

How Many Odours Can Be Told Apart Is Set Not by the Number of Receptors but by the Rule for Reading Them

— Even with the number of receptor types fixed at **400**, the number of distinguishable odours is not fixed — the separator is whether one asks about the number of receptors or about the rule for reading them — [Paper 851]

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— *From thinking to syncing.* —

Abstract

“There are this many receptors, so this many odours can be told apart,” it is said. This paper counts that “this many” does not follow from the number of receptors. No new theorem or law is claimed. First, counting every combination as different gives an enormous number: 2^{400} for 400 receptor types, **120.411998** orders of magnitude (Section 2). Second, fixing how many are active shrinks it sharply: exactly 5 active gives **10.920220** orders, and 1 to 10 gives **19.422809** (Section 2). Third, reading only the strongest one gives the receptor count itself: 400, or **2.602060** orders (Section 2). Fourth, and this is the core. The same 400 yields a spread of more than 117 orders: widest and narrowest rules differ by **117.809938** orders (Section 2). Fifth, the effect of adding receptors also depends on the rule: doubling to 800 adds 120.411998 orders when every combination counts, and only **1.510609** for exactly five (Section 3). Sixth, the separator is whether one asks about the number of receptors or about the rule for reading them: the distinguishable number is a consequence of the rule on the reading side, not of the receptors (Section 4).
Keywords: olfactory receptor, combinatorial coding, binomial coefficient, counting rule, order of magnitude, model.

Scope of this paper (scope note): No new theorem or law is claimed: that smell represents odours by combinations of many receptors, that the number of subsets is 2^R and of k -subsets a binomial coefficient, and that estimates of the number of distinguishable odours vary greatly with the assumptions made, are all known. No real value is claimed: 400 is a model number placed for comparison, not a claim about any organism. No human ability is stated: how many odours people can actually tell apart is not stated. The brain is not entered: neural processing, learning and adaptation are not treated. Chemistry is not entered, which substances bind which receptors is not treated. Relation to earlier papers: Paper 323 showed that the “three” in three primaries is not a property of light. This paper stands beside it: there the number of colours came from the count on the receiving side; here the number of odours comes from the reading rule on the receiving side. Paper 182 showed that “the curse of dimensionality” is not one curse. Here too one question, “how many”, admits an answer per rule. What is added is setting four reading rules on the same 400 and laying out their orders of magnitude, measuring a spread of 117.809938 orders, measuring that the gain from doubling receptors also depends on the rule, and placing the separator on receptor count versus reading rule.

1. Notation and the Question

Setting: let R be the number of receptor types, and let odours be told apart by which receptors they activate. Four rules are placed for what counts as “a different odour”.

$$N_{\text{all}} = 2^R, \quad N_k = \binom{R}{k}, \quad N_{\leq 10} = \sum_{k=1}^{10} \binom{R}{k}, \quad N_{\text{max}} = R$$

The last rule reads only the most strongly activated receptor. Here $R = 400$, and since the numbers are large they are compared by order of magnitude (common logarithm).

Question: once the number of receptors is fixed, is the number of distinguishable odours fixed?

2. Four Numbers From the Same 400

Computation 2.1: at $R = 400$, the orders of magnitude under the four rules were computed.

rule	orders of magnitude
every combination different (2^R)	120.411998
1 to 10 active	19.422809
exactly 5 active	10.920220
only the strongest one read	2.602060
widest minus narrowest	117.809938

Observation 2.2

this is the core. The same 400 yields a spread of more than 117 orders. The receptor count is the same under all four rules, yet the answer runs from 2.602060 to 120.411998. What fixes the number is not the receptors but the rule for what counts as different.

Observation 2.3

the narrower the rule, the smaller the number. Constraining how many may be active cuts the choices: saying “represented by combinations” does not yet say which combinations are allowed.

3. The Effect of Adding Receptors

Computation 3.1: receptors were doubled from 400 to 800.

rule	$R = 400$	$R = 800$
every combination different	120.411998	240.823997
exactly 5 active	10.920220	12.430830

Observation 3.2

the gain from doubling also depends on the rule. Under the first rule the orders rise by 120.411998; under exactly five, by only 1.510609: the first grows in orders proportionally to the count, the second only as its fifth power.

Observation 3.3

so “more receptors, more odours” holds to a degree set by the rule. The same doubling doubles the orders under one rule and adds fewer than two under another: even the sensitivity to the receptor count is decided on the reading side.

4. The Separator

Observation 4.1

the separator is whether one asks about the number of receptors or about the rule for reading them. With the first fixed, the second moves the answer by 117.809938 orders: the distinguishable number is a consequence not of the count on the receiving side but of how what is received is counted.

Observation 4.2

placed beside Paper 323.323 showed that the “three” in three primaries is not a property of light. There the number of colours came from a count on the receiving side; here, from the same count, the number changes utterly with the reading. One step past the count lies the rule. Paper 182 showed that “the curse of dimensionality” is not one curse. Here too one question admits an answer per rule.

Observation 4.3

what is not said. Real receptor counts, human discrimination, neural processing and odour chemistry are not treated. What is shown is that “how many” becomes one number only once a rule is fixed.

5. Census and Closing

1. **400 receptor types assumed** (Section 1): **a model number.**
2. **every combination: 120.411998** (Computation 2.1): **the widest.**
3. **1 to 10 active: 19.422809** (Computation 2.1): **constrained, smaller.**
4. **exactly 5: 10.920220** (Computation 2.1): **smaller still.**
5. **strongest only: 2.602060** (Computation 2.1): **the count itself.**
6. **spread 117.809938 orders** (Computation 2.1): **the core.**
7. **doubling adds 120.411998** (Computation 3.1): **wide rule.**
8. **doubling adds 1.510609** (Computation 3.1): **narrow rule.**
9. **sensitivity to the count depends on the rule** (Observation 3.3): **the reading side.**
10. **receptor count, or reading rule** (Observation 4.1): **the separator; Papers 323, 182.**

Closing: How many odours can be told apart is set not by the number of receptors but by the rule for reading them. With 400 receptor types, counting every combination as different gives 120.411998 orders, exactly five active gives 10.920220, and reading only the strongest gives 2.602060, a spread of 117.809938 orders: the receptor count is the same throughout; only the rule for what counts as different changed. Doubling to 800 adds 120.411998 orders under the widest rule and only 1.510609 under exactly five: the first grows in orders with the count, the second only as its fifth power. So how far “more receptors, more odours” holds is decided on the reading side. Placed among the earlier papers: beside Paper 323’s “the number comes from the count on the receiving side”, as the stage of rules one step past the count, and counting with Paper 182’s pattern one question with an answer per rule. To be honest: 400 is a model number, and nothing is said about how many odours people can actually tell apart.

References

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