Recap

- Sternberg paradigm
- Serial search models:
  - Self-terminating
  - Exhaustive

Attribute models!

PSYC 51.09: Human Memory
Spring 2022

Jeremy Manning
jeremy@dartmouth.edu

Laying the groundwork…

- How can we (formally) represent complex thoughts?
- Extensions of strength theory

Laying the groundwork…

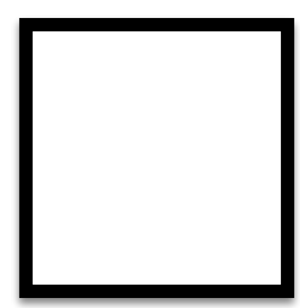
- How can we (formally) represent complex thoughts?
- Extensions of strength theory

Attribute theory

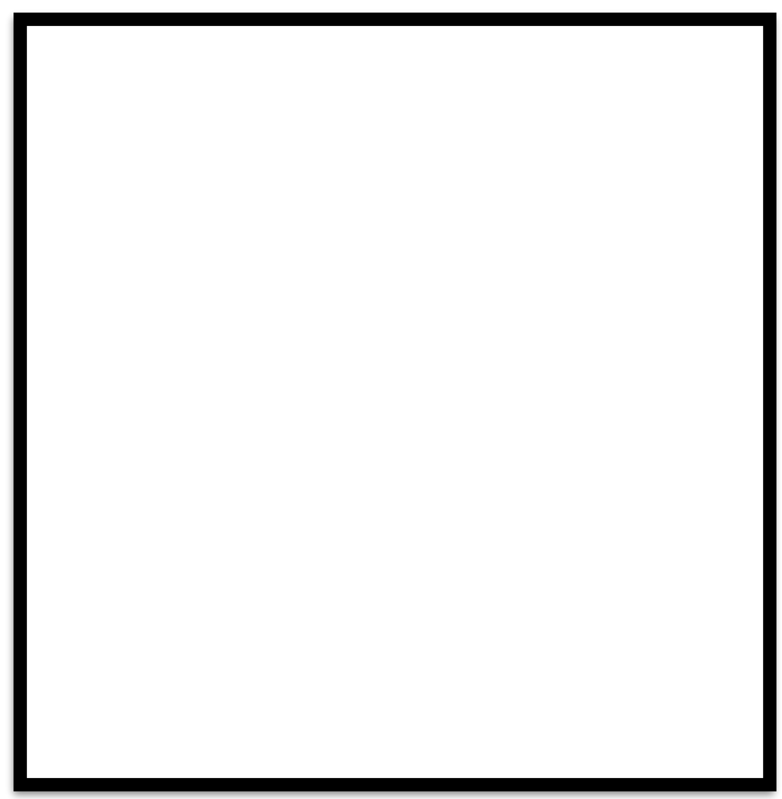
- Mathematics is the language of nature
- Everything around us can be represented and understood through numbers
- We create a model of our world inside our brain
- What can we do with this idea?

