Similarity

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Cogsci 131

Kemp & Tenenbaum (2008)

- **In many cases, psychological space has interesting, nontrivial structure.**
- **How do you learn these domains?**

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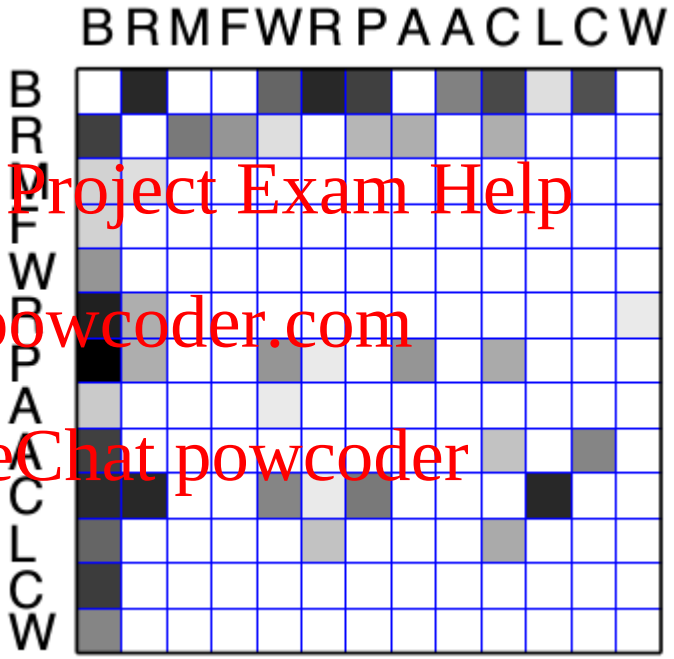
+ relational data
(or similarity, or feature-based)



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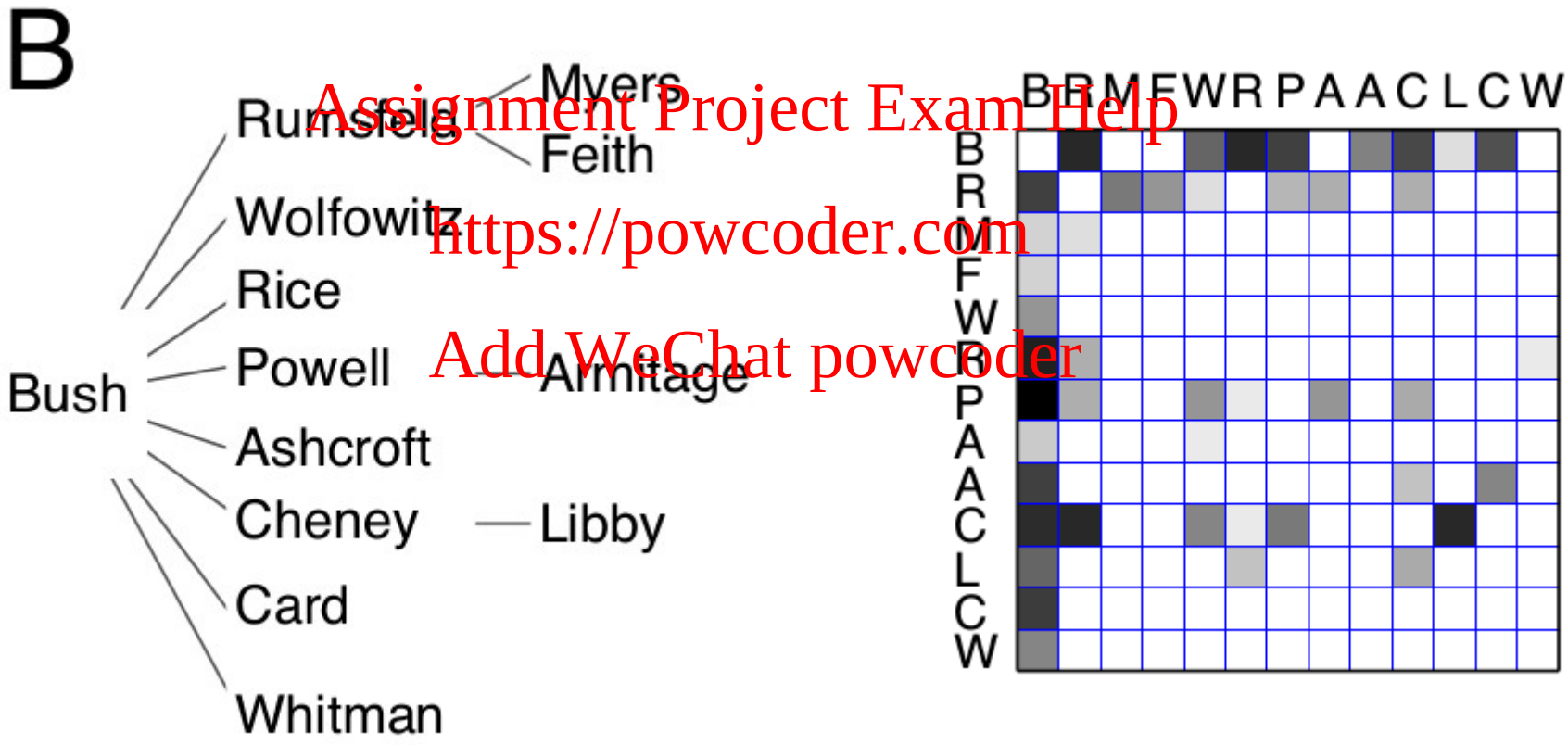
The model infers the structure behind the observed relational data



