

#Install dependencies

```
!pip install tomsup
```

```
Collecting tomsup
```

```
  Downloading tomsup-1.3.1-py2.py3-none-any.whl.metadata (11 kB)
```

```
Collecting numpy<1.21.0,>=1.2.4 (from tomsup)
```

```
  Downloading numpy-1.20.3.zip (7.8 MB)
```

```
7.8/7.8 MB 82.2 MB/s eta
```

```
0:00:00
```

```
ents to build wheel ... etadata (pyproject.toml) ... tomsup)
```

```
  Downloading pandas-1.2.5.tar.gz (5.5 MB)
```

```
5.5/5.5 MB 104.5 MB/s eta
```

```
0:00:00
```

```
ents to build wheel ... etadata (pyproject.toml) ... ultiple versions  
of tomsup to determine which version is compatible with other  
requirements. This could take a while.
```

```
Collecting tomsup
```

```
  Downloading tomsup-1.3.0-py2.py3-none-any.whl.metadata (11 kB)
```

```
  Downloading tomsup-1.2.0-py2.py3-none-any.whl.metadata (11 kB)
```

```
  Downloading tomsup-1.1.7-py2.py3-none-any.whl.metadata (11 kB)
```

```
Requirement already satisfied: numpy>=1.2.4 in
```

```
/usr/local/lib/python3.11/dist-packages (from tomsup) (2.0.2)
```

```
Requirement already satisfied: pandas>=1.2.3 in
```

```
/usr/local/lib/python3.11/dist-packages (from tomsup) (2.2.2)
```

```
Requirement already satisfied: scipy>=1.6.3 in
```

```
/usr/local/lib/python3.11/dist-packages (from tomsup) (1.15.3)
```

```
Requirement already satisfied: matplotlib>=3.4.2 in
```

```
/usr/local/lib/python3.11/dist-packages (from tomsup) (3.10.0)
```

```
Requirement already satisfied: seaborn>=0.11.1 in
```

```
/usr/local/lib/python3.11/dist-packages (from tomsup) (0.13.2)
```

```
Requirement already satisfied: joblib>=1.0.1 in
```

```
/usr/local/lib/python3.11/dist-packages (from tomsup) (1.5.1)
```

```
Collecting wasabi<0.10.0,>=0.8.2 (from tomsup)
```

```
  Downloading wasabi-0.9.1-py3-none-any.whl.metadata (28 kB)
```

```
Requirement already satisfied: contourpy>=1.0.1 in
```

```
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-  
>tomsup) (1.3.2)
```

```
Requirement already satisfied: cyclor>=0.10 in
```

```
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-  
>tomsup) (0.12.1)
```

```
Requirement already satisfied: fonttools>=4.22.0 in
```

```
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-  
>tomsup) (4.58.5)
```

```
Requirement already satisfied: kiwisolver>=1.3.1 in
```

```
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-  
>tomsup) (1.4.8)
```

```
Requirement already satisfied: packaging>=20.0 in
```

```
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-
```

```

>tomsup) (24.2)
Requirement already satisfied: pillow>=8 in
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-
>tomsup) (11.2.1)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-
>tomsup) (3.2.3)
Requirement already satisfied: python-dateutil>=2.7 in
/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.4.2-
>tomsup) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.11/dist-packages (from pandas>=1.2.3->tomsup)
(2025.2)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.11/dist-packages (from pandas>=1.2.3->tomsup)
(2025.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.7-
>matplotlib>=3.4.2->tomsup) (1.17.0)
Downloading tomsup-1.1.7-py2.py3-none-any.whl (42 kB)
_____ 42.4/42.4 kB 4.2 MB/s eta
0:00:00
sup
  Attempting uninstall: wasabi
    Found existing installation: wasabi 1.1.3
    Uninstalling wasabi-1.1.3:
      Successfully uninstalled wasabi-1.1.3
Successfully installed tomsup-1.1.7 wasabi-0.9.1

```

#Import dependencies

```

import tomsup as ts
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
import scipy.stats as stats
import time

```

#Define agents and environment

```

# create a list of agents
agents = ["0-TOM", "1-TOM", "2-TOM", "3-TOM", "4-TOM", "5-TOM"]

# create a list of their starting parameters (an empty dictionary {})
simply assumes defaults)
start_params = [
    {"level": 1, "save_history":True},
    {"level": 2, "save_history":True},
    {"level": 3, "save_history":True},

```

```

    {"level": 4, "save_history":True},
    {"level": 5, "save_history":True},
    {"level": 6, "save_history":True}
]

# create a group of agents
group = ts.create_agents(agents, start_params)

print(group)
#set environment
group.set_env(
    env="round_robin"
)

```

```
<Class AgentGroup, environmnet = None>
```

```

0-TOM | {'level': 1, 'save_history': True}
1-TOM | {'level': 2, 'save_history': True}
2-TOM | {'level': 3, 'save_history': True}
3-TOM | {'level': 4, 'save_history': True}
4-TOM | {'level': 5, 'save_history': True}
5-TOM | {'level': 6, 'save_history': True}

```

#Define payoff matrices

```

penny = ts.PayoffMatrix(name='penny_competitive')
print(penny)

prisoners_dilemma = ts.PayoffMatrix(name='prisoners_dilemma')
print(prisoners_dilemma)

```

```
<Class PayoffMatrix, Name = penny_competitive>
```

The payoff matrix of agent 0

		Choice agent 1	
		0	1

Choice		0	-1
agent 0		1	1

The payoff matrix of agent 1

		Choice agent 1	
		0	1

Choice		0	1
agent 0		1	-1

```
<Class PayoffMatrix, Name = prisoners_dilemma>
```

The payoff matrix of agent 0

		Choice agent 1	
		0	1

Choice		-----	
agent 0		0 1 5	
		1 0 3	

The payoff matrix of agent 1

		Choice agent 1	
		0 1	
Choice		-----	
agent 0		0 1 0	
		1 5 3	

#Matching Pennies game

##Save results from the competition

```
#results_penny = group.compete(p_matrix=penny, n_rounds=100, n_sim=30, verbose=True)
```

```
agent_names = group.get_names()
```

```
timing_data = []
```

```
results_all = []
```

```
for i, name_a in enumerate(agent_names):
```

```
    for j, name_b in enumerate(agent_names):
```

```
        if i <= j:
```

```
            continue
```

```
        agent_a = group.get_agent(name_a)
```

```
        agent_b = group.get_agent(name_b)
```

```
        print(f"\n Simulating pair: ({name_a}, {name_b})")
```

```
        start_time = time.time()
```

```
        df = ts.compete(agent_a, agent_b, p_matrix=penny,
n_rounds=100, n_sim=30)
```

```
        elapsed = time.time() - start_time
```

```
        timing_data.append({
```

```
            "agent_a": name_a,
```

```
            "agent_b": name_b,
```

```
            "elapsed_sec": elapsed
```

```
        })
```

```
        df['agent_a'] = name_a
```

```
        df['agent_b'] = name_b
```

```
        results_all.append(df)
```

```
timing_df = pd.DataFrame(timing_data)
df_all = pd.concat(results_all, ignore_index=True)

Simulating pair: (1-TOM, 0-TOM)
Simulating pair: (2-TOM, 0-TOM)
Simulating pair: (2-TOM, 1-TOM)
Simulating pair: (3-TOM, 0-TOM)
Simulating pair: (3-TOM, 1-TOM)
Simulating pair: (3-TOM, 2-TOM)
Simulating pair: (4-TOM, 0-TOM)
Simulating pair: (4-TOM, 1-TOM)
Simulating pair: (4-TOM, 2-TOM)
Simulating pair: (4-TOM, 3-TOM)
Simulating pair: (5-TOM, 0-TOM)
Simulating pair: (5-TOM, 1-TOM)
Simulating pair: (5-TOM, 2-TOM)
Simulating pair: (5-TOM, 3-TOM)
Simulating pair: (5-TOM, 4-TOM)
Simulating pair: (QL, 0-TOM)
Simulating pair: (QL, 1-TOM)
Simulating pair: (QL, 2-TOM)
Simulating pair: (QL, 3-TOM)
Simulating pair: (QL, 4-TOM)
Simulating pair: (QL, 5-TOM)

df_all.to_csv("MP_results.csv", index=False)
timing_df.to_csv("MP_timing_results.csv", index=False)
```

```
group.compete(p_matrix=penny, n_rounds=100, n_sim=30, verbose=True)
results = group.get_results()
results.head()
```

```
i Currently the pair, ('0-TOM', '1-TOM'), is competing for 30
simulations, each containing 100 rounds.
```

```
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
```

```
i Currently the pair, ('0-TOM', '2-TOM'), is competing for 30
simulations, each containing 100 rounds.
```

```
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
```

```
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
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i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('0-TOM', '3-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
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i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
```

```
i      Running simulation 30 out of 30
i Currently the pair, ('0-TOM', '4-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('0-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
```



```
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('1-TOM', '2-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('1-TOM', '3-TOM'), is competing for 30
```

simulations, each containing 100 rounds.

i Running simulation 1 out of 30
i Running simulation 2 out of 30
i Running simulation 3 out of 30
i Running simulation 4 out of 30
i Running simulation 5 out of 30
i Running simulation 6 out of 30
i Running simulation 7 out of 30
i Running simulation 8 out of 30
i Running simulation 9 out of 30
i Running simulation 10 out of 30
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i Running simulation 17 out of 30
i Running simulation 18 out of 30
i Running simulation 19 out of 30
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i Running simulation 21 out of 30
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i Running simulation 25 out of 30
i Running simulation 26 out of 30
i Running simulation 27 out of 30
i Running simulation 28 out of 30
i Running simulation 29 out of 30
i Running simulation 30 out of 30

i Currently the pair, ('1-TOM', '4-TOM'), is competing for 30 simulations, each containing 100 rounds.

i Running simulation 1 out of 30
i Running simulation 2 out of 30
i Running simulation 3 out of 30
i Running simulation 4 out of 30
i Running simulation 5 out of 30
i Running simulation 6 out of 30
i Running simulation 7 out of 30
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i Running simulation 9 out of 30
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i Running simulation 15 out of 30
i Running simulation 16 out of 30

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i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
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i      Running simulation 24 out of 30
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i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('1-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
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i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('2-TOM', '3-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
```

```
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
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i      Running simulation 22 out of 30
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i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('2-TOM', '4-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
```

```
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('2-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
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i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('3-TOM', '4-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
```

```
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
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i      Running simulation 14 out of 30
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i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('3-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
```

```

i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('4-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.

```

```

i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
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i      Running simulation 30 out of 30

```

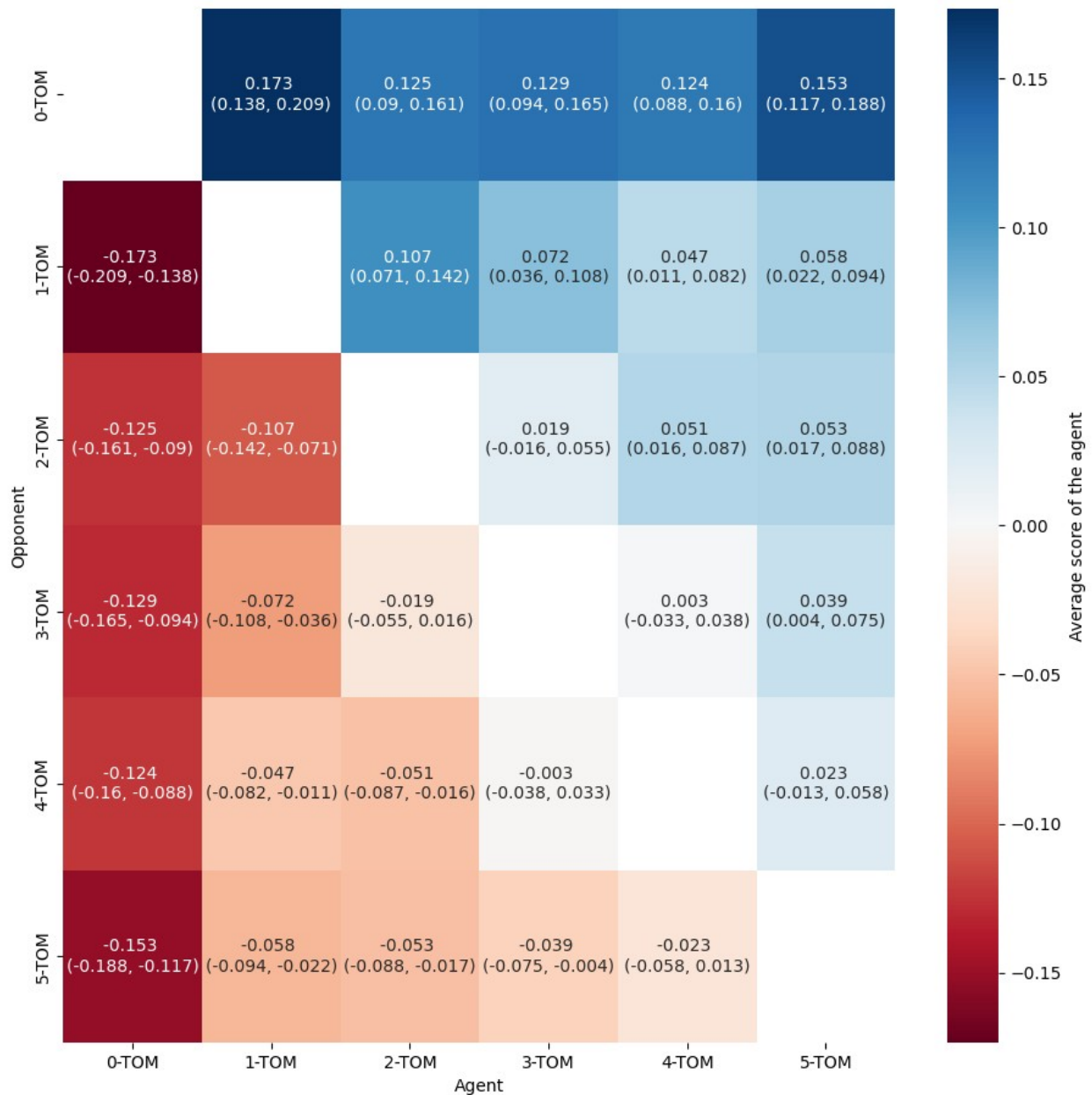
✓ Simulation complete

```

{"summary":{"\n  \"name\": \"results\", \n  \"rows\": 45000, \n  \"fields\": [\n    {\n      \"column\": \"n_sim\", \n      \"properties\": {\n        \"dtype\": \"number\", \n        \"std\": 8, \n        \"min\": 0, \n        \"max\": 29, \n        \"num_unique_values\": 30, \n        \"samples\": [\n          27, \n          15, \n          23\n        ], \n        \"semantic_type\": \"\", \n
```



```
plt.rcParams["figure.figsize"] = [11, 11]
fig = group.plot_heatmap(cmap="RdBu")
```



###Bar Graphs for Average Score per Agent

```
# First reshape to get all agent performances into one column
agent0_df = results[['agent0',
'payoff_agent0']].rename(columns={'agent0': 'agent', 'payoff_agent0':
'payoff'})
agent1_df = results[['agent1',
```

```

'payoff_agent1']].rename(columns={'agent1': 'agent', 'payoff_agent1':
'payoff'})
all_agents = pd.concat([agent0_df, agent1_df])

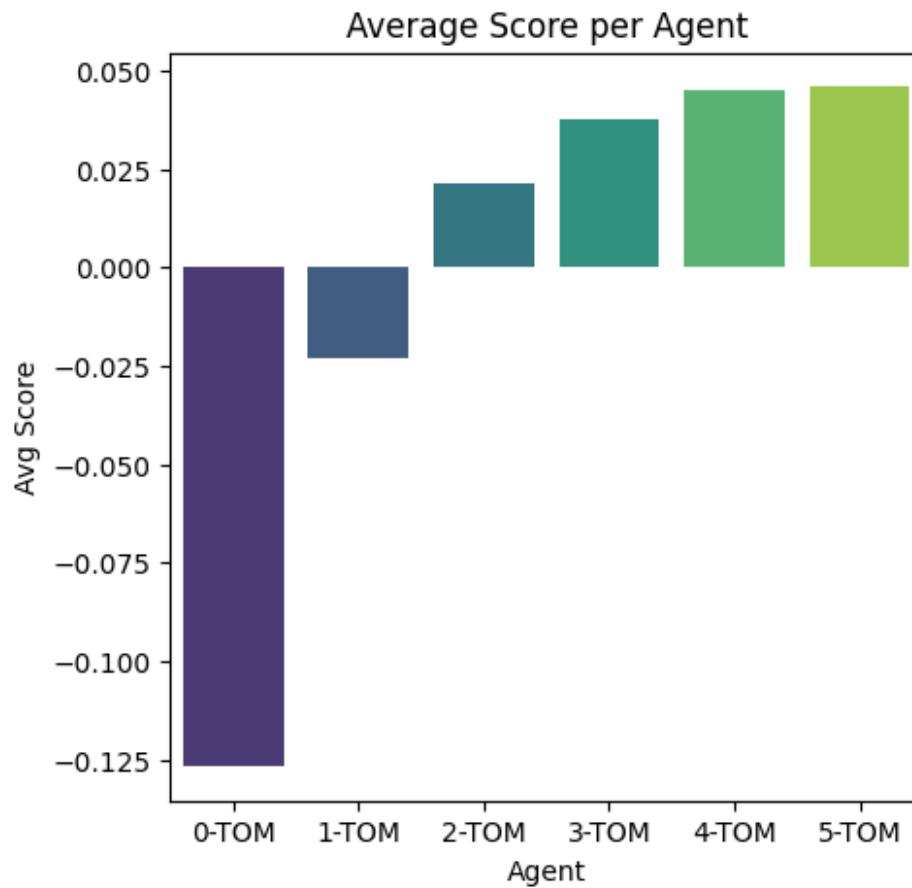
# Group and average
avg_scores = all_agents.groupby('agent')
['payoff'].mean().reset_index()

# Plot
sns.barplot(data=avg_scores, x='agent', y='payoff', palette='viridis')
plt.title('Average Score per Agent')
plt.ylabel('Avg Score')
plt.xlabel('Agent')
plt.rcParams["figure.figsize"] = [7, 7]
plt.savefig("MP_average_score_bar.jpg", dpi=300)
plt.show()

/tmp/ipython-input-12-2638055944.py:10: FutureWarning:
Passing `palette` without assigning `hue` is deprecated and will be
removed in v0.14.0. Assign the `x` variable to `hue` and set
`legend=False` for the same effect.

