COGSCI131–Spring 2019 — Homework 1Solutions

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1.

(a) Suppose that we repeatedly pair a light with food. Plot the association strength between light and food according to the Rescorla-Wagner model for

$$\lambda = 1.0, \alpha = 0.75, \beta = 0.1$$

for an initial association of 0.05 and for 0.5. Plot 20 trials.

- Rescorla-Wagner model writes as

$$\Delta V_x = \alpha_x \beta(\lambda - \Sigma_y V_y)$$

- Simplify model as

$$\Delta V_{light} = \alpha_{light} \beta(\lambda - V_{light})$$

  in numerical form:

$$\Delta V_{light} = 0.75 \times 0.1(1 - V_{light})$$

- for an initial association of 0.05

```
import matplotlib.pyplot as plt

fig=plt.figure()
ax=fig.add_subplot(111)
x=[None]*20
y = [i for i in range(20)]
x[0]=0.05
for i in range(0,19):
    x[i+1]=x[i]+0.075*(1-x[i])
ax.plot(x,color="lightblue",linewidth=1)
ax.scatter(y,x,color="black",marker="*")
plt.ylabel('Association Strength')
plt.xlabel('Number of pairings')
plt.savefig("1aa.png")
plt.show()
```

- for an initial association of 0.5

```
import matplotlib.pyplot as plt

fig=plt.figure()
ax=fig.add_subplot(111)
x=[None]*20
y = [i for i in range(20)]
x[0]=0.5
for i in range(0,19):
```

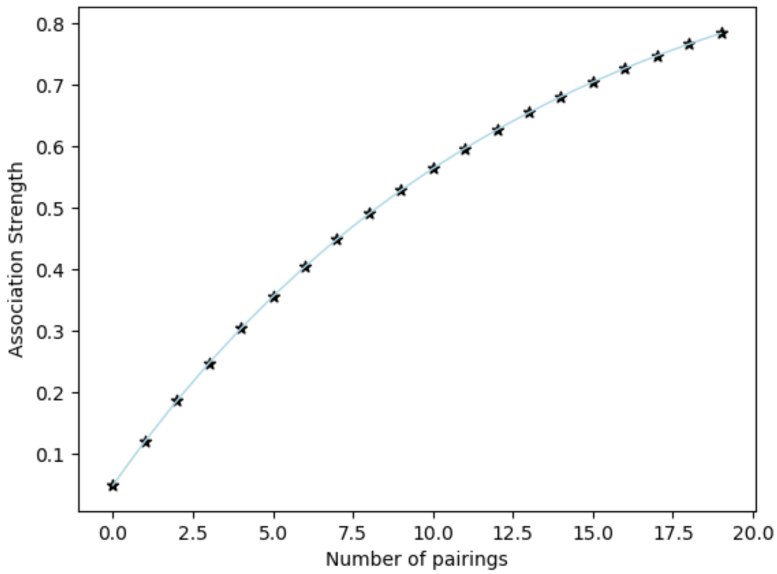

Figure 1: initial association of 0.05.

```
    x[i+1]=x[i]+0.075*(1-x[i])
ax.plot(x,color="lightblue",linewidth=1)
ax.scatter(y,x,color="black",marker="*")
plt.ylabel('Association Strength')
plt.xlabel('Number of pairings')
plt.savefig("1a.png")
plt.show()
```

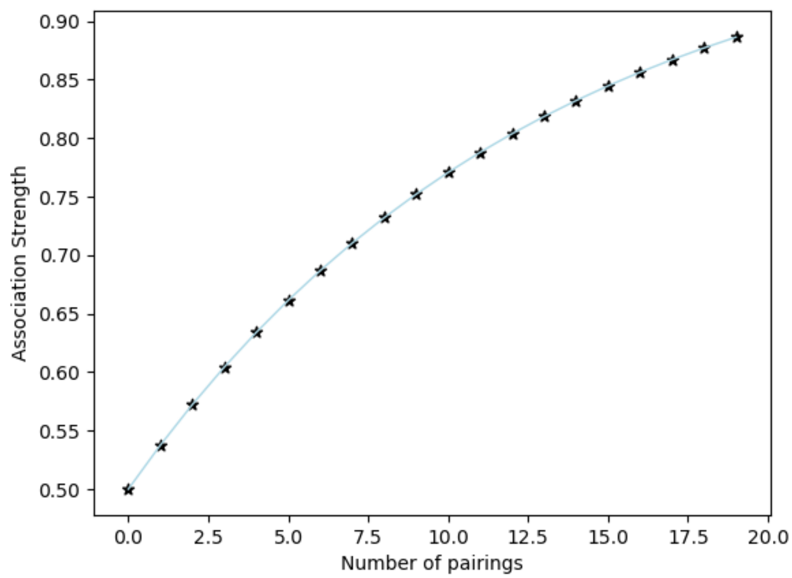

Figure 2: initial association of 0.5.