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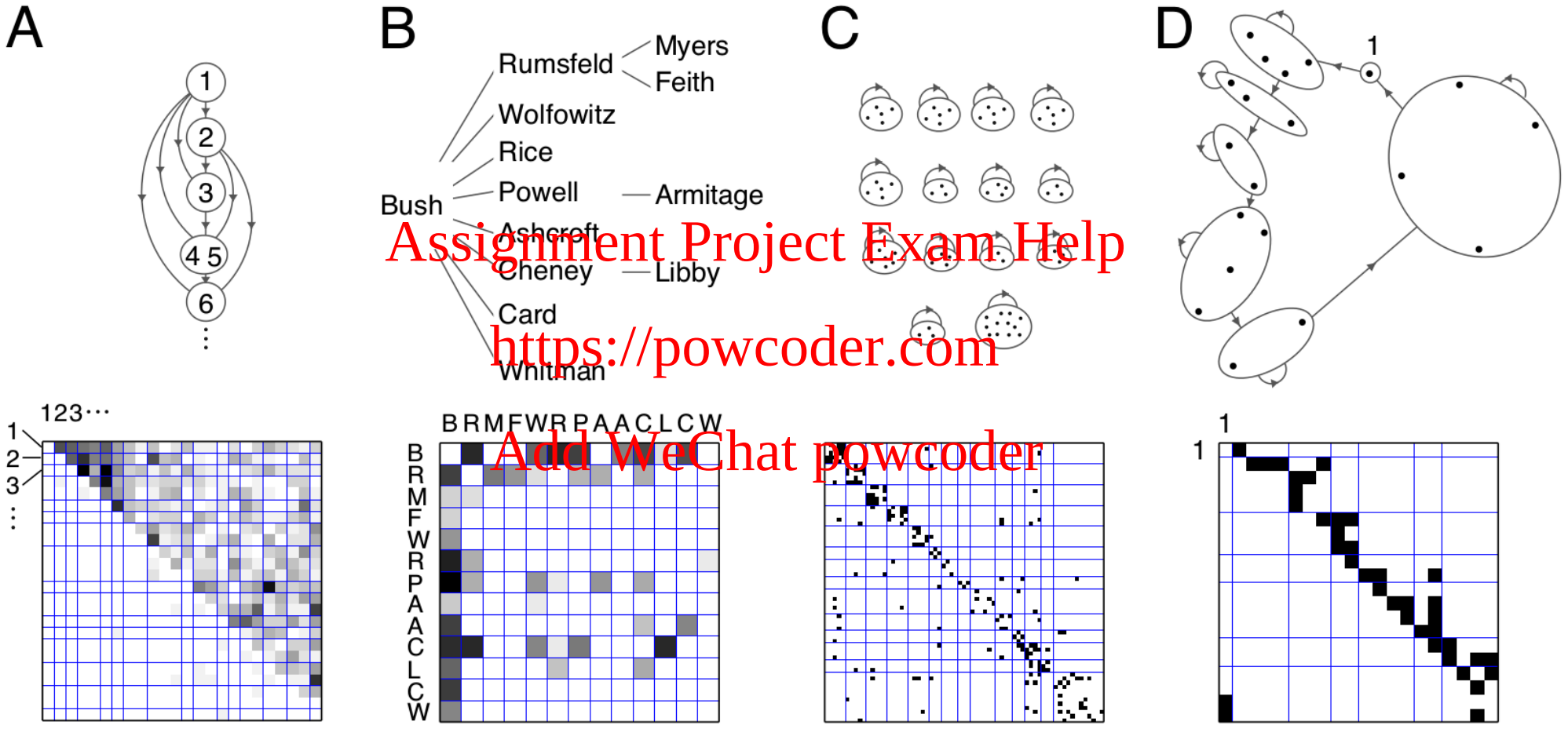

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A rich set of hypotheses:

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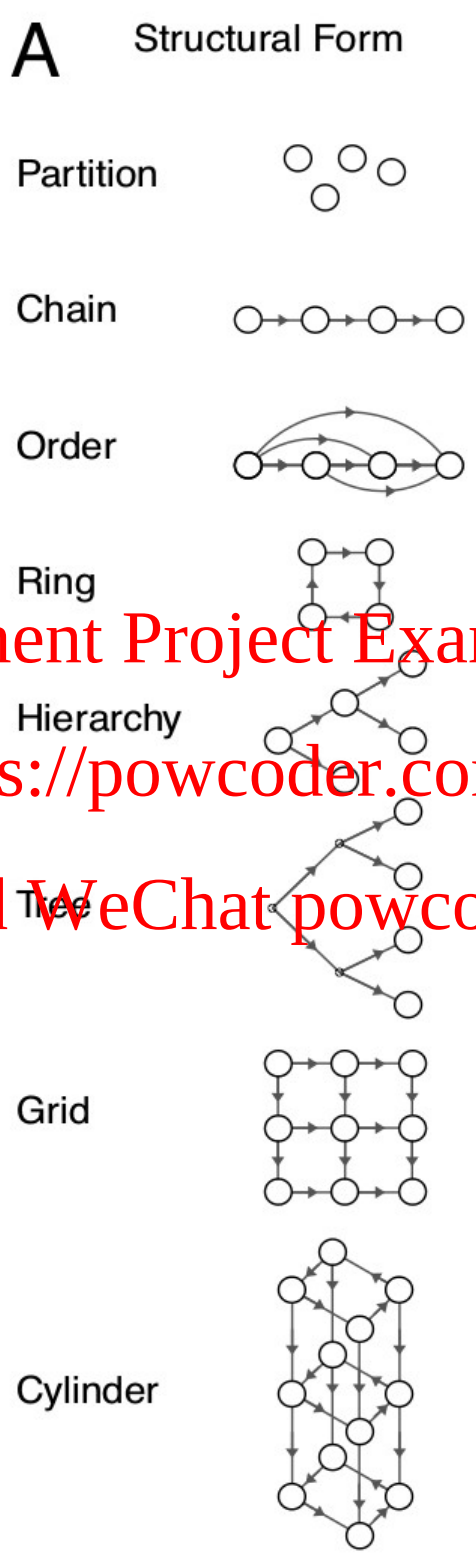

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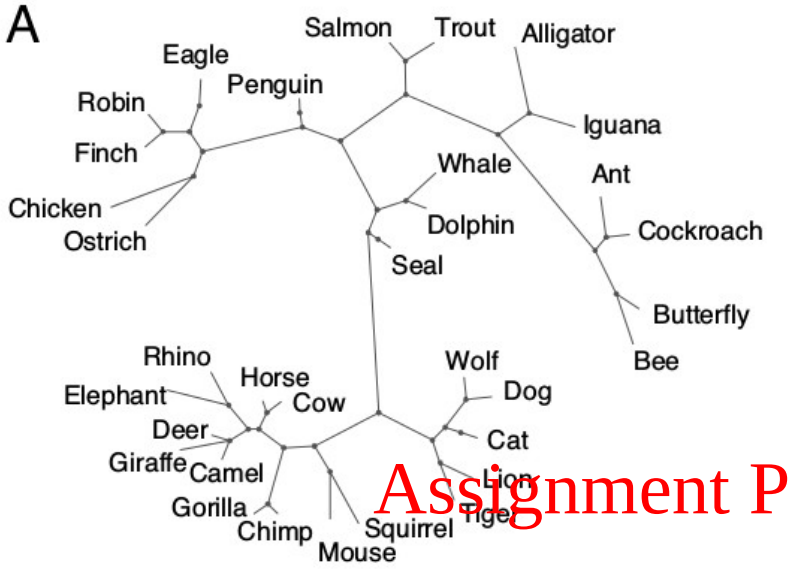