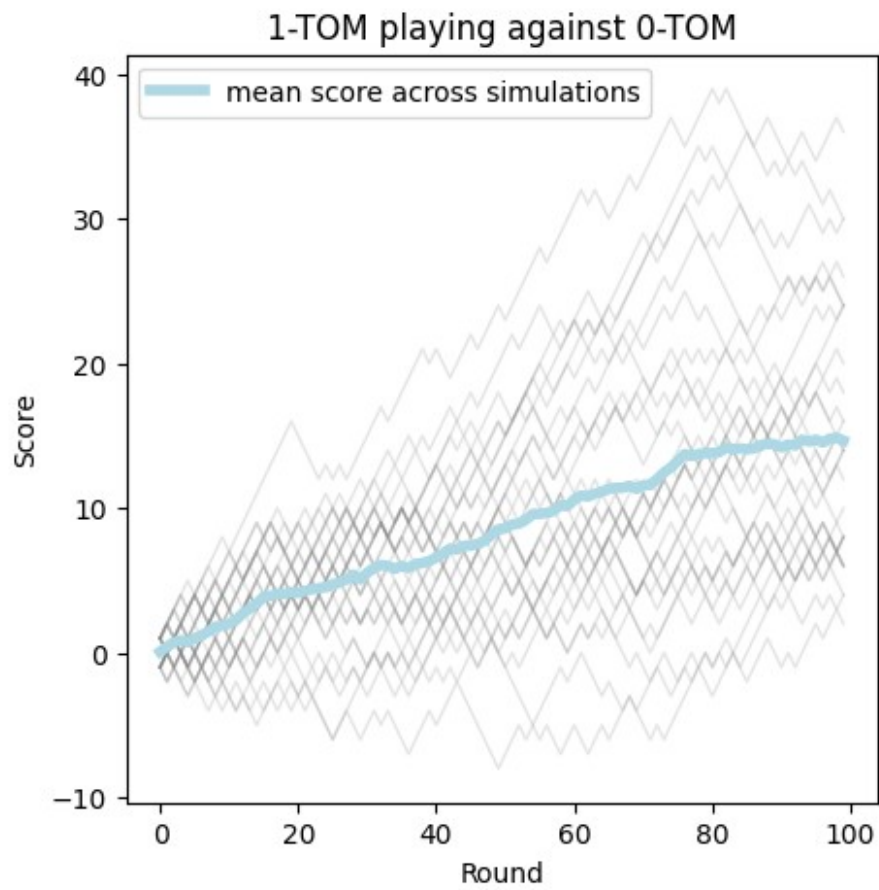
    sns.barplot(data=avg_scores, x='agent', y='payoff',
palette='viridis')

```

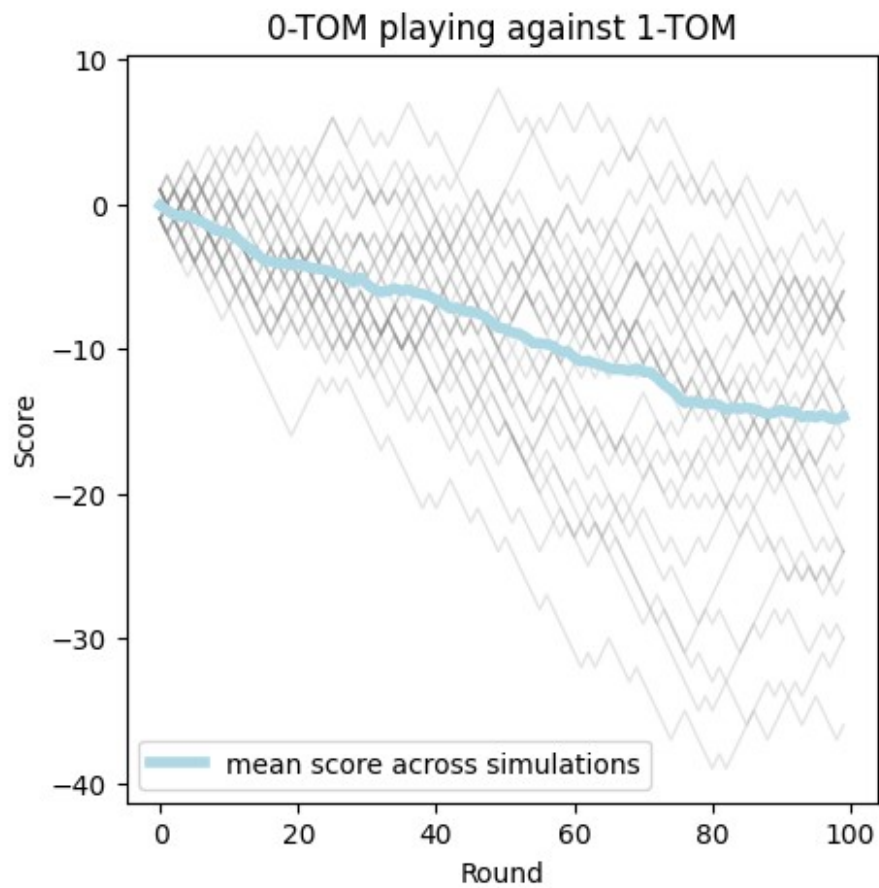


###Learning Speed: Performance Over Time

```
plt.rcParams["figure.figsize"] = [5, 5]
group.plot_score(agent0="0-TOM", agent1="1-TOM", agent=1)
group.plot_score(agent0="0-TOM", agent1="1-TOM", agent=0)
<Figure size 500x500 with 0 Axes>
```

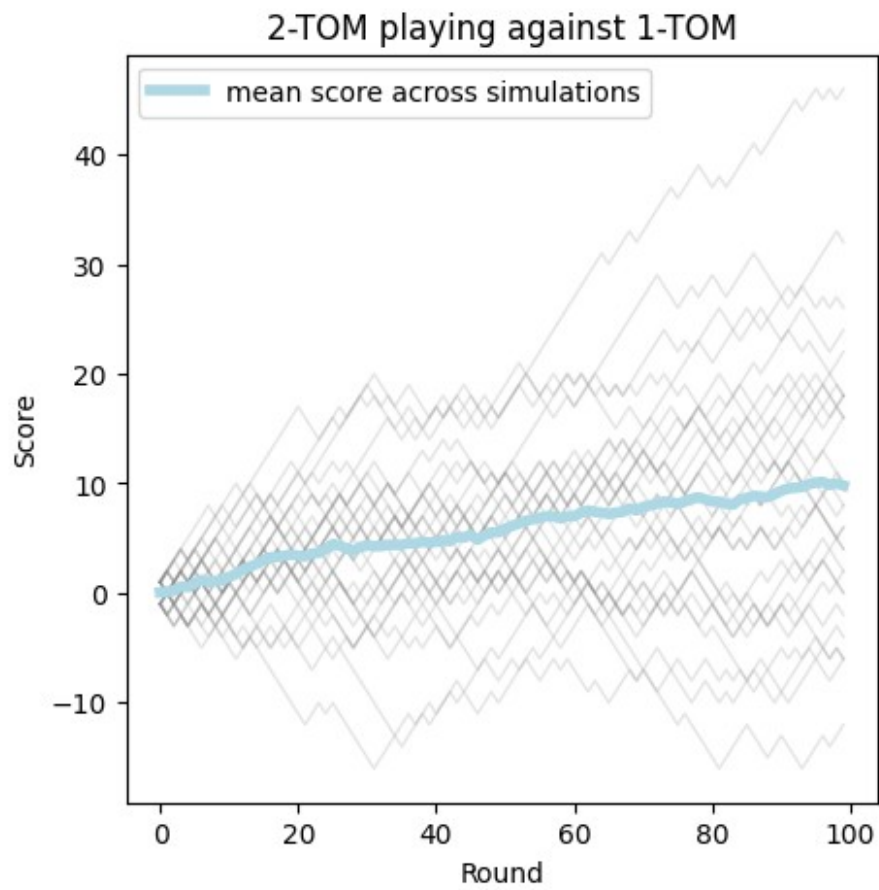


<Figure size 500x500 with 0 Axes>

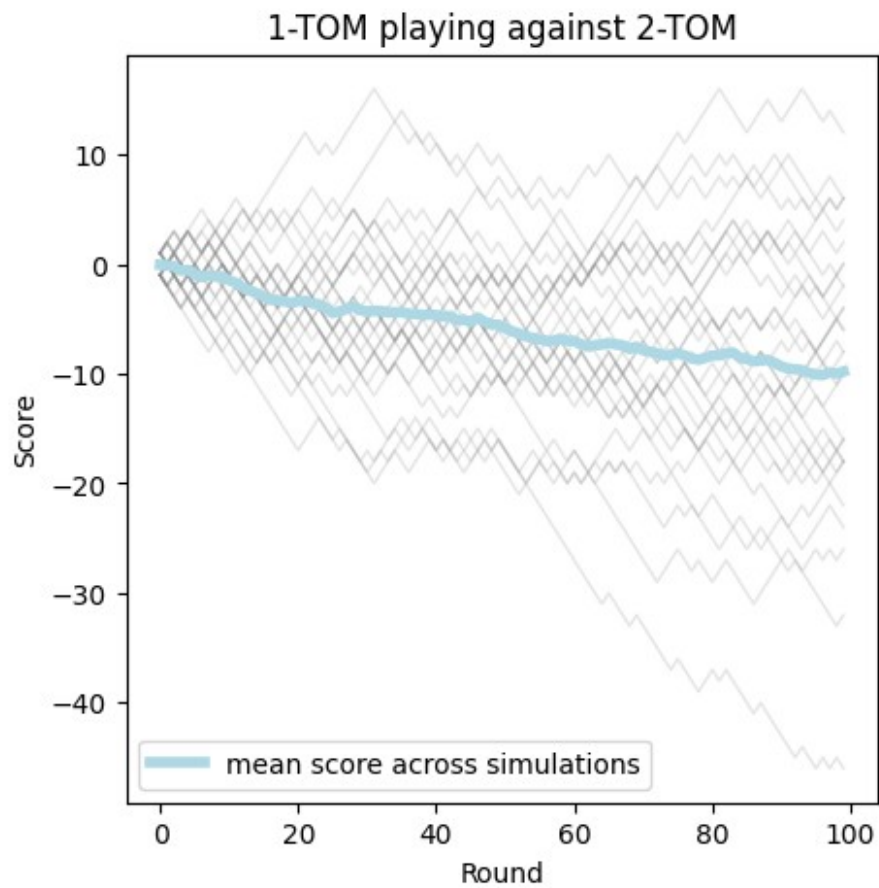


```
group.plot_score(agent0="1-TOM", agent1="2-TOM", agent=1)  
group.plot_score(agent0="1-TOM", agent1="2-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

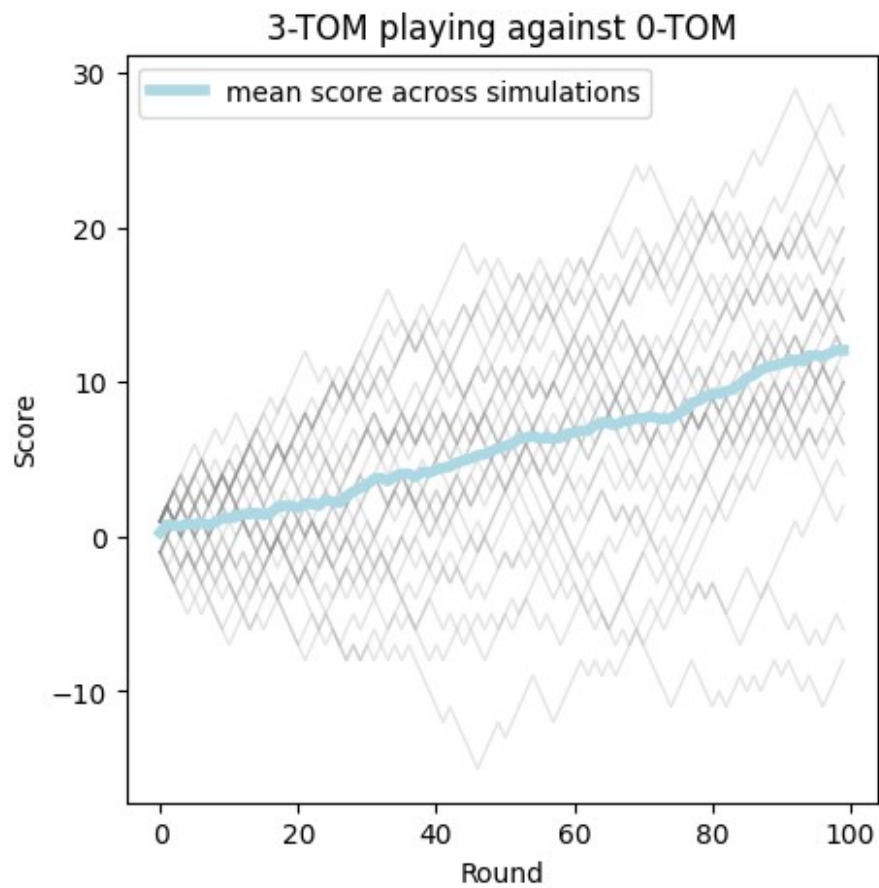


<Figure size 500x500 with 0 Axes>

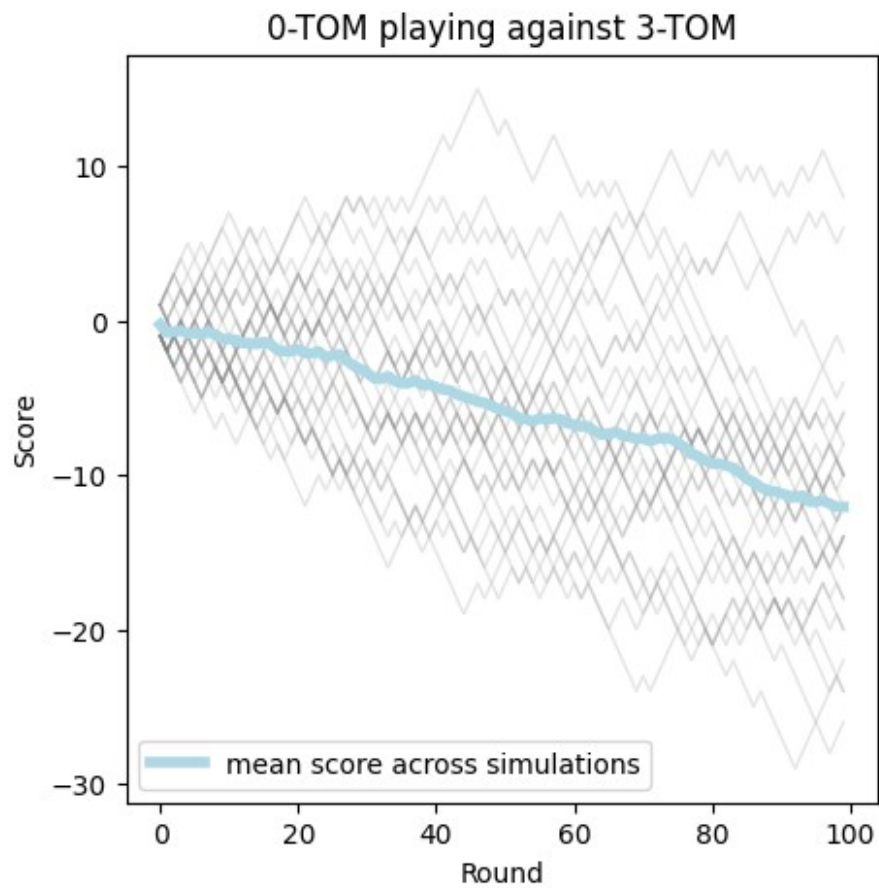


```
group.plot_score(agent0="0-TOM", agent1="3-TOM", agent=1)  
group.plot_score(agent0="0-TOM", agent1="3-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

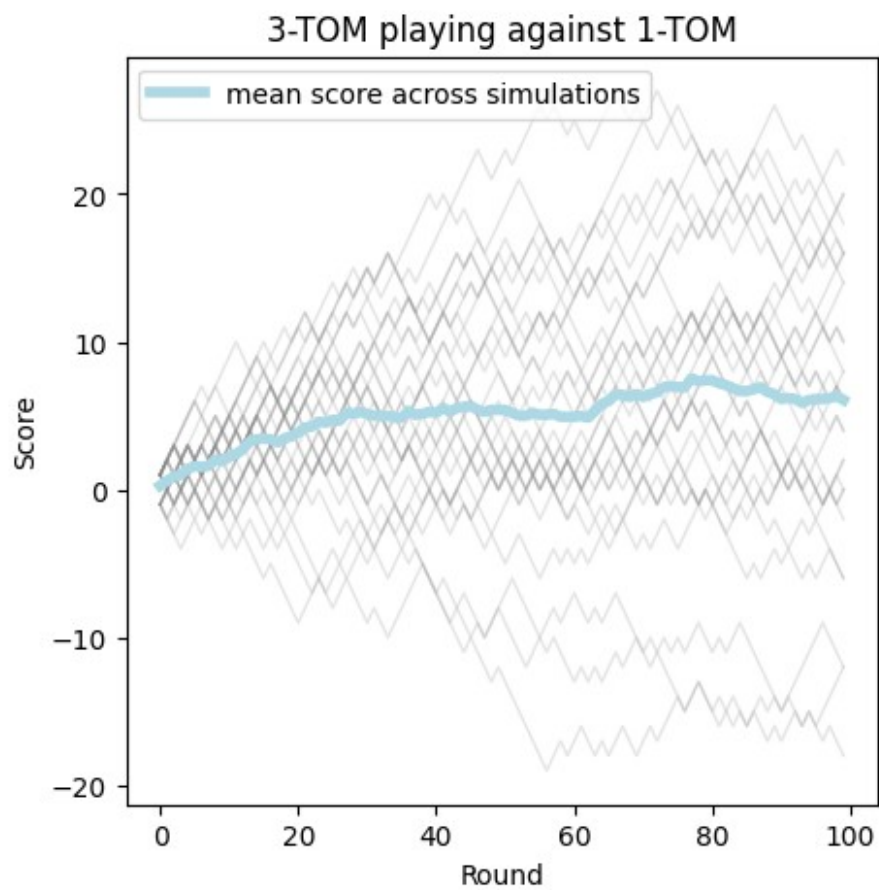


<Figure size 500x500 with 0 Axes>

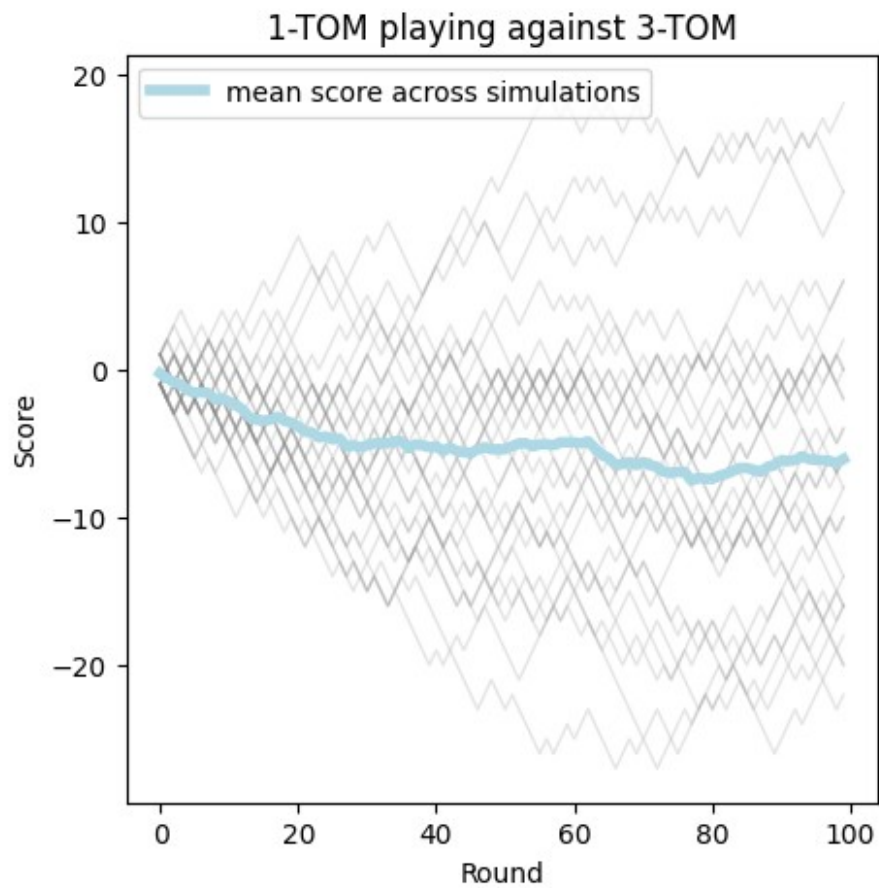


```
group.plot_score(agent0="1-TOM", agent1="3-TOM", agent=1)  
group.plot_score(agent0="1-TOM", agent1="3-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

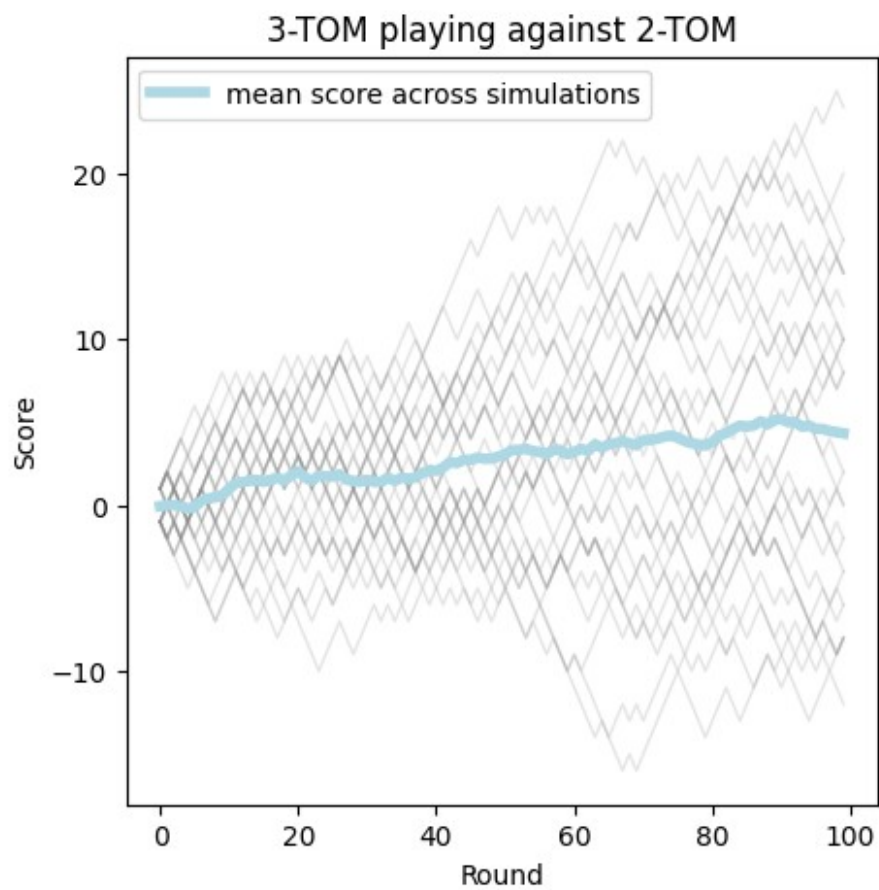


<Figure size 500x500 with 0 Axes>

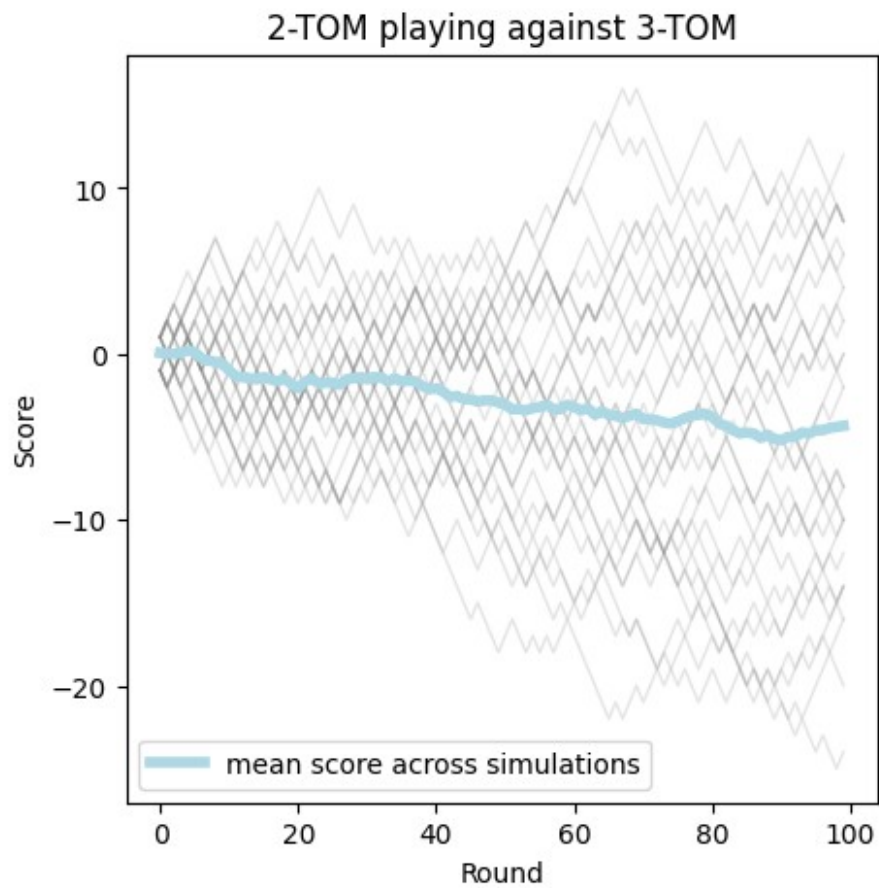


```
group.plot_score(agent0="2-TOM", agent1="3-TOM", agent=1)  
group.plot_score(agent0="2-TOM", agent1="3-TOM", agent=0)
```

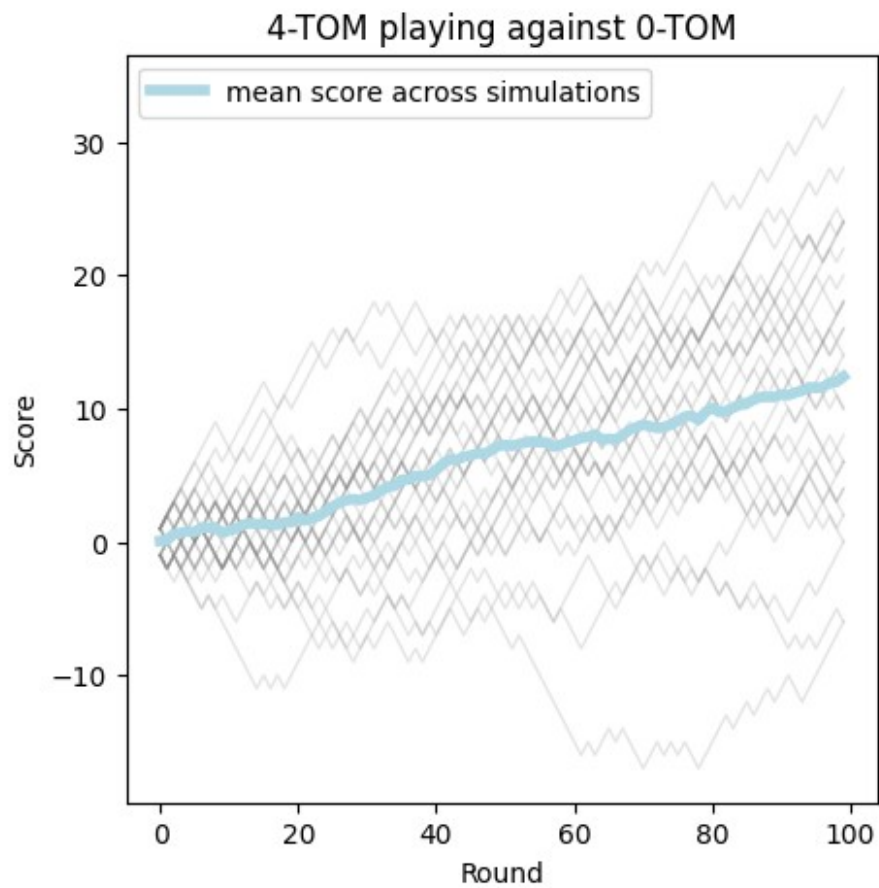
<Figure size 500x500 with 0 Axes>



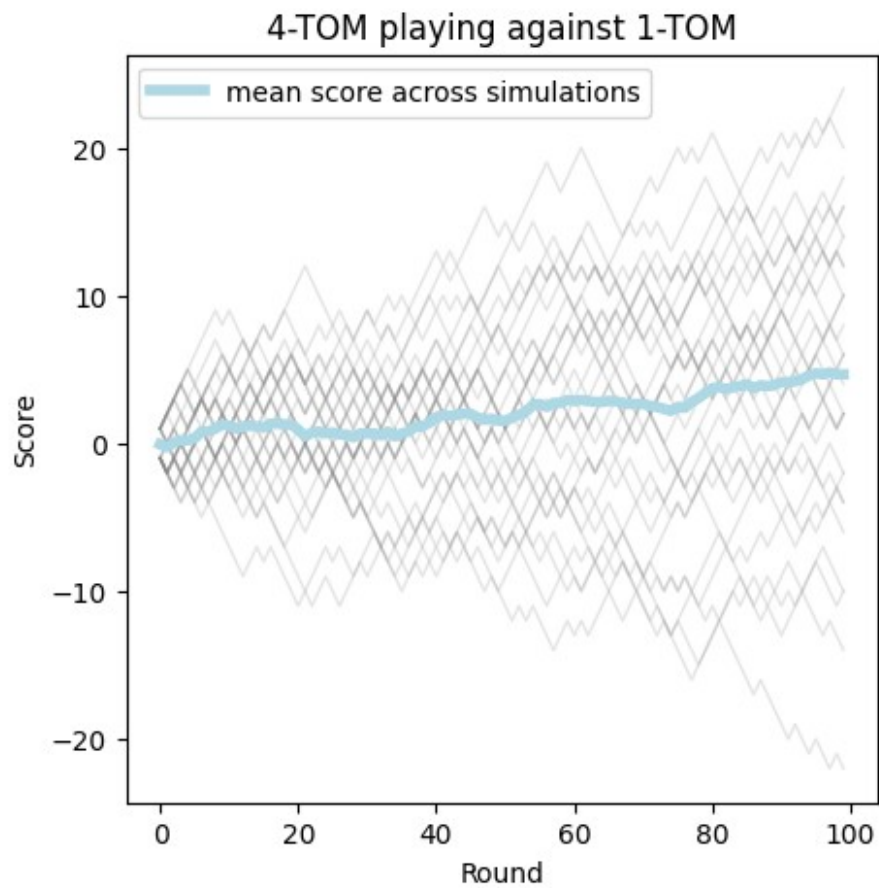
<Figure size 500x500 with 0 Axes>



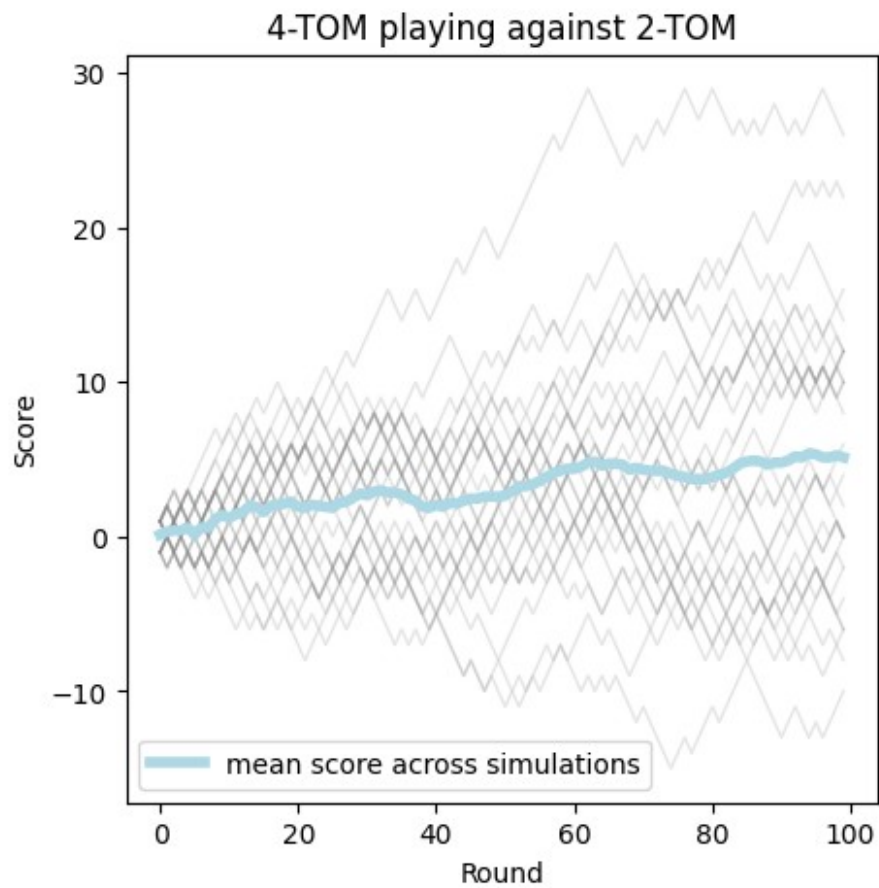
```
group.plot_score(agent0="0-TOM", agent1="4-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```



```
group.plot_score(agent0="1-TOM", agent1="4-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

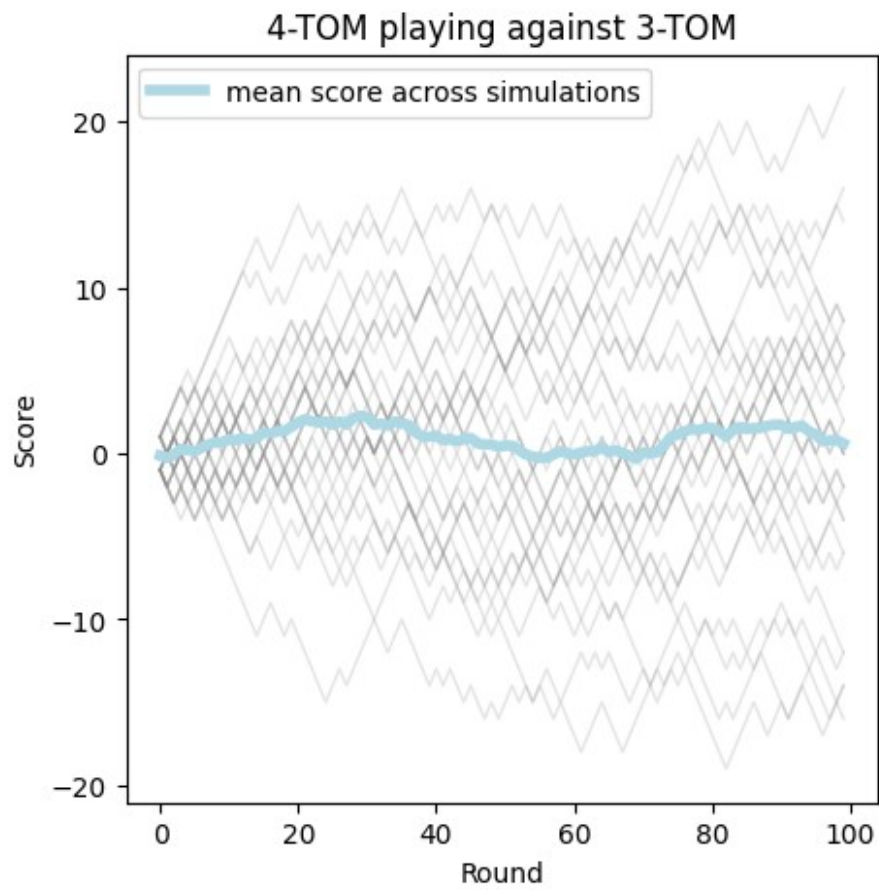


```
group.plot_score(agent0="2-TOM", agent1="4-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

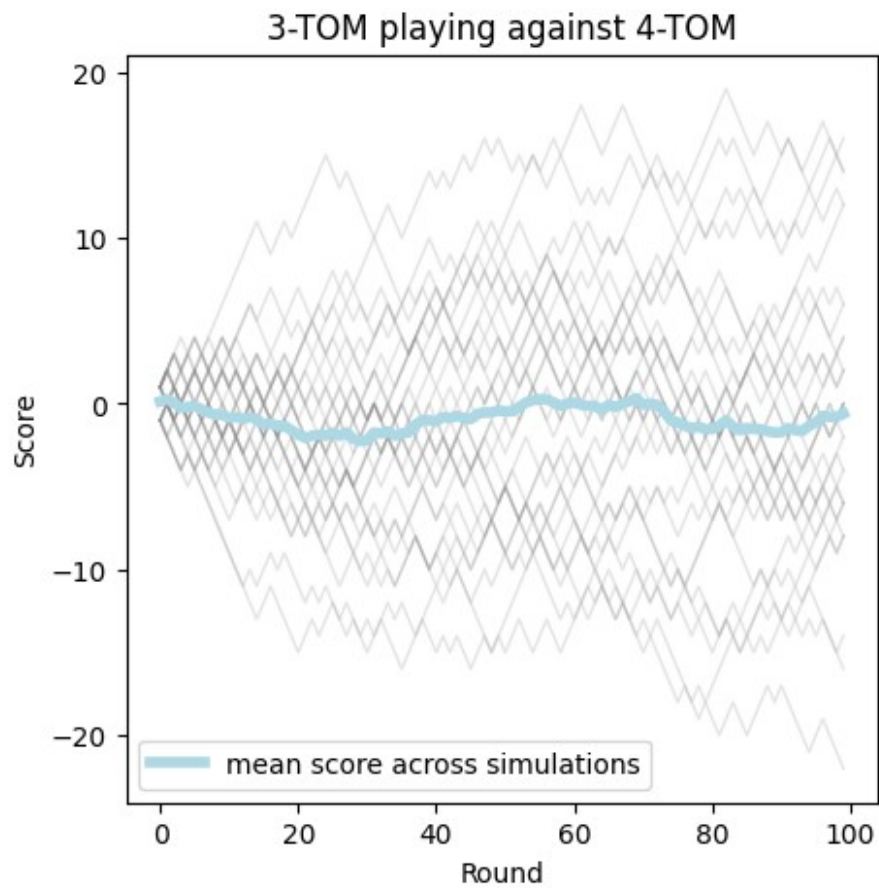


```
group.plot_score(agent0="3-TOM", agent1="4-TOM", agent=1)  
group.plot_score(agent0="3-TOM", agent1="4-TOM", agent=0)
```

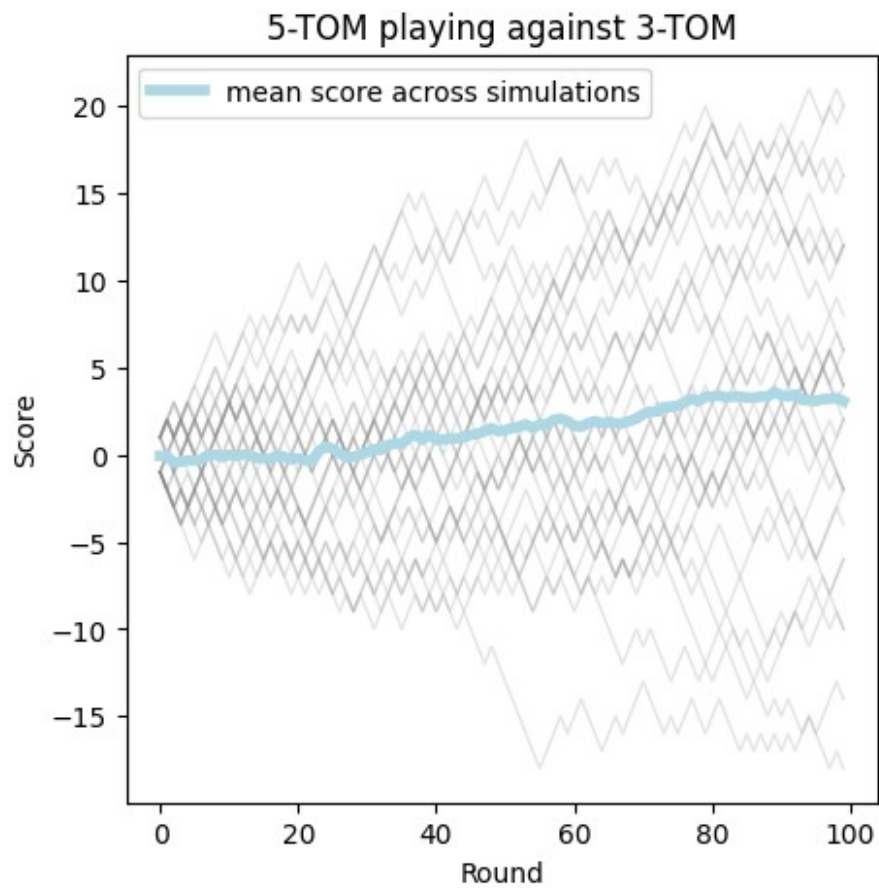
<Figure size 500x500 with 0 Axes>



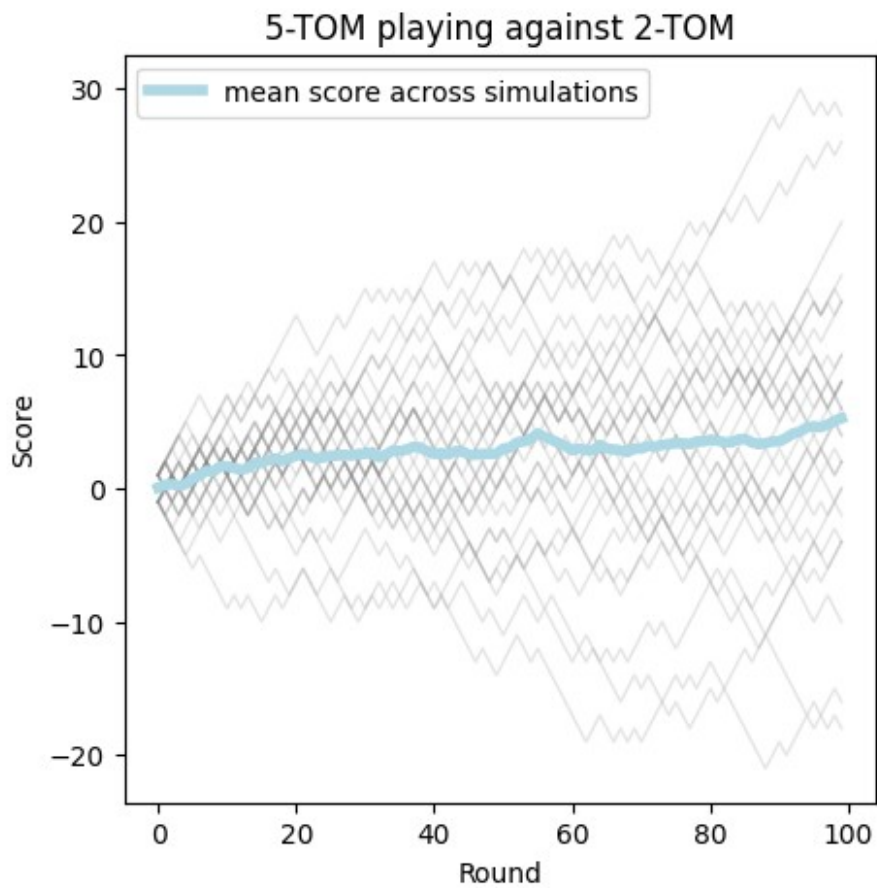
<Figure size 500x500 with 0 Axes>



```
group.plot_score(agent0="3-TOM", agent1="5-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

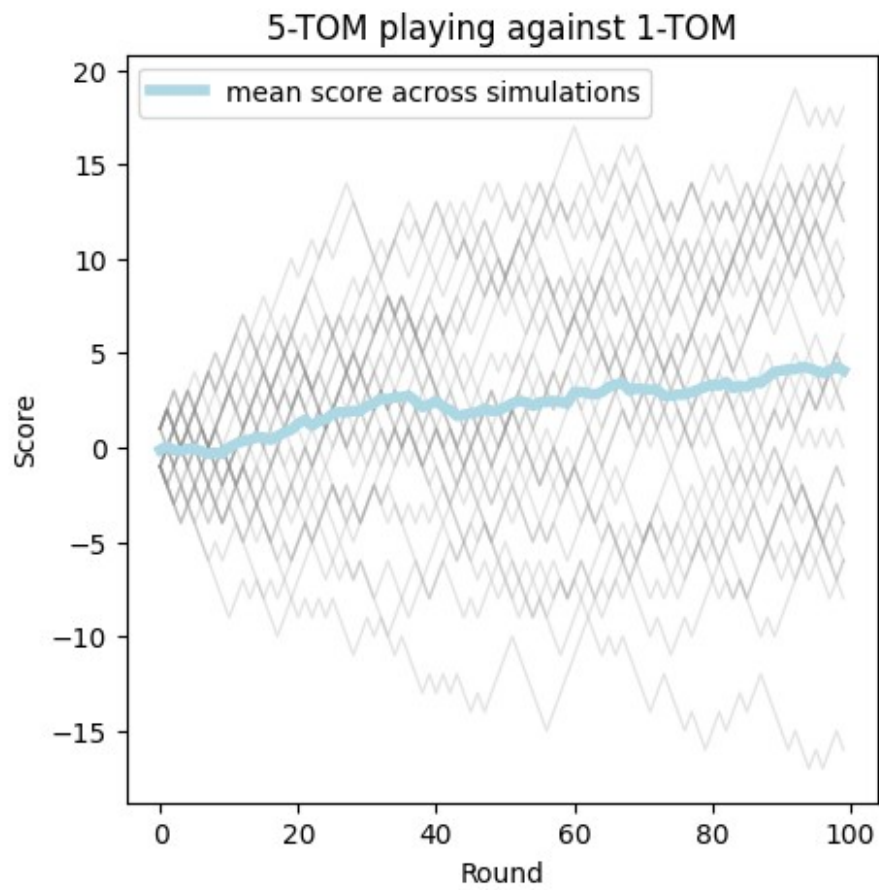


```
group.plot_score(agent0="2-TOM", agent1="5-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

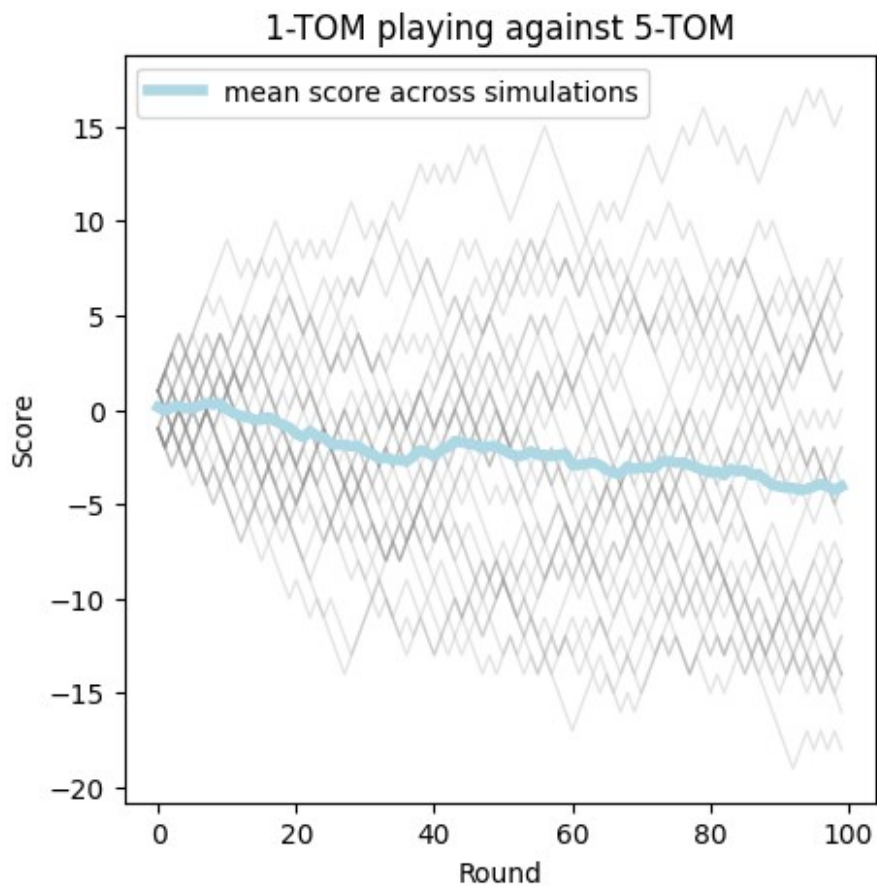


```
group.plot_score(agent0="1-TOM", agent1="5-TOM", agent=1)  
group.plot_score(agent0="1-TOM", agent1="5-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

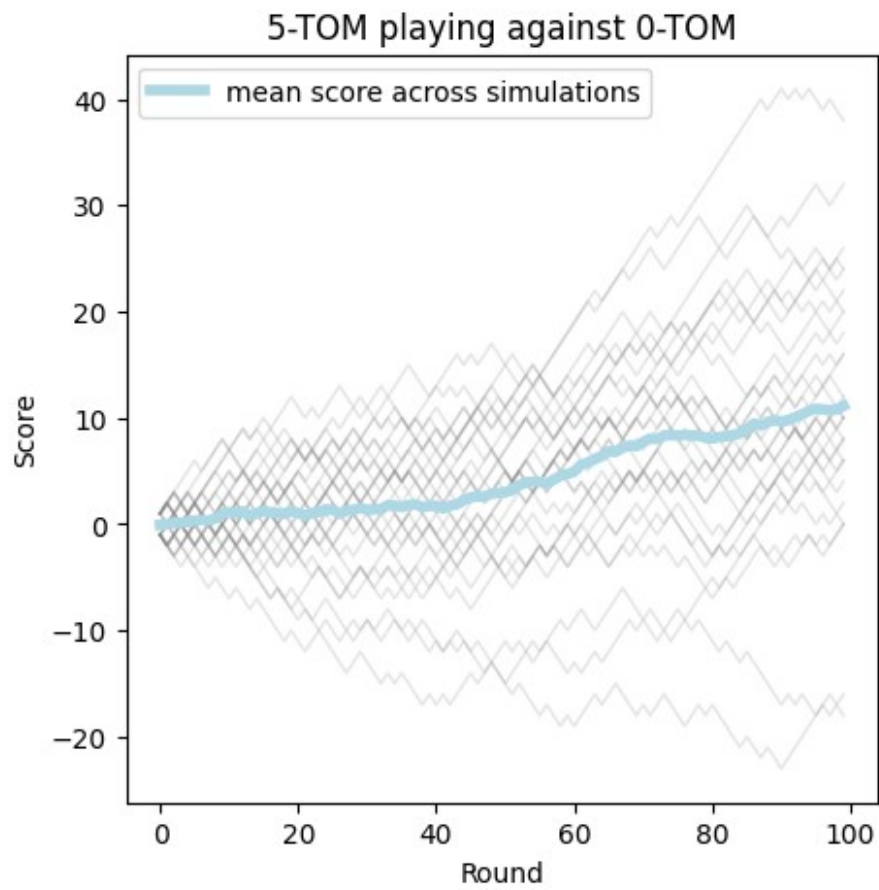


<Figure size 500x500 with 0 Axes>

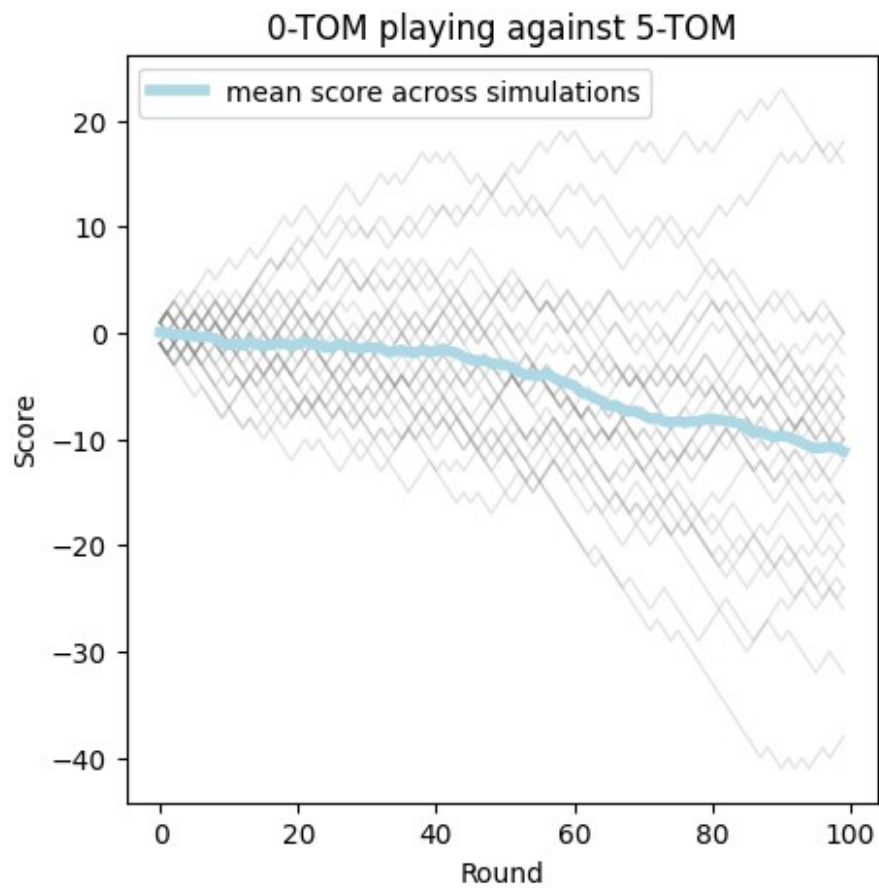


```
plt.rcParams["figure.figsize"] = [5, 5]
group.plot_score(agent0="0-TOM", agent1="5-TOM", agent=1)
group.plot_score(agent0="0-TOM", agent1="5-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

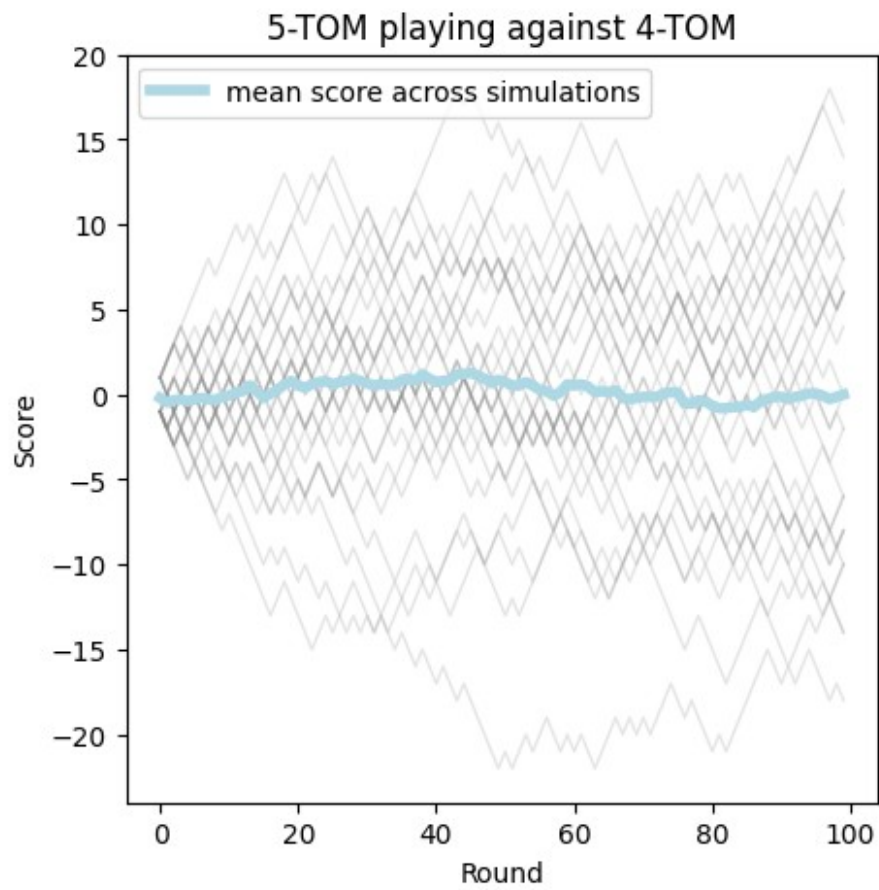


<Figure size 500x500 with 0 Axes>

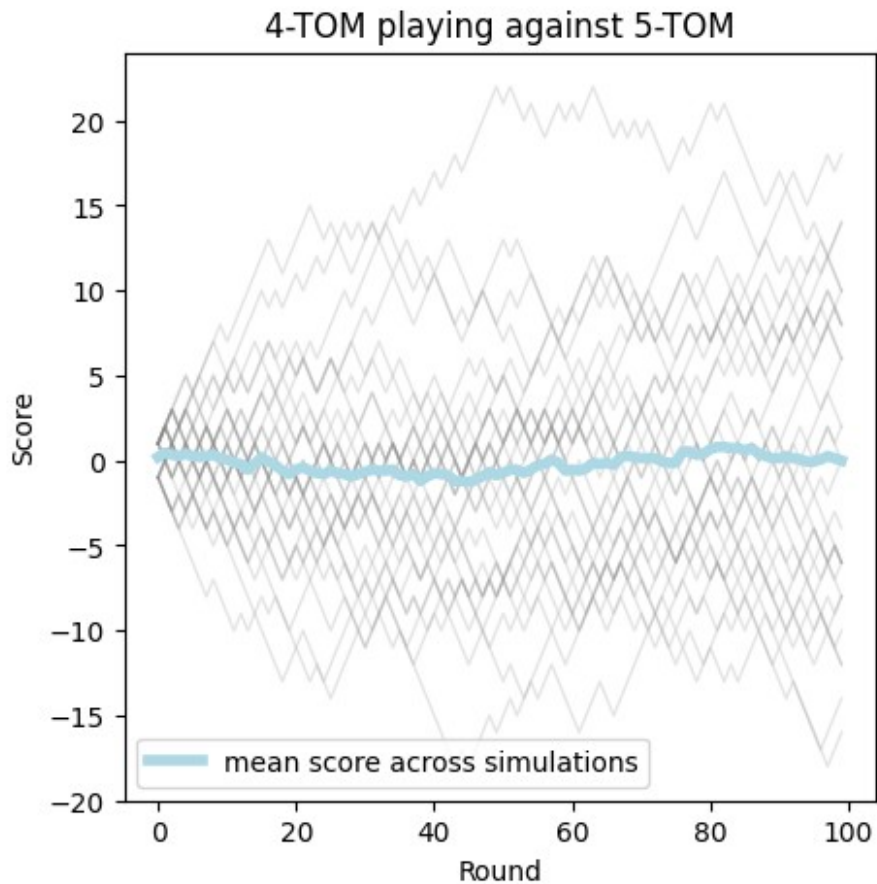


```
group.plot_score(agent0="4-TOM", agent1="5-TOM", agent=1)  
group.plot_score(agent0="4-TOM", agent1="5-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

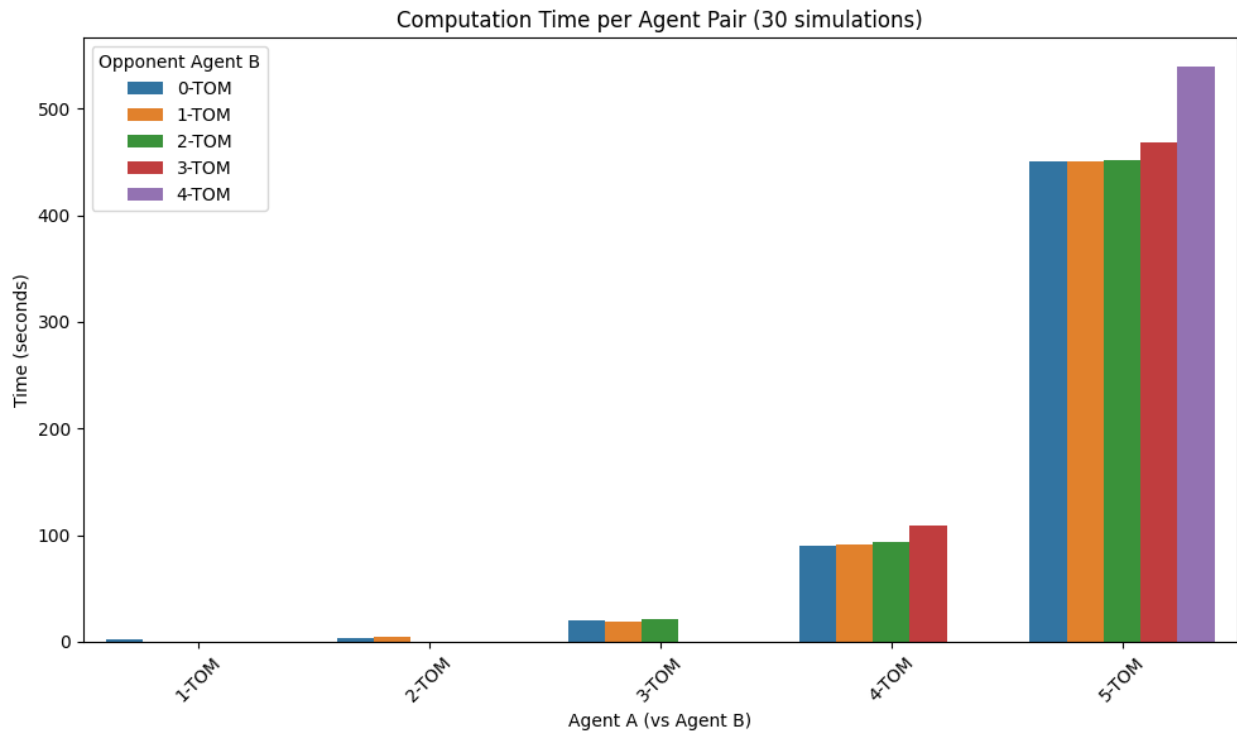


<Figure size 500x500 with 0 Axes>



###Runtime plot

```
plt.figure(figsize=(10, 6))
sns.barplot(data=timing_df, x="agent_a", y="elapsed_sec",
            hue="agent_b")
plt.title("Computation Time per Agent Pair (30 simulations)")
plt.ylabel("Time (seconds)")
plt.xlabel("Agent A (vs Agent B)")
plt.xticks(rotation=45)
plt.legend(title="Opponent Agent B")
plt.tight_layout()
plt.savefig("MP_runtime_plt.jpg", dpi=300)
plt.show()
```



#Prisoners dilemma game

##Save results from the competition

```
group.compete(p_matrix=prisoners_dilemma, n_rounds=100, n_sim=30,
verbose=True)
results_pd = group.get_results()
```

i Currently the pair, ('0-TOM', '1-TOM'), is competing for 30 simulations, each containing 100 rounds.

```
i Running simulation 1 out of 30
i Running simulation 2 out of 30
i Running simulation 3 out of 30
i Running simulation 4 out of 30
i Running simulation 5 out of 30
i Running simulation 6 out of 30
i Running simulation 7 out of 30
i Running simulation 8 out of 30
i Running simulation 9 out of 30
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i Running simulation 11 out of 30
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i Running simulation 18 out of 30
```

```
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i Currently the pair, ('0-TOM', '2-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
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i      Running simulation 3 out of 30
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i Currently the pair, ('0-TOM', '3-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
```

```
i      Running simulation 4 out of 30
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i Currently the pair, ('0-TOM', '4-TOM'), is competing for 30
simulations, each containing 100 rounds.
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i Currently the pair, ('0-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
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i Currently the pair, ('1-TOM', '2-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
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i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
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i      Currently the pair, ('1-TOM', '3-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
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i Currently the pair, ('1-TOM', '4-TOM'), is competing for 30
simulations, each containing 100 rounds.
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i Currently the pair, ('1-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
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```



```
i      Running simulation 8 out of 30
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i Currently the pair, ('2-TOM', '3-TOM'), is competing for 30
simulations, each containing 100 rounds.
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```

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i      Running simulation 30 out of 30
i Currently the pair, ('2-TOM', '4-TOM'), is competing for 30
simulations, each containg 100 rounds.
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i Currently the pair, ('2-TOM', '5-TOM'), is competing for 30
simulations, each containg 100 rounds.
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i      Running simulation 5 out of 30
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i      Running simulation 9 out of 30
```

```
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i      Currently the pair, ('3-TOM', '4-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
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i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
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i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
```

```
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('3-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
i Currently the pair, ('4-TOM', '5-TOM'), is competing for 30
simulations, each containing 100 rounds.
i      Running simulation 1 out of 30
i      Running simulation 2 out of 30
i      Running simulation 3 out of 30
i      Running simulation 4 out of 30
i      Running simulation 5 out of 30
i      Running simulation 6 out of 30
i      Running simulation 7 out of 30
i      Running simulation 8 out of 30
i      Running simulation 9 out of 30
i      Running simulation 10 out of 30
i      Running simulation 11 out of 30
```

```
i      Running simulation 12 out of 30
i      Running simulation 13 out of 30
i      Running simulation 14 out of 30
i      Running simulation 15 out of 30
i      Running simulation 16 out of 30
i      Running simulation 17 out of 30
i      Running simulation 18 out of 30
i      Running simulation 19 out of 30
i      Running simulation 20 out of 30
i      Running simulation 21 out of 30
i      Running simulation 22 out of 30
i      Running simulation 23 out of 30
i      Running simulation 24 out of 30
i      Running simulation 25 out of 30
i      Running simulation 26 out of 30
i      Running simulation 27 out of 30
i      Running simulation 28 out of 30
i      Running simulation 29 out of 30
i      Running simulation 30 out of 30
```

```
✓ Simulation complete
```

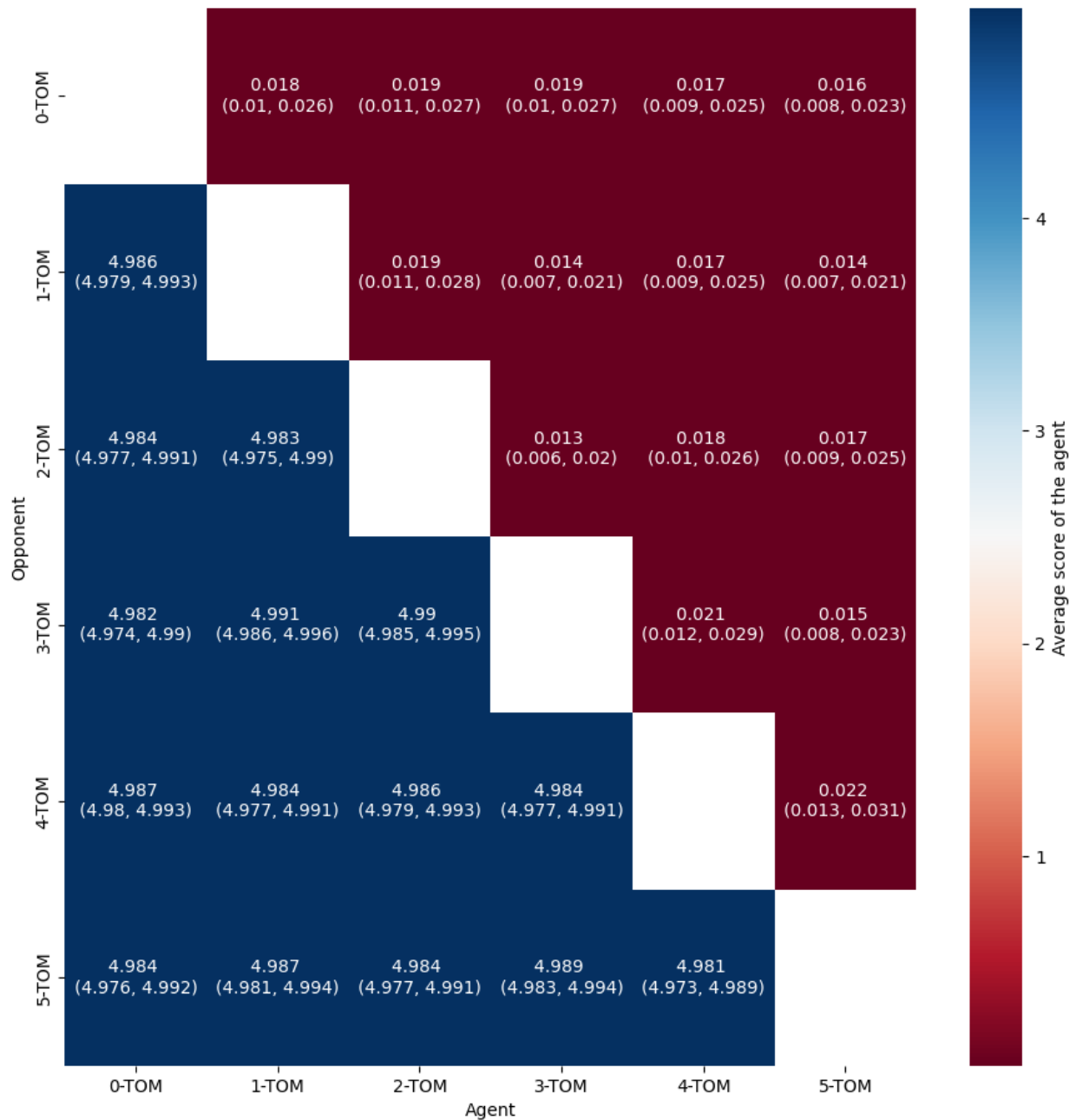
```
results_pd.to_csv("PD_results.csv", index=False)
```

```
##Plot the results
```

```
###Heatmap
```

```
plt.rcParams["figure.figsize"] = [11, 11]
```

```
group.plot_heatmap(cmap="RdBu")
```



###Bar Graphs for Average Score per Agent

```
agent0_df = results_pd[['agent0',
'payoff_agent0']].rename(columns={'agent0': 'agent', 'payoff_agent0':
'payoff'})
agent1_df = results_pd[['agent1',
'payoff_agent1']].rename(columns={'agent1': 'agent', 'payoff_agent1':
'payoff'})
all_agents = pd.concat([agent0_df, agent1_df])
avg_scores = all_agents.groupby('agent')
```

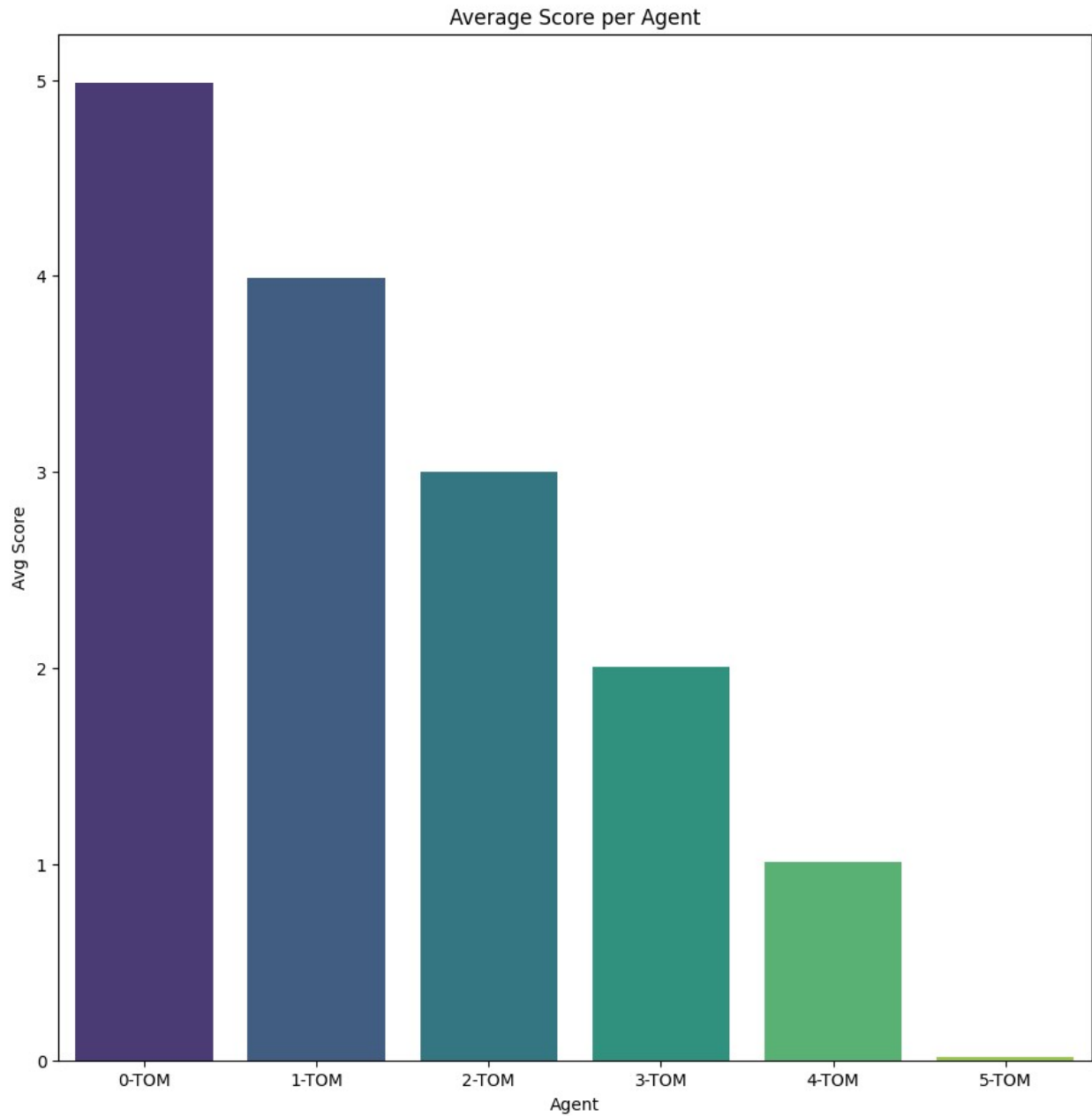
```
['payoff'].mean().reset_index()

sns.barplot(data=avg_scores, x='agent', y='payoff', palette='viridis')
plt.title('Average Score per Agent')
plt.ylabel('Avg Score')
plt.xlabel('Agent')
plt.show()
```

/tmp/ipython-input-42-1116538753.py:10: FutureWarning:

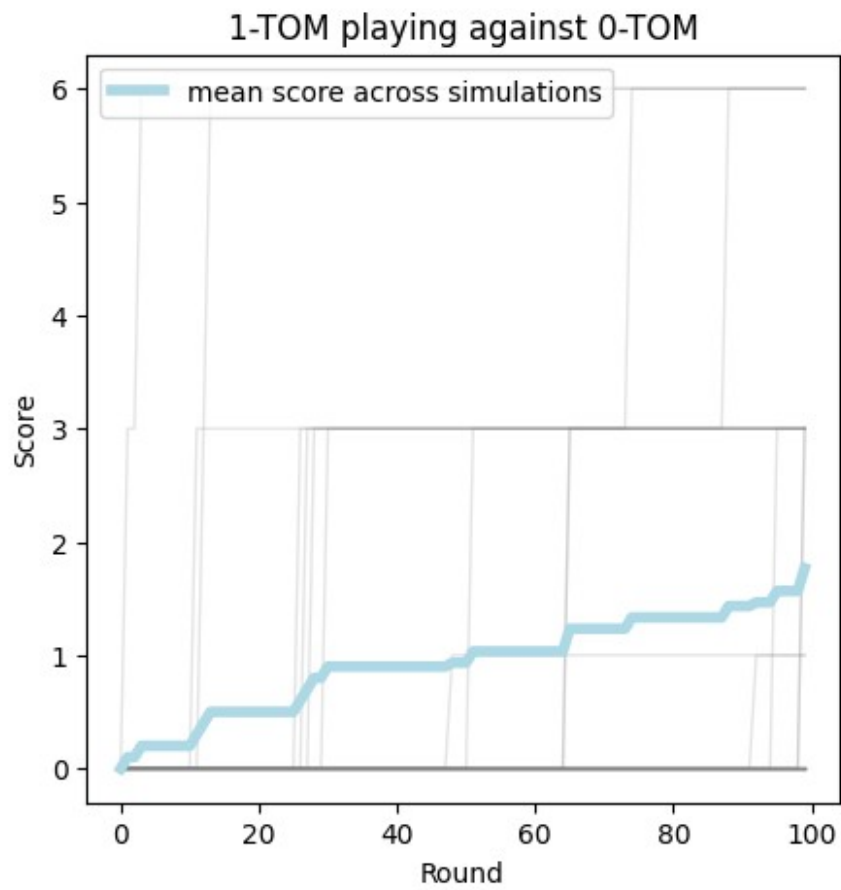
Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

```
sns.barplot(data=avg_scores, x='agent', y='payoff',
palette='viridis')
```

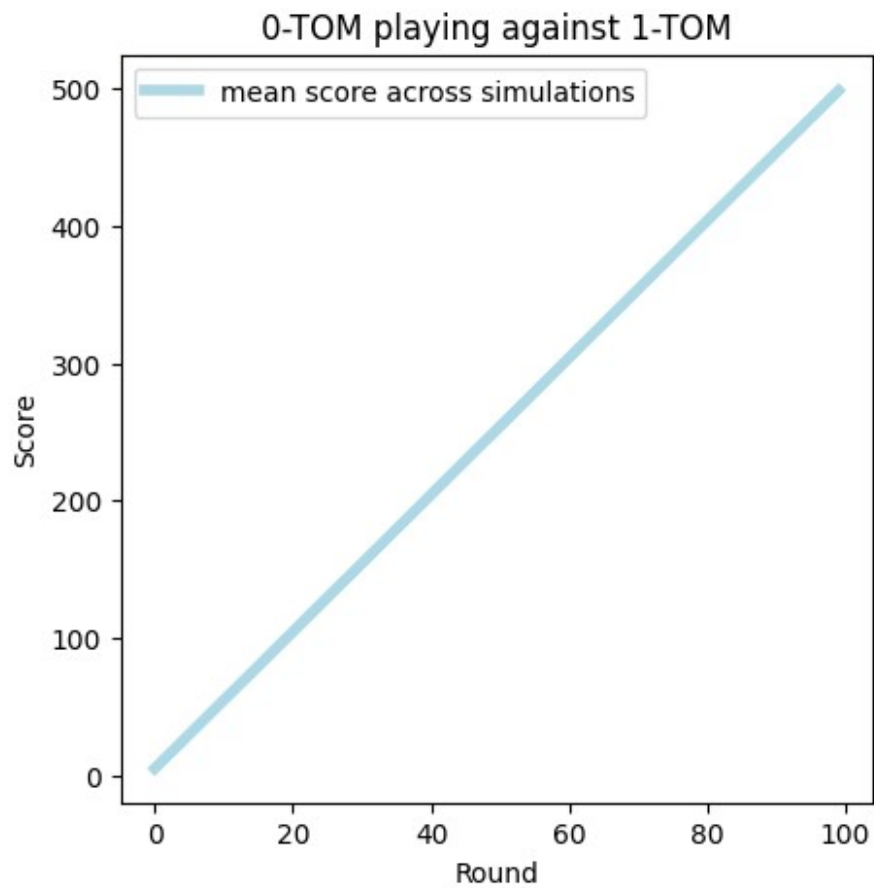


###Learning Speed: Performance Over Time

```
plt.rcParams["figure.figsize"] = [5, 5]
group.plot_score(agent0="0-TOM", agent1="1-TOM", agent=1)
group.plot_score(agent0="0-TOM", agent1="1-TOM", agent=0)
<Figure size 500x500 with 0 Axes>
```

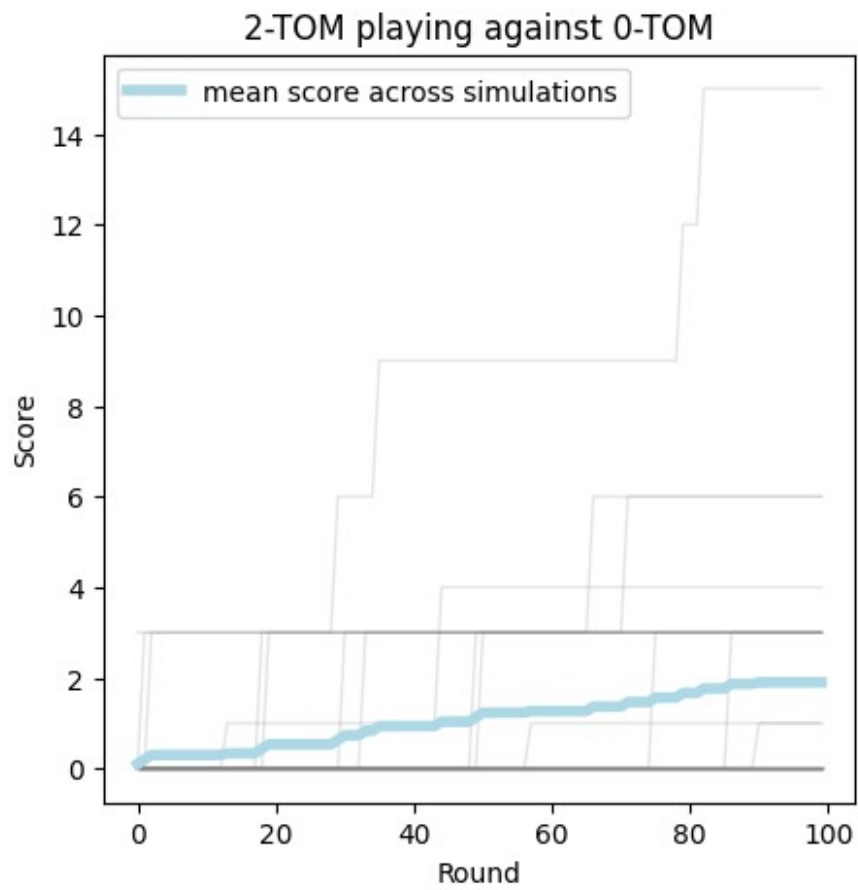



<Figure size 500x500 with 0 Axes>

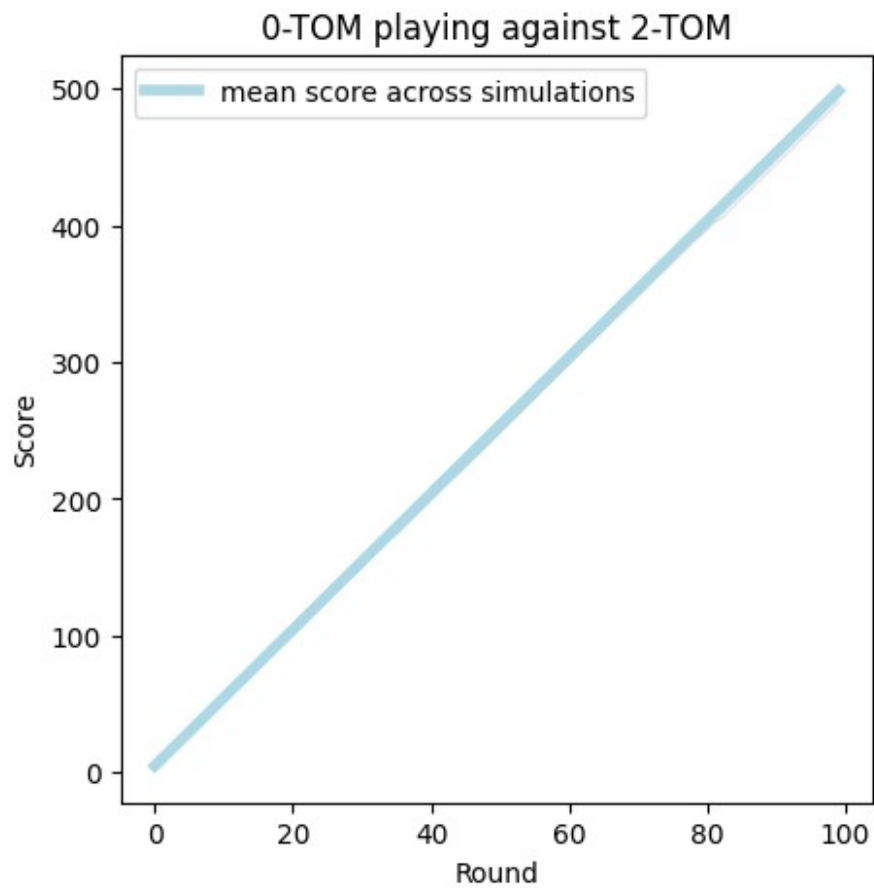


```
group.plot_score(agent0="0-TOM", agent1="2-TOM", agent=1)  
group.plot_score(agent0="0-TOM", agent1="2-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

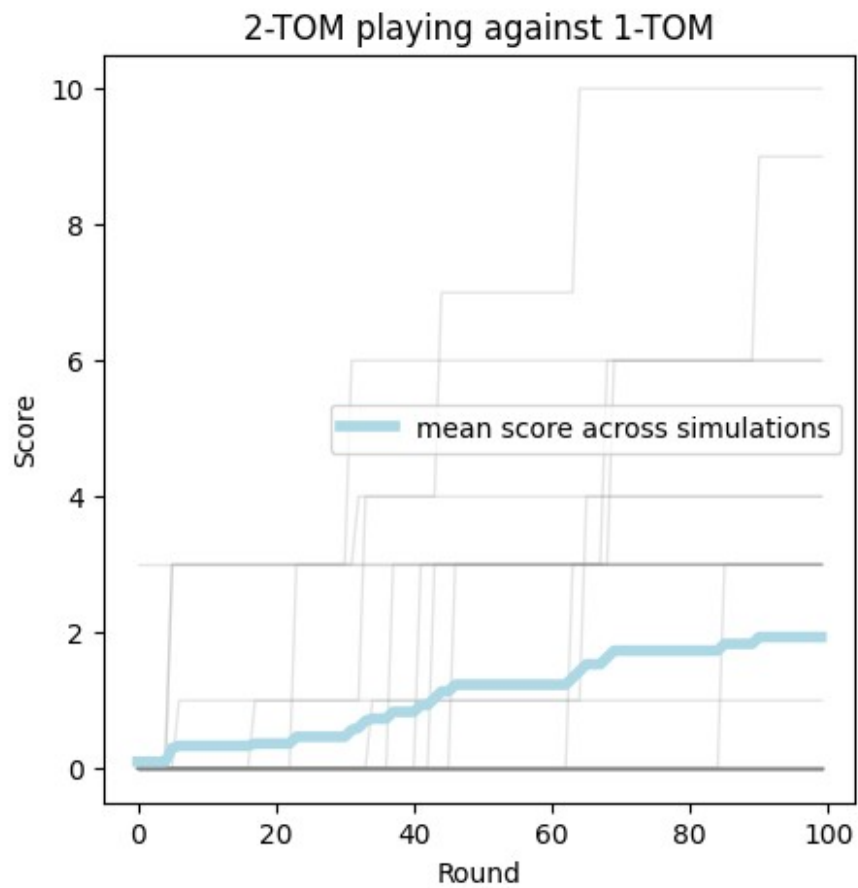


<Figure size 500x500 with 0 Axes>

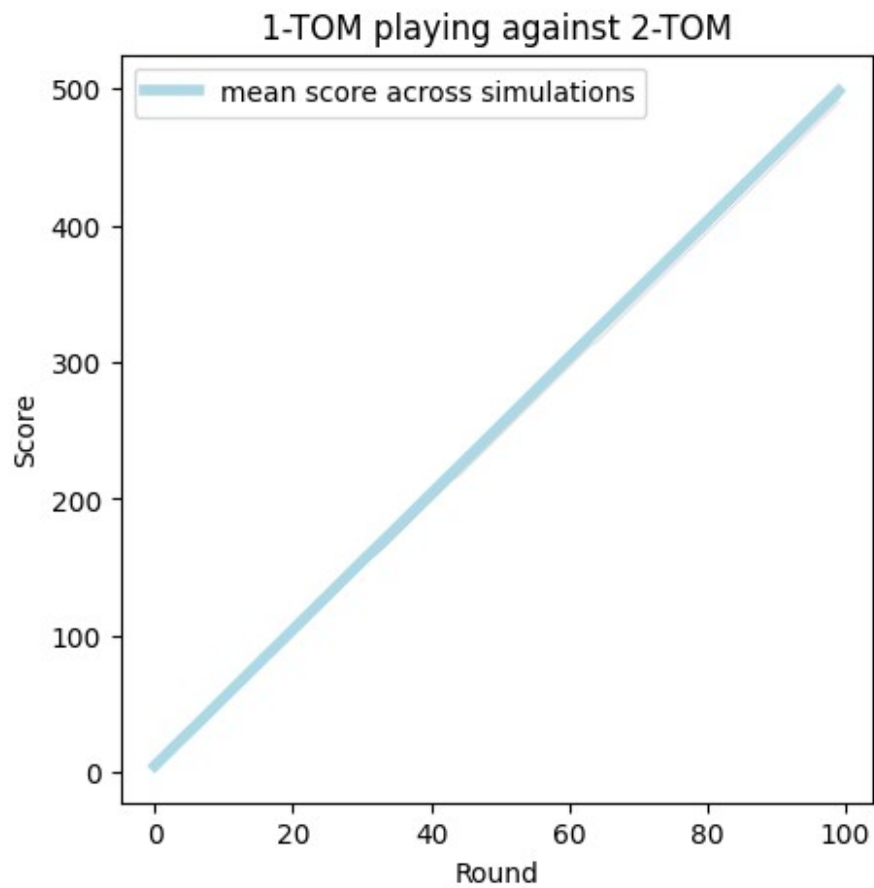


```
group.plot_score(agent0="1-TOM", agent1="2-TOM", agent=1)
```

<Figure size 500x500 with 0 Axes>

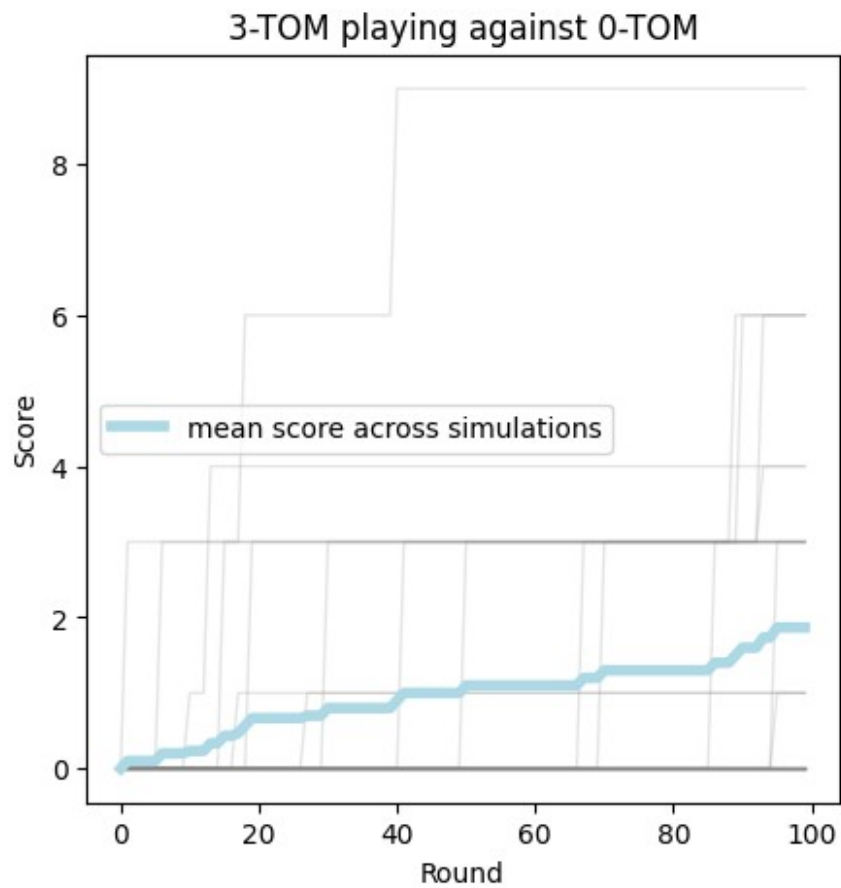


```
group.plot_score(agent0="1-TOM", agent1="2-TOM", agent=0)  
<Figure size 500x500 with 0 Axes>
```

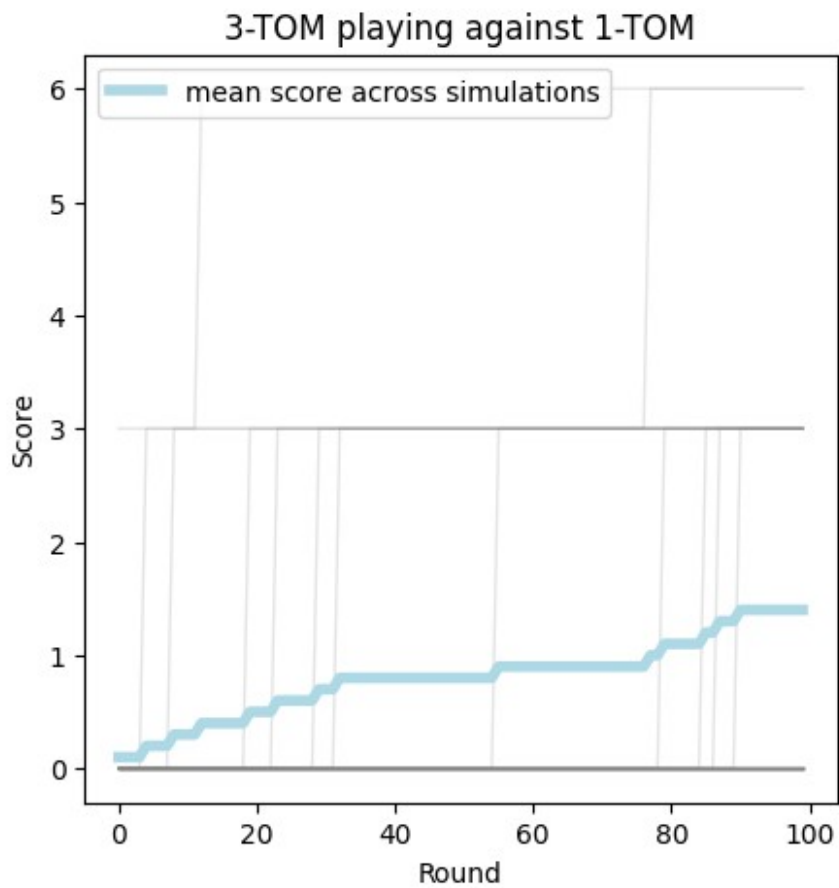


```
group.plot_score(agent0="0-TOM", agent1="3-TOM", agent=1)
```

<Figure size 500x500 with 0 Axes>

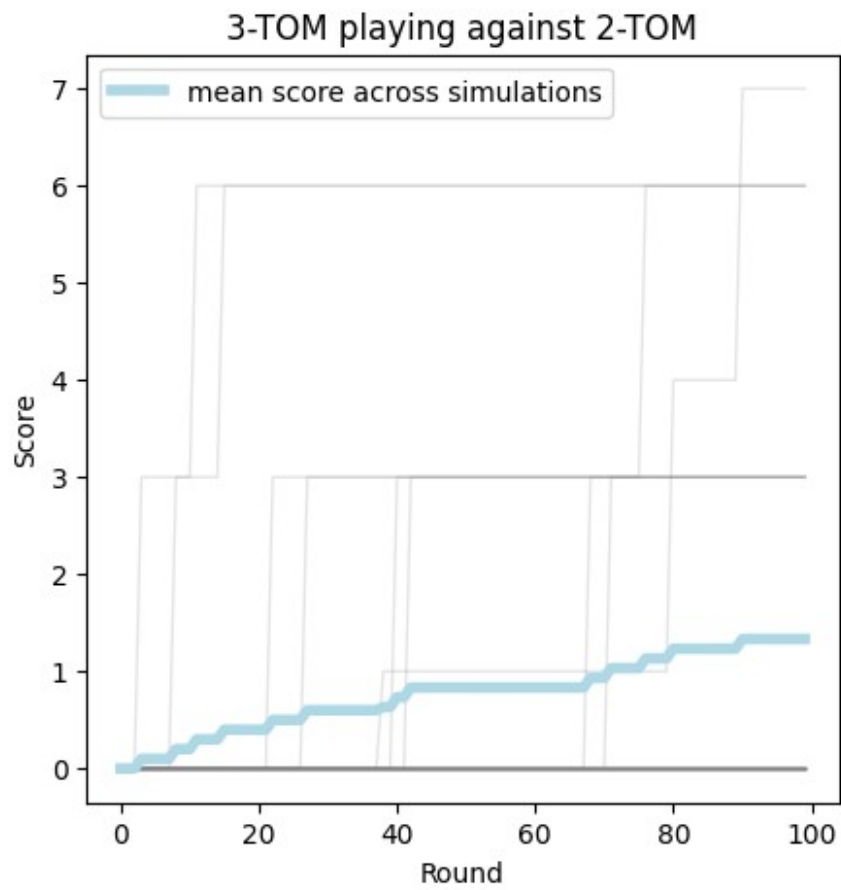


```
group.plot_score(agent0="1-TOM", agent1="3-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

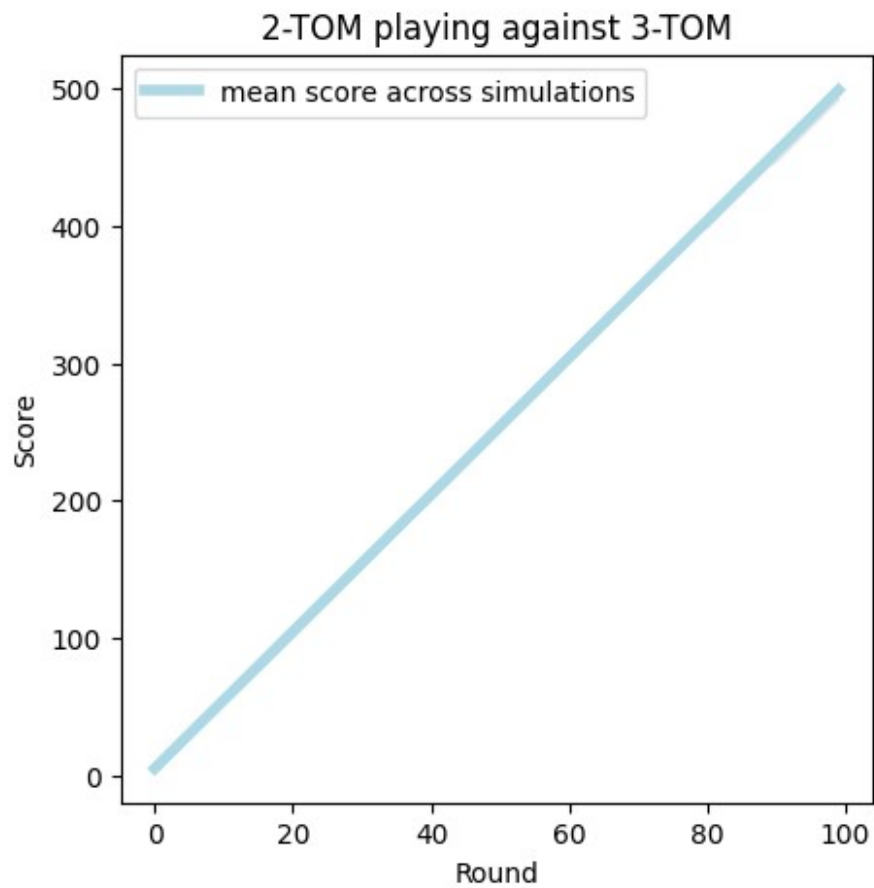


```
group.plot_score(agent0="2-TOM", agent1="3-TOM", agent=1)  
group.plot_score(agent0="2-TOM", agent1="3-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

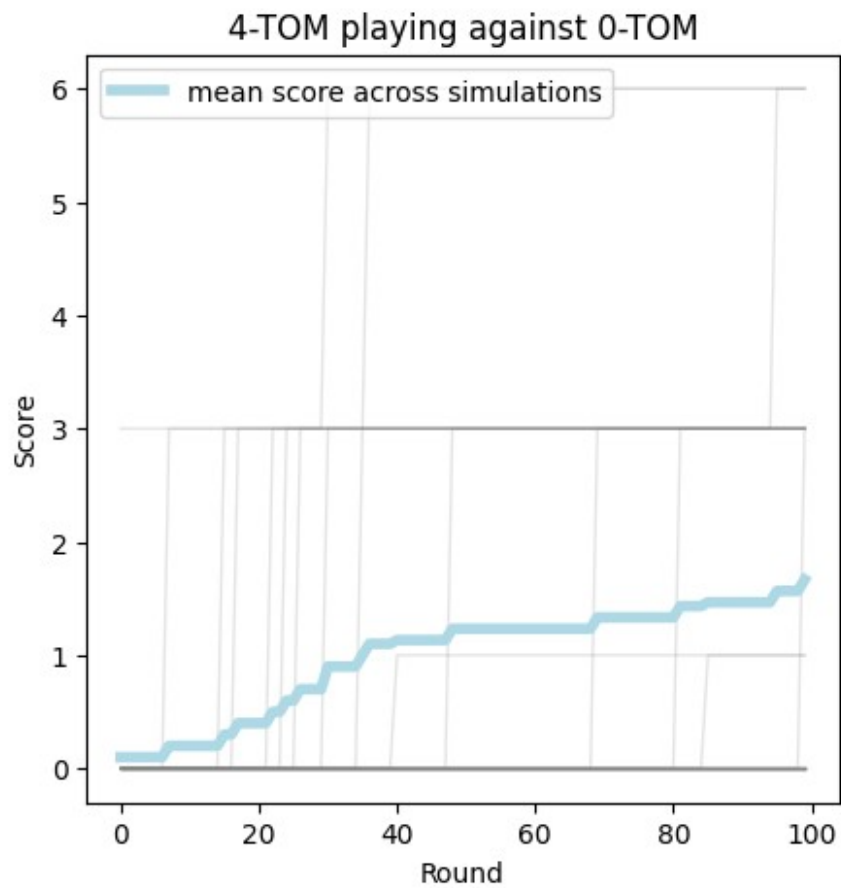


<Figure size 500x500 with 0 Axes>

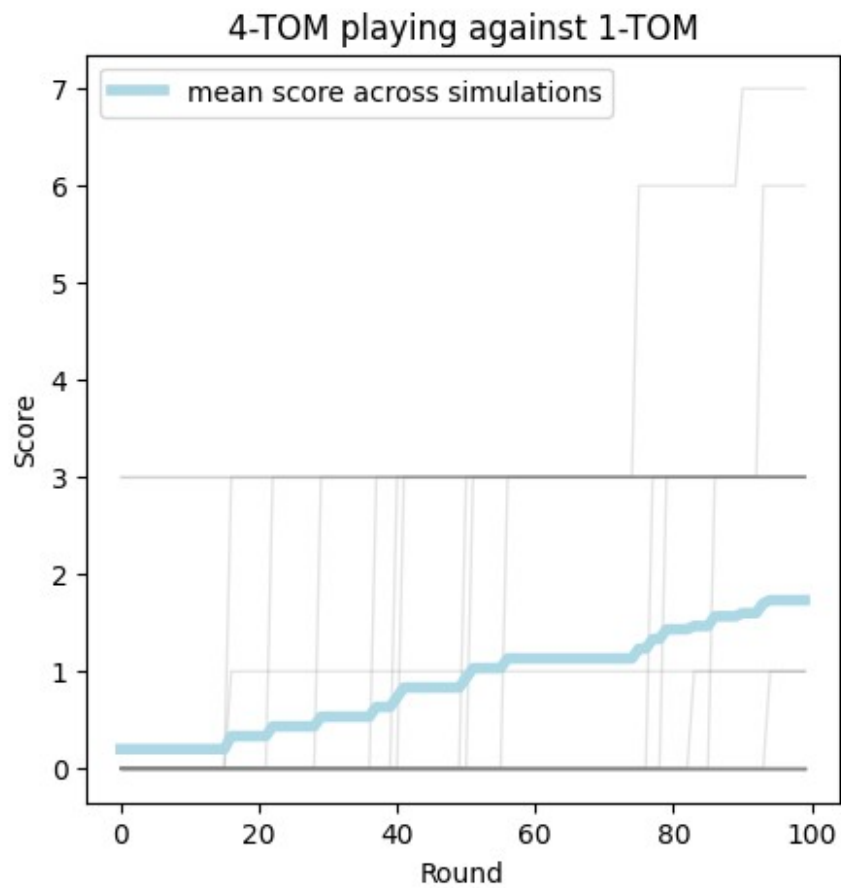


```
group.plot_score(agent0="0-TOM", agent1="4-TOM", agent=1)
```

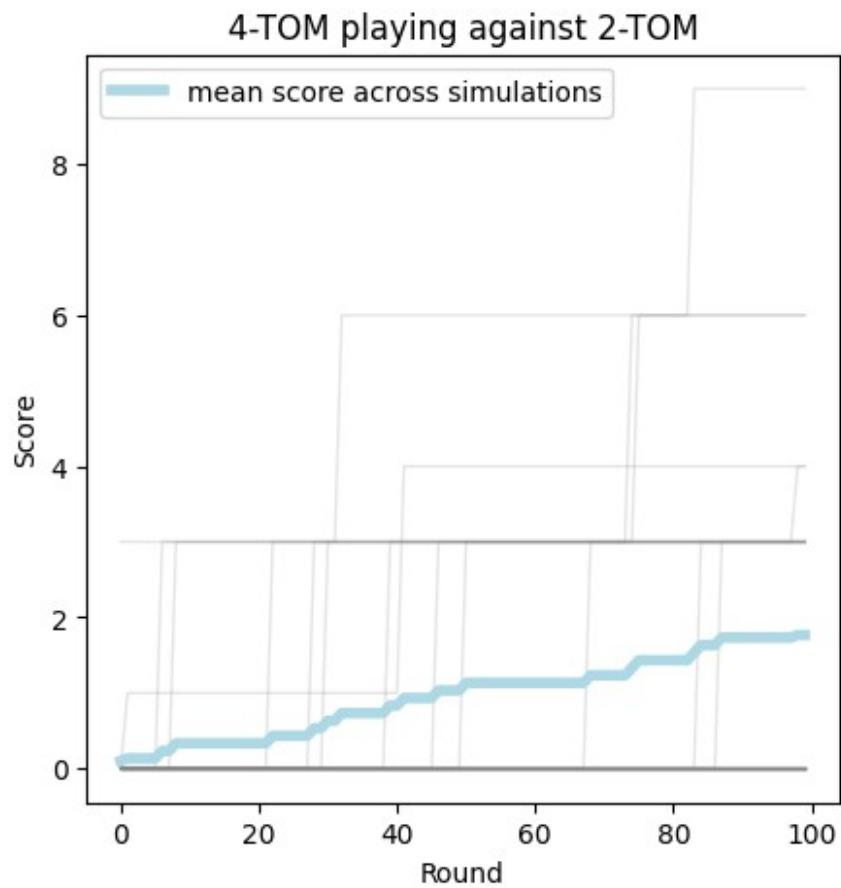
<Figure size 500x500 with 0 Axes>



```
group.plot_score(agent0="1-TOM", agent1="4-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

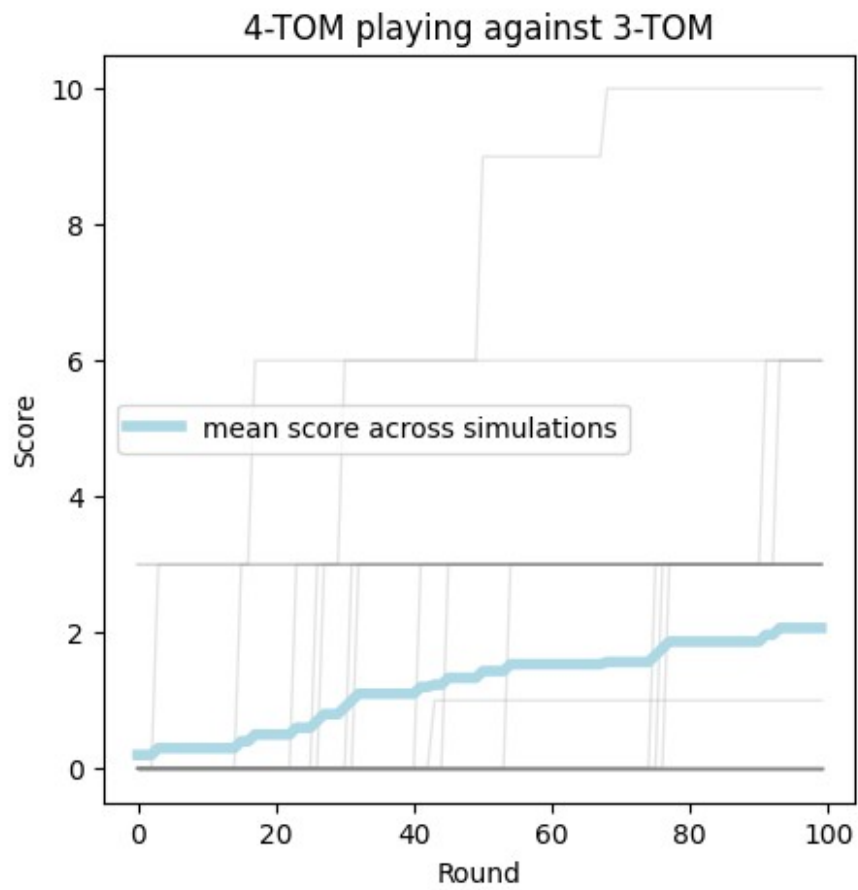


```
group.plot_score(agent0="2-TOM", agent1="4-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

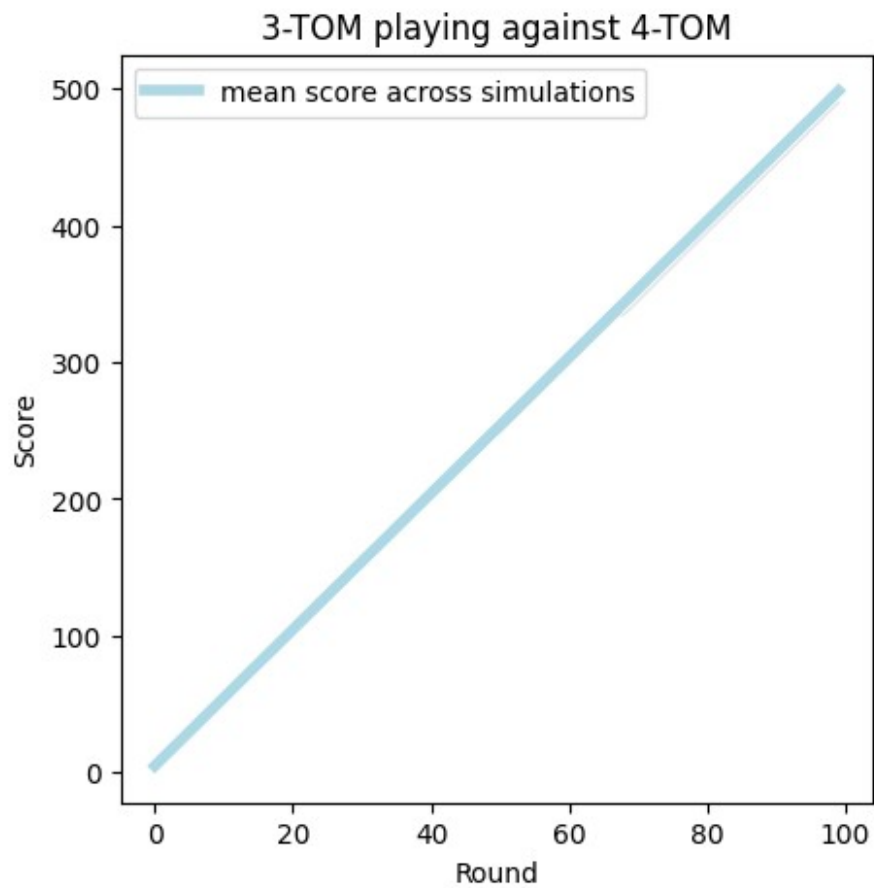


```
group.plot_score(agent0="3-TOM", agent1="4-TOM", agent=1)  
group.plot_score(agent0="3-TOM", agent1="4-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>

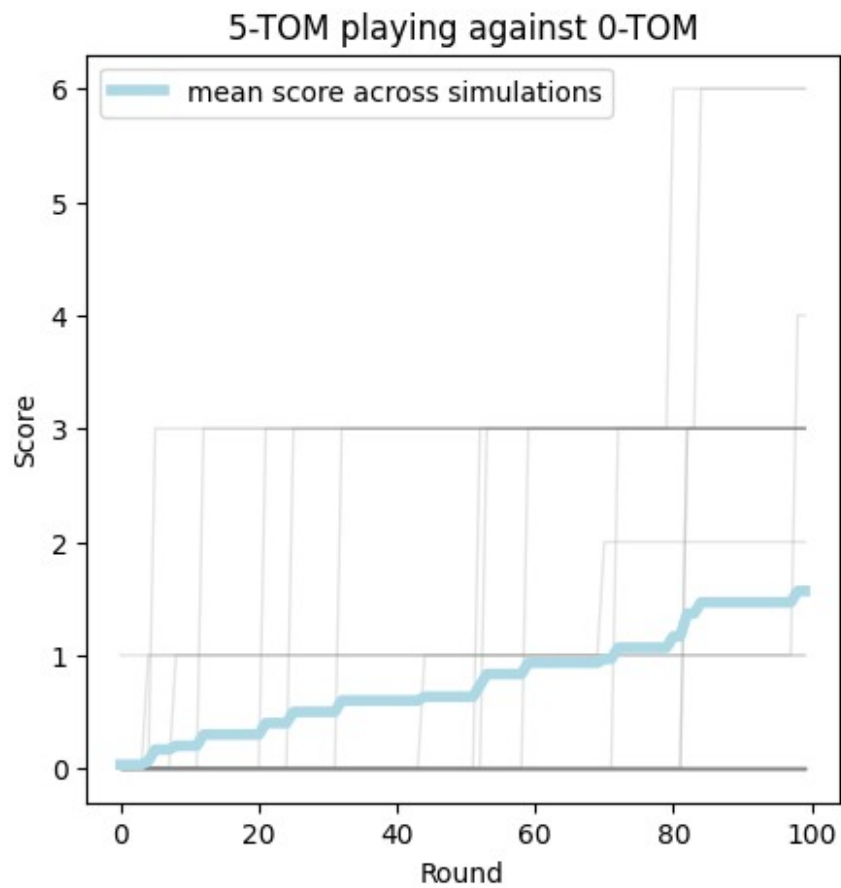


<Figure size 500x500 with 0 Axes>

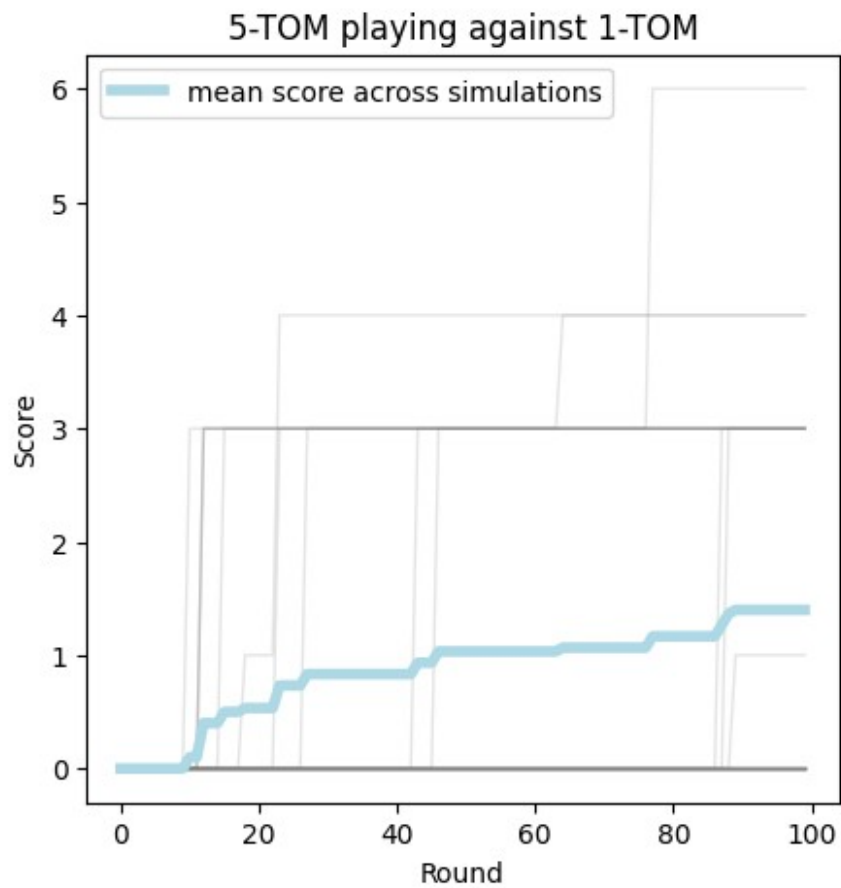


```
group.plot_score(agent0="0-TOM", agent1="5-TOM", agent=1)
```

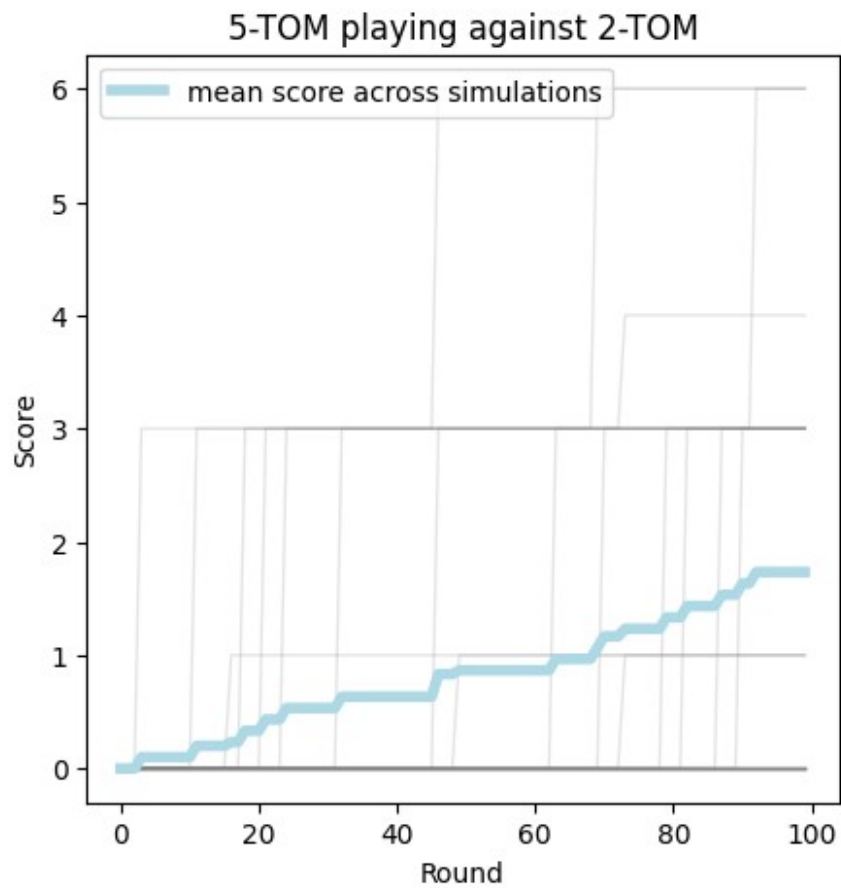
<Figure size 500x500 with 0 Axes>



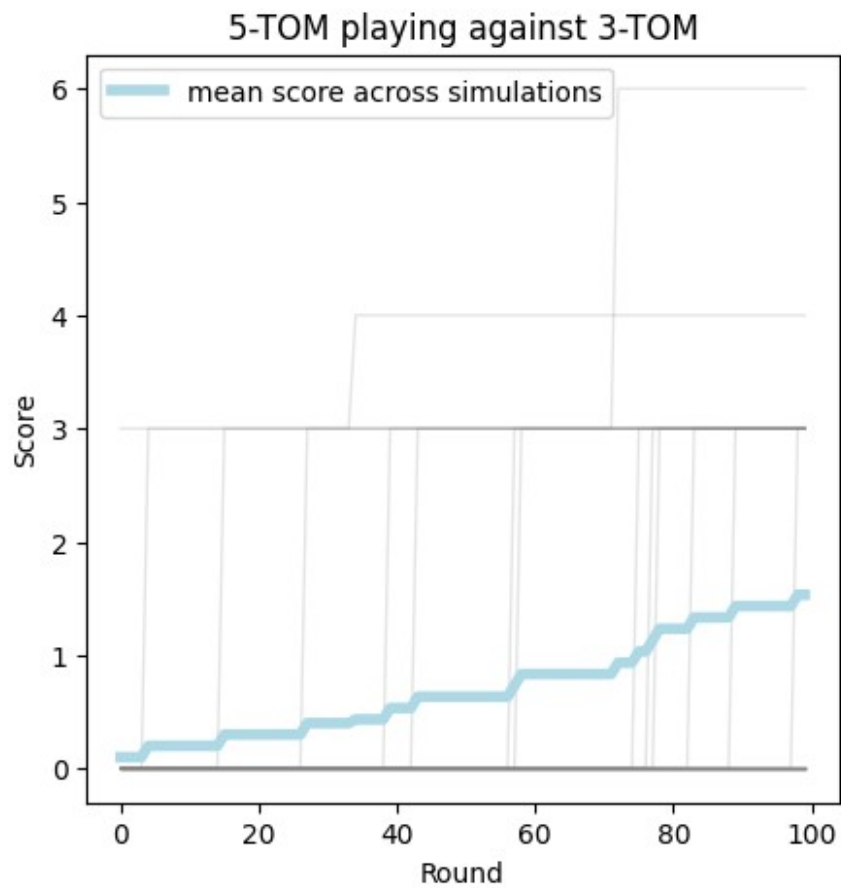
```
group.plot_score(agent0="1-TOM", agent1="5-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

```
group.plot_score(agent0="2-TOM", agent1="5-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```

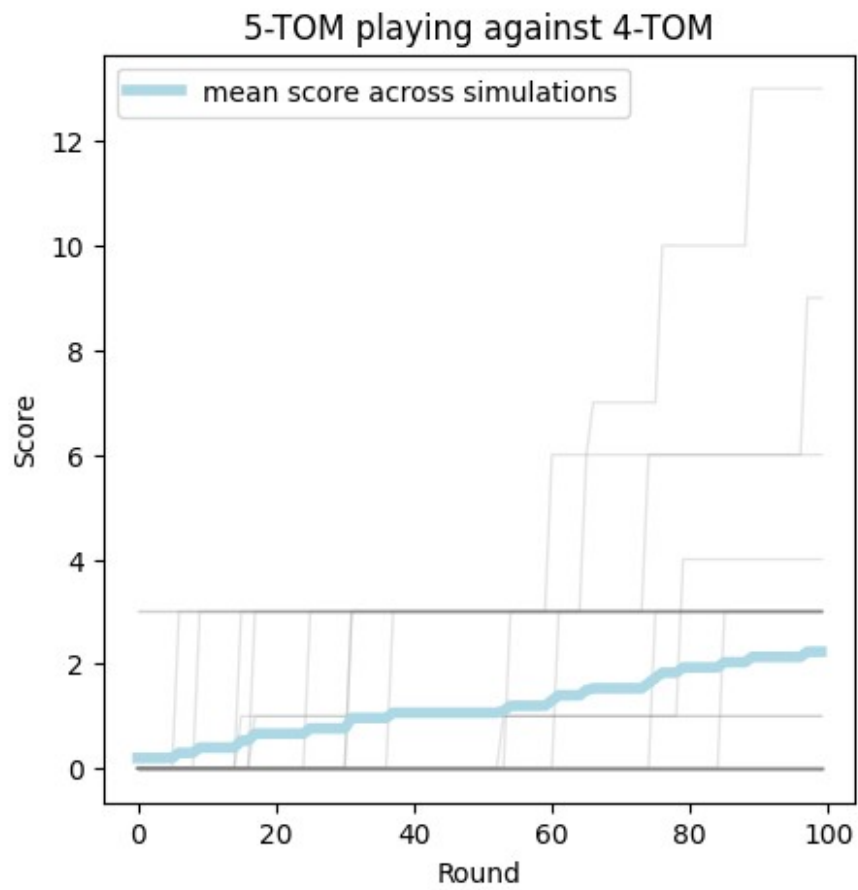


```
group.plot_score(agent0="3-TOM", agent1="5-TOM", agent=1)  
<Figure size 500x500 with 0 Axes>
```



```
group.plot_score(agent0="4-TOM", agent1="5-TOM", agent=1)  
group.plot_score(agent0="4-TOM", agent1="5-TOM", agent=0)
```

<Figure size 500x500 with 0 Axes>



<Figure size 500x500 with 0 Axes>

4-TOM playing against 5-TOM

