

Learning mechanism takes place in milliseconds

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When stimuli are presented simultaneously or in rapid succession within less than one second, humans can form multiple associations between visual or verbal items. Individual stimuli can be processed on the order of tens to hundreds of milliseconds, allowing several associations to be encoded within a total time window of approximately one second or less. These findings indicate that associative learning can take place in sub-second timescales.

Rapid statistical learning (sub-second presentations): Humans can extract associations between visual or auditory stimuli presented very briefly, typically on the order of tens to hundreds of milliseconds per item (e.g., Jenny R. Saffran et al., 1996; Nicholas B. Turk-Browne et al., 2005). These studies demonstrate learning from rapid stimulus streams at approximately 100 ms per item.

Rapid paired-associate encoding: Neural signatures of associative encoding emerge rapidly following stimulus onset. For example, associative encoding-related signals can appear within approximately 100–400 ms (R. Endemann and S. M. Kamp, 2025), and encoding activity predictive of later memory has been observed within approximately 300–800 ms (J. B. Hales and J. B. Brewer, 2011). These findings indicate that the neural processes underlying associative binding are engaged within a few hundred milliseconds of stimulus onset.

However, even when stimuli are presented simultaneously, associative learning may require extended durations, particularly when associations are weak, complex, or depend on repeated exposures (Jan De Houwer et al., 2001; L. Zhan et al., 2018). This suggests that while associative learning can be initiated rapidly, the underlying changes often require additional time and repetition to stabilize and consolidate.

References

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