Rectangle space

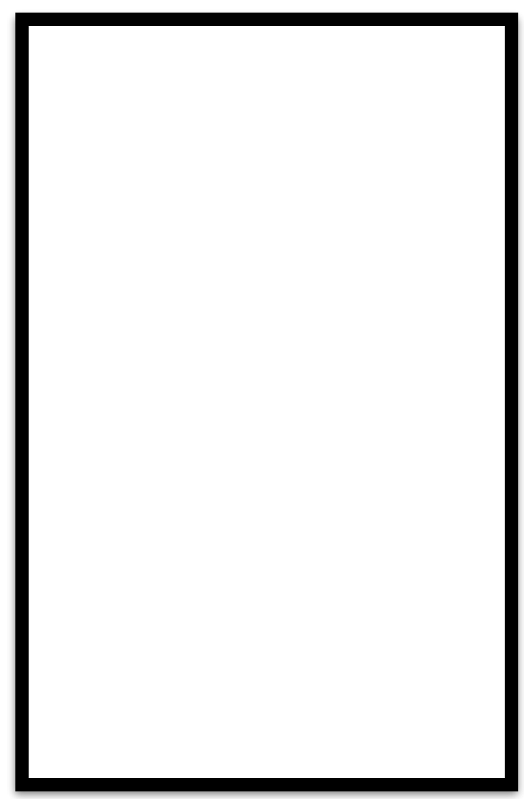
Rectangle space



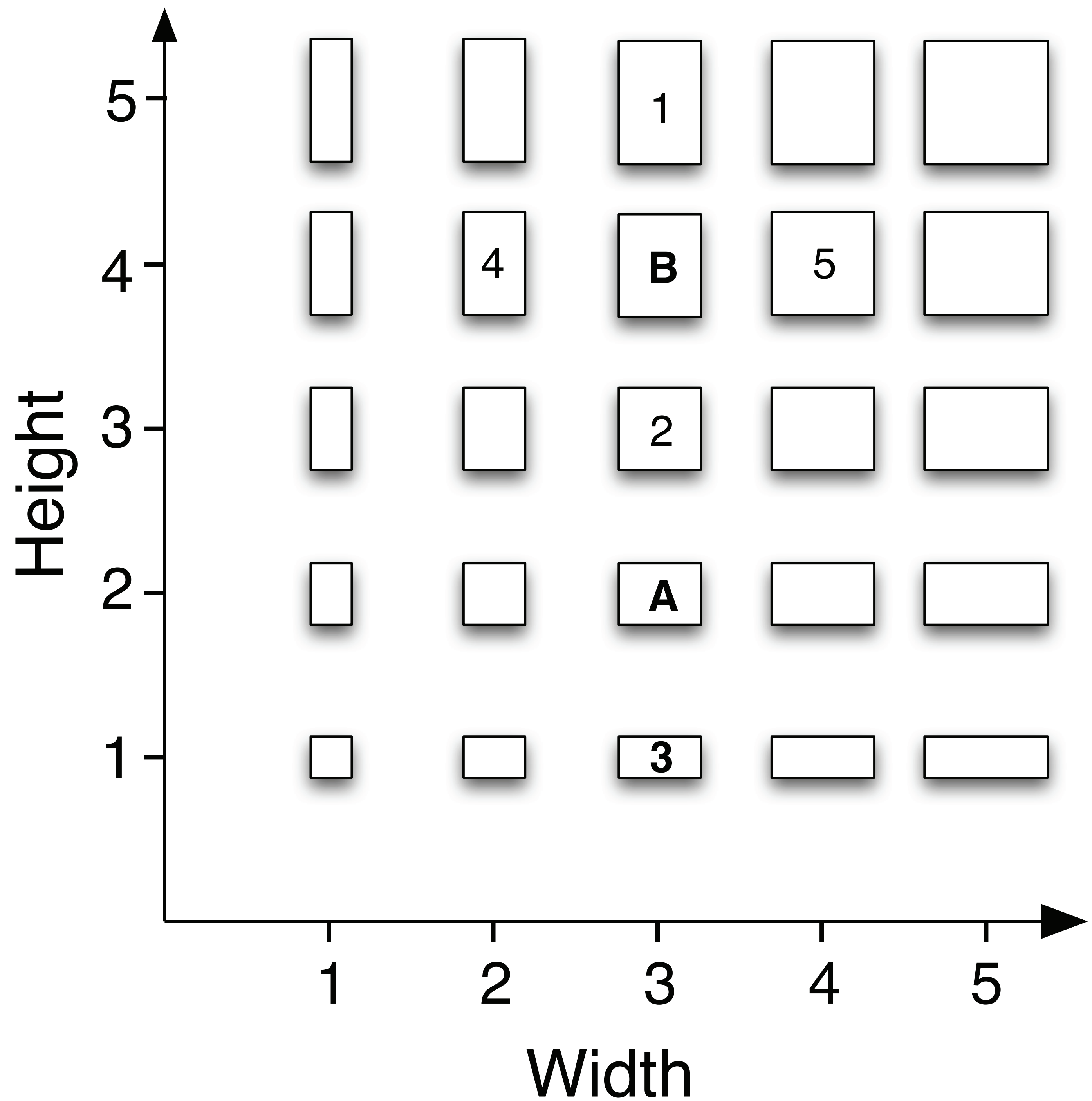
Rectangle space



Rectangle space



Rectangle space



Rectangle space

- Any point in rectangle space is a rectangle
- You can go from points to rectangles: x = width, y = height
- You can go from rectangles to points: width = x, height = y
- We can represent any rectangle (or point) as a **vector**

