## Contents



```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Main Simulation Script for BoundingOverwatch Project with R Integration
% Randomly 10 trials is used to validate predictions
% DFT Parameters:
% phi1 - sensitivity to attribute differences (typically 0.5-2)
% phi2 - memory/feedback strength (0-1)
% tau - decision time steps (integer > 0)
% error_sd - noise standard deviation (σ_ε)
% beta - attribute weights from R estimation
% w -  attention weights (default [0.5;0.5])
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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\Bounding_Overwatch_Data\HumanData_Bounding_Overwatch_NORMALIZED.csv
% Convert all column headers to lowercase
robotChoice_Data.Properties.VariableNames = lower(robotChoice_Data.Properties.VariableNames);
disp('User robot choice data imported successfully.');

% Randomly select 10 rows (or all rows if fewer than 10)
numRows = height(robotChoice_Data);
randomIndices = randperm(numRows, min(10, numRows));
robotChoice_Data = robotChoice_Data(randomIndices, :);

% Extract robot state attributes dynamically
robot_states = struct();
attributeSuffixes = {'traversability', 'visibility'}; % No leading underscores
for i = 1:3
    for attr = attributeSuffixes
        csvColName = sprintf('robot%d_%s', i, attr{1});  % Matches CSV column names
        structFieldName = attr{1};  % Valid field name
        if ismember(csvColName, robotChoice_Data.Properties.VariableNames)
            robot_states.(['robot' num2str(i)]).(structFieldName) = robotChoice_Data.(csvColName);
        else
            warning('Missing attribute column: %s', csvColName);
            robot_states.(['robot' num2str(i)]).(structFieldName) = NaN(height(robotChoice_Data), 1);
        end
    end
end

% Extract choice data and other metadata
choices = robotChoice_Data.choice;
participant_ids = robotChoice_Data.id;
stake_types = robotChoice_Data.stakes;
time_spent = robotChoice_Data.timeelapsed;
```

```
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_Bounding_Overwatch.R';
csvFile = 'G:\My Drive\myResearch\Research Experimentation\Apollo\apollo\data\Bounding_Overwatch_Data\HumanData_Bounding_Overwatch_NORMALIZED.csv';
outputDir = 'G:\My Drive\myResearch\Research Experimentation\Apollo\apollo\Output_BoundingOverwatch';

% 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 = [
                params.b_attr1;
                params.b_attr2;
                params.b_attr3;
                params.b_attr4
            ];

            % Get initial preferences from ASCs
            initial_P = [
                validateParam(params, 'asc_1', 0);
                validateParam(params, 'asc_2', 0);
                validateParam(params, 'asc_3', 0);
            ];

            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; 0.5]; % Default weights
    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) Create M matrix from current trial's attributes C11-C14 are consequence attributes for Robot 1 C21-C24 are consequence attributes for Robot 2 C31-C34 are consequence attributes for Robot 3

```
for current_trial = 1:height(robotChoice_Data)
    num_attributes = 4;

    M = [
        robotChoice_Data.c11(current_trial), robotChoice_Data.c12(current_trial), robotChoice_Data.c13(current_trial), robotChoice_Data.c14(current_trial);
        robotChoice_Data.c21(current_trial), robotChoice_Data.c22(current_trial), robotChoice_Data.c23(current_trial), robotChoice_Data.c24(current_trial);
```

```
        robotChoice_Data.c31(current_trial), robotChoice_Data.c32(current_trial), robotChoice_Data.c33(current_trial), robotChoice_Data.c34(current_trial)
    ];

    %M = M / 100;             % Convert all values from 0-100 to 0.00-1.00 scale

    attributes = {'C1 - Easy Nav, Low Exposure', 'C2 - Hard Nav, Low Exposure', 'C3 - Easy Nav, High Exposure', 'C4 - Hard Nav, High Exposure'};
    beta = beta_weights ./ sum(abs(beta_weights));
    beta = beta';

    [E_P, V_P, choice_probs, P_tau] = calculateDFTdynamics(...
        phi1, phi2, tau, error_sd, beta, M, initial_P);

    % Display results for the trial
    disp('=== 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));

    disp('DFT Results:');
    disp(['E_P: ', num2str(E_P', '%.2f  ')]);
    disp(['Choice probabilities: ', num2str(choice_probs', '%.3f  ')]);
    [~, predicted_choice] = max(choice_probs);
    disp(['Predicted choice: Robot ', num2str(predicted_choice)]);
    disp(['Actual choice: Robot ', num2str(choices(current_trial))]);
    disp(' ');

    if predicted_choice == choices(current_trial)
        disp('✓ Prediction matches actual choice');
    else
        disp('✗ Prediction differs from actual choice');
    end

