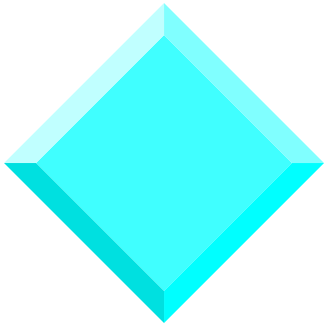

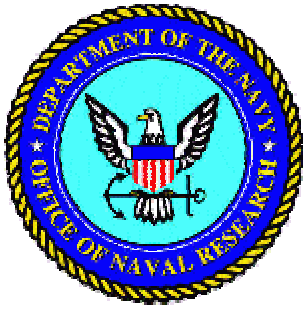

Frequency Learning with Symbolic Concept Acquisition

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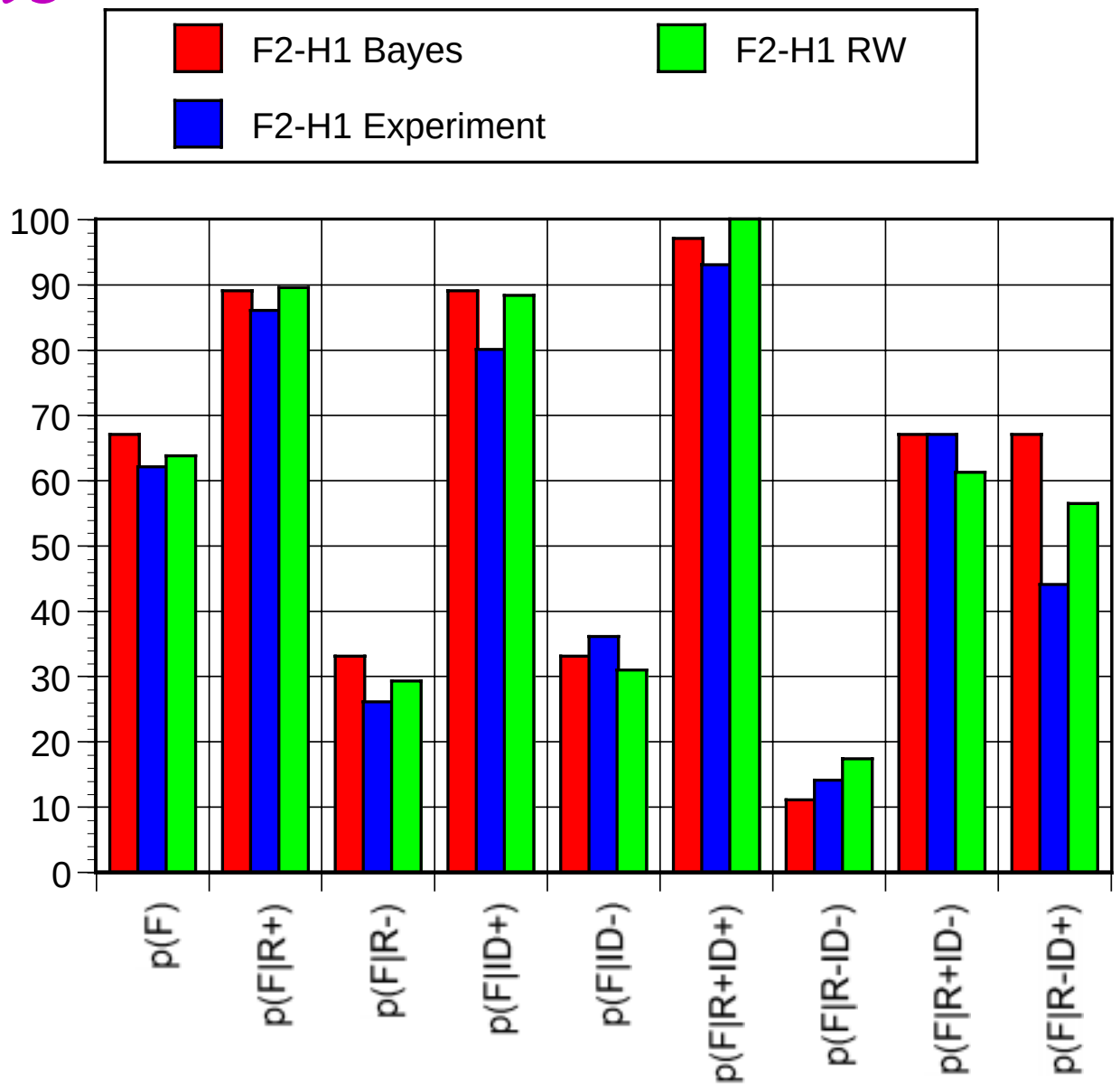
Frequency Learning

- Through experience people implicitly acquire and correctly use frequency information (e.g., Hasher & Zacks, 1984; Gluck & Bower, 1988).
  - Frequency of occurrence (base rates)
  - Conditional probabilities (P(H | D))
- Frequency acquisition is exhibited in subject behavior
  - Probability matching: Distribution of choices (approximately) matches the probability of each choice
  - People can closely estimate the acquired probabilities

Example: Identify Friend or Foe

- Determine whether a plane is hostile or friendly based on
  - Route: on (R+) or off (R-) a commercial air route
  - ID: commercial response (ID+) or no response (ID-) to a radio warning
- Probabilities
  - $P(F) = 2/3$, $P(H) = 1/3$
  - $P(ID+ \mid F) = P(R+ \mid F) = P(ID- \mid H) = P(R- \mid H) = .8$
  - $P(ID- \mid F) = P(R- \mid F) = P(ID+ \mid H) = P(R+ \mid H) = .2$
- Design
  - 75 trials for each subject (50 friendly, 50 hostile)
  - Each trial
    - Present evidence
    - Receive subject's decision (friendly or hostile)
    - Present actual intent

Results


F2-H1 Bayes
F2-H1 RW
F2-H1 Experiment
100
90
80
70
60
50
40
30
20
10
0
p(F)
p(F|R+)
p(F|R-)
p(F|ID+)
p(F|ID-)
p(F|R+ID+)
p(F|R-ID-)
p(F|R+ID-)
p(F|R-ID+)

Can Soar Learn and Use Frequencies?

- Soar has no direct support for frequency learning or for probabilistic selection of choices
- But: Symbolic Concept Acquisition (SCA) can exhibit frequency effects
- Learning
  - Supervised inductive concept learning
  - Learns a mapping from a set of features to a class
  - Mapping is a set of recognition rules
  - Acquires recognition rules from abstract (few features) to specific (all features)

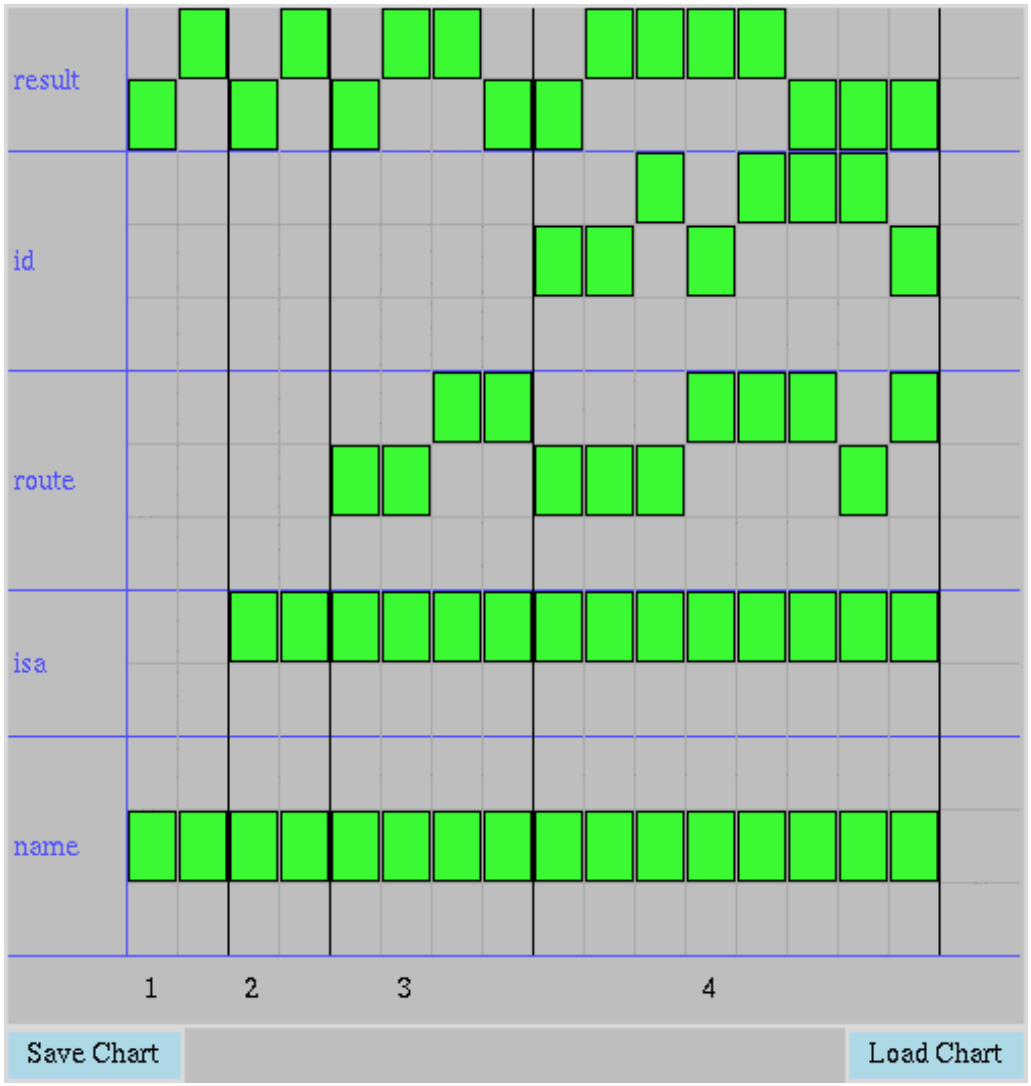
SCA Rules Example

result

id

route

isa



hostile
friendly

no-response
commercial

off-commercial
on-commercial

contact

object1

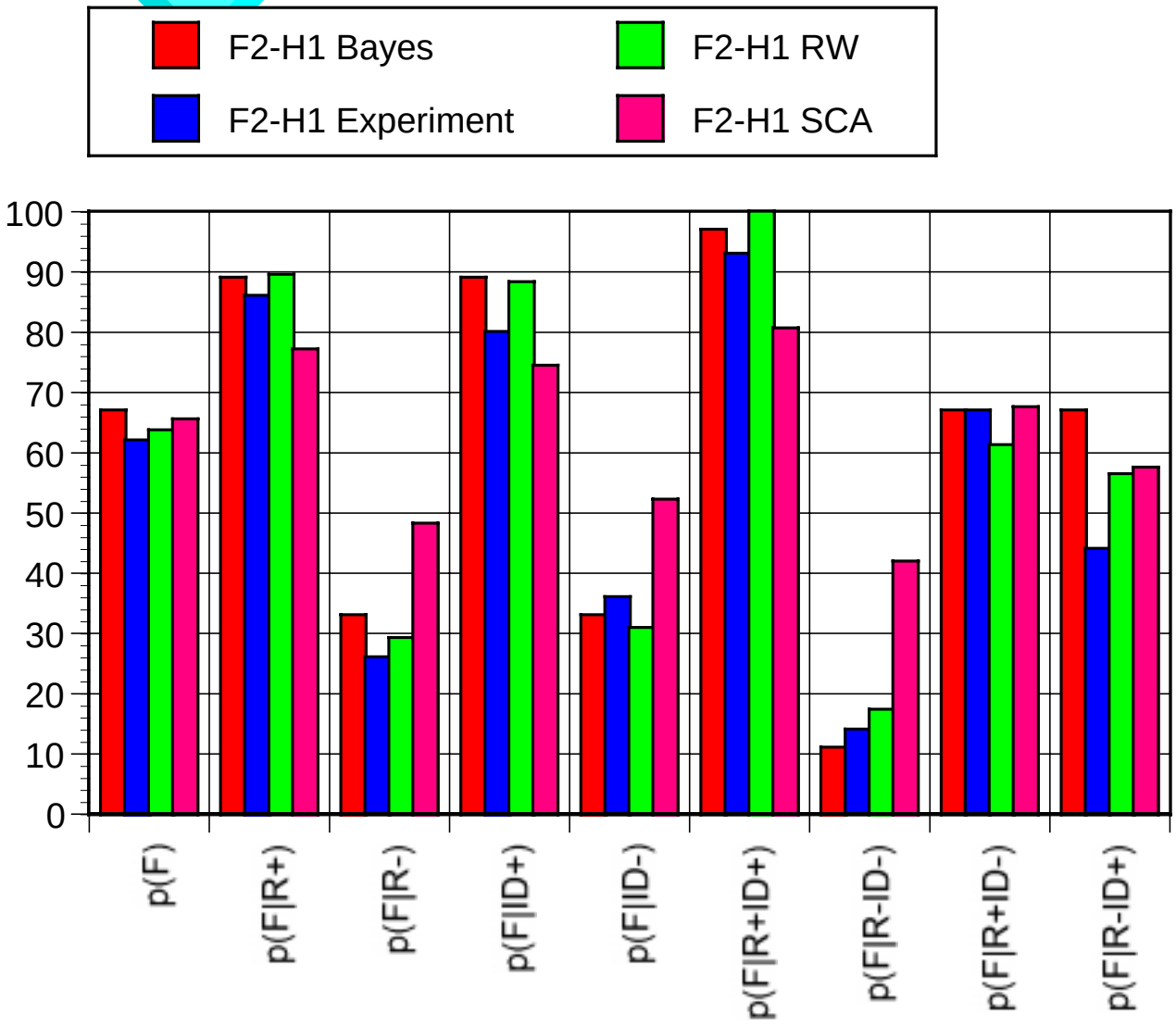
Prediction in SCA

- Try to match recognition rules from specific to general, based on the number of features tested by the rules.
- Example: 4 feature rules, 3, 2, 1.
- Stop whenever one or more rules fire and randomly select from among the proposed classes

Applying SCA to the Friend or Foe Task

- Using Doug Pearson's SCA2
- Features and values
  - Name: object1
  - isa: contact
  - Route: on_commercial, off_commercial
  - ID: commercial, no_response
- Categories
  - Friendly
  - Hostile
- For each instance (trial)
  - First, SCA makes a prediction
  - Second, SCA is trained using the instance and the actual outcome

SCA Results



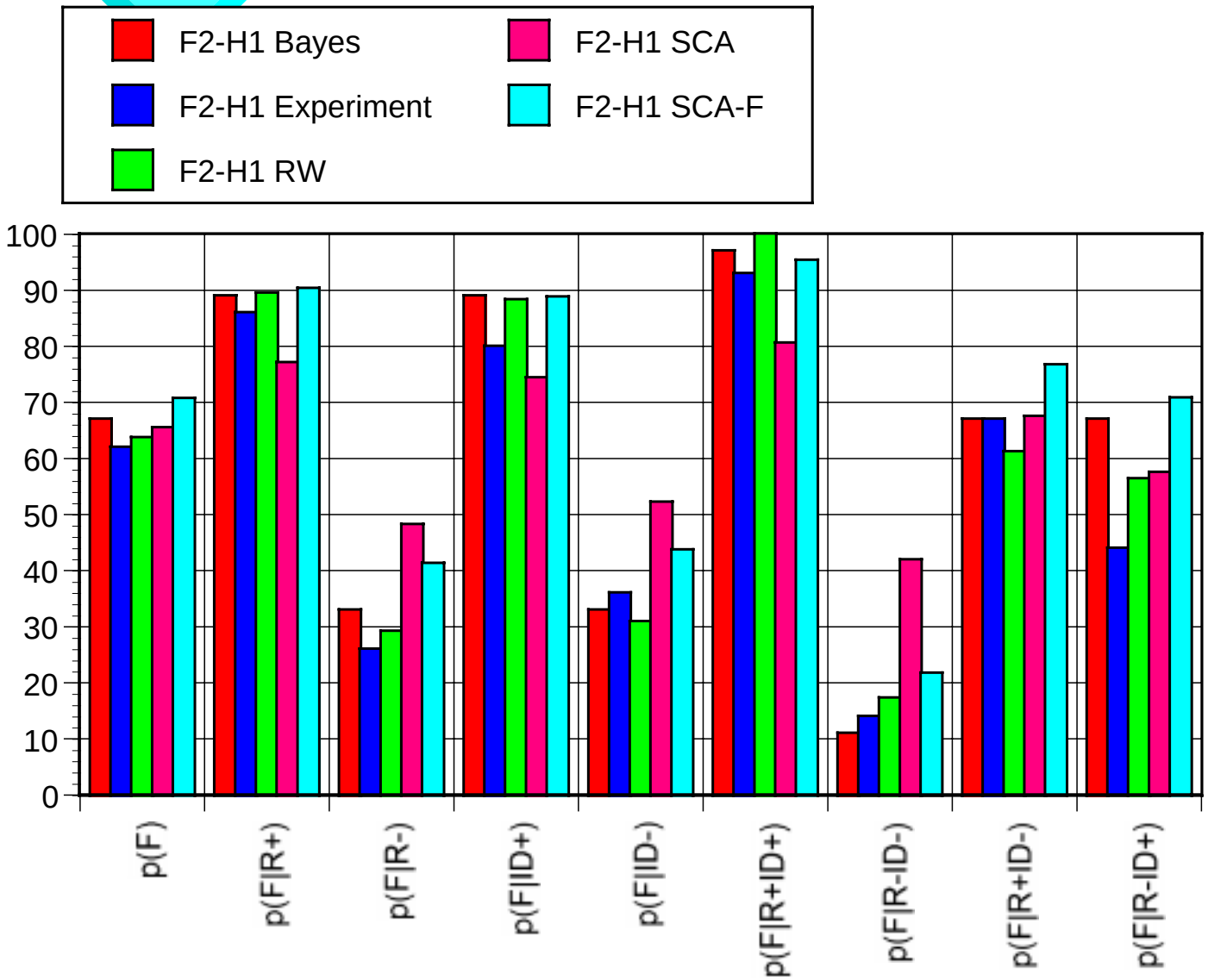
The model tends to get pulled to 50%.

Explanation: With enough trials SCA learns a friendly and hostile rule for each feature set.

Modifyng SCA to Support Frequency Learning (SCA-F)

- Learn a duplicate rule for fully specialized instances
- For example:
  - If R+, ID+ then Propose F1: Friendly
  - If R+, ID+ then Propose F2: Friendly
  - If R+, ID+ then Propose H1: Hostile
  - Since Soar will randomly select a class,
    - P(F|R+ID+) = 2/3
    - P(H|R+ID+) = 1/3

SCA-F Results



In all cases, SCA-F produces better results than SCA.

Conclusion

- Golden Nuggets
  - SCA-F (and Soar) can do frequency learning
  - Performs almost as well as Rescorla-Wagner
  - Consistent with instance based theories of learning (e.g., Logan)
- Lumps of Coal
  - Does not handle temporal sequences of features
  - Does not predict order effects in belief updating
  - No theory for converting implicit frequencies into verbalizable ones
- Coal Dust
  - Currently time increases with the number of rules