Vectors

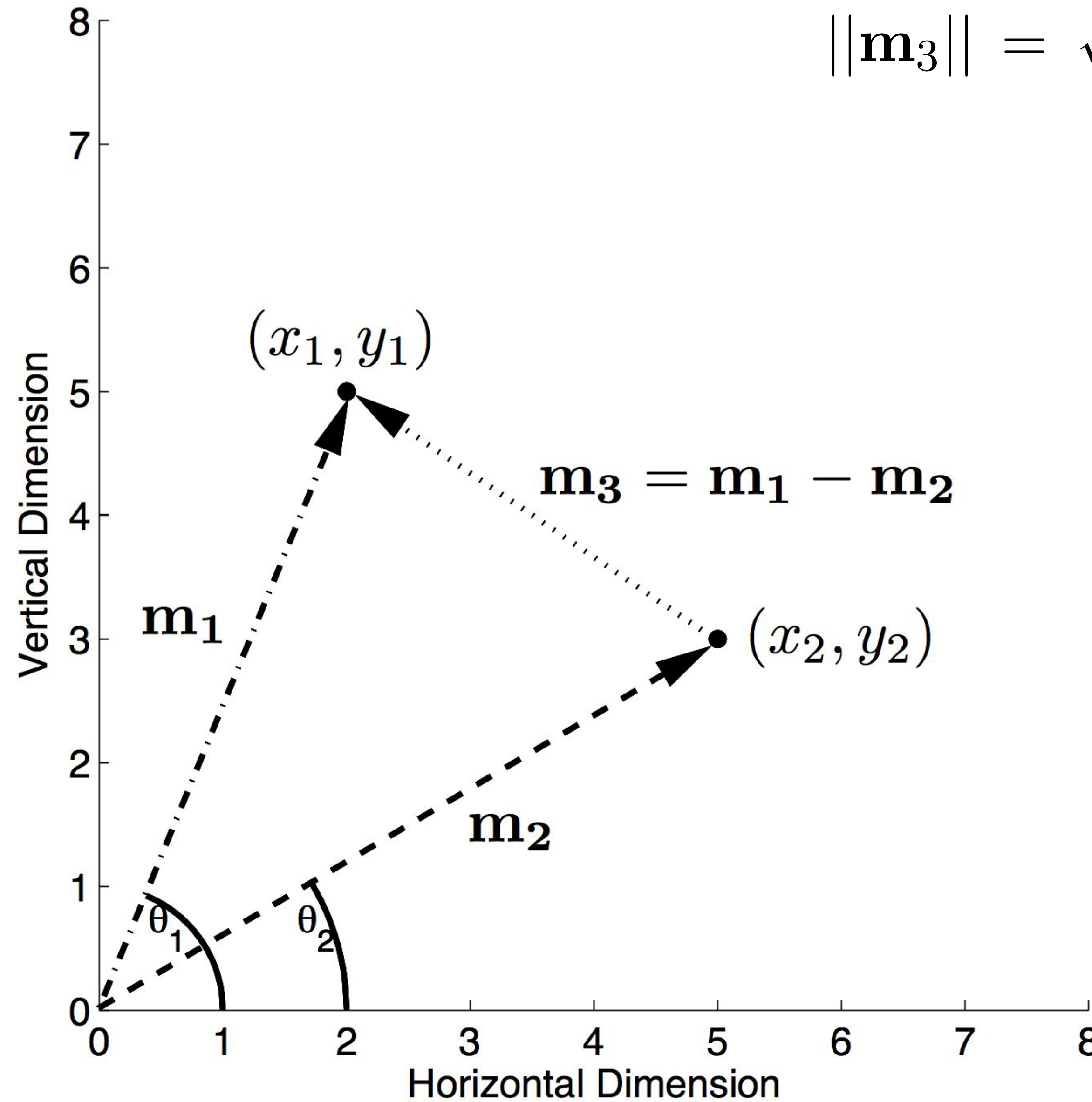
$$\mathbf{m} = \vec{m} = \begin{pmatrix} m(1) \\ m(2) \\ m(3) \\ \vdots \\ m(N) \end{pmatrix} = \begin{pmatrix} m_1 \\ m_2 \\ m_3 \\ \vdots \\ m_N \end{pmatrix}$$

