Temporal anticipation affects decision-making in an olfactory discrimination task.

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Time is an important variable in decision-making. Human reaction time (RT) studies have emphasized the concept of “speed-accuracy tradeoff”, whereby performance accuracy tends to covary with the speed of response, sometimes for several seconds. But for most simple perceptual decisions, performance saturates much more quickly\(^1\). Indeed, studies of olfactory processing in rodents reported RTs of 200-300 ms\(^2,3\), suggesting a rapidly-developing olfactory code and short integration times. However, in a recent report using an auditory ‘go’ signal to instruct mice when to respond odor discrimination performance improved for up to 1.0 s\(^4\), challenging these results and suggesting that rats simply trade accuracy for speed in RT studies. Here, we sought to address this controversy by replicating their results.

Performance is affected not only by the amount of time available for a decision but by the ability to anticipate when the decision must be made. The effects of temporal anticipation can be seen as a kind of "attention in time", modulating both the speed and the accuracy of decisions\(^6\). The ‘go’ signal paradigm presents subjects with a random response deadline. Performance may vary depending on how subjects allocate their attention to the time interval during which the signal occurs. Mathematically, how an ideal observer would allocate attention in time is given by the hazard rate, which, for a probability distribution of an event in time, quantifies the probability of that event to occur, given that it has not already occurred.

Could increased readiness with elapsed time masquerade as temporal integration? For events distributed exponentially in time, the hazard rate is flat. However, for a flat probability distribution (0.1 – 1s), as used in the previous ‘go’ signal study\(^4\), the hazard rate is monotonically rising. In order to test whether this could account for the previous results, we directly compared performance on a ‘go’ signal instructed odor mixture discrimination task using an exponential and a flat probability distribution of ‘go’ signal delays. As predicted by the hazard rate manipulation of temporal attention (as well as a temporal integration model), performance accuracy increased over >0.7 s when ‘go’ signals were distributed to achieve a rising hazard rate. In contrast, performance asymptoted in <0.3 s in a flat hazard rate condition. When the same rats were trained on the RT paradigm, accuracy was equivalent to that obtained with the highest readiness in the ‘go’ signal paradigms. Further testing with 1.0 s fixed ‘go’ signal (on difficult mixture ratios, resulting in <75% peak accuracy) failed to result in improved performance.

These results confirm the notion that temporal manipulations exert a strong influence on olfactory discrimination performance, but point to the readiness of the subject to respond as a predominant factor for odor sampling time longer than 0.2-0.3 s. The results confirm the idea that rats’ RTs are well-matched to the temporal requirements of their olfactory systems\(^5\). Although it remains a possibility that longer temporal integration and temporally evolving olfactory code could improve performance on a different class of olfactory problems, these results support the previous contention that fine odor mixture discrimination can be performed optimally in 200-300 ms or 1-2 sniffs by well-trained subjects.

Acknowledgments: Supported by the NIDCD.

References