(b) How many trials will it take to reach

$$V_{light} = 0.8$$

if the initial association is 0.05?

- the 21st trail reach
$$V_{light} = 0.8$$
- at this point
$$V_{light} = 0.8002171243267356$$

```
import matplotlib.pyplot as plt

fig=plt.figure()
ax=fig.add_subplot(111)
x=[0.05]
i=0
while (x[i]<0.8):
    x.append(x[i]+0.075*(1-x[i]))
    i=i+1
print(i+1)
print(x[i])
```

(c) Suppose, with

$$\lambda = 1.0, \beta = 0.1,$$

that it takes a 13 trials for a bell's association with food to exceed 0.8. What is the salience?

- Model writes as

$$\Delta V_{light} = 0.1\alpha_{light}(1 - V_{light})$$

Solve numerically: formula write in sequence of number form:

$$\begin{aligned} a_{n+1} - a_n &= k(1 - a_n) && (1) \\ \Rightarrow a_{n+1} - 1 &= (1 - k)(1 - a_n) && (2) \\ \Rightarrow a_n &= 1 + (a_0 - 1)(1 - k)^n && (3) \\ a_0 = 0,\ (0 - 1) \times (1 - k)^{13} &= 0.8 - 1 && (4) \\ \Rightarrow k &= 0.11644604222876276 && (5) \end{aligned}$$

thus, salience

$$\alpha_{light} = 1.16$$

2.

- Model writes as

$$\Delta V_{bell} = 0.75 \times 0.1(1 - V_{light} - V_{bell}) \tag{6}$$
$$\Delta V_{light} = 0.75 \times 0.1(1 - V_{light} - V_{bell}) \tag{7}$$

  (6)-(7),

$$\Delta V_{bell} = \Delta V_{light}$$

- initial

$$V_{light} = 0.8$$
$$V_{bell} = 0$$

  thus, for every trail:

$$V_{light} = V_{bell} + 0.8$$
$$\Delta V_{bell} = 0.075(0.2 - 2V_{bell})$$

  Solve numerically: formula write in sequence of number form:

$$a_{n+1} - a_n = 0.075(0.2 - 2a_n) \tag{8}$$
$$\Rightarrow a_{n+1} - 0.1 = 0.85(a_n - 0.1) \tag{9}$$
$$\Rightarrow a_n = 0.1 + (0 - 0.1)0.85^{n-1} \tag{10}$$

$$\Rightarrow V_{bell}(n) = 0.1 - 0.1 \times 0.85^{n-1}$$

```python
import matplotlib.pyplot as plt

fig=plt.figure()
ax=fig.add_subplot(111)
x=[0]*100
y=[0]*100
z = [i for i in range(100)]
x[0]=0.8
y[0]=0
for i in range(0,99):
    x[i+1]=x[i]+0.075*(1-x[i]-y[i])
    y[i+1]=y[i]+0.075*(1-x[i]-y[i])
ax.plot(x,color="lightblue",linewidth=1)
ax.plot(y,color="lightgreen",linewidth=1)
#ax.scatter(z,x,color="black",marker="*")
#ax.scatter(z,y,color="black",marker="+")
plt.ylabel('Association Strength')
plt.xlabel('Number of pairings')
plt.savefig("2.png")
plt.show()
```

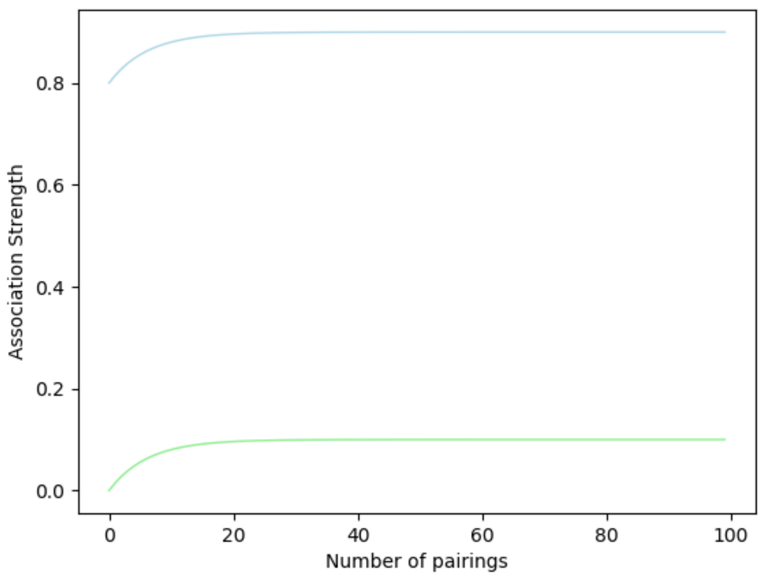

Figure 3: association strength between bell and food(green)

3.