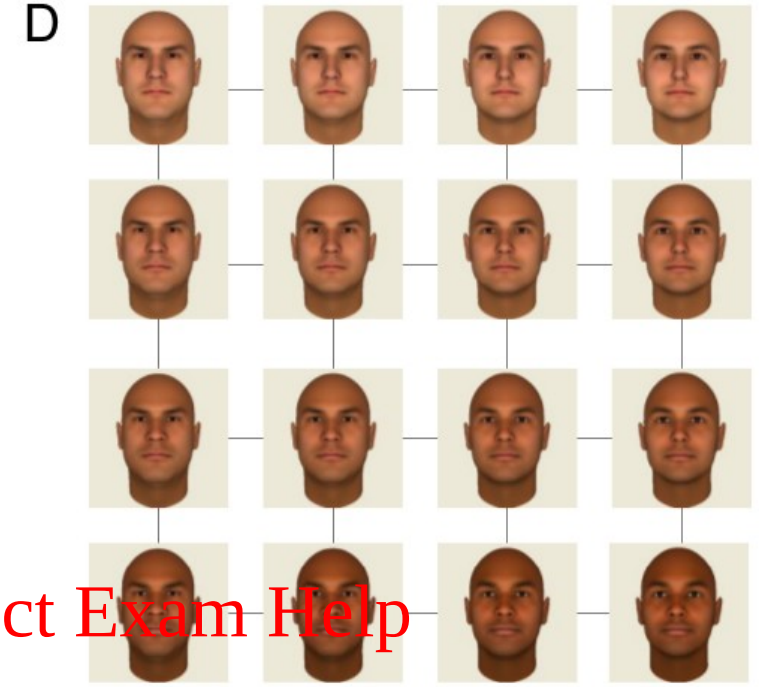

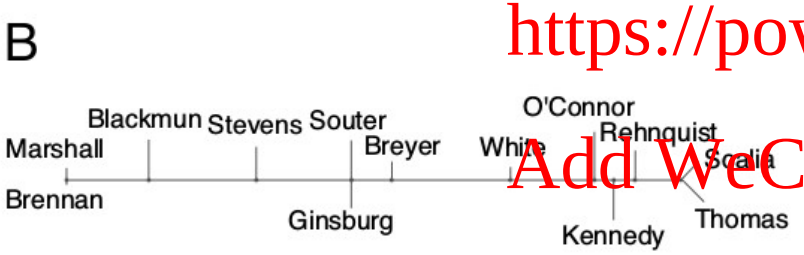

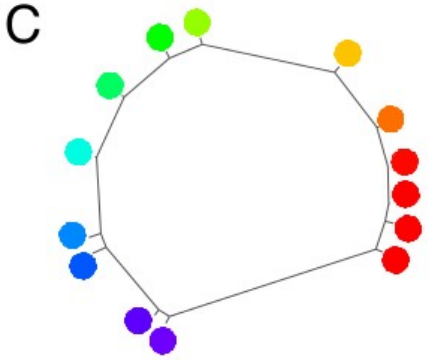

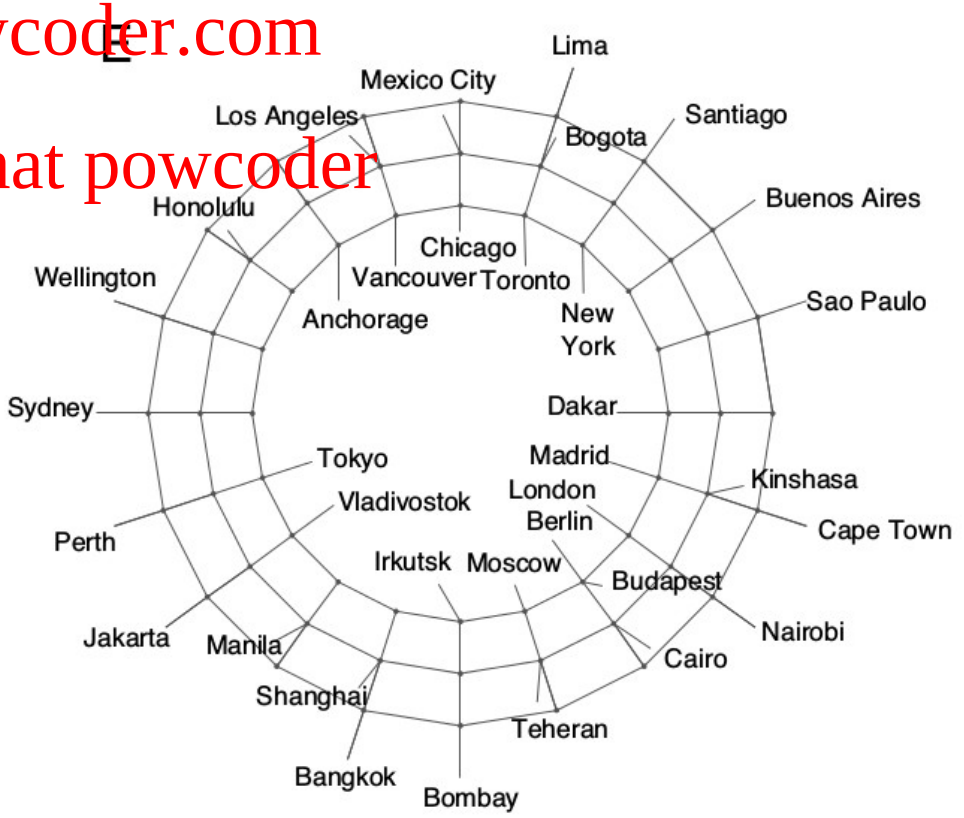

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