Rectangle space

- We can also ask how different rectangles compare to each other

Euclidean distance

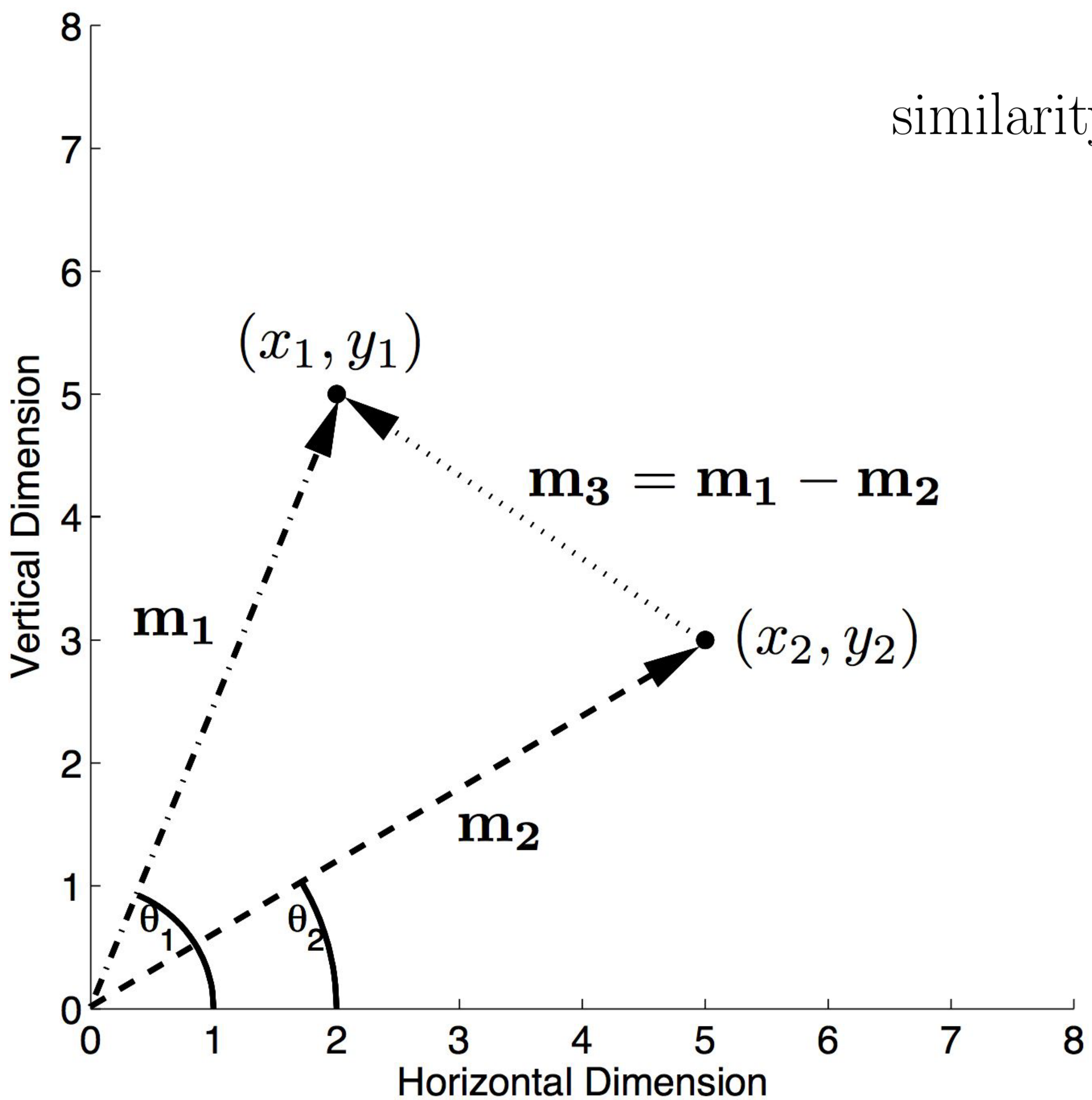
$$||\mathbf{m}_3|| = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