(a) Suppose you repeatedly alternate trials, pairing a bell and food and a bell and no food. If you do this for a long time, what will the association strength be if

$$\lambda = 0$$

Make a plot of what happens and provide an intuitive explanation for why

- Learning and Extinction model:

$$\Delta V_x = \alpha_x \beta(\lambda - \Sigma_y V_y)$$

$$\Delta V_x = \alpha_x \beta(-\Sigma_y V_y)$$

in numerical form:

$$\Delta V_{light} = 0.75 \times 0.1(1 - V_{light})$$
$$\Delta V_{light} = 0.75 \times 0.1(-V_{light})$$

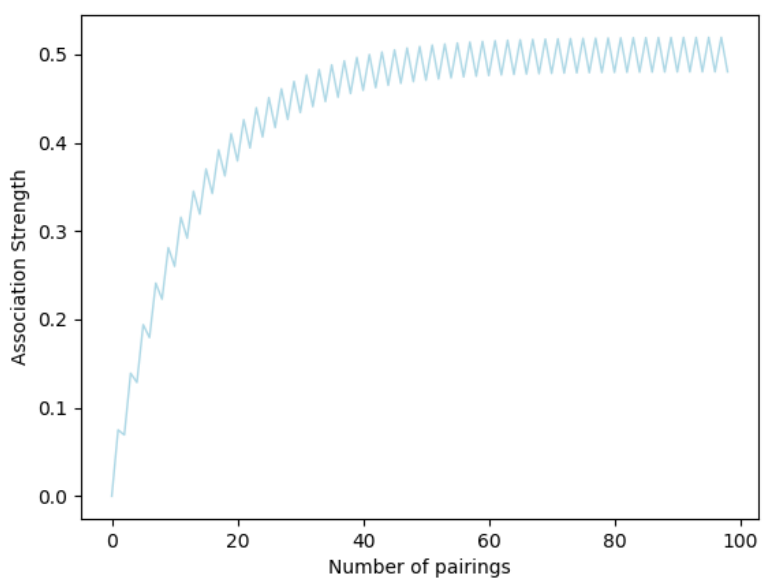

Figure 4: alternate trials curve

```
import matplotlib.pyplot as plt

fig=plt.figure()
ax=fig.add_subplot(111)
x=[None]*100
z = [i for i in range(100)]
x[0]=0
for i in range(0,49):
    x[2*i+1]=x[2*i]+0.075*(1-x[2*i])
    x[2*i+2] = x[2*i+1] - 0.075*(x[2*i+1])
ax.plot(x,color="lightblue",linewidth=1)
```

```
#ax.plot(y,color="lightgreen",linewidth=1)
#ax.scatter(z,x,color="black",marker="*")
#ax.scatter(z,y,color="black",marker="+")
plt.ylabel('Association Strength')
plt.xlabel('Number of pairings')
plt.savefig("3a.png")
plt.show()
```

Association goes to an expectation of 0.5. That is exactly the mathematical result of such a random variable.

(b) Suppose that, on a given trial, with probability P you pair a bell with food, and with probability 1-P you pair a bell with no food. What will the association strength be after many trials of this, if you assume

$$\lambda = 1.0$$

Plot some examples. Provide a short intuitive explanation on Marr's computational level.

- assume p=0.7, on a small scale

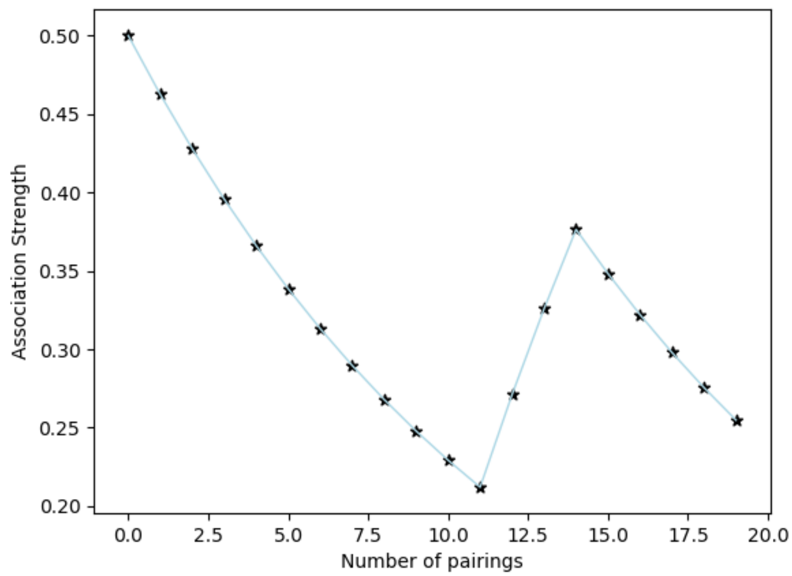

Figure 5: p=0.7, trail 20 times

```
import matplotlib.pyplot as plt
import random
fig=plt.figure()
ax=fig.add_subplot(111)
x=[None]*20
p=0.7
y = [i for i in range(20)]
x[0]=0.5
for i in range(0,19):
    if(random.random()>p):x[i+1]=x[i]+0.075*(1-x[i])
    else:x[i+1]=x[i]-0.075*(x[i])
ax.plot(x,color="lightblue",linewidth=1)
ax.scatter(y,x,color="black",marker="*")
plt.ylabel('Association Strength')
plt.xlabel('Number of pairings')
plt.savefig("3b1.png")
plt.show()
```

- assume p=0.7, trail on a large scale

```
import matplotlib.pyplot as plt
import random
fig=plt.figure()
```

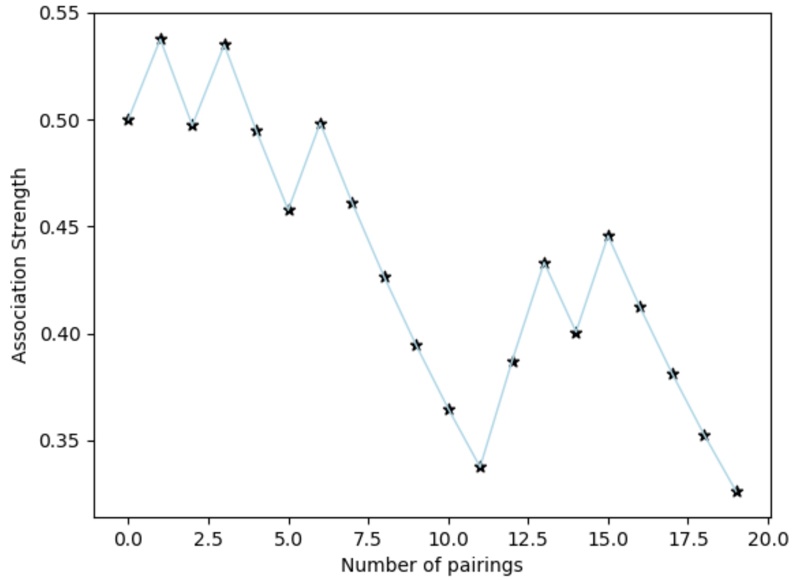

Figure 6: p=0.7, trail 20 times

```
ax=fig.add_subplot(111)
x=[None]*2000
p=0.7
y = [i for i in range(2000)]
x[0]=0.5
for i in range(0,1999):
    if(random.random()>p):x[i+1]=x[i]+0.075*(1-x[i])
    else:x[i+1]=x[i]-0.075*(x[i])
ax.plot(x,color="lightblue",linewidth=1)
#ax.scatter(y,x,color="black",marker="*")
plt.ylabel('Association Strength')
plt.xlabel('Number of pairings')
plt.savefig("3b5.png")
plt.show()
```

Conclusion: Association can not built, no matter how many trails have been executed.

Computational level in Marr's levels of analysis: what problem does the system solve? Is the organism optimal in some sense?
As we read from the figure, association are totally not built.

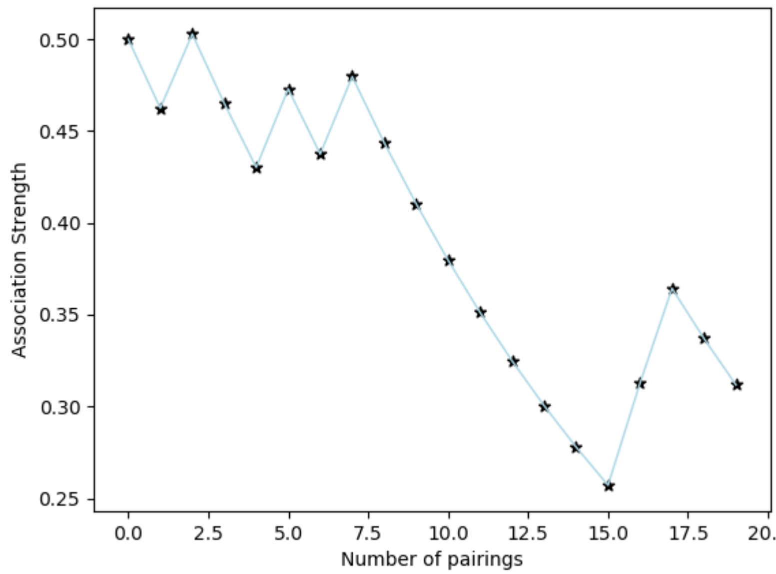

Figure 7: p=0.7, trail 20 times

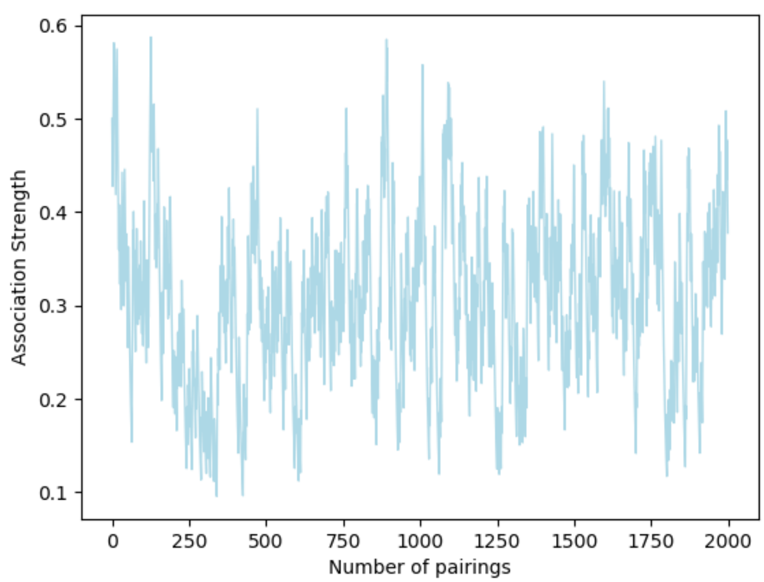

Figure 8: p=0.7, trail 2000 times

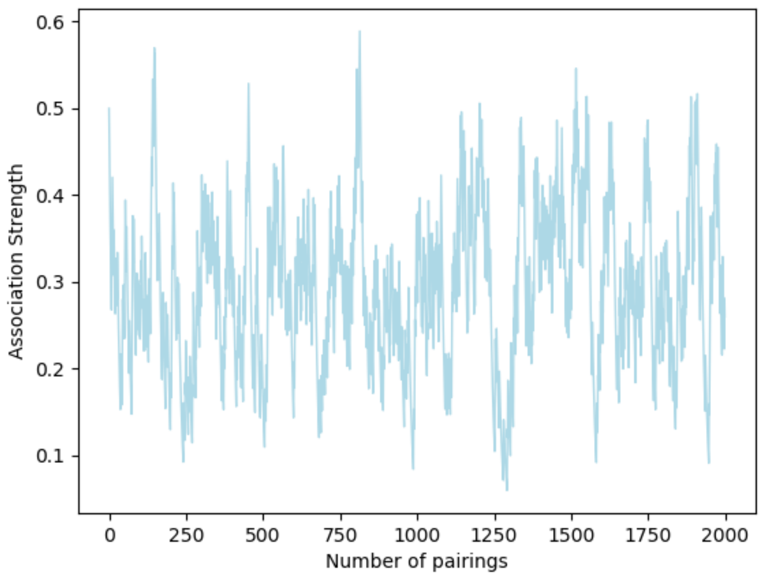

Figure 9: p=0.7, trail 2000 times

4.

(a) Salience is the intensity of stimulus while learning rate is relevant to inner characteristics which varies from different kinds of species or even personalities.

(b) Trail on one dog and always build new association after it forget the former one. In that way, differences are caused by salience.
Trail on two dog under the same stimulus, different association building rates are something to do with learning rate.