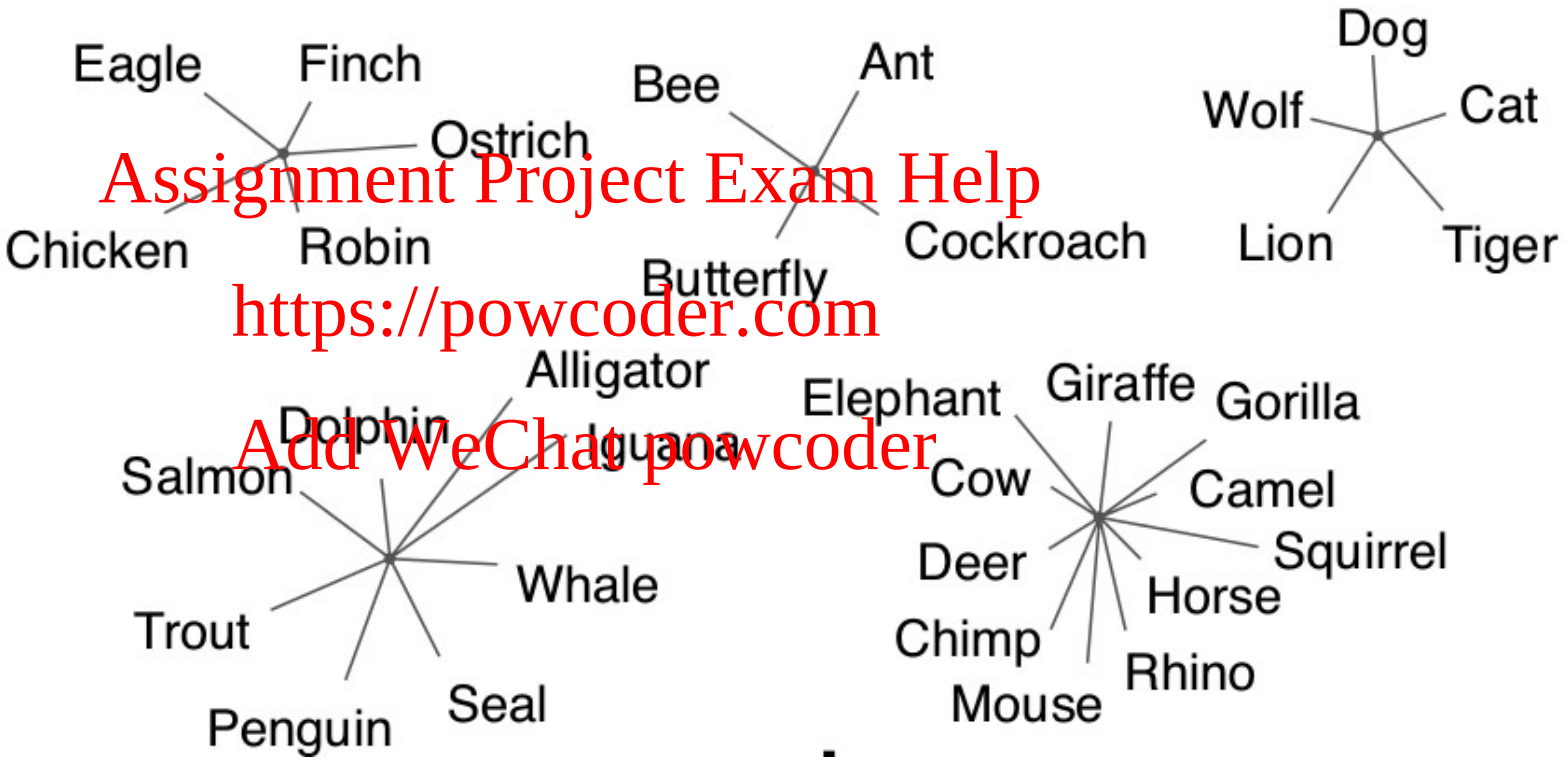
Also can model developmental trends



5 features

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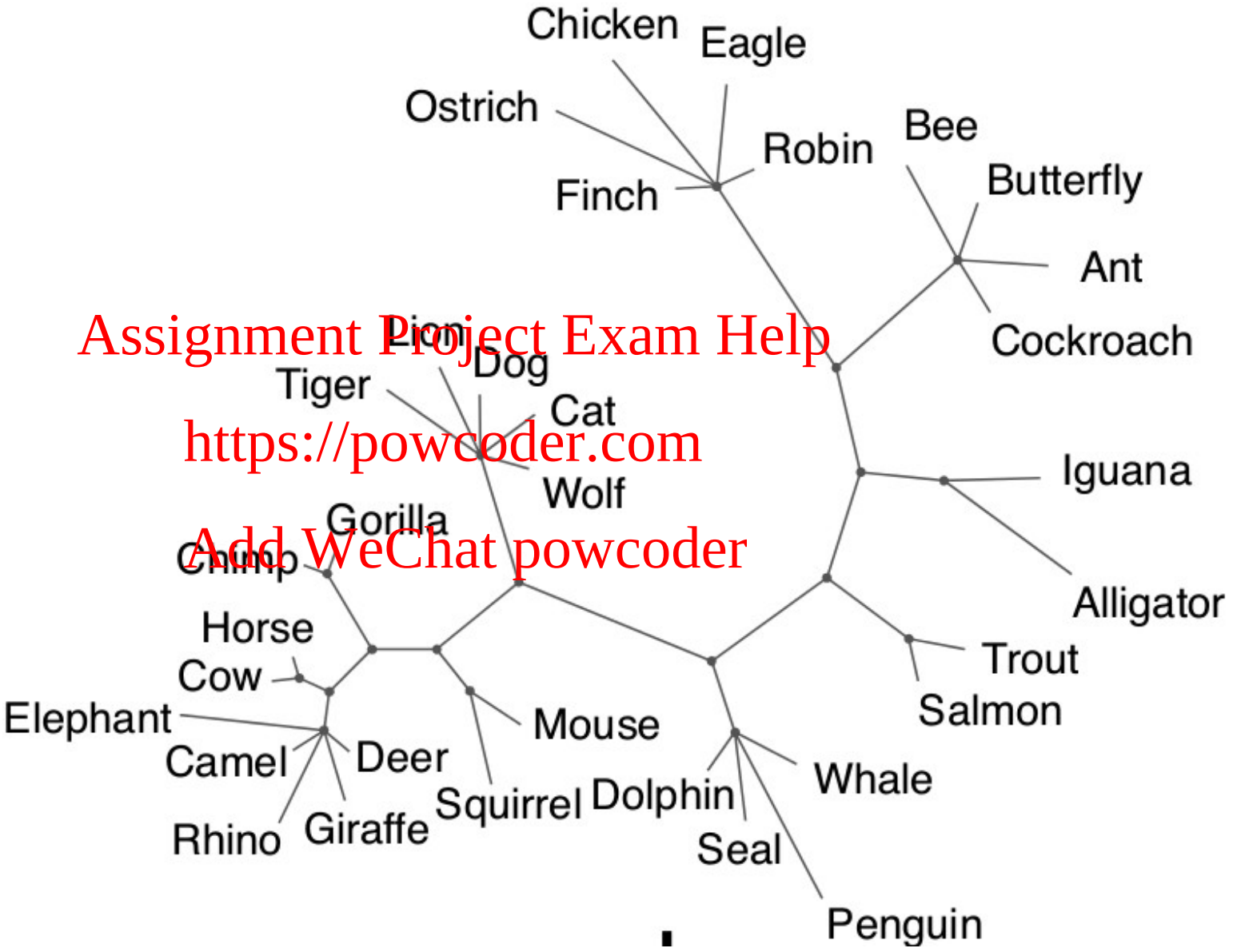
20 features