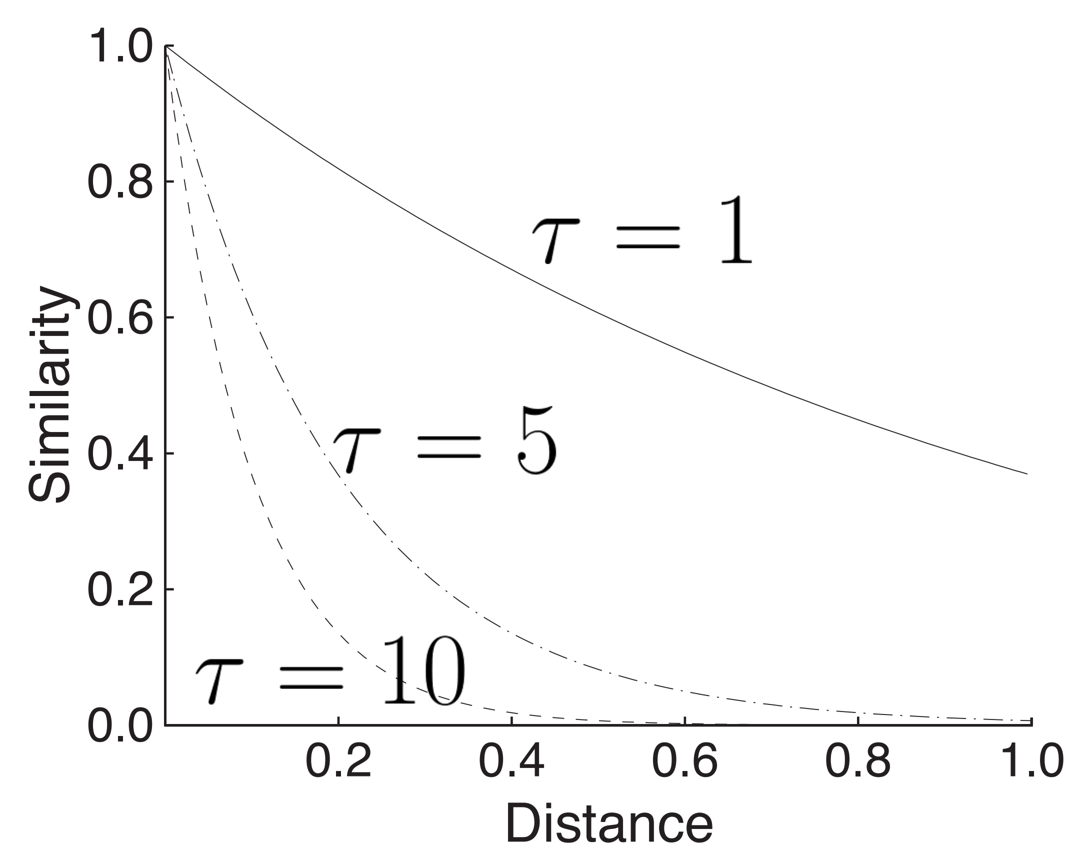


Distance vs. similarity

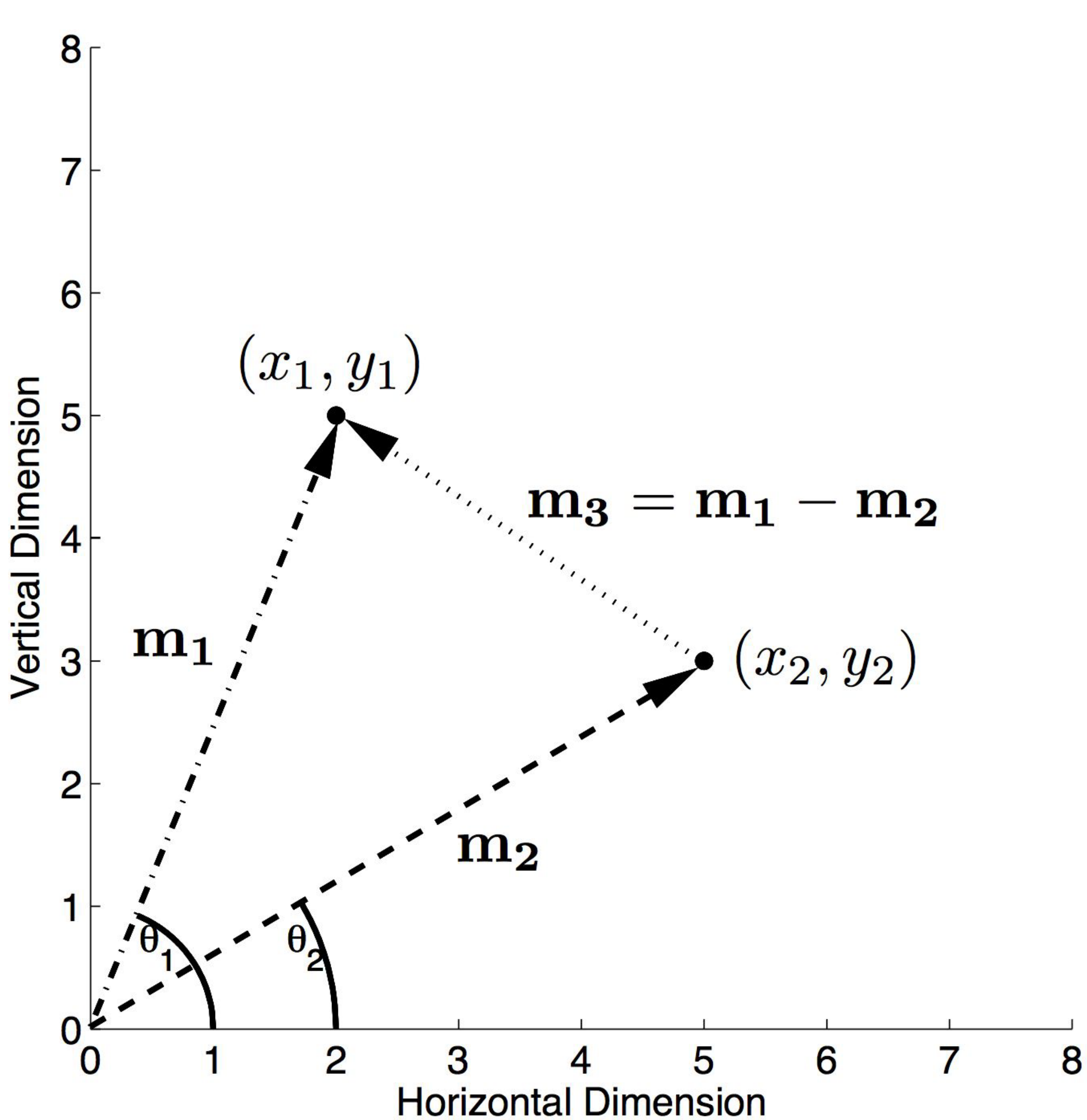
$$||\mathbf{m}_3|| = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

