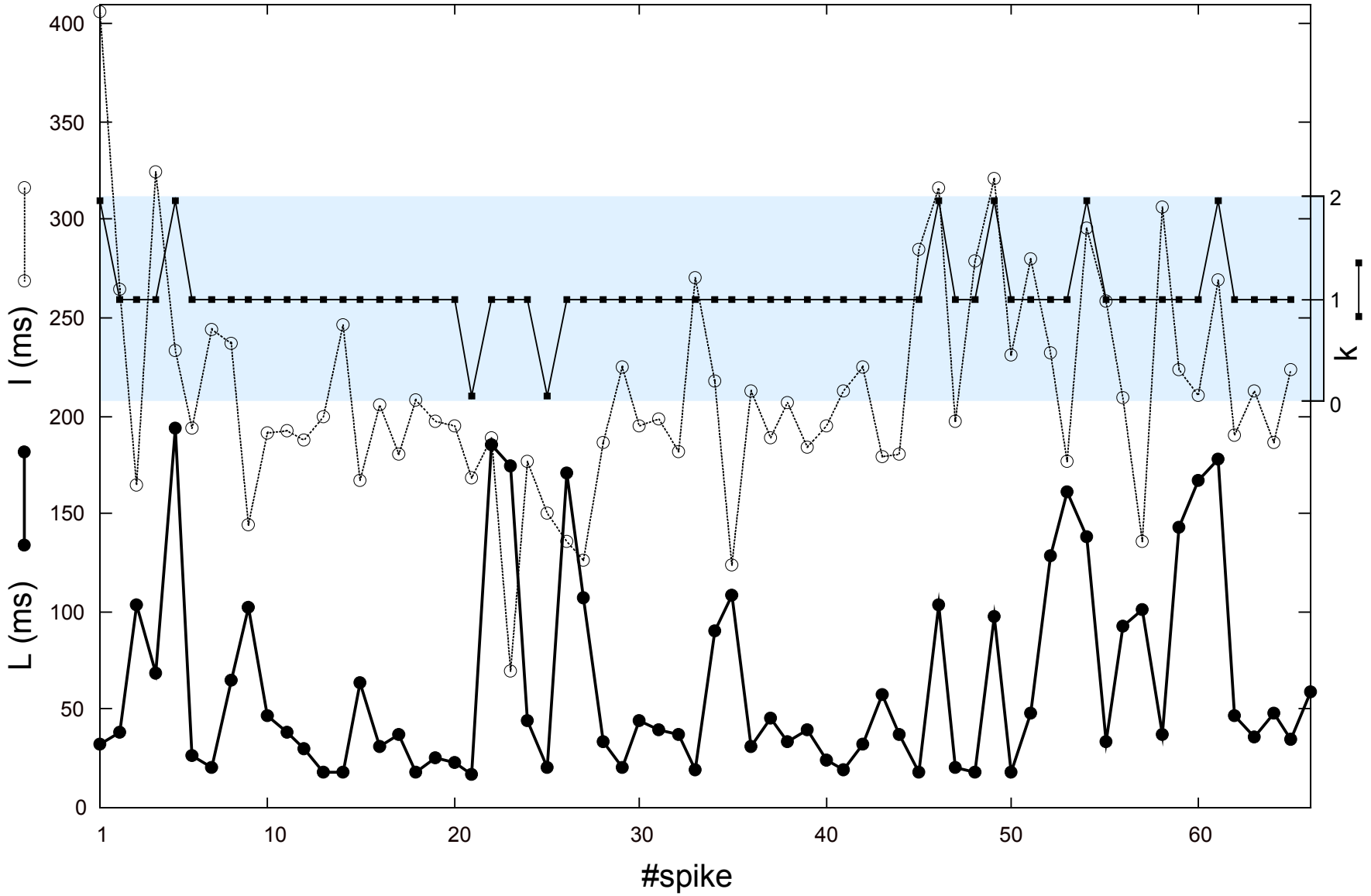
Schematic drawing of the brain stem on the L4 parasagittal plane (Mori, Shik and Yagodnitsyn, 1977)



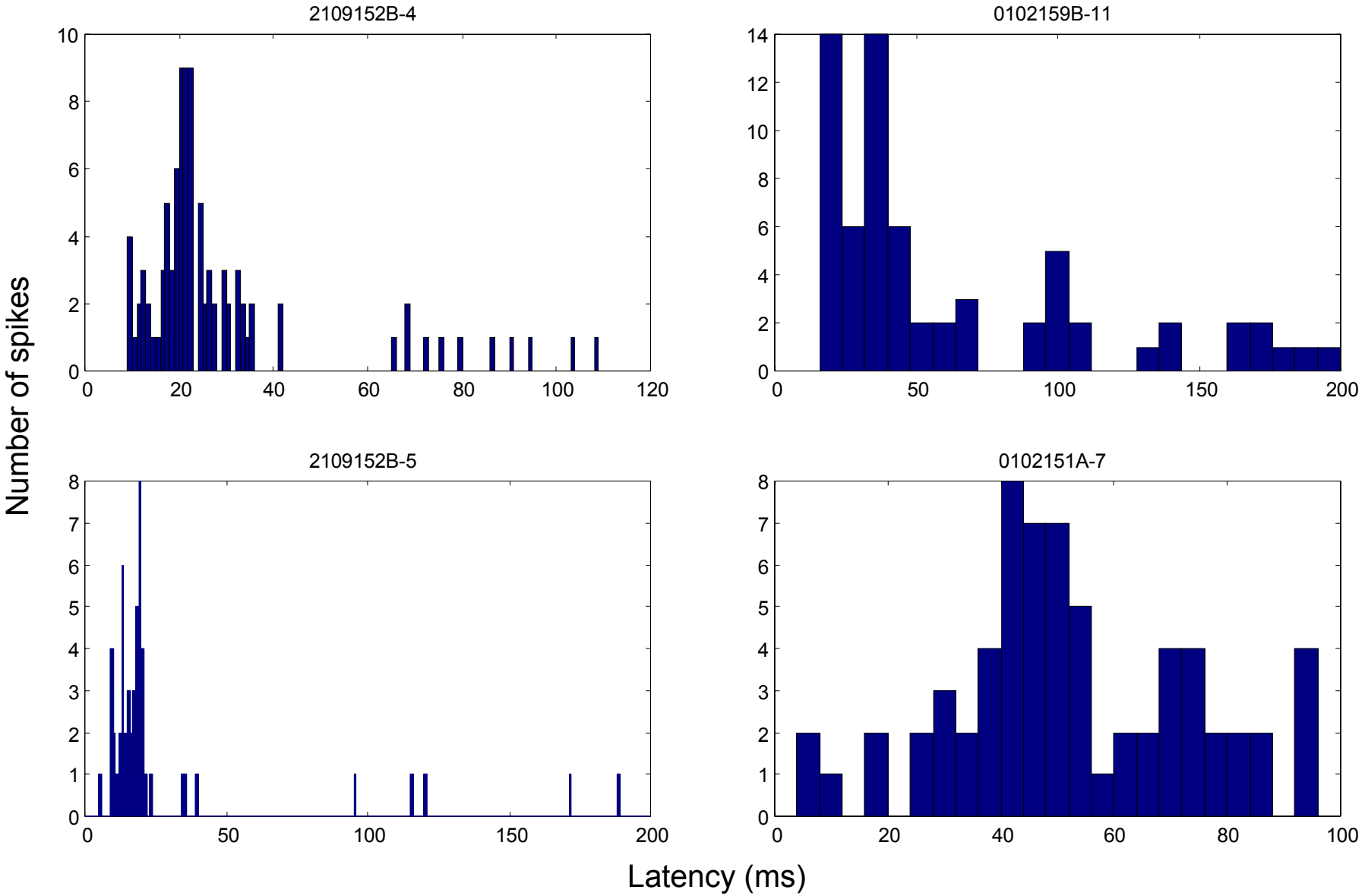
Near-threshold train of weak stimuli with intervals of 100-200 ms delivered to *MLR* elicits locomotion of salamander after about 15 s. Dozens of impulses of a single hindbrain neuron can be recorded before the movements start. Basic variability of number of stimuli *k* between consecutive impulses, latency of time-locked impulses and appearance of either time-locked or delayed impulse persists throughout a train.



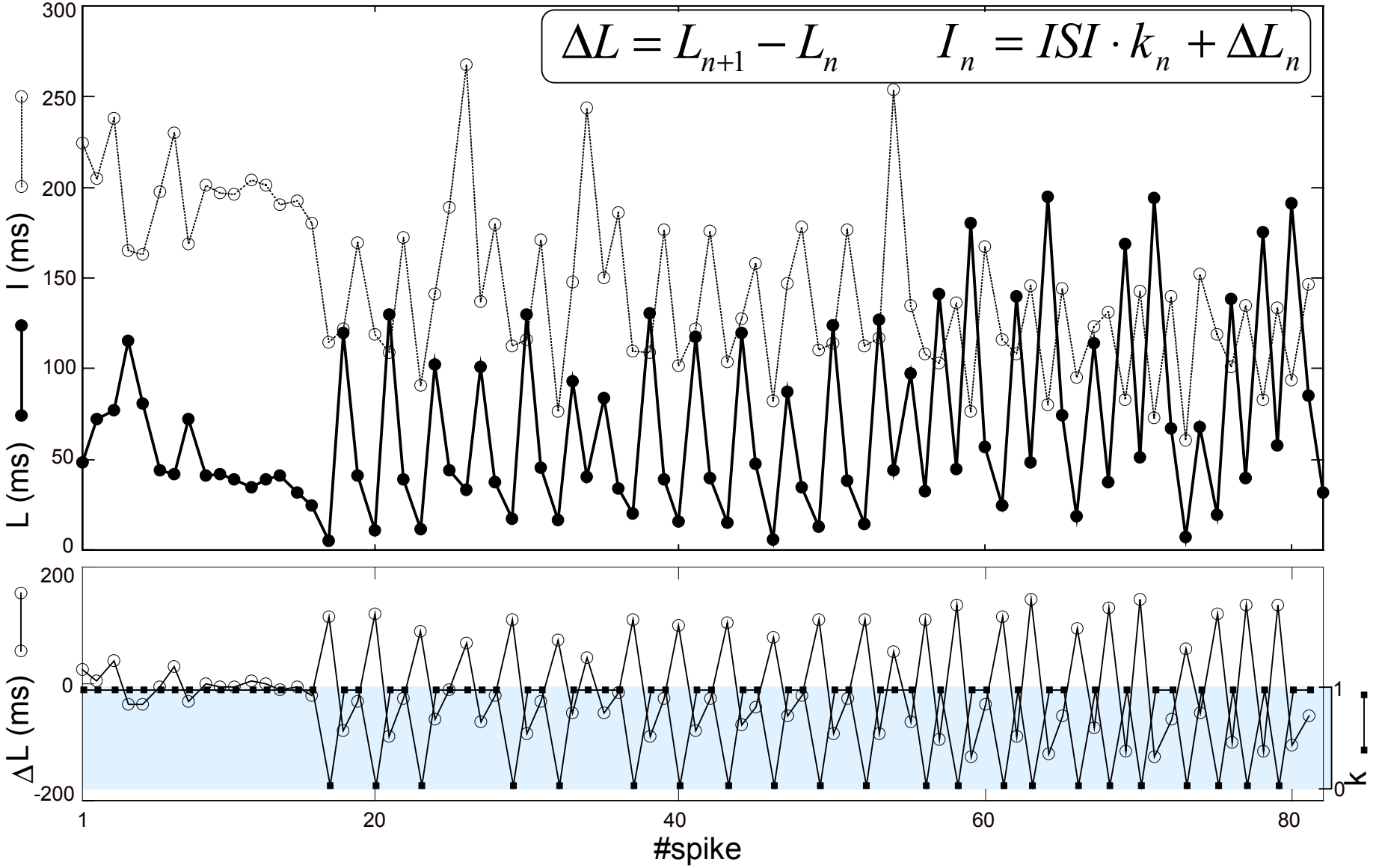
ISI 120 ms


400
350
300
250
200
150
100
50
0
l (ms)
L (ms)
1
10
20
30
40
50
60
#spike
2
1
0
k

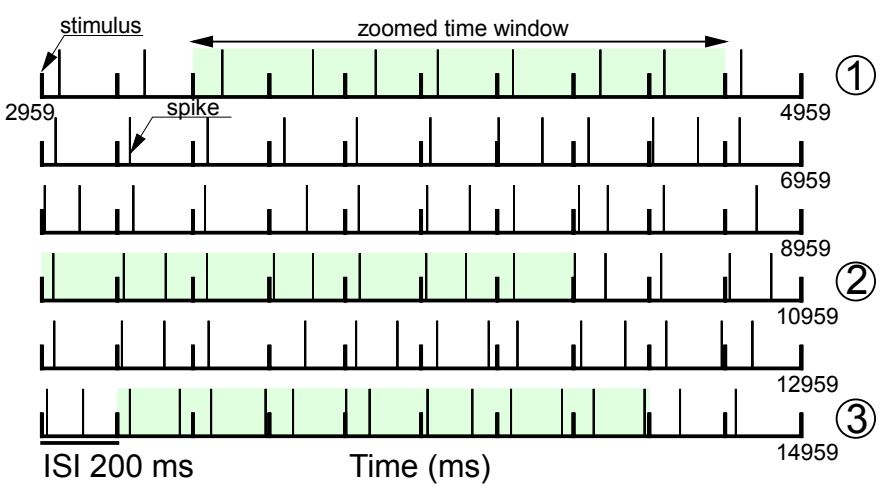
ISI 200 ms

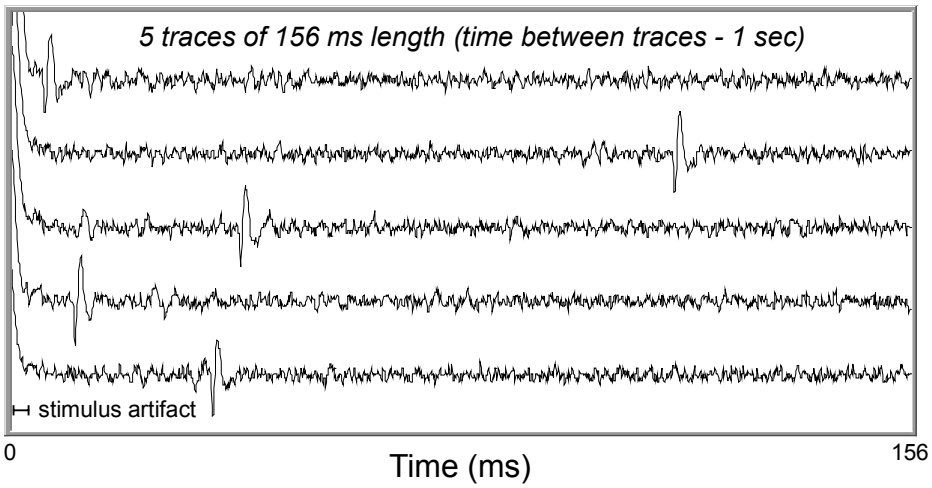

2109152B-4
0102159B-11
2109152B-5
0102151A-7
Number of spikes
Latency (ms)

