Contents


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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Main Simulation Script for Resource Allocation Project with R Integration
% Using Human data to estimate parameters and compare to synthetic data
% The choice predictions from human parameters is used to update survey GUI
% inputs. This helps us validate human-centric choice predictions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
clc;
clear all;
```

Step 1: Import CSV Data

(reference apolloMain_5 amd apolloMain_6 as example for data manipulation) biasData = readtable('user_choices.csv'); % Replace with the path to your data file disp('User bias data imported successfully.'); taskChoice_Data = readtable('user_choices.csv'); % Replace with the path to your data file disp('User task choice data imported successfully.');

```
robotChoice_Data = readtable('G:\My Drive\myResearch\Research Experimentation\Apollo\apollo\data\WarehouseRobot_Pairing_Data\test_pairing_data.csv');
disp('User robot choice data imported successfully.');

% Extract relevant data (modify based on your CSV structure)
% task_attributes = data{:, {'efficiency', 'speed', 'safety', 'durability', 'skill'}};

% Extract and organize robot states for all three alternatives
robot_states = struct();
attributes = {'energy','pace','safety','reliability','intelligence'};
for i = 1:3
    for attr = attributes
        robot_states.(['robot' num2str(i)]).(attr{1}) = ...
            robotChoice_Data.(['robot' num2str(i) attr{1}]);
    end
end

% Extract choice data and other metadata
choices = robotChoice_Data.choice;
participant_ids = robotChoice_Data.participantid;
trial_numbers = robotChoice_Data.trial;
stake_types = robotChoice_Data.staketype;
time_spent = robotChoice_Data.timespent;
```

```
User robot choice data imported successfully.
```

Step 2: R Bridge Implementation

```
disp('Initializing R bridge...');

% Configure paths
rscript_path = 'C:\Program Files\R\R-4.4.2\bin\x64\Rscript.exe';
r_script = 'G:\My Drive\myResearch\Research Experimentation\Apollo\apollo\example\DFT_Resource_Allocation.R';
csvFile = 'G:\My Drive\myResearch\Research Experimentation\Apollo\apollo\data\WarehouseRobot_Pairing_Data\HumanData_Resource_Allocation.csv';
outputDir = 'G:\My Drive\myResearch\Research Experimentation\Apollo\apollo\ResourceAllocation_Output';

% Verify installations
if ~isfile(rscript_path)
    error('Rscript.exe not found at: %s', rscript_path);
elseif ~isfile(r_script)
    error('R script not found at: %s', r_script);
elseif ~isfile(csvFile)
    error('Input CSV not found at: %s', csvFile);
elseif ~isfolder(outputDir)
    warning('Output folder does not exist, creating: %s', outputDir);
    mkdir(outputDir);
end

% Execute R with JSON output
try
    % Use proper argument formatting
    cmd = sprintf(['"%s" "%s" ', ...
```

```
                '-i "%s" -o "%s"'], ...
                rscript_path, r_script, csvFile, outputDir);

[status,result] = system(cmd);

    if status == 0
        % Handle output path (whether directory or file)
        if isfolder(outputDir)
            jsonFile = fullfile(outputDir, 'DFT_output.json');
        else
            jsonFile = outputDir;
        end

        % Parse JSON output
        if exist(jsonFile, 'file')
            jsonText = fileread(jsonFile);
            params = jsondecode(jsonText);

            % Extract parameters with validation
            %Boundedphi1, phi2 parameters
            phi1 = max(0, validateParam(params, 'phi1', 0.5)); % Ensure non-negative
            phi2 = min(max(0, validateParam(params, 'phi2', 0.8)), 1); % Constrain 0-1

            %Raw phi1, phi2 parameters
            %phi1 = validateParam(params, 'phi1', 0.5);
            %phi2 = validateParam(params, 'phi2', 0.8);
            tau = 1 + exp(validateParam(params, 'timesteps', 0.5));
            error_sd = min(max(0.1, validateParam(params, 'error_sd', 0.1)), 1); % still clip here

            % Extract attribute weights
            beta_weights = exp([
                params.b_energy;
                params.b_pace;
                params.b_safety;
                params.b_reliability;
                params.b_intelligence
            ]);

            % Get initial preferences from ASCs
            initial_P = [
                params.asc_1;
                params.asc_2;
                params.asc_3;
              %  0  % Control alternative1 has 0 initial preference
               % 0  % Control alternative2 has 0 initial preference
            ];

            disp('Estimated Parameters:');
            disp(['phi1: ', num2str(phi1)]);
            disp(['phi2: ', num2str(phi2)]);
            disp(['tau: ', num2str(tau)]);
            disp(['error_sd: ', num2str(error_sd)]);
            disp('Initial Preferences (from ASCs):');
            disp(initial_P');
        else
            error('R output file not found');
        end
    else
        error('R execution failed: %s', result);
    end
catch ME
    disp('Error during R execution:');
    disp(getReport(ME, 'extended'));
    [phi1, phi2, tau, error_sd] = getFallbackParams();
    beta_weights = [0.3; 0.2; 0.4]; % Default weights ; 0.1; 0.5
    initial_P = zeros(3,1); % Neutral initial preferences
end
```

```
Initializing R bridge...
```

Step 3: MDFT Formulation to Calculate Preference Dynamics

(MDFT calculations based on estimated parameters)

```
%current_trial = 1; % Analyze first trial (can be looped later)

num_trials = size(robotChoice_Data, 1);  % Assuming each row is a trial
```

```matlab
for current_trial = 1:num_trials
    % Extract data for the current trial
    trial_data = robotChoice_Data(current_trial, :);

% Create M matrix from current trial's attributes
M = [
    robotChoice_Data.robot1energy(current_trial), ...
    robotChoice_Data.robot1pace(current_trial), ...
    robotChoice_Data.robot1safety(current_trial), ...
    robotChoice_Data.robot1reliability(current_trial), ...
    robotChoice_Data.robot1intelligence(current_trial);

    robotChoice_Data.robot2energy(current_trial), ...
    robotChoice_Data.robot2pace(current_trial), ...
    robotChoice_Data.robot2safety(current_trial), ...
    robotChoice_Data.robot2reliability(current_trial), ...
    robotChoice_Data.robot2intelligence(current_trial);

    robotChoice_Data.robot3energy(current_trial), ...
    robotChoice_Data.robot3pace(current_trial), ...
    robotChoice_Data.robot3safety(current_trial), ...
    robotChoice_Data.robot3reliability(current_trial), ...
    robotChoice_Data.robot3intelligence(current_trial);

  %  0.1*ones(1,5) % Control alternative1

   % 0.9*ones(1,5) % Control alternative2
];

% Normalize beta weights
beta = beta_weights ./ sum(abs(beta_weights));

% Calculate DFT dynamics with initial preferences
[E_P, V_P, probs, P_tau] = calculateDFTdynamics(...
    phi1, phi2, tau, error_sd, beta, M, initial_P);

% Display results
disp('=== Current Trial Analysis ===');
disp(['Trial: ', num2str(current_trial)]);
disp(['Participant: ', num2str(participant_ids(current_trial))]);
disp(['Actual Choice: Robot ', num2str(choices(current_trial))]);

disp('M matrix (alternatives × attributes):');
disp(array2table(M, ...
    'RowNames', {'Robot1','Robot2','Robot3'}, ...
    'VariableNames', attributes)); %,'Control Alt1','Control Alt2'

% Create comparison table
result_table = table(probs, 'VariableNames', {'Probability'}, ...
                    'RowNames', {'Robot1','Robot2','Robot3'});
disp('Choice Probability Distribution:'); %,'Control1','Control2'
disp(result_table);

% Display DFT results with prediction
disp('DFT Results:');
disp(['E_P: ', num2str(E_P', '%.2f  ')]);
disp(['Choice probabilities: ', num2str(probs', '%.3f  ')]);
[~, predicted_choice] = max(probs); % Get index of highest probability
disp(['Predicted choice: Robot ', num2str(predicted_choice)]);
disp(['Actual choice: Robot ', num2str(choices(current_trial))]);
disp(' ');

% Display match/mismatch
if predicted_choice == choices(current_trial)
    disp('✓ Prediction stayed the same');
else
    disp('✗ Prediction changed');
end


% Plot preference evolution
figure;
time_steps = 0:size(P_tau, 2)-1;
h = plot(time_steps, P_tau', 'LineWidth', 2);

legend(h, {'Robot 1', 'Robot 2', 'Robot 3'}, 'Location', 'best');
xlabel('Time Step (\tau)');
ylabel('Preference Strength');
title(sprintf('Preference Evolution (Trial %d)', current_trial));
```

```
grid on;


end
%{
%% Step 4: Solve Equilibrium Function
% Ensure DFT outputs match expected dimensions
assert(length(E_P) == 5, 'DFT must return 5 alternatives');
assert(isequal(size(V_P), [5 5]), 'DFT covariance must be 5x5');

% Use DFT outputs for equilibrium calculation
Ep_mins = E_P;       % 4×1 expected preferences from DFT
Varp_mins = V_P;     % 4×4 preference covariance from DFT
% using robot attribute to map to product the robot can build type A vs
% type B. this is made using each robot attribute.
% 5 robot produce 2 things. each trial outputs x_mins as 10x1
x_mins = robot_production_capacity(M); % 10×1 robot state vector could recursive for each neighboring robot

% Call equilibrium solver
solutions = solve_equilibrium(Ep_mins, Varp_mins, x_mins);

% Extract solutions (works with both old and new versions)
if isfield(solutions, 'x')
    % Old version field names
    P_final = solutions.x;
    E_P_eq = solutions.lambda;
    V_P_eq = solutions.mu_vec;
else
    % New version field names
    P_final = solutions.P_final;
    E_P_eq = solutions.E_P_eq;
    V_P_eq = solutions.V_P_eq;
end

% Display results
disp('=== Equilibrium Results ===');
disp(['Final Preferences (P_final): ', num2str(P_final')]);
disp(['Expected Preferences (E_P_eq): ', num2str(E_P_eq')]);
disp(['Preference Variance (V_P_eq diagonal): ', num2str(V_P_eq')]);

%% Step 5: Output Results
disp('Saving results to CSV...');
output_table = table(E_P, V_P, P_final, ...
                     'VariableNames', {'ExpectedPreference', 'VariancePreference', 'FinalPreferences'});
writetable(output_table, 'results.csv');
disp('Results saved successfully!');
%}
```

```
=== Current Trial Analysis ===
Trial: 1
Participant: 1001
Actual Choice: Robot 2
M matrix (alternatives × attributes):
              energy    pace    safety    reliability    intelligence
              ______    ____    ______    ___________    ____________

    Robot1     0.65     0.55      0.7         0.6            0.58
    Robot2     0.75     0.45      0.8        0.65            0.62
    Robot3      0.5      0.6     0.65        0.55             0.5

Choice Probability Distribution:
              Probability
              ___________

    Robot1      0.88477
    Robot2     0.078084
    Robot3     0.037147

DFT Results:
E_P: 1.84  -0.58  -1.33
Choice probabilities: 0.885  0.078  0.037
Predicted choice: Robot 1
Actual choice: Robot 2

✗ Prediction changed
=== Current Trial Analysis ===
Trial: 2
Participant: 1001
```

```
Actual Choice: Robot 1
M matrix (alternatives × attributes):
             energy    pace    safety    reliability    intelligence
             ______    ____    ______    ___________    ____________

    Robot1     0.55     0.45      0.6         0.5            0.48
    Robot2      0.7     0.35     0.75         0.6            0.57
    Robot3     0.45     0.55      0.6         0.5            0.45

Choice Probability Distribution:
             Probability
             ___________

    Robot1     0.040823
    Robot2      0.43942
    Robot3      0.51976

DFT Results:
E_P: -1.62   0.76   0.93
Choice probabilities: 0.041  0.439  0.520
Predicted choice: Robot 3
Actual choice: Robot 1

✗ Prediction changed
=== Current Trial Analysis ===
Trial: 3
Participant: 1001
Actual Choice: Robot 3
M matrix (alternatives × attributes):
             energy    pace    safety    reliability    intelligence
             ______    ____    ______    ___________    ____________

    Robot1      0.6      0.5     0.65        0.55            0.53
    Robot2     0.65      0.4      0.7        0.55             0.6
    Robot3     0.55     0.65      0.7         0.6            0.55

Choice Probability Distribution:
             Probability
             ___________

    Robot1     0.026676
    Robot2      0.46883
    Robot3      0.50449

DFT Results:
E_P: -1.91   0.96   1.03
Choice probabilities: 0.027  0.469  0.504
Predicted choice: Robot 3
Actual choice: Robot 3

✓ Prediction stayed the same
=== Current Trial Analysis ===
Trial: 4
Participant: 1002
Actual Choice: Robot 2
M matrix (alternatives × attributes):
             energy    pace    safety    reliability    intelligence
             ______    ____    ______    ___________    ____________

    Robot1     0.7      0.6      0.75        0.65            0.63
    Robot2     0.8      0.5      0.85         0.7            0.67
    Robot3     0.6      0.7      0.75        0.65             0.6

Choice Probability Distribution:
             Probability
             ___________

    Robot1     0.030265
    Robot2      0.45697
    Robot3      0.51276

DFT Results:
E_P: -1.83   0.89   1.00
Choice probabilities: 0.030  0.457  0.513
Predicted choice: Robot 3
Actual choice: Robot 2

✗ Prediction changed
=== Current Trial Analysis ===
```

Trial: 5
Participant: 1002
Actual Choice: Robot 1
M matrix (alternatives × attributes):

	energy	pace	safety	reliability	intelligence
Robot1	0.5	0.4	0.55	0.45	0.43
Robot2	0.6	0.3	0.65	0.5	0.52
Robot3	0.4	0.5	0.55	0.45	0.4

Choice Probability Distribution:

	Probability
Robot1	0.023216
Robot2	0.45813
Robot3	0.51866

DFT Results:
E_P: -2.00 0.98 1.10
Choice probabilities: 0.023 0.458 0.519
Predicted choice: Robot 3
Actual choice: Robot 1

✗ Prediction changed
=== Current Trial Analysis ===
Trial: 6
Participant: 1002
Actual Choice: Robot 3
M matrix (alternatives × attributes):

	energy	pace	safety	reliability	intelligence
Robot1	0.75	0.65	0.8	0.7	0.68
Robot2	0.85	0.55	0.9	0.75	0.73
Robot3	0.65	0.75	0.8	0.7	0.65

Choice Probability Distribution:

	Probability
Robot1	0.027882
Robot2	0.45788
Robot3	0.51424

DFT Results:
E_P: -1.88 0.92 1.03
Choice probabilities: 0.028 0.458 0.514
Predicted choice: Robot 3
Actual choice: Robot 3

✓ Prediction stayed the same
=== Current Trial Analysis ===
Trial: 7
Participant: 1003
Actual Choice: Robot 2
M matrix (alternatives × attributes):

	energy	pace	safety	reliability	intelligence
Robot1	0.58	0.48	0.63	0.53	0.51
Robot2	0.68	0.38	0.73	0.58	0.61
Robot3	0.48	0.58	0.63	0.53	0.48

Choice Probability Distribution:

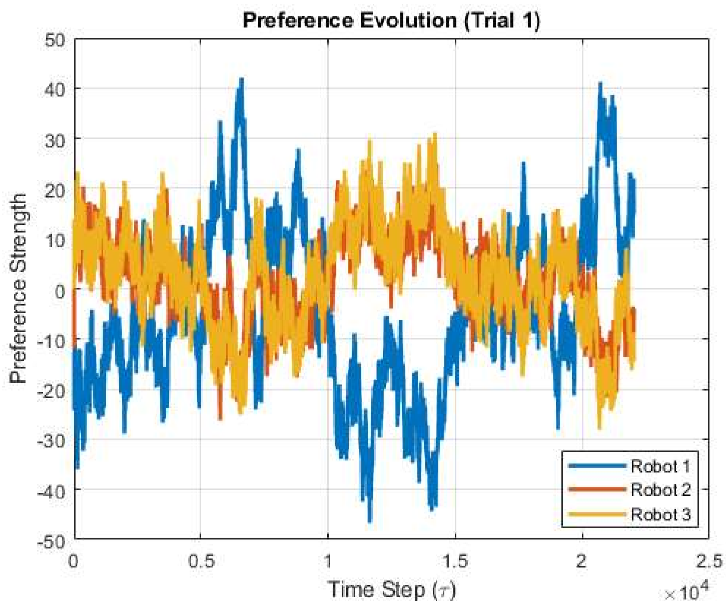
	Probability
Robot1	0.02297
Robot2	0.45758
Robot3	0.51945

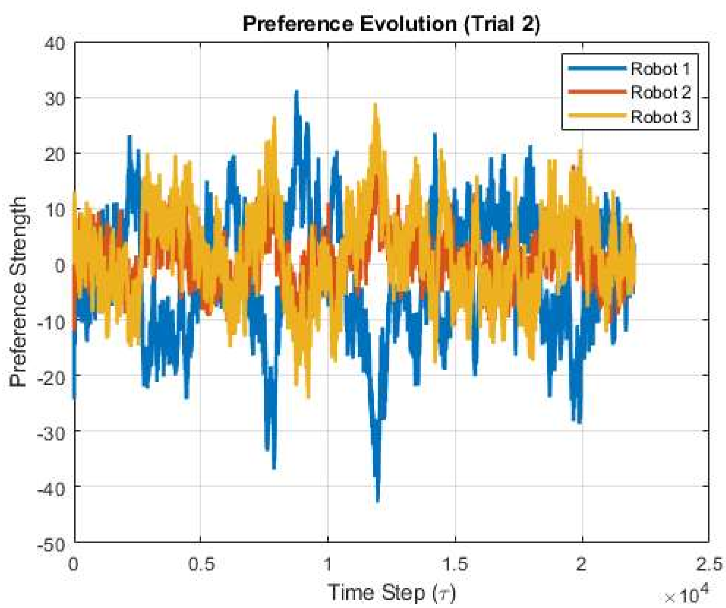
DFT Results:
E_P: -2.01 0.98 1.11
Choice probabilities: 0.023 0.458 0.519
Predicted choice: Robot 3
Actual choice: Robot 2

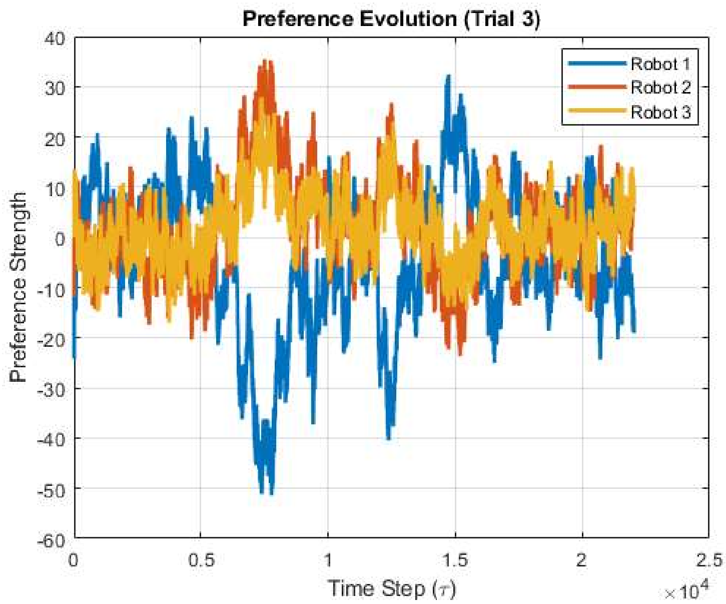
```
✗ Prediction changed
=== Current Trial Analysis ===
Trial: 8
Participant: 1003
Actual Choice: Robot 1
M matrix (alternatives × attributes):
              energy    pace    safety    reliability    intelligence
              ______    ____    ______    ___________    ____________

    Robot1     0.62     0.52     0.67        0.57            0.55
    Robot2     0.72     0.42     0.77        0.62            0.65
    Robot3     0.52     0.62     0.67        0.57            0.52

Choice Probability Distribution:
              Probability
              ___________

    Robot1      0.02297
    Robot2      0.45758
    Robot3      0.51945

DFT Results:
E_P: -2.01   0.98   1.11
Choice probabilities: 0.023  0.458  0.519
Predicted choice: Robot 3
Actual choice: Robot 1

✗ Prediction changed
=== Current Trial Analysis ===
Trial: 9
Participant: 1003
Actual Choice: Robot 3
M matrix (alternatives × attributes):
              energy    pace    safety    reliability    intelligence
              ______    ____    ______    ___________    ____________

    Robot1     0.67     0.57     0.72        0.62             0.6
    Robot2     0.77     0.47     0.82        0.67             0.7
    Robot3     0.57     0.67     0.72        0.62            0.57

Choice Probability Distribution:
              Probability
              ___________

    Robot1      0.02297
    Robot2      0.45758
    Robot3      0.51945

DFT Results:
E_P: -2.01   0.98   1.11
Choice probabilities: 0.023  0.458  0.519
Predicted choice: Robot 3
Actual choice: Robot 3

✓ Prediction stayed the same
=== Current Trial Analysis ===
Trial: 10
Participant: 1004
Actual Choice: Robot 2
M matrix (alternatives × attributes):
              energy    pace    safety    reliability    intelligence
              ______    ____    ______    ___________    ____________

    Robot1     0.53     0.43     0.58        0.48            0.46
    Robot2     0.63     0.33     0.68        0.53            0.56
    Robot3     0.43     0.53     0.58        0.48            0.43

Choice Probability Distribution:
              Probability
              ___________

    Robot1      0.02297
    Robot2      0.45758
    Robot3      0.51945

DFT Results:
E_P: -2.01   0.98   1.11
Choice probabilities: 0.023  0.458  0.519
Predicted choice: Robot 3
```

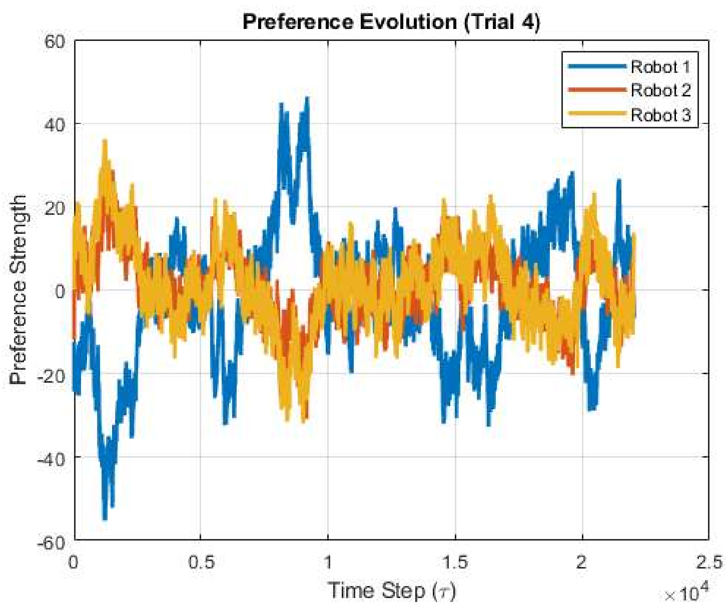
Actual choice: Robot 2

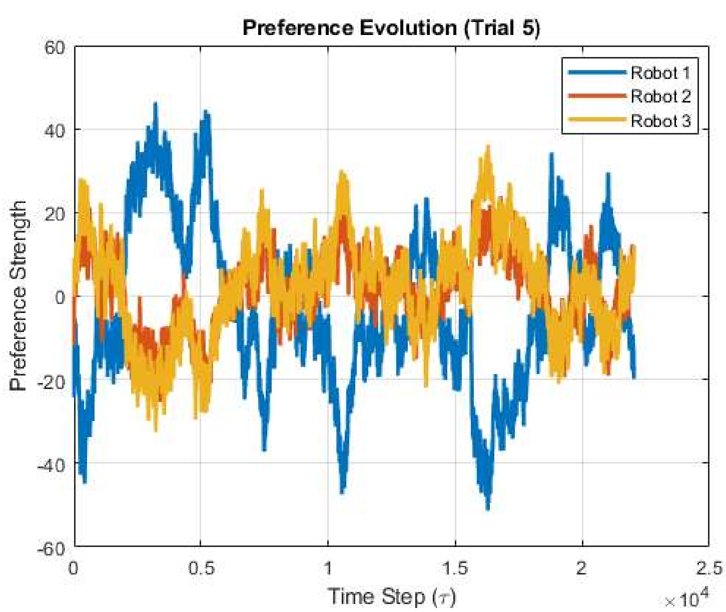
✗ Prediction changed

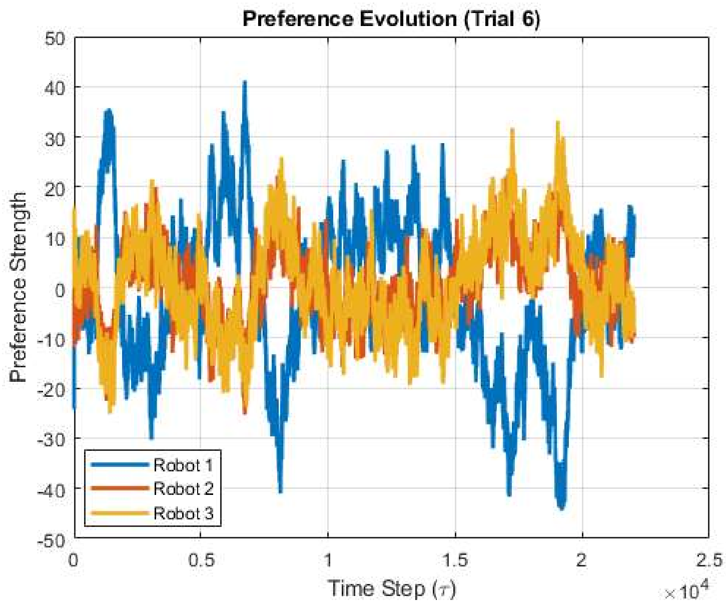


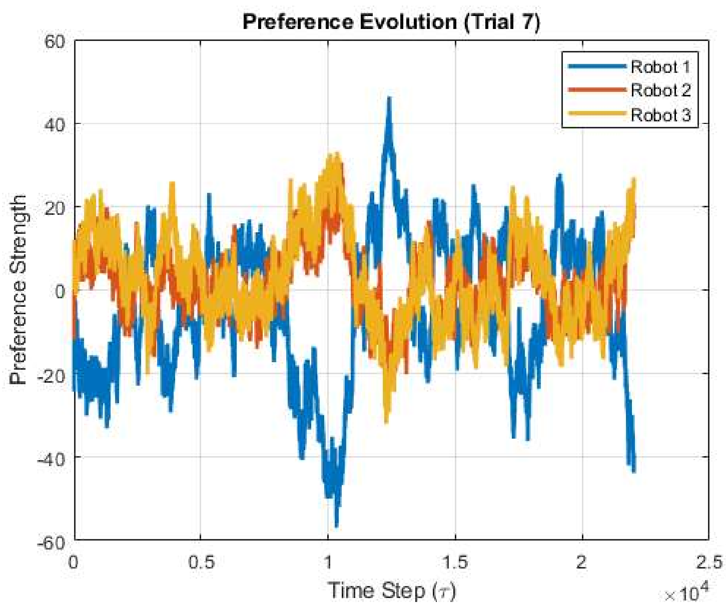


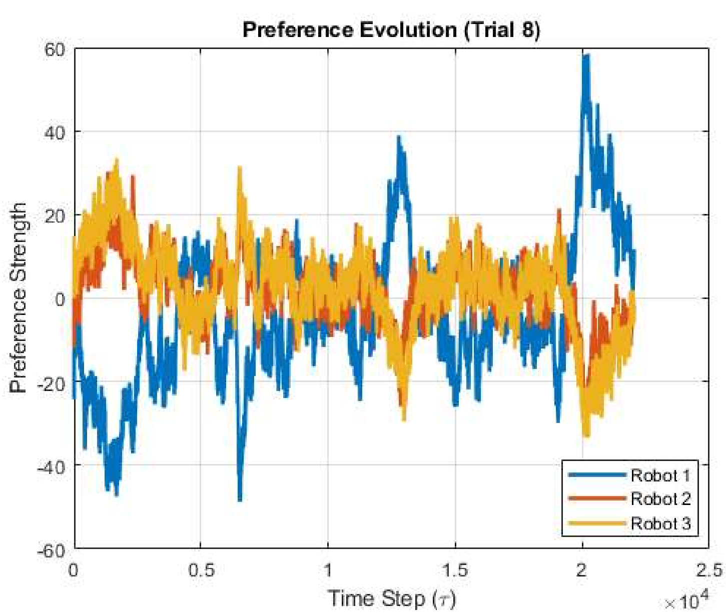

Preference Evolution (Trial 3)
Robot 1
Robot 2
Robot 3
Preference Strength
Time Step (τ)
$\times 10^4$
40
30
20
10
0
-10
-20
-30
-40
-50
-60
0
0.5
1
1.5
2
2.5

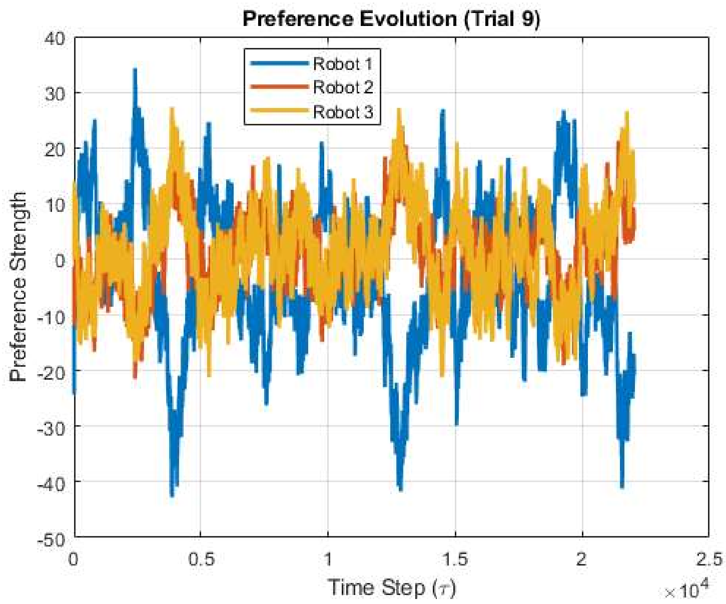

Preference Evolution (Trial 4)
Robot 1
Robot 2
Robot 3
Preference Strength
Time Step (τ)
$\times 10^4$
60
40
20
0
-20
-40
-60
0
0.5
1
1.5
2
2.5

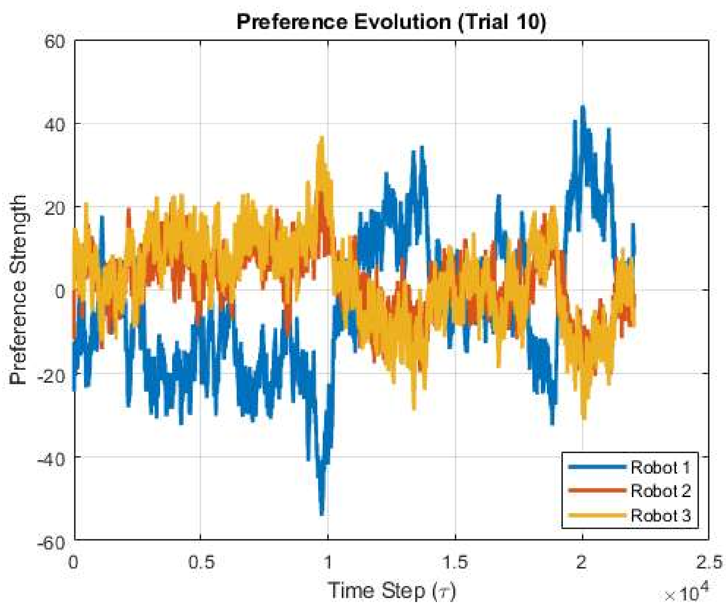

Preference Evolution (Trial 5)
Robot 1
Robot 2
Robot 3
Preference Strength
Time Step (τ)
$\times 10^4$
60
40
20
0
-20
-40
-60
0
0.5
1
1.5
2
2.5


Preference Evolution (Trial 6)
Preference Strength
Time Step (τ)
$\times 10^4$
Robot 1
Robot 2
Robot 3
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
0.5
1
1.5
2
2.5


Preference Evolution (Trial 7)
Preference Strength
Time Step (τ)
$\times 10^4$
Robot 1
Robot 2
Robot 3
60
40
20
0
-20
-40
-60
0
0.5
1
1.5
2
2.5


Preference Evolution (Trial 8)
Preference Strength
Time Step (τ)
$\times 10^4$
Robot 1
Robot 2
Robot 3
60
40
20
0
-20
-40
-60
0
0.5
1
1.5
2
2.5





Helper Functions

```
function param = validateParam(params, name, default)
    if isfield(params, name) && isnumeric(params.(name))
        param = params.(name);
    else
        warning('Using default for %s', name);
        param = default;
    end
end

function [phi1, phi2, tau, error_sd] = getFallbackParams()
    phi1 = 0.5;
    phi2 = 0.8;
    tau = 10;
    error_sd = 0.1;
    warning('Using default parameters');
end
```

```
Estimated Parameters:
phi1: 32.7954
phi2: 0.1601
tau: 22027.4658
error_sd: 1
Initial Preferences (from ASCs):
```

```
   -24.2300  -11.8930         0
```

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