$$\text{similarity}(\mathbf{m}_1, \mathbf{m}_2) = e^{-\tau\sqrt{[m_1(1)-m_2(1)]^2+[m_1(2)-m_2(2)]^2}}$$





Another measure of similarity: cos$\boldsymbol{\theta}$



$$||\mathbf{m}_3|| = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

$$\cos\theta(\mathbf{m}_1, \mathbf{m}_2) = \frac{\mathbf{m}_1 \cdot \mathbf{m}_2}{||\mathbf{m}_1||\ ||\mathbf{m}_2||}$$

$$\mathbf{m}_1 \cdot \mathbf{m}_2 = m_1(1)m_2(1) + m_1(2)m_2(2)$$

House space

House space

House space

House space

House space

House space

Dimension	House 1	House 2	House 3	House 4	House 5
size (sq. feet)	3000	2200	1800	4700	8500
floors	2	2	1	3	2.5
windows	6	5	4	12	10
age (in years)	25	15	70	97	3
wood	0	1	0	0	1
brick	1	0	0	0	0
stone	0	0	0	1	0
colonial	1	0	1	0	0
Victorian	0	0	0	1	0
contemporary	0	1	0	0	1

House space

- We can represent each house as a vector of *features* or *attributes* (sometimes called **feature vectors**)
- Houses live in a more complicated space than rectangles:
    - More dimensions
    - We can go from houses to vectors, but not always from vectors to houses (some features are missing)
- We can compare which houses are similar

Generalized Euclidean distance

$$dist(\mathbf{a}, \mathbf{b}) = \sqrt{\sum_{i=1}^{N} (a_i - b_i)^2}$$

Sums

$$\sum_{i=1}^{N} x_i$$

Solve the sum…

$$\sum_{i=1}^{3} i^2 + 3$$

Solve the sum

(1) 2i

(2) $(1/3)i^3 + 3i$

(3) 15

(4) 23

(5) 9

$$\sum_{i=1}^{3} i^2 + 3$$

Solve the sum…

$$\sum_{i=1}^{3} i^2 + 3 = (1^2 + 3) + (2^2 + 3) + (3^2 + 3)$$

$$= 4 + 7 + 12$$

$$= 23$$

Generalized Euclidean distance

$$dist(\mathbf{a}, \mathbf{b}) = \sqrt{\sum_{i=1}^{N} (a_i - b_i)^2}$$

Thinking about lots of dimensions

- Geometric interpretation (tricky to visualize!)
- Abstract interpretation:
  - Think of things in 3 dimensions and (mentally) pretend they're roughly the same
- Problem set 3: work with many-dimensional versions of the similarity formulae