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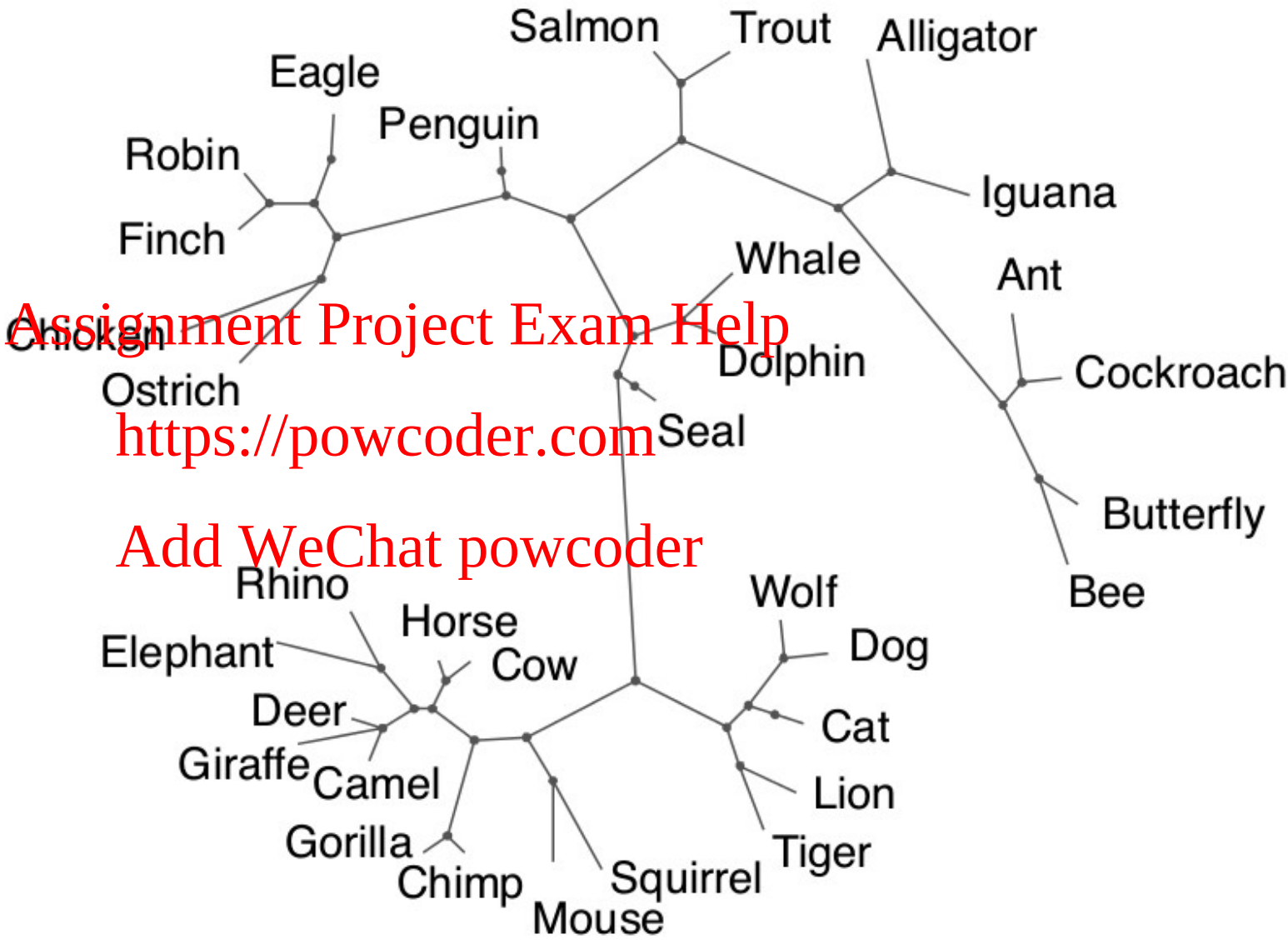
110 features



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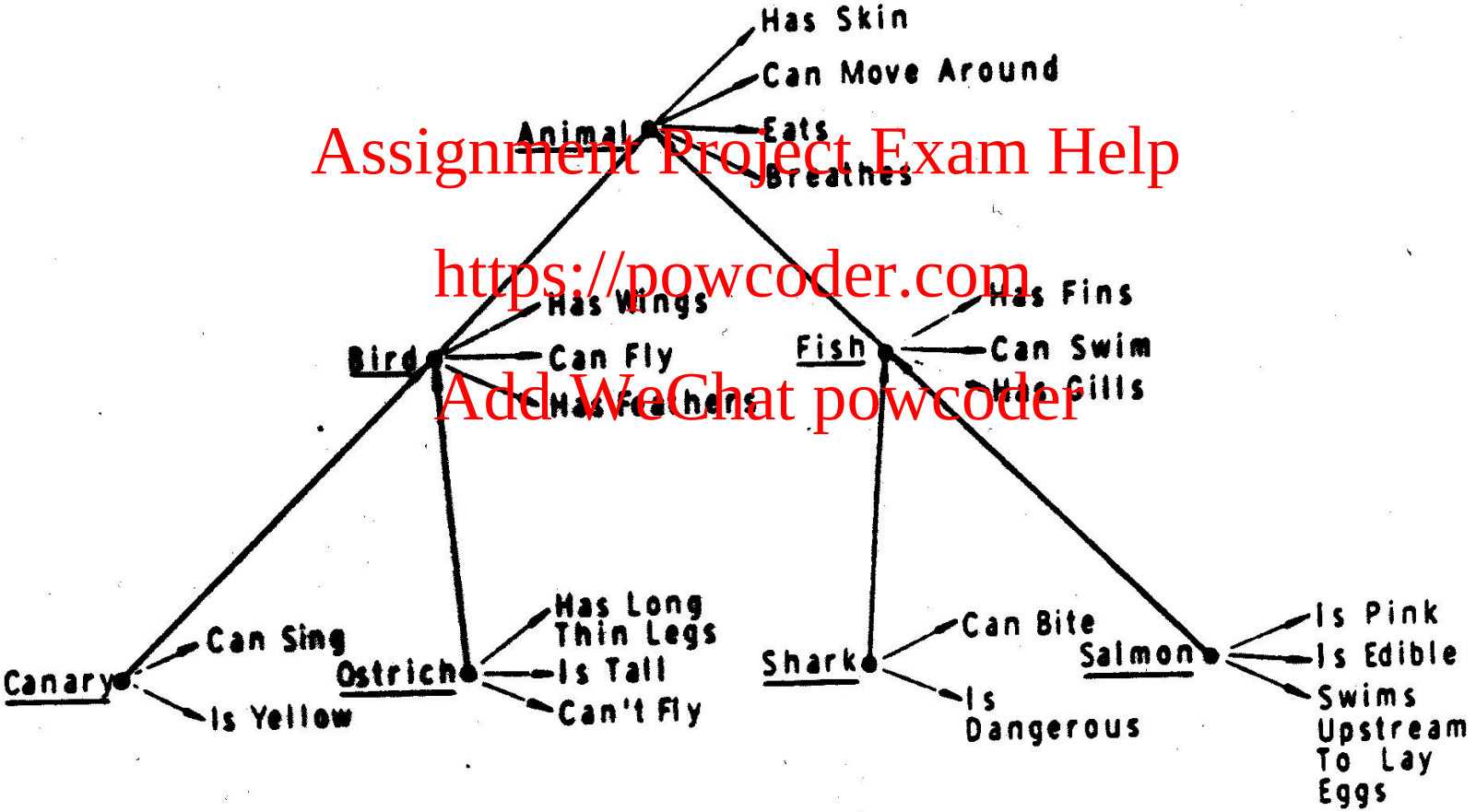
Quillian 1968



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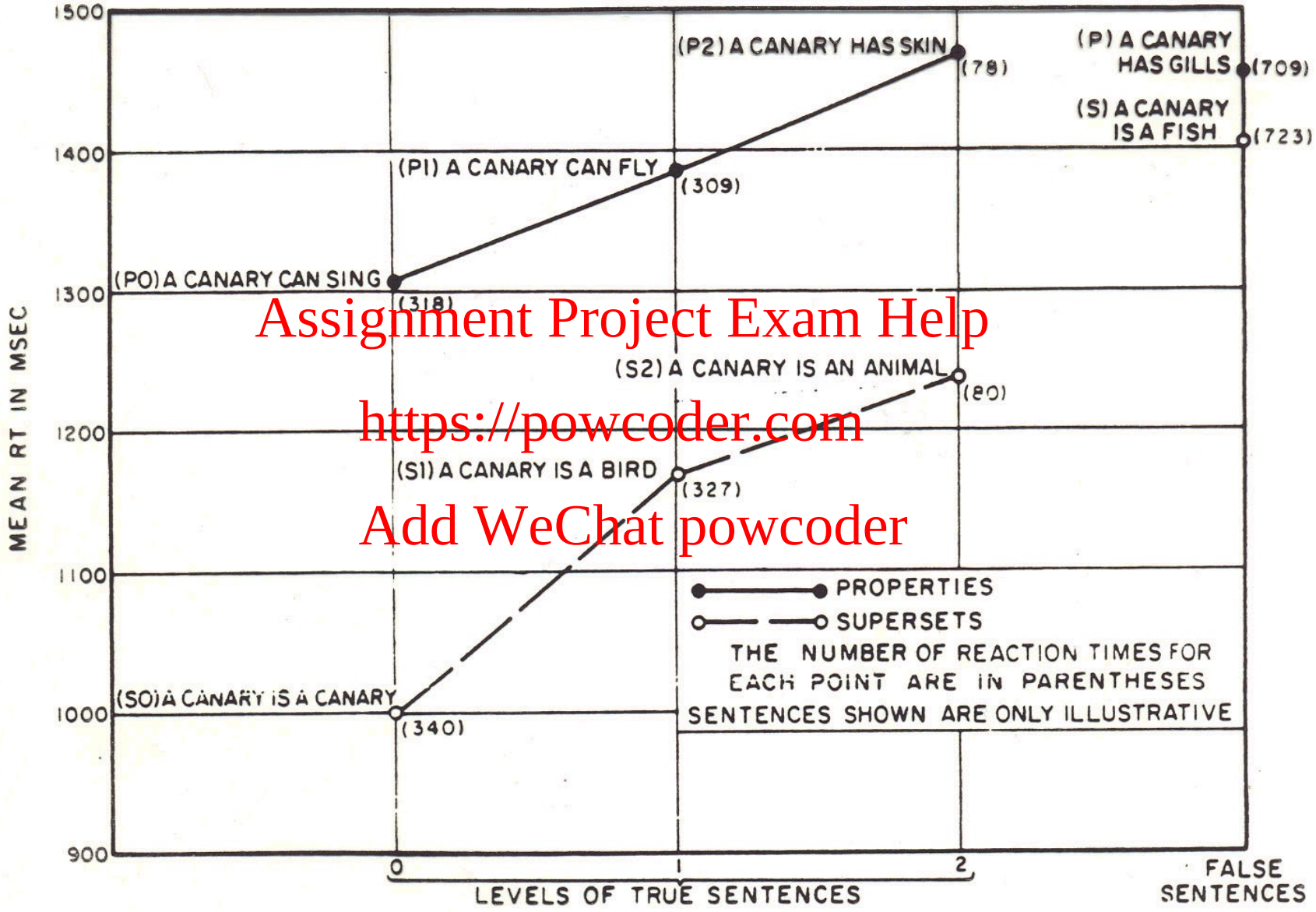

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Semantic networks

(Collins & Loftus 1975)

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Similarity?

- **So what is similarity exactly?**
- **Can it function as the "core" of conceptual representations?**

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Properties of distance

- **A lot of work on similarity is motivated by thinking about properties of distance (in mathematics, called a metric)**

- **Distances are symmetric:**

$$d(a,b) = d(b,a)$$

- **Distances obey the triangle inequality:**

$$d(a,b) \leq d(a,c) + d(c,b)$$

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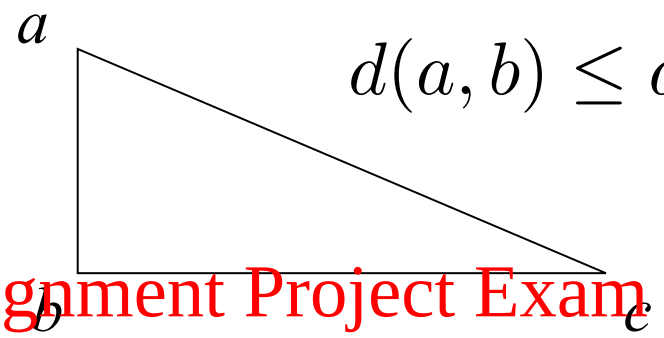
Violations of triangle inequality



$$d(a,b) \leq d(a,c) + d(c,b)$$

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Can find similarity judgments that violate this:

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a

c

b

(Tversky, 1977)

Some complications of similarity

- **Some quirks of psychological similarity:**
  - Similarity and distance are not always inversely related (across studies)
  - Similarity is not always symmetric.
  - Similarity depends on context.

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Similarity is not symmetric

- **Examples:**
  - 1007 is similar to 1000, but 1000 is not similar to 1007
  - An ellipse is similar to a circle, but a circle is not similar to an ellipse.
- Why is this a problem for MDS? Are distance measures in MDS necessarily symmetric?

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Tversky & Gati

TABLE 4.1
Percentage of Subjects That Selected the Prominent Pair in the Similarity Group (Π_s) and in the Difference Group (Π_d)

	Prominent Pairs	*Nonprominent Pairs*	Π_s	Π_d	$\Pi_s + \Pi_d$
1	W. Germany–E. Germany	Ceylon–Nepal	66.7	70.0	136.7
2	Lebanon–Jordan	Upper Volta–Tanzania	69.0	43.3	112.3
3	Canada–U.S.A.	Bulgaria–Albania	80.0	16.7	96.7
4	Belgium–Holland	Peru–Costa Rica	78.6	21.4	100.0
5	Switzerland–Denmark	Pakistan–Mongolia	55.2	28.6	83.8
6	Syria–Iraq	Liberia–Kenya	63.3	28.6	91.9
7	U.S.S.R.–U.S.A.	Paraguay–Ecuador	20.0	100.0	120.0
8	Sweden–Norway	Thailand–Burma	69.0	40.7	109.7
9	Turkey–Greece	Bolivia–Honduras	51.7	86.7	138.4
10	Austria–Switzerland	Zaire–Madagascar	79.3	24.1	103.4
11	Italy–France	Bahrain–Yemen	44.8	70.0	114.8
12	China–Japan	Guatemala–Costa Rica	40.0	93.1	133.1
13	S. Korea–N. Korea	Nigeria–Zaire	63.3	60.0	123.3
14	Uganda–Libya	Paraguay–Ecuador	23.3	65.5	88.8
15	Australia–S. Africa	Iceland–New Zealand	57.1	60.0	117.1
16	Poland–Czechoslovakia	Colombia–Honduras	82.8	37.0	119.8
17	Portugal–Spain	Tunis–Morocco	55.2	73.3	128.5
18	Vatican–Luxembourg	Andorra–San Marino	50.0	85.7	135.7
19	England–Ireland	Pakistan–Mongolia	80.0	58.6	138.6
20	Norway–Denmark	Indonesia–Philippines	51.7	25.0	76.7
	Average		59.1	54.4	113.5

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	p	q	Π
1	U.S.A.	Mexico	91.1
2	U.S.S.R.	Poland	98.6
3	China	Albania	94.1
4	U.S.A.	Israel	95.6
5	Japan	Philippines	94.2
6	U.S.A.	Canada	97.1
7	U.S.S.R.	Israel	91.1
8	England	Ireland	97.1
9	W. Germany	Austria	87.0
10	U.S.S.R.	France	82.4
11	Belgium	Luxembourg	95.6
12	W. Ger.	U.S.S.R.	65.7
13	China	N. Korea	95.6
14	India	Ceylon	97.1
15	U.S.A.	France	86.8
16	U.S.S.R.	Cuba	91.1
17	England	Jordan	98.5
18	France	Israel	86.8
19	U.S.A.	W. Germany	94.1
20	U.S.S.R.	Syria	98.5
21	France	Algeria	95.6

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Similarity depends on context

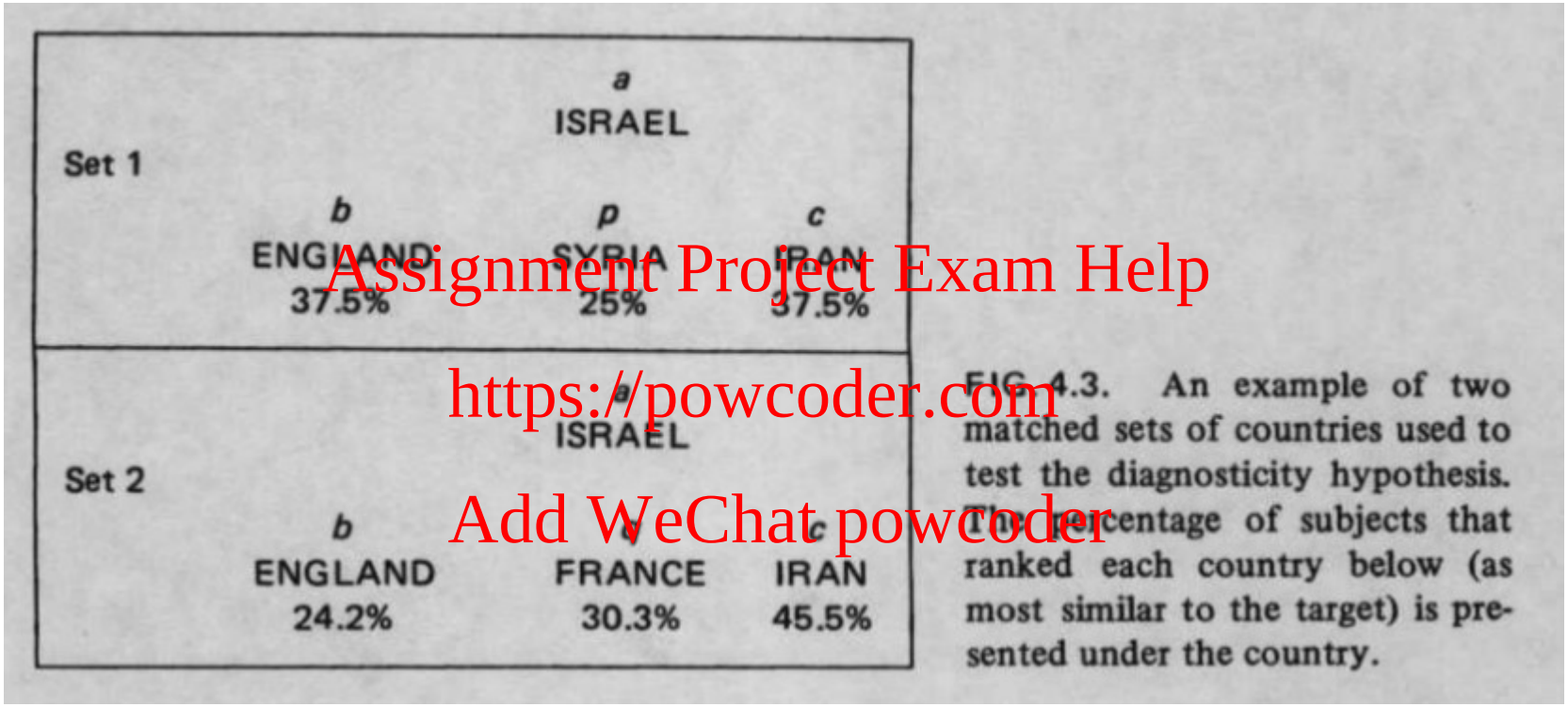

FIG. 4.3. An example of two matched sets of countries used to test the diagnosticity hypothesis. The percentage of subjects that ranked each country below (as most similar to the target) is presented under the country.

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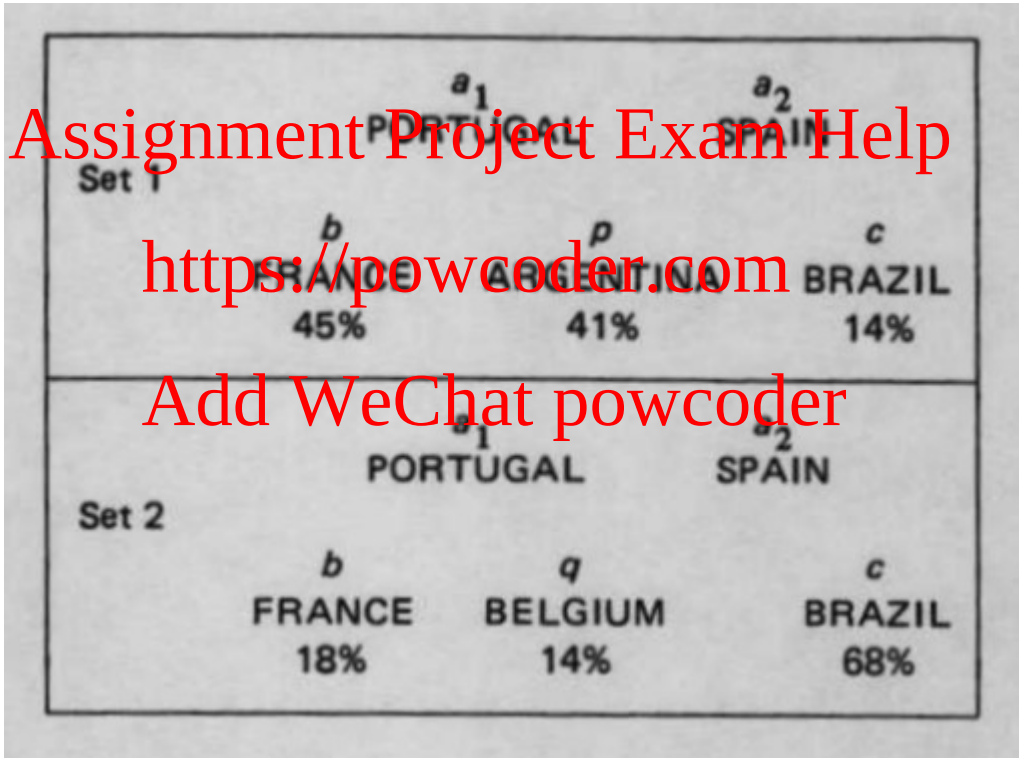

Similarity depends on context

TABLE 4.3
Average Similarities of Countries in Homogeneous (s_1) and Heterogeneous (s_2) Contexts

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Domain		$s_0(a, b)$	$s_e(a, b)$
American countries	Panama–Costa Rica	12.30	13.29
	Argentina–Chile	13.17	14.36
	Canada–U.S.A.	16.10	15.86
	Paraguay–Bolivia	13.48	14.43
	Mexico–Guatemala	11.36	12.81
	Venezuela–Colombia	12.66	13.06
	Brazil–Uruguay	13.03	14.64
	Peru–Ecuador	13.52	14.61
European countries	England–Ireland	13.88	13.37
	Spain–Portugal	15.44	14.45
	Bulgaria–Greece	11.44	11.00
	Sweden–Norway	17.09	15.03
	France–W. Germany	10.88	11.81
	Yugoslavia–Austria	8.47	9.86
	Italy–Switzerland	10.03	11.14
	Belgium–Holland	15.39	17.06

$$s(a,b) = \theta f(A \cap B) - \alpha f(A - B) - \beta f(B - A)$$

where $\theta, \alpha, \beta \geq 0$

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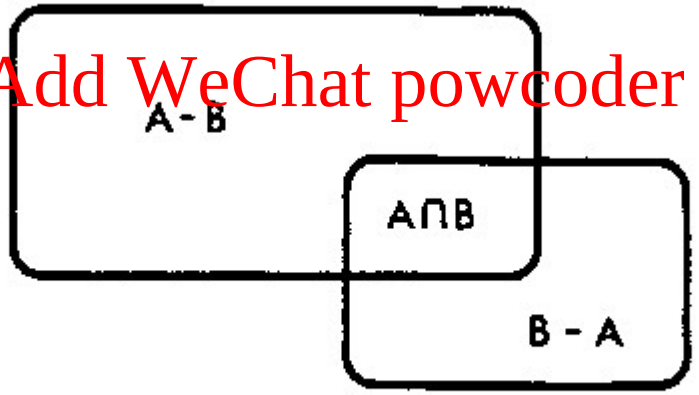

$$s(a,b) = \theta f(A \cap B) - \alpha f(A - B) - \beta f(B - A)$$

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where $\theta, \alpha, \beta \geq 0$

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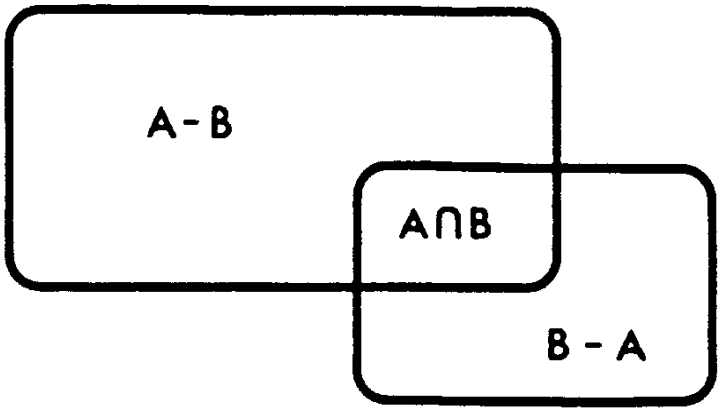

Tversky's contrast model

$$s(a,b) = \theta f(A \cap B) - \alpha f(A - B) - \beta f(B - A)$$

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where $\theta, \alpha, \beta \geq 0$

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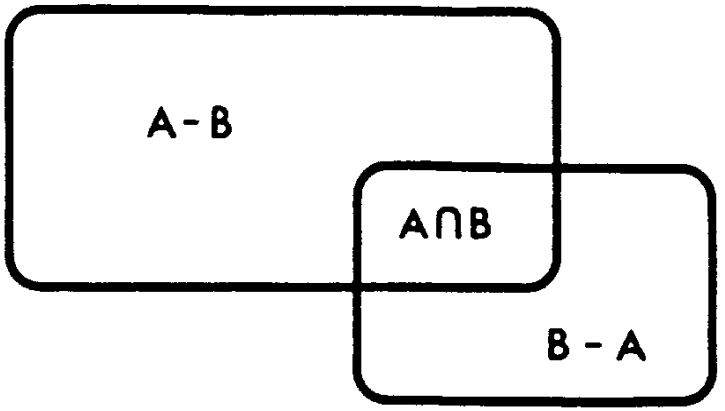
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