    % Plot evolution
    figure;
    plot(0:tau, P_tau);
    xlabel('Preference Step (\tau)');
    ylabel('Preference Strength');
    legend({'Robot1','Robot2','Robot3'});
    title(sprintf('Preference Evolution (Trial %d)', current_trial));
    grid on;
end
%{
%% Step 4: Output Results
disp('Saving results to CSV...');
output_table = table(E_P, V_P, P_tau(end,:)', ...
                     'VariableNames', {'ExpectedPreference', 'VariancePreference', 'FinalPreferences'});
writetable(output_table, 'results.csv');
disp('Results saved successfully!');
%}
```

```
=== Trial Analysis ===
Trial: 1
Participant: 124737
Actual Choice: Robot 1
M matrix (alternatives × attributes):
              C1 - Easy Nav, Low Exposure    C2 - Hard Nav, Low Exposure    C3 - Easy Nav, High Exposure    C4 - Hard Nav, High Exposure
              ___________________________    ___________________________    ____________________________    ____________________________

    Robot1                0.58                           0.88                            0.28                            0.28
    Robot2                0.42                            0.8                            0.06                            0.72
    Robot3                0.02                           0.34                            0.64                               1

DFT Results:
E_P: NaN  NaN  NaN
Choice probabilities: NaN  NaN  NaN
Predicted choice: Robot 1
Actual choice: Robot 1

✓ Prediction matches actual choice
=== Trial Analysis ===
Trial: 2
Participant: 142426
Actual Choice: Robot 2
M matrix (alternatives × attributes):
              C1 - Easy Nav, Low Exposure    C2 - Hard Nav, Low Exposure    C3 - Easy Nav, High Exposure    C4 - Hard Nav, High Exposure
              ___________________________    ___________________________    ____________________________    ____________________________