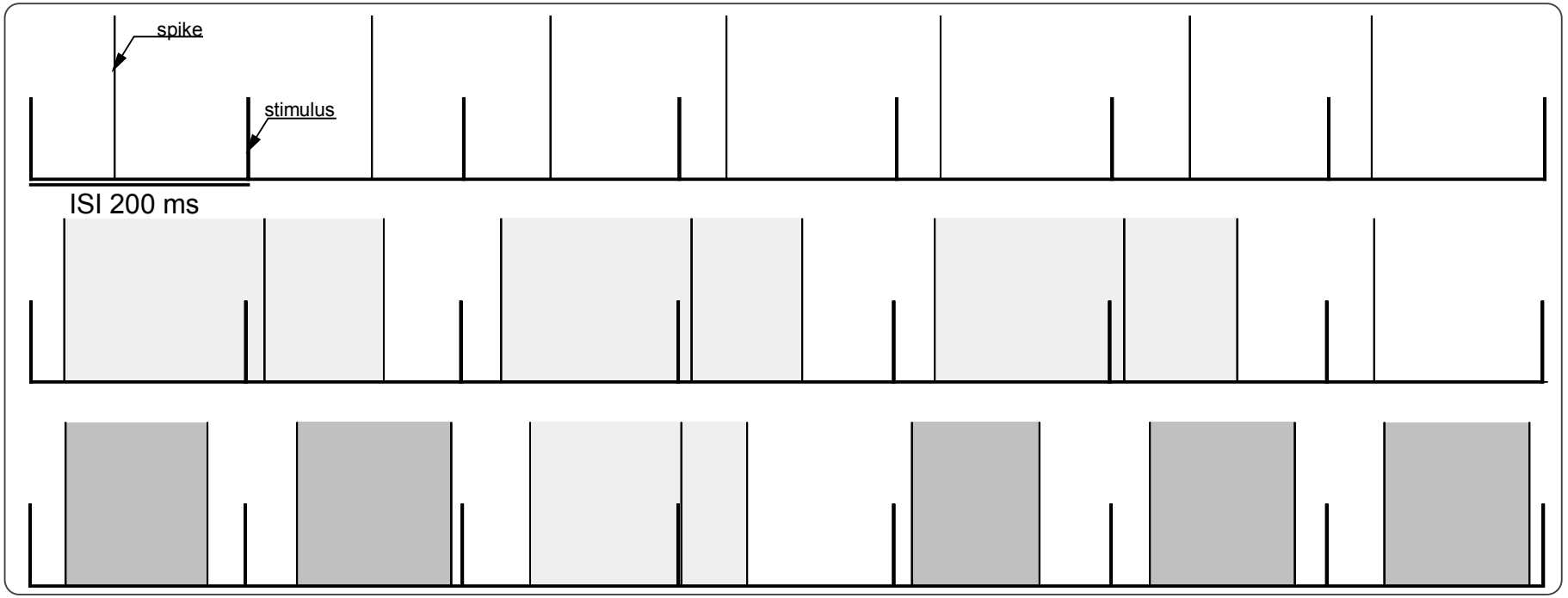
Value of *k* alternated mostly among 1, 2 and 3. Time-locked impulses formed integer (1), (2) and (3) intervals, respectively. Latency staggered irregularly, usually among two or three discrete ranges, 5-10 ms apart. Monosynaptic responses occurred infrequently. Prevailed polysynaptic responses ceased sharply after 3 to 5 translations.


$\Delta L = L_{n+1} - L_n$
$I_n = ISI \cdot k_n + \Delta L_n$
I (ms)
L (ms)
ΔL (ms)
k
#spike
300
250
200
150
100
50
0
200
0
-200
1
20
40
60
80

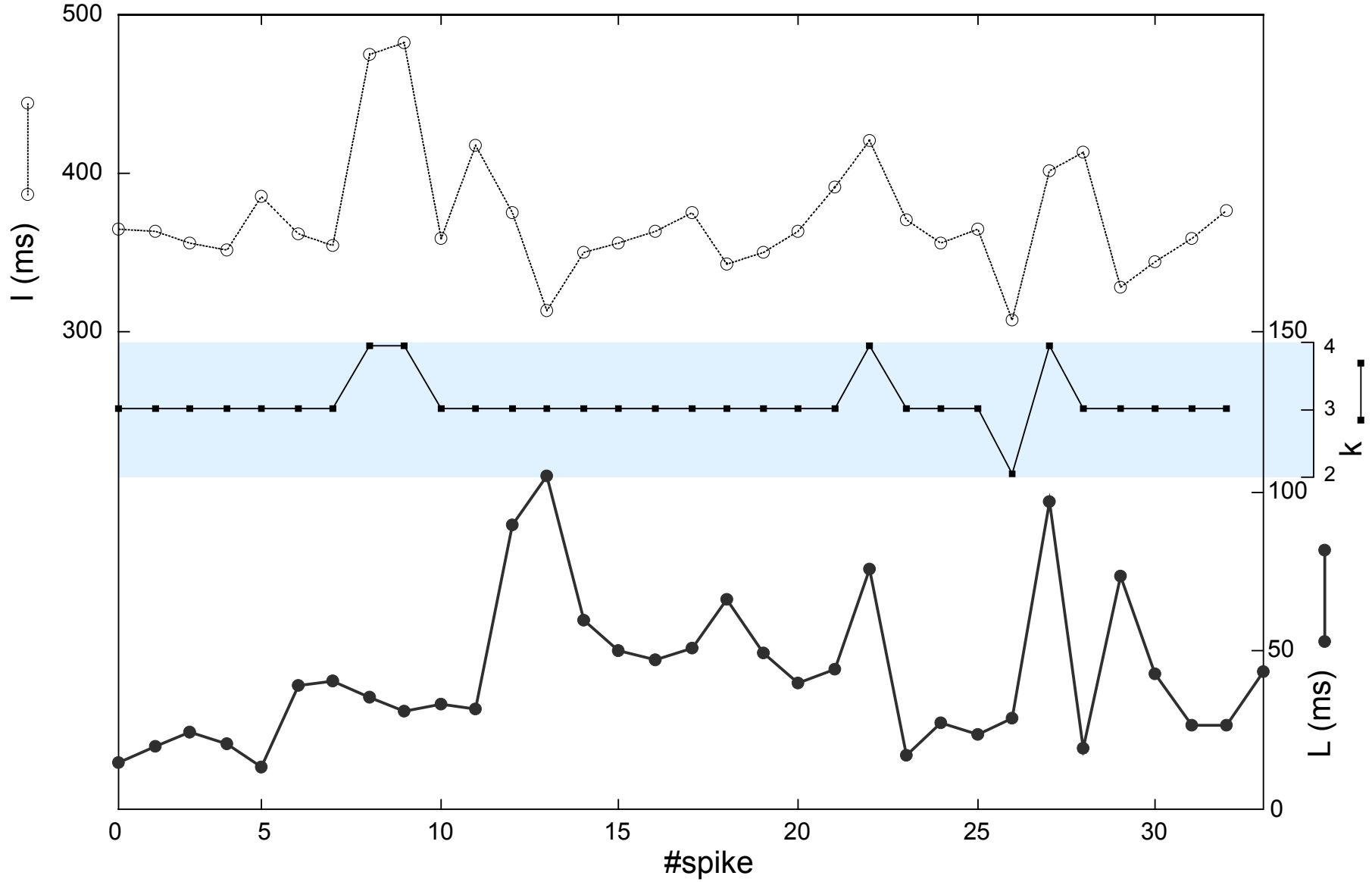
ISI 200 ms


stimulus
zoomed time window
2959
spike
4959
6959
8959
10959
12959
14959
①
②
③
ISI 200 ms
Time (ms)

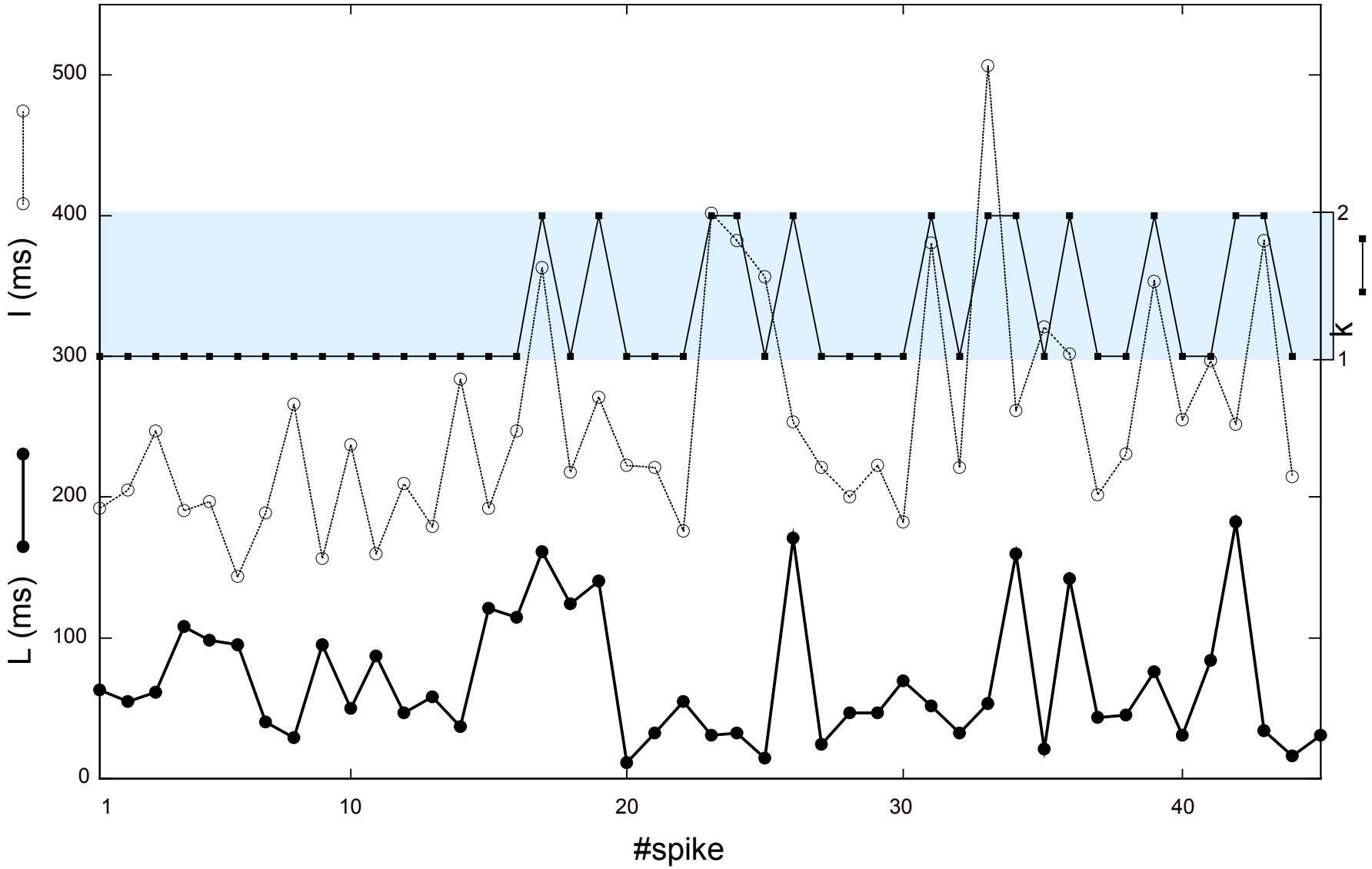

5 traces of 156 ms length (time between traces - 1 sec)
stimulus artifact
0
156
Time (ms)


spike
stimulus
ISI 200 ms

Delayed impulse occurred, mainly in the middle or at the end of interstimulus interval, rather than time-locked one. Correspondingly, non-integer intervals emerged, primarily *(1+1/2)* and *(2-1/2)* containing *1* and *2* impulses, respectively. Sometimes a time-locked and delayed impulse originated in the same interstimulus interval.

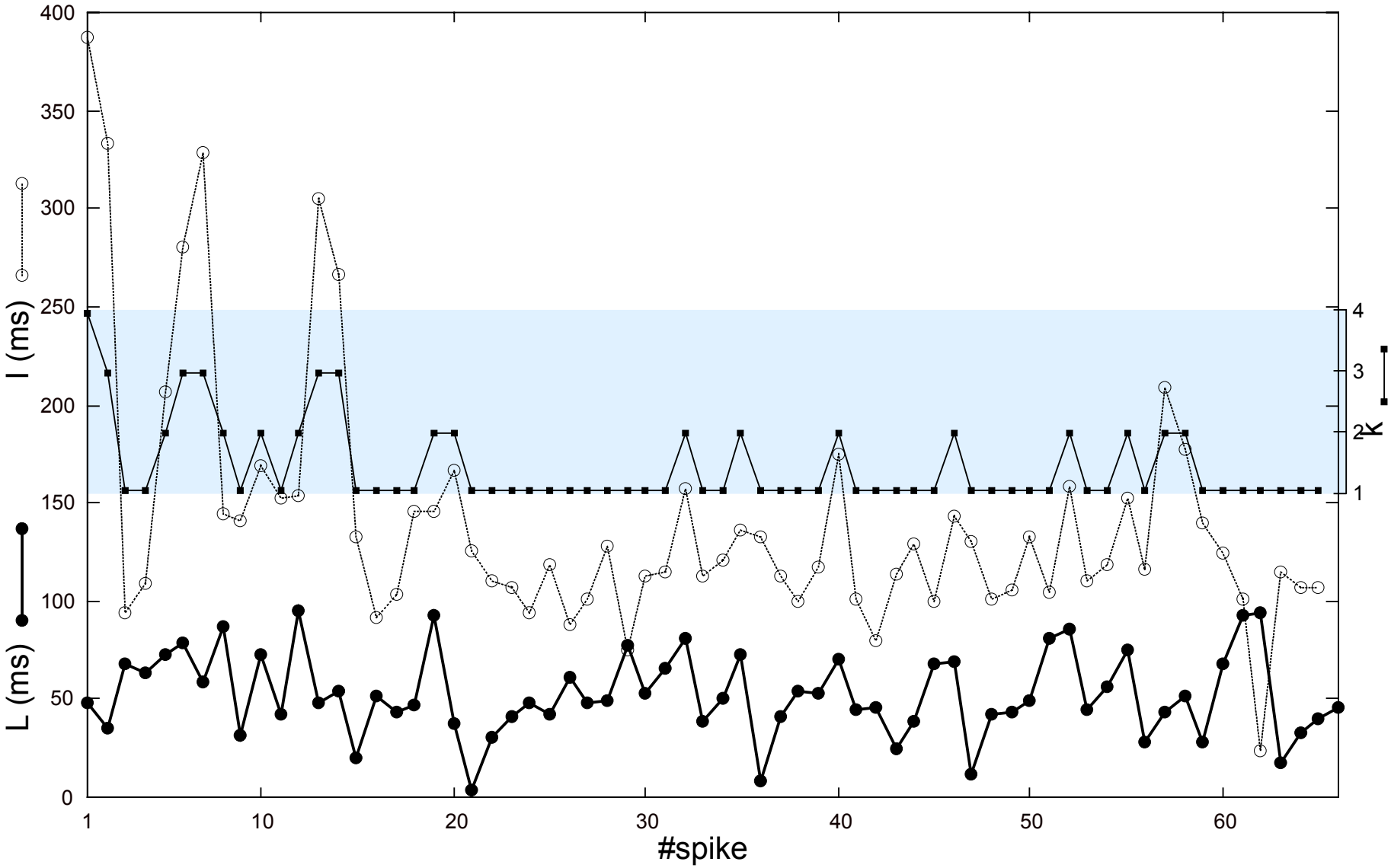


ISI 120 ms



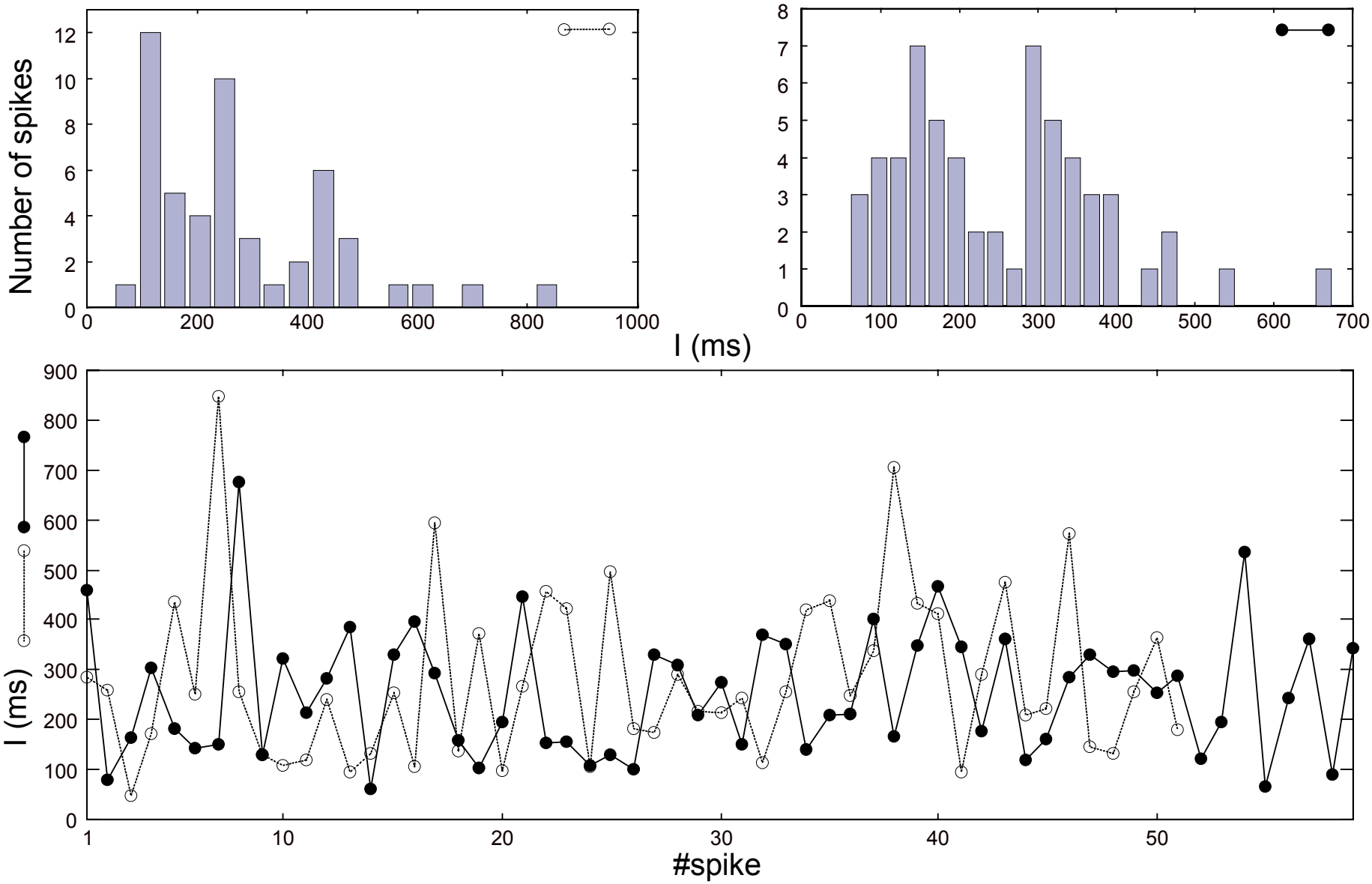
ISI 200 ms

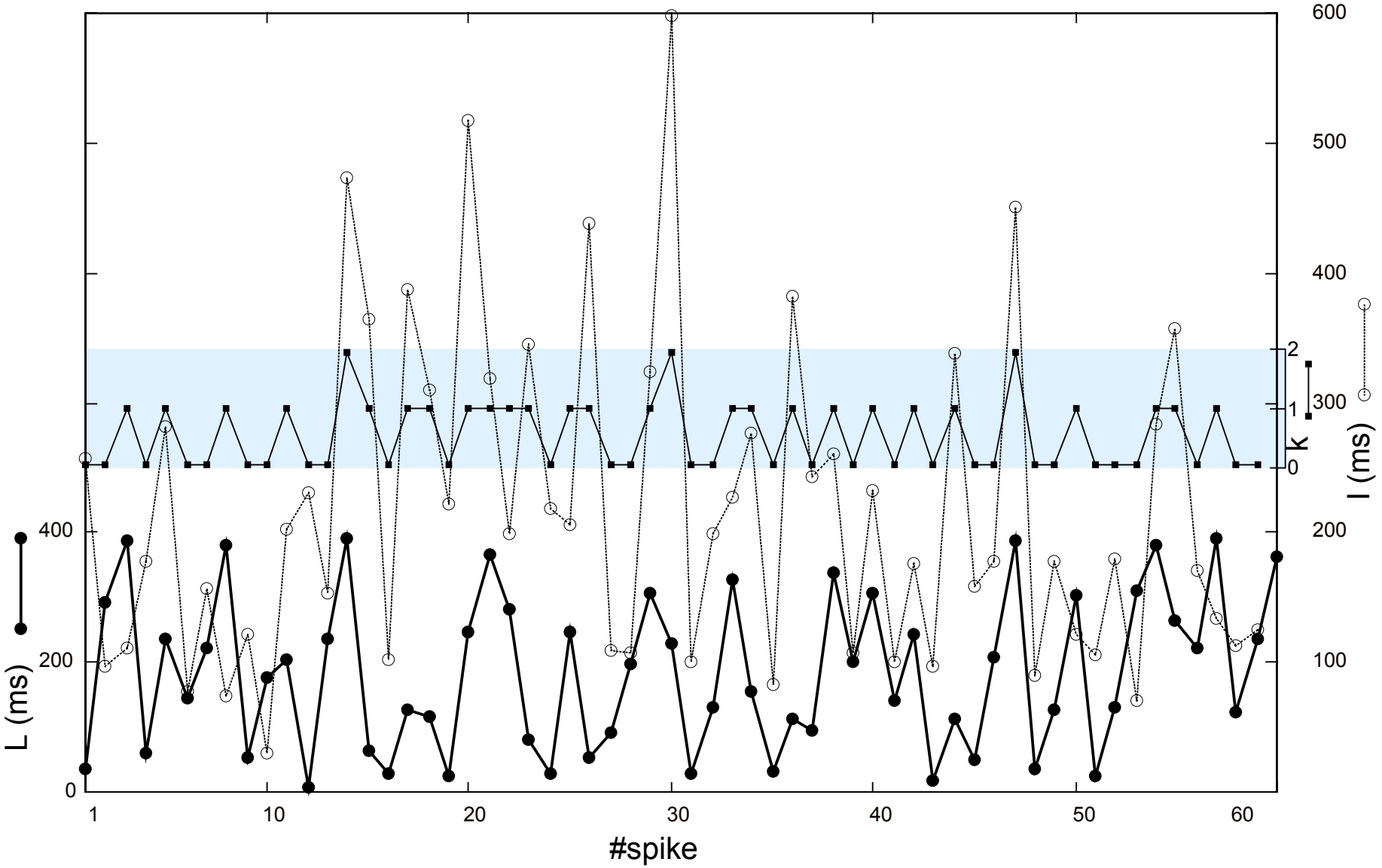
Basic variability expresses divergent pathways of polysynaptic wave. The doubling explicitly exhibits “unfolding” initiated in the hindbrain by monosynaptically excited neurons. Modifications in interaction of neurons and their operational properties discursively define the number and composition of the active population.


I (ms)
L (ms)
K
#spike
0
50
100
150
200
250
300
350
400
1
2
3
4
1
10
20
30
40
50
60

ISI 100 ms

Both gradual and abrupt shifts of range of *k*, modal latency and occurrence of delayed impulses develop throughout a train. Together with persistent basic variability the shifts contribute to transition from rest to locomotion. Abrupt shifts of different kind appear either during the same train or separately. The two shifts can arise simultaneously or successively.


Number of spikes
0
2
4
6
8
10
12
0
200
400
600
800
1000
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
600
700
I (ms)
I (ms)
0
100
200
300
400
500
600
700
800
900
1
10
20
30
40
50
#spike


L (ms)
I (ms)
k
#spike
0
200
400
100
200
300
400
500
600
1
10
20
30
40
50
60
0
1
2

ISI 400 ms

Stronger stimuli delivered to *MLR* excite more hindbrain neurons monosynaptically. Hindbrain decreases its functional depth, and its behavior becomes less autonomous. Confined non-individual control at this level forces the transfer of solving the Bernsteinian problem to higher centers.