The category of 1:1 ratio caused by assimilations of two neighboring empty time intervals

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Assimilation of time intervals

- Time-shrinking (Nakajima, et al., 2004)
- Bilateral assimilation
  (Miyauchi & Nakajima, 2005)

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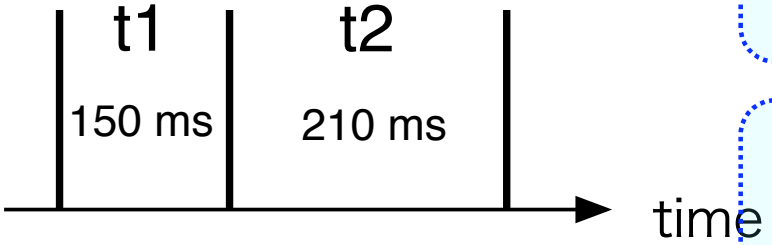


PSE of t2 = 185 [ms]
Underestimated

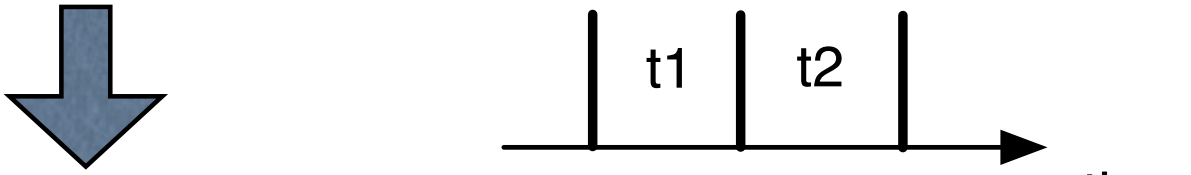
PSE of t1 = 173 [ms]
Overestimated

$$-80 \leq t_1 - t_2 \leq +40 \quad \text{[ms]}$$

"Asymmetric"

Research Question

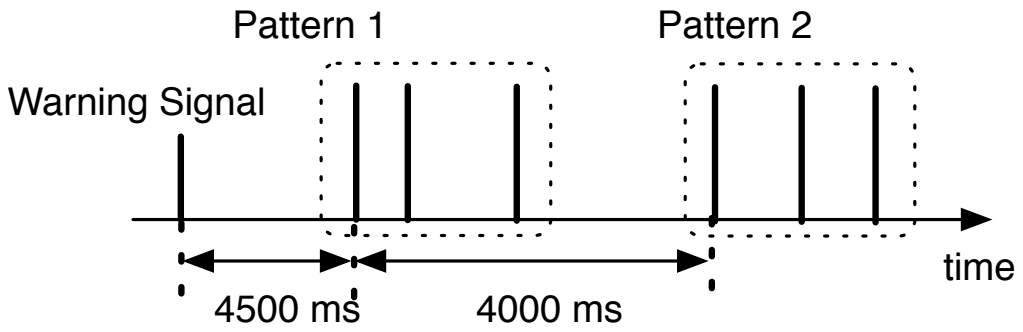
- We were uncertain as to whether the subjective durations of t1 and t2 were actually perceived as 1:1?



We investigated how the whole stimulus pattern was perceived and whether the category of 1:1 ratio was formed by the two types of assimilation.

Experiment 1

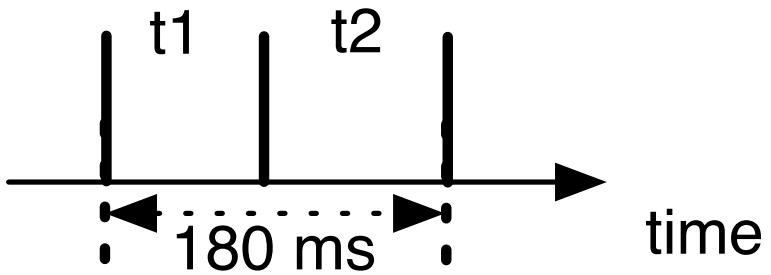
- We measured subjective similarities between two patterns.



- We analyzed similarity by cluster analysis.

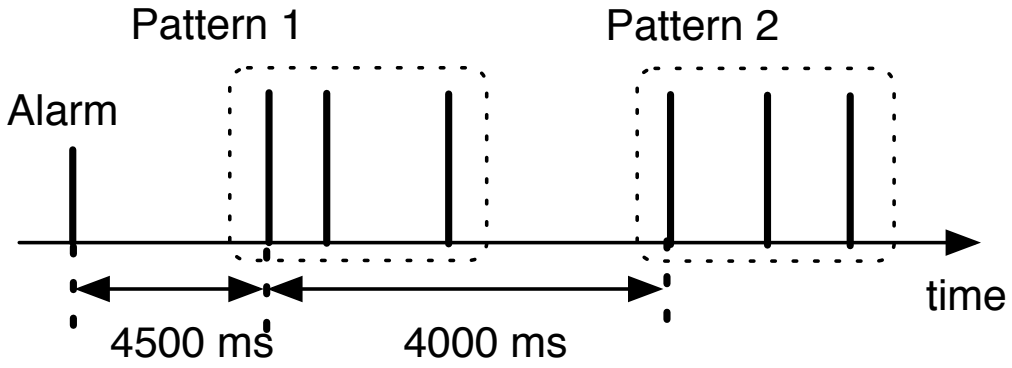
Exp.1: Method

- Six Participants took part.
- Stimuli
  - Each pattern comprised two neighboring empty time intervals.
  - t1 + t2 = 180 [ms]
  - t1 was varied from 30 to 150 ms in 5 ms steps (25 patterns in total).

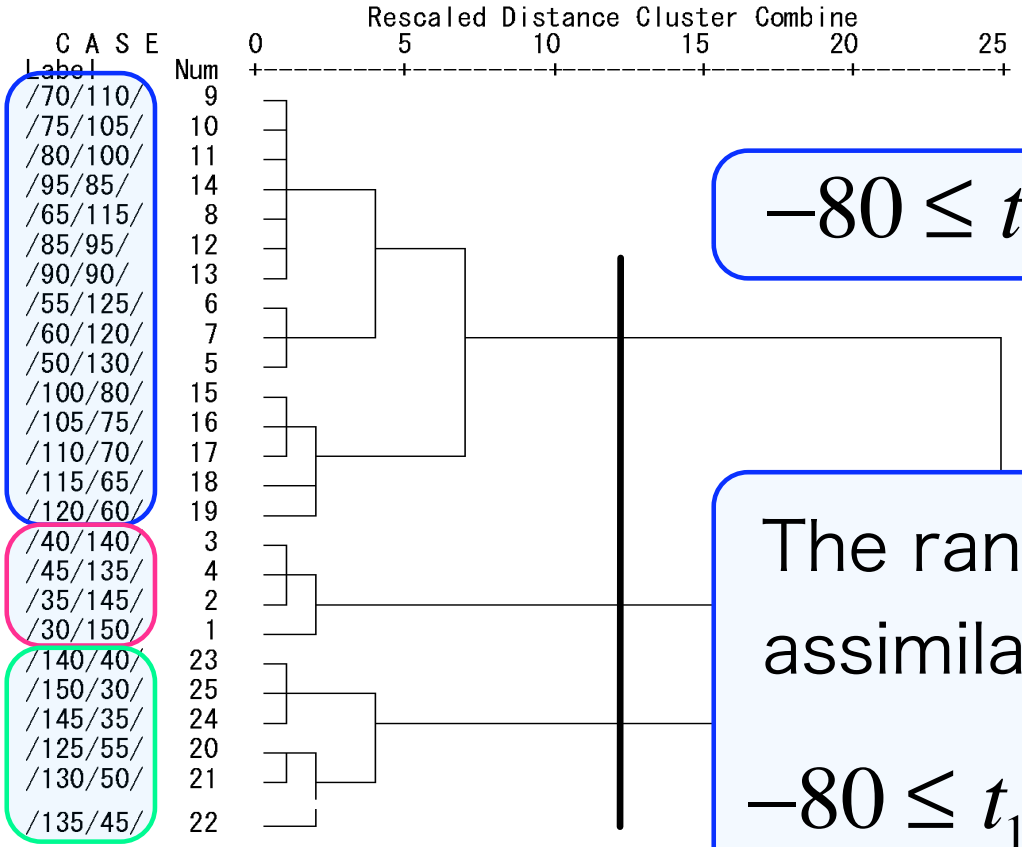


Exp.1: Method

- We prepared all possible pairs of the 25 patterns (625 combinations).
- We presented all combinations in a random order.
- Participants rated the similarity of two patterns on a scale of 0 (Same) to 9 (Different).



Exp.1: Cluster Analysis



$$-80 \leq t_1 - t_2 \leq +60 \text{ [ms]}$$

The range in which assimilation took place

$$-80 \leq t_1 - t_2 \leq +40 \text{ [ms]}$$

Exp.1: Conclusion

- One cluster consisted of the patterns in which assimilation took place.

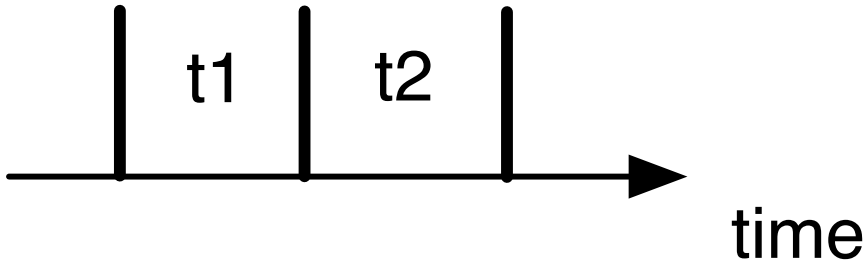
$$-80 \leq t_1 - t_2 \leq +60 \text{ [ms]}$$

But it is uncertain whether this cluster is equivalent to a 1:1 category.

Because, the participants were not instructed to pay attention to the difference between the subjective durations of t1 and t2.

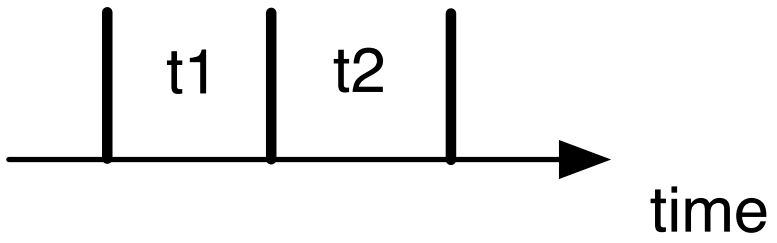
Experiment 2

- We asked the participant to judge whether subjective durations of t1 and t2 were the ‘Same’ or the ‘Different.’
- We determined the boundaries between the ‘Same’ and the ‘Different’ with regard to the subjective durations of t1 and t2.



Exp.2: Method

- Six Participants
- Stimuli
  - t1 + t2 = 180, 360, 540, 720 [ms]
  - t1 – t2 was varied from –200 to +200 ms in 4 ms steps.
    (When t1 + t2 =180 ms, t1 – t2 was varied from –120 to +120 ms.)

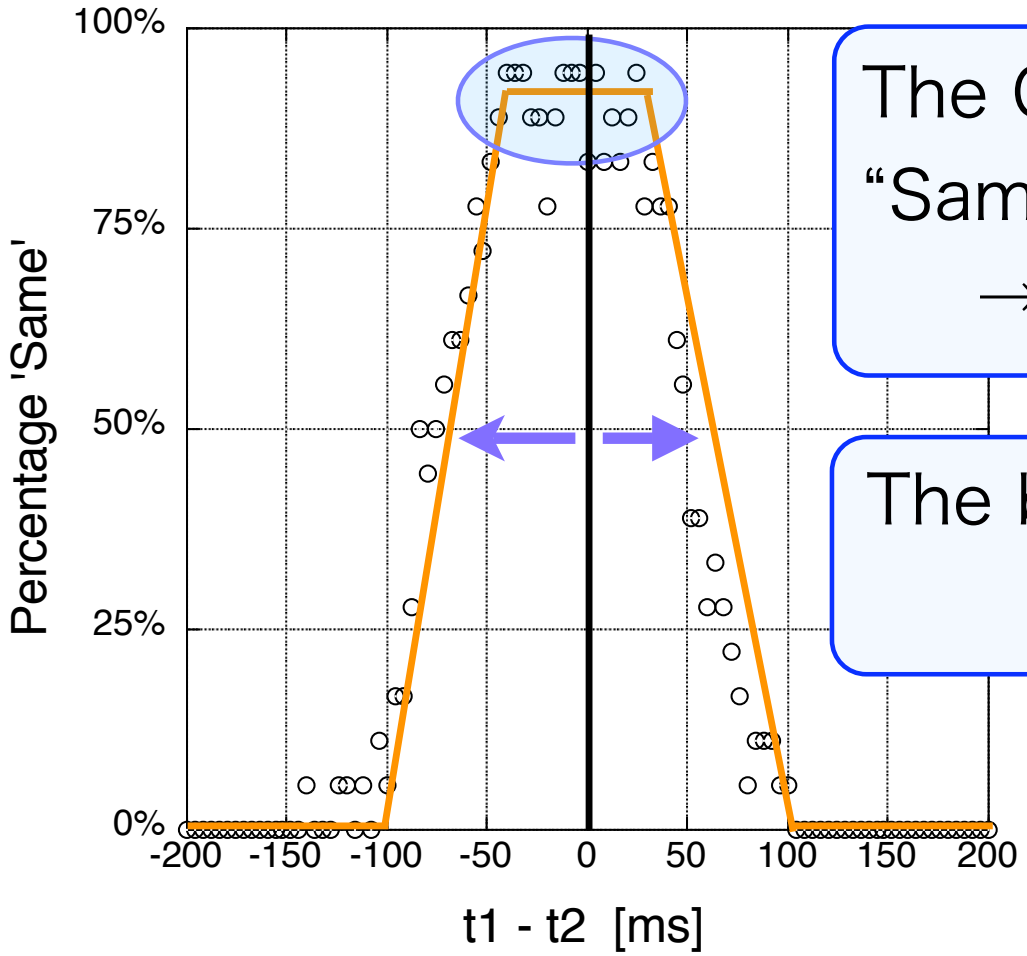


Exp.2: Method

- We presented all 374 patterns in a random order.
- The participants judged whether the subjective durations of t1 and t2 were the ‘Same’ or the ‘Different.’ (2AFC)
- We calculated the percentage of ‘Same’ responses from 18 judgments for each pattern.

  [3 repetitions x 6 participants]

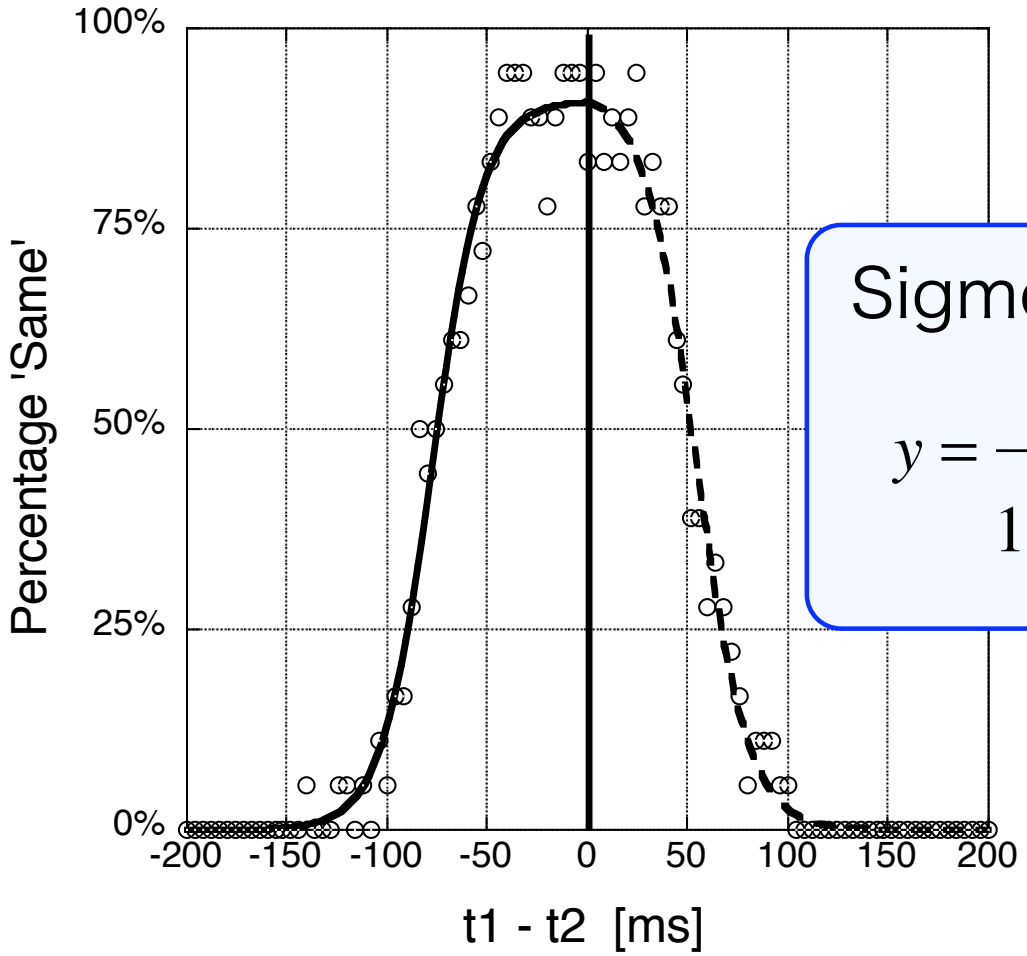
Exp.2: Results of t1 + t2 = 360 [ms]



The Category of "Same" responses → 1:1 Category

The boundaries are "asymmetric."

Exp.2: Curve fitting (360 ms)



Sigmoid function

$$y = \frac{b_1}{1 + \exp(-\frac{x + b_2}{b_3})}$$

$t_1 < t_2$

$R^2 = 0.99$

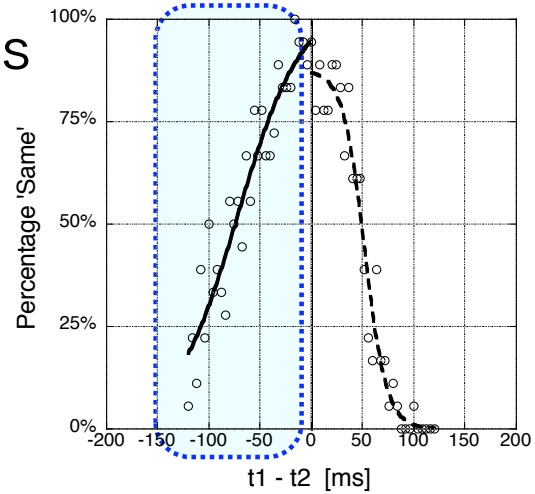
$t_1 > t_2$

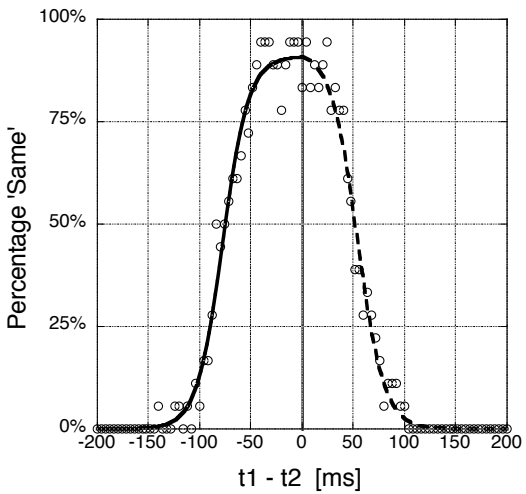
$R^2 = 0.99$

Exp.2: Fitted curves

(a) 180 ms

$t_1 < t_2$
$R^2 = 0.90$
$t_1 > t_2$
$R^2 = 0.96$



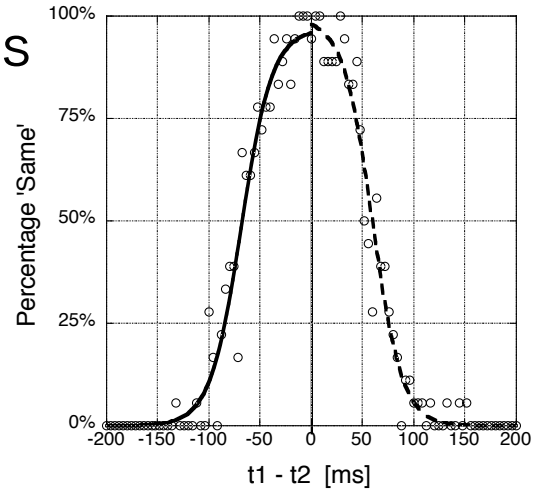


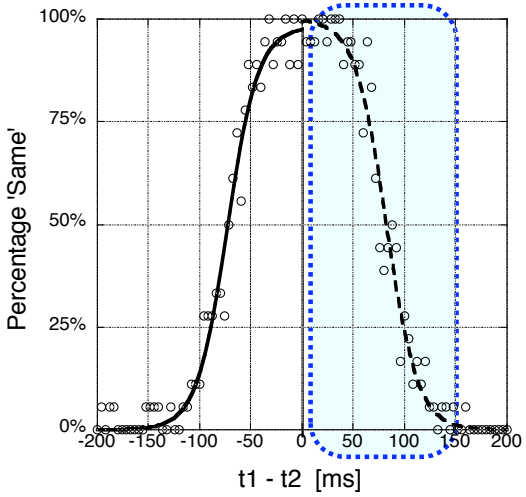
(b) 360 ms

$t_1 < t_2$
$R^2 = 0.99$
$t_1 > t_2$
$R^2 = 0.99$

(c) 540 ms

$t_1 < t_2$
$R^2 = 0.97$
$t_1 > t_2$
$R^2 = 0.97$

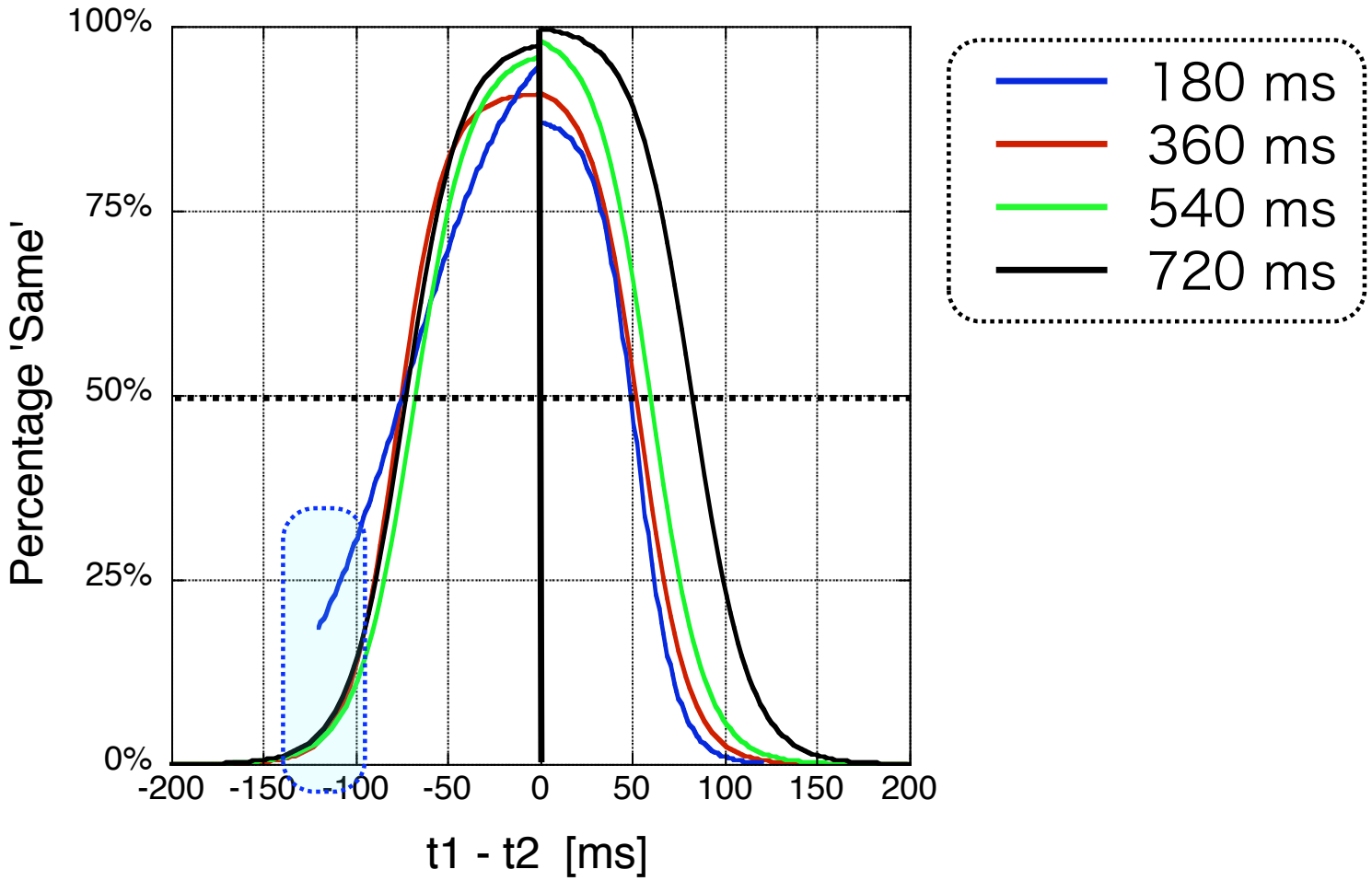




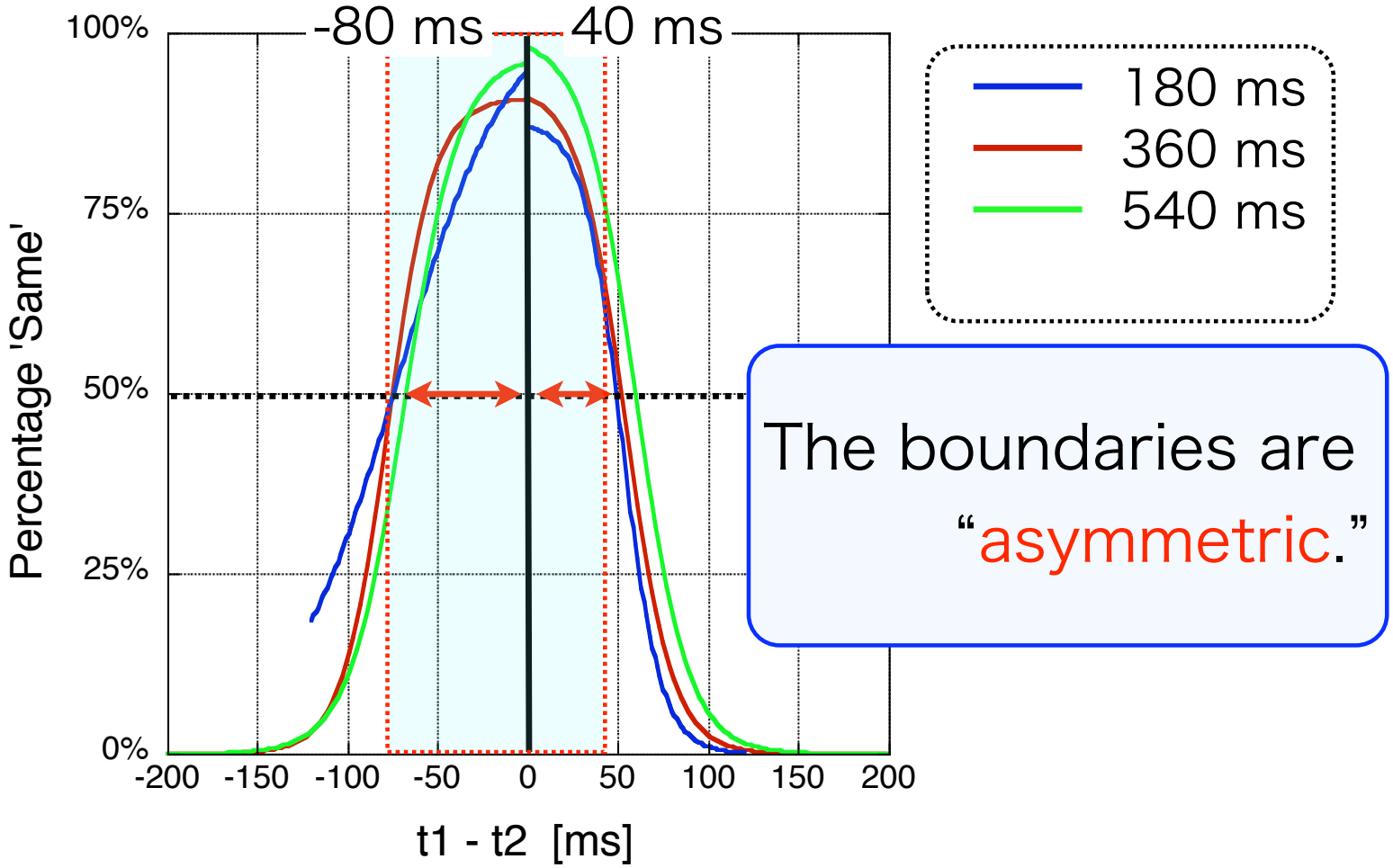
(d) 720 ms

$t_1 < t_2$
$R^2 = 0.98$
$t_1 > t_2$
$R^2 = 0.98$

Exp.2: Fitted curves (All together)

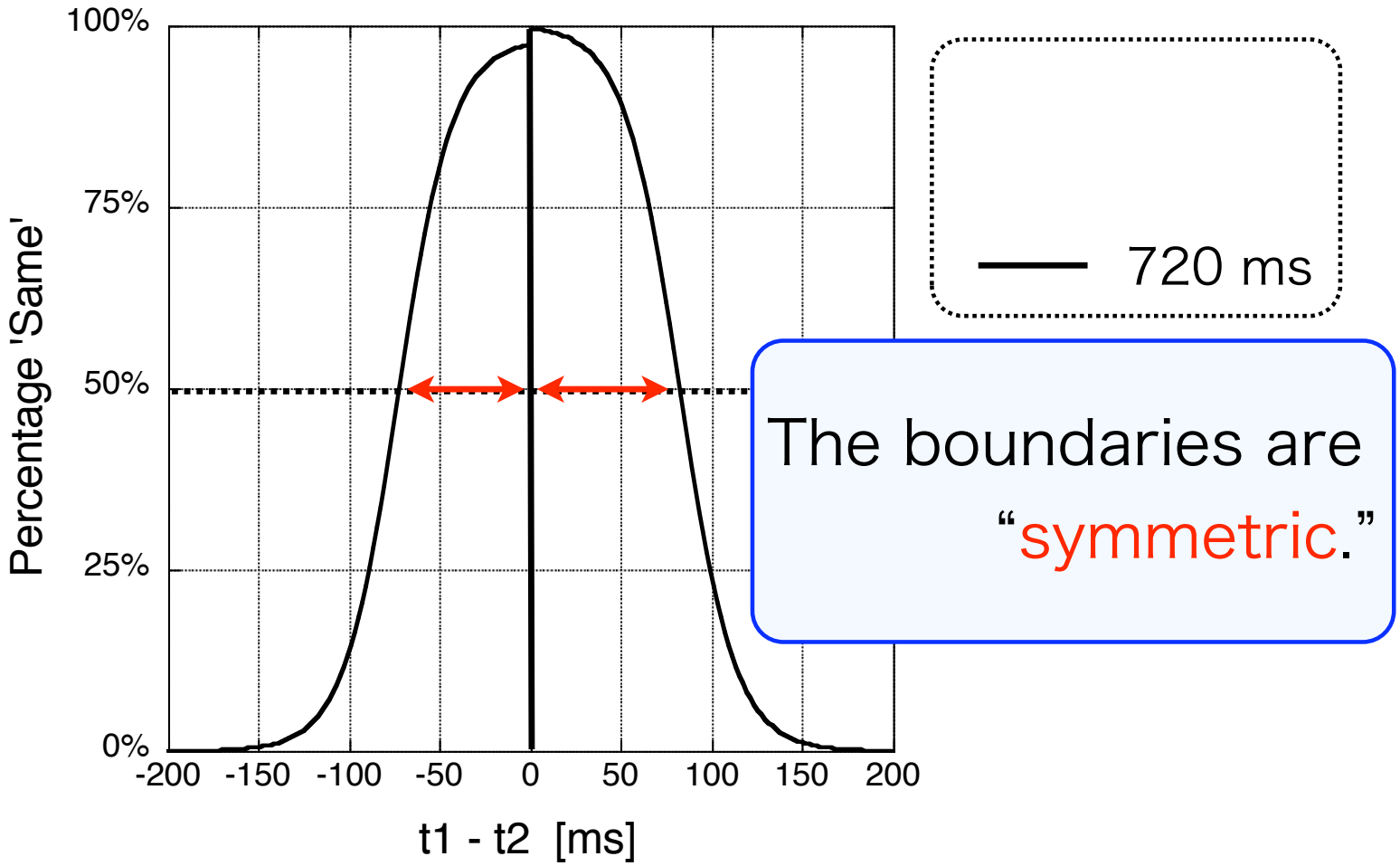


Exp.2: Fitted curves (≦ 540 ms)



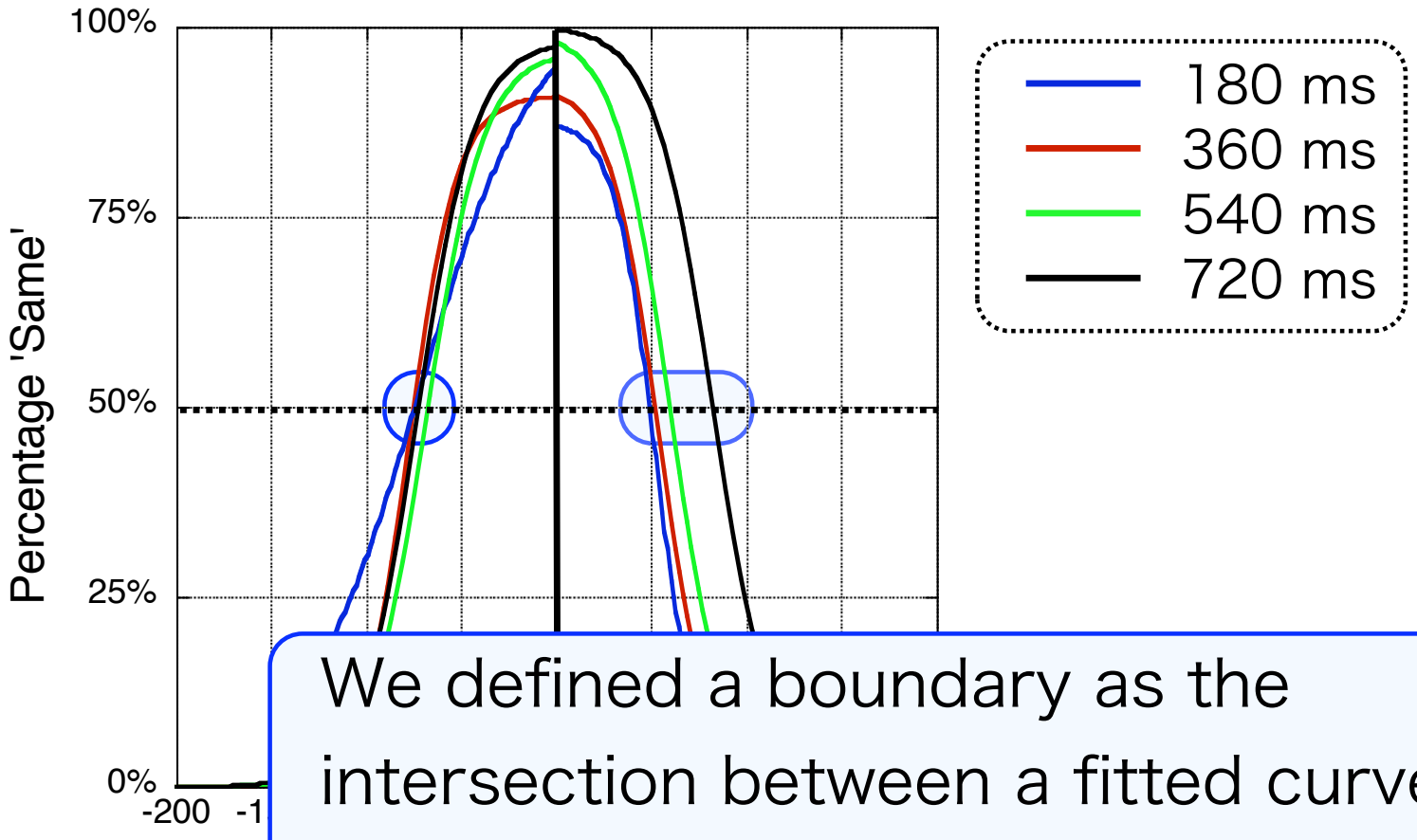
The boundaries are "asymmetric."

Exp.2: Fitted curves (720 ms)



The boundaries are "symmetric."

Exp.2: Boundaries



We defined a boundary as the intersection between a fitted curve and the 50% line.

Exp.2: Boundaries

Total duration	t1 < t2	t1 > t2
180	-74	+49
360	-75	+52
540	-68	+60
720	-72	+82

[ms]

When the total duration was 540 ms or shorter, the 1:1 category occupied basically the same range.

Exp.2: Boundaries

Total duration	t1 < t2	t1 > t2
180	-74	+49
360	-75	+52
540	-68	+60
720	-72	+82

[ms]

When the total duration was 720 ms,
the 1:1 category expanded in the direction
where t1 was longer than t2.

Conclusion 1

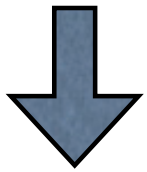
- We found the existence of a 1:1 category in the experiments of different types.
- RPPW 2003 $-80 \leq t_1 - t_2 \leq +40$
  Experiment 1 $-80 \leq t_1 - t_2 \leq +60$
  Experiment 2 $-75 \leq t_1 - t_2 \leq +60$ **[ms]**

  The two types of assimilation contributed to the formation of the asymmetric 1:1 category when the total duration was ≦ 540 ms.

Conclusion 2

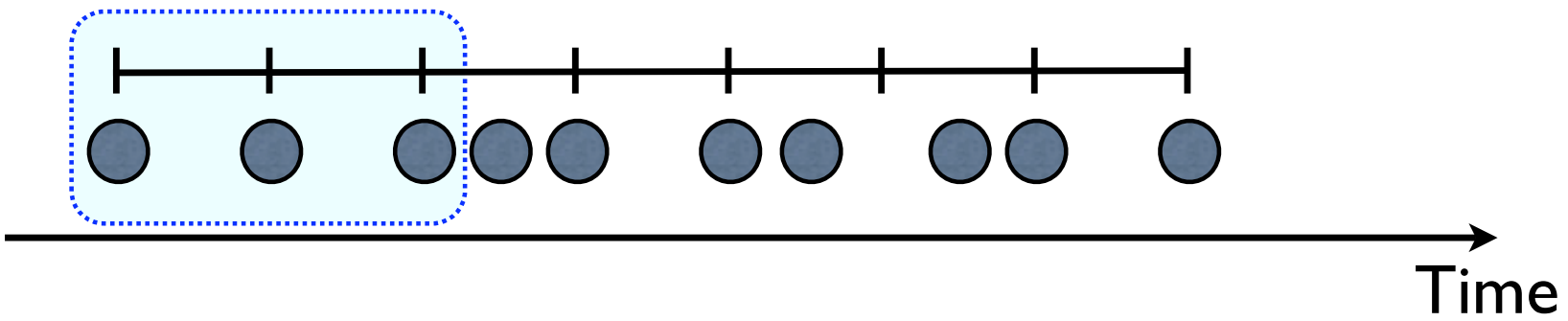
- When the total duration was as long as 720 ms, the range of the 1:1 category was “symmetric.”
- Time-shrinking disappeared when the total duration was long.

Nakajima et al. (2004)



We speculate that only the bilateral assimilation takes place for long time intervals.

Perception of temporal sequences

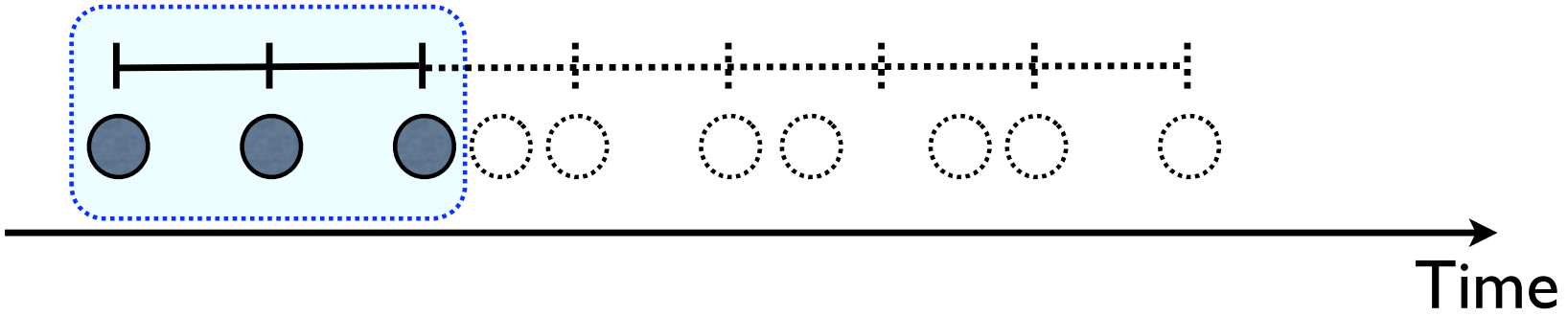


- A ‘temporal grid’ is used to specify the temporal structure of a sequence.

  Povel (1984), Essens (1986)

- A grid is a time scale consisting of isochronous intervals.

Perception of temporal sequences



- Isochrony (Same-Different) Judgment

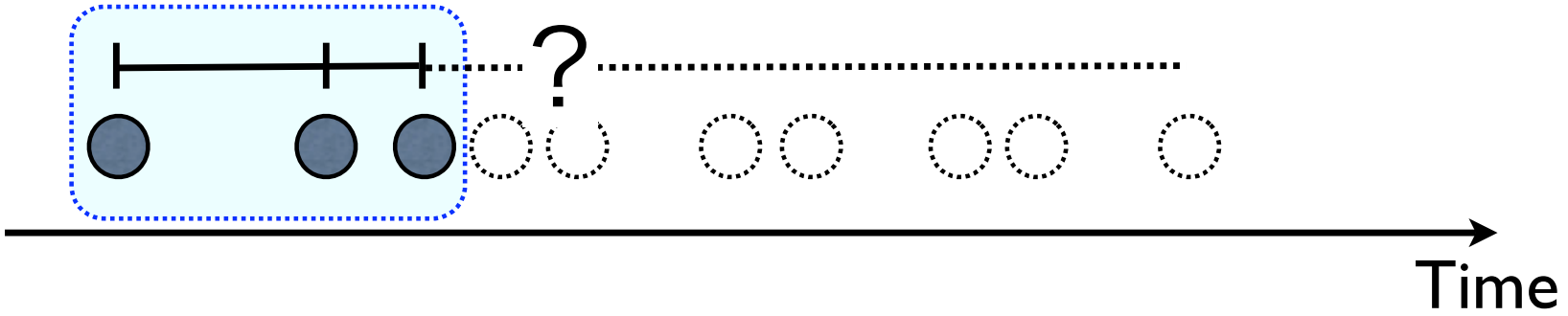
  “Same” --- The durations are selected as a tentative temporal grid.

  “Different” --- No temporal grid.

The formation of a 1:1 category facilitates the selection of a temporal grid in real time.

Thank you for listening!

Perception of temporal sequences



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