    Robot1              0.019231                       0.71154                         0.21154                               1
    Robot2              0.038462                       0.71154                         0.32692                         0.84615
    Robot3               0.46154                       0.53846                        0.057692                         0.86538
```

DFT Results:
E_P: NaN  NaN  NaN
Choice probabilities: NaN  NaN  NaN
Predicted choice: Robot 1
Actual choice: Robot 2

✗ Prediction differs from actual choice
=== Trial Analysis ===
Trial: 3
Participant: 175044
Actual Choice: Robot 2
M matrix (alternatives × attributes):

| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.35185 | 0.48148 | 0.51852 | 0.5 |
| Robot2 | 0.11111 | 0.37037 | 0.87037 | 0.51852 |
| Robot3 | 0.38889 | 1 | 0.24074 | 0.22222 |

DFT Results:
E_P: NaN  NaN  NaN
Choice probabilities: NaN  NaN  NaN
Predicted choice: Robot 1
Actual choice: Robot 2

✗ Prediction differs from actual choice
=== Trial Analysis ===
Trial: 4
Participant: 123310
Actual Choice: Robot 2
M matrix (alternatives × attributes):

| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.22951 | 0.27869 | 0.13115 | 1 |
| Robot2 | 0.44262 | 0.36066 | 0.29508 | 0.54098 |
| Robot3 | 0.31148 | 0.98361 | 0.31148 | 0.032787 |

DFT Results:
E_P: NaN  NaN  NaN
Choice probabilities: NaN  NaN  NaN
Predicted choice: Robot 1
Actual choice: Robot 2

✗ Prediction differs from actual choice
=== Trial Analysis ===
Trial: 5
Participant: 141831
Actual Choice: Robot 1
M matrix (alternatives × attributes):

| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.14286 | 0.8 | 0.028571 | 0.44286 |
| Robot2 | 0.27143 | 0.11429 | 0.18571 | 0.85714 |
| Robot3 | 0.32857 | 0.028571 | 0.085714 | 1 |

DFT Results:
E_P: NaN  NaN  NaN
Choice probabilities: NaN  NaN  NaN
Predicted choice: Robot 1
Actual choice: Robot 1

✓ Prediction matches actual choice
=== Trial Analysis ===
Trial: 6
Participant: 123310
Actual Choice: Robot 3
M matrix (alternatives × attributes):

| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.15385 | 0.82051 | 0.69231 | 0.89744 |
| Robot2 | 0.4359 | 0.71795 | 0.41026 | 1 |
| Robot3 | 0.23077 | 0.79487 | 0.61538 | 0.94872 |

DFT Results:
E_P: NaN  NaN  NaN
Choice probabilities: NaN  NaN  NaN
Predicted choice: Robot 1
Actual choice: Robot 3

✗ Prediction differs from actual choice
=== Trial Analysis ===
Trial: 7
Participant: 124737
Actual Choice: Robot 3

M matrix (alternatives × attributes):

| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.86364 | 0.77273 | 0.13636 | 0.5 |
| Robot2 | 0.81818 | 1 | 0.40909 | 0.022727 |
| Robot3 | 0.45455 | 0.36364 | 0.59091 | 0.86364 |

DFT Results:
E_P: NaN NaN NaN
Choice probabilities: NaN NaN NaN
Predicted choice: Robot 1
Actual choice: Robot 3

✗ Prediction differs from actual choice
=== Trial Analysis ===
Trial: 8
Participant: 123310
Actual Choice: Robot 3
M matrix (alternatives × attributes):

| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.28333 | 1 | 0.33333 | 0.05 |
| Robot2 | 0.43333 | 0.28333 | 0.9 | 0.05 |
| Robot3 | 0.016667 | 0.3 | 0.4 | 0.96667 |

DFT Results:
E_P: 22051490872661763211172253711817852201283453747113122993087807803404506081372780076483437279147280021487502981009990925194075901003415116840960.00 223399190573
Choice probabilities: NaN NaN NaN
Predicted choice: Robot 1
Actual choice: Robot 3

✗ Prediction differs from actual choice
=== Trial Analysis ===
Trial: 9
Participant: 141831
Actual Choice: Robot 2
M matrix (alternatives × attributes):

| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.16071 | 1 | 0.10714 | 0.51786 |
| Robot2 | 0.44643 | 0.46429 | 0.23214 | 0.625 |
| Robot3 | 0.25 | 0.21429 | 0.33929 | 0.98214 |

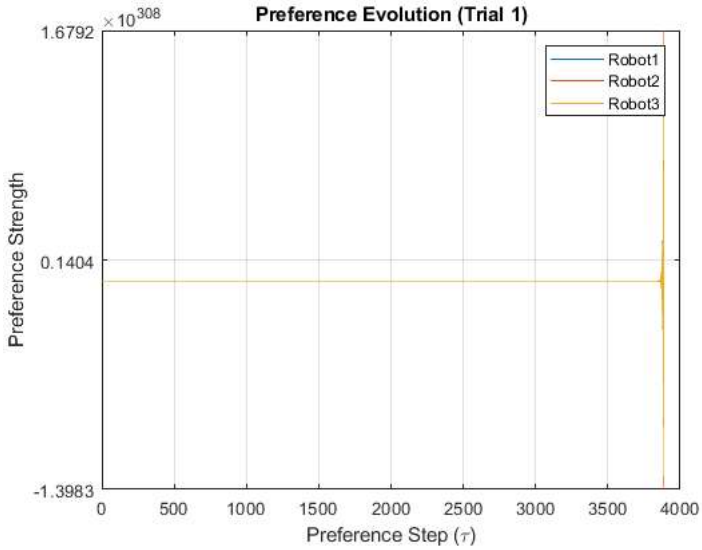
DFT Results:
E_P: NaN NaN NaN
Choice probabilities: NaN NaN NaN
Predicted choice: Robot 1
Actual choice: Robot 2

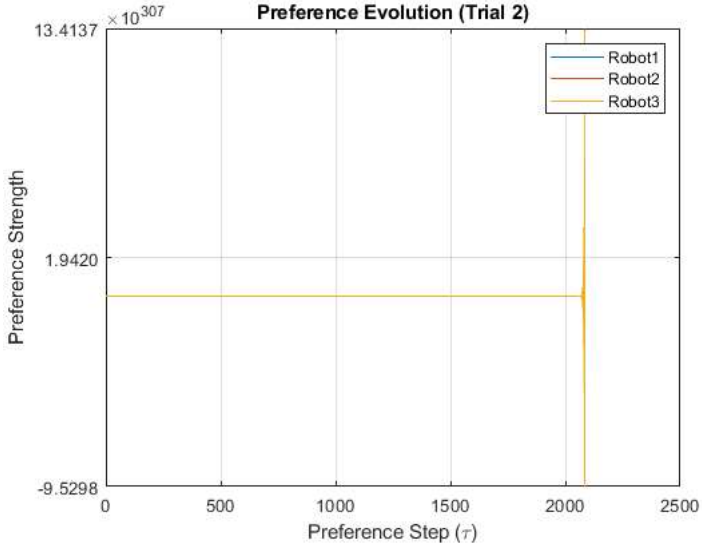
✗ Prediction differs from actual choice
=== Trial Analysis ===
Trial: 10
Participant: 175044
Actual Choice: Robot 2
M matrix (alternatives × attributes):

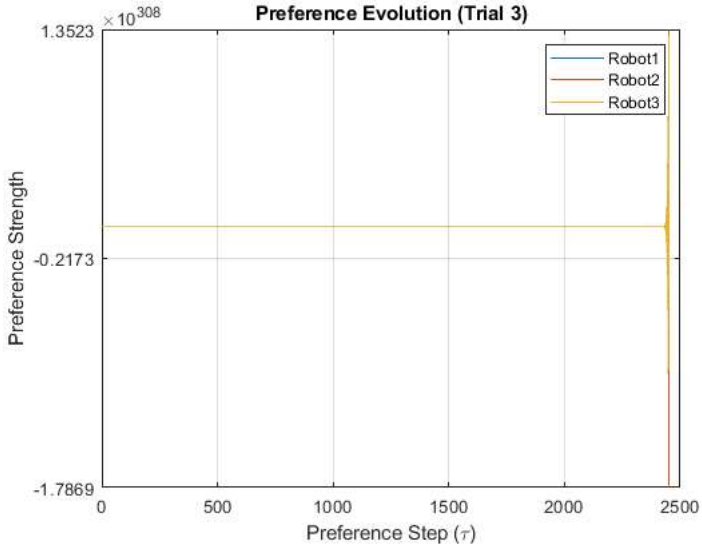
| | C1 - Easy Nav, Low Exposure | C2 - Hard Nav, Low Exposure | C3 - Easy Nav, High Exposure | C4 - Hard Nav, High Exposure |
|---|---|---|---|---|
| Robot1 | 0.33846 | 0.13846 | 0.29231 | 0.76923 |
| Robot2 | 0.046154 | 0.015385 | 0.46154 | 1 |
| Robot3 | 0.41538 | 0.16923 | 0.15385 | 0.78462 |

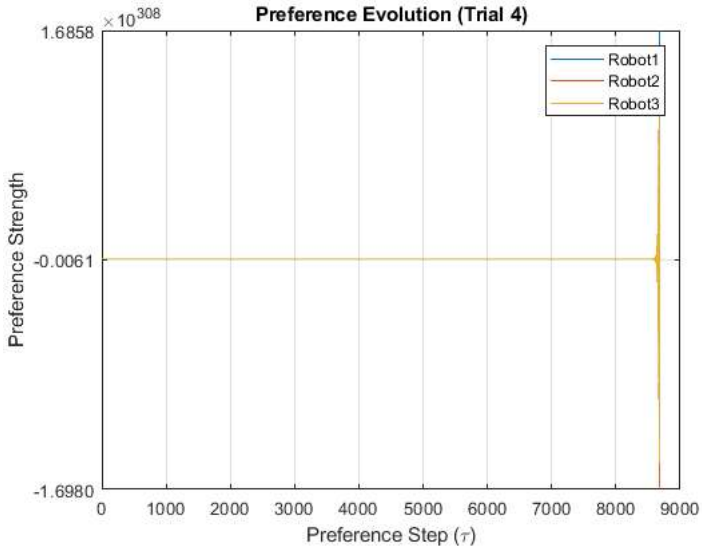
DFT Results:
E_P: NaN NaN NaN
Choice probabilities: NaN NaN NaN
Predicted choice: Robot 1
Actual choice: Robot 2

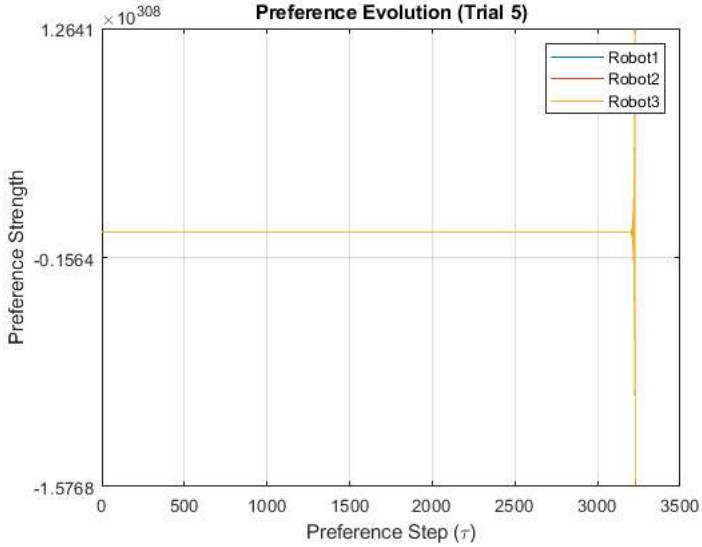
✗ Prediction differs from actual choice

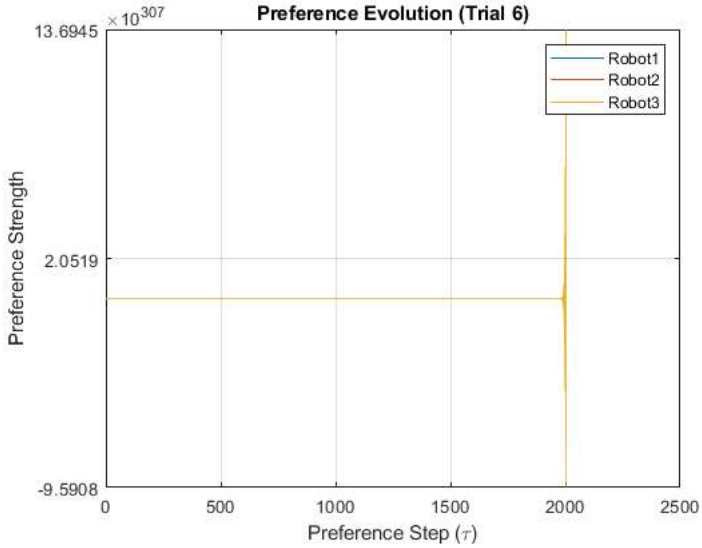

Preference Evolution (Trial 1)
×10^308
1.6792
0.1404
-1.3983
Preference Strength
0
500
1000
1500
2000
2500
3000
3500
4000
Preference Step (τ)
Robot1
Robot2
Robot3

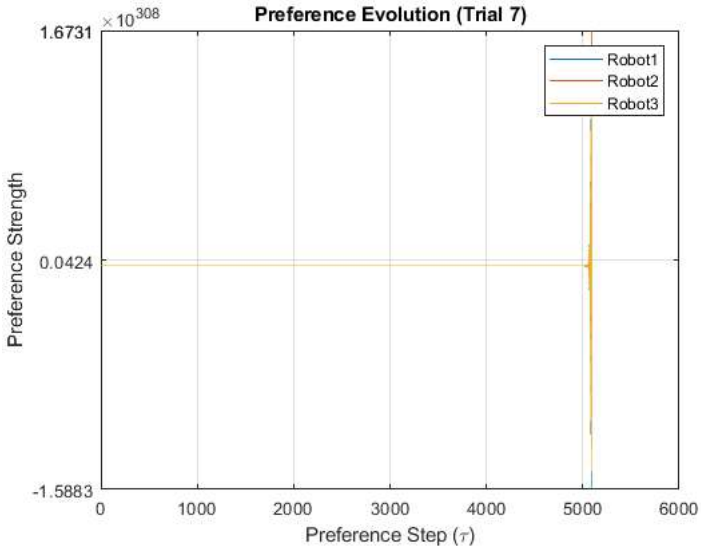

Preference Evolution (Trial 2)
×10^307
13.4137
1.9420
-9.5298
Preference Strength
0
500
1000
1500
2000
2500
Preference Step (τ)
Robot1
Robot2
Robot3

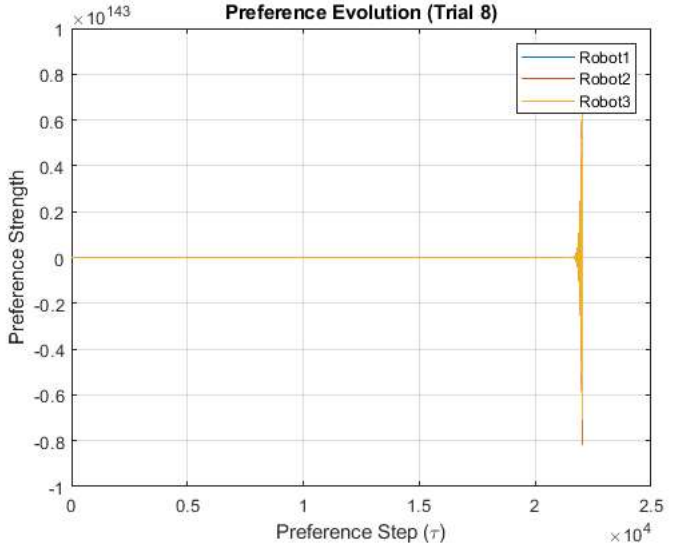

Preference Evolution (Trial 3)
×10^308
1.3523
-0.2173
-1.7869
Preference Strength
0
500
1000
1500
2000
2500
Preference Step (τ)
Robot1
Robot2
Robot3

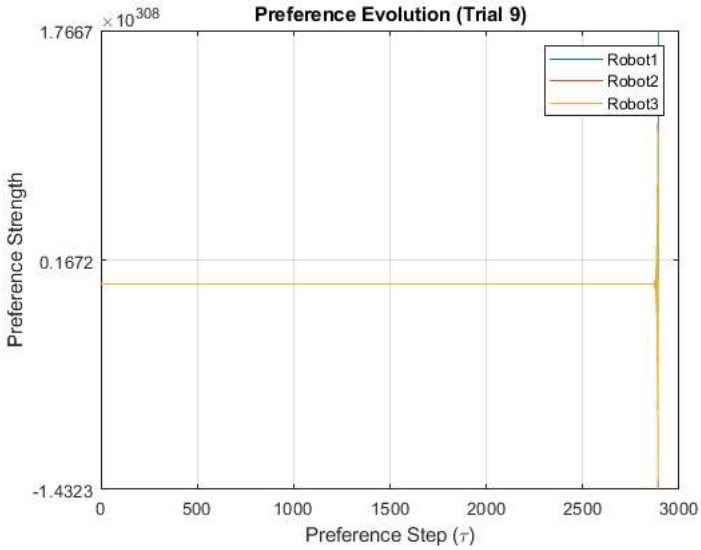

Preference Evolution (Trial 4)
×10^308
1.6858
-0.0061
-1.6980
Preference Strength
Robot1
Robot2
Robot3
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Preference Step (τ)

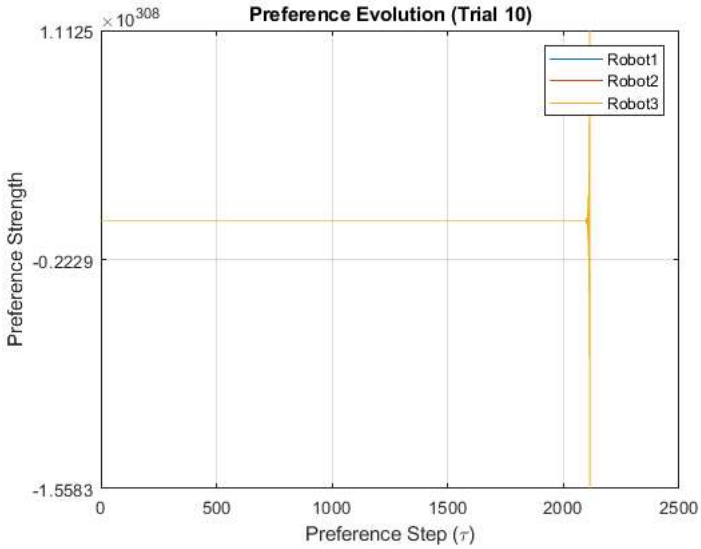

Preference Evolution (Trial 5)
×10^308
1.2641
-0.1564
-1.5768
Preference Strength
Robot1
Robot2
Robot3
0
500
1000
1500
2000
2500
3000
3500
Preference Step (τ)


Preference Evolution (Trial 6)
×10^307
13.6945
2.0519
-9.5908
Preference Strength
Robot1
Robot2
Robot3
0
500
1000
1500
2000
2500
Preference Step (τ)


Preference Evolution (Trial 7)
×10^308
1.6731
0.0424
-1.5883
Preference Strength
0
1000
2000
3000
4000
5000
6000
Preference Step (τ)
Robot1
Robot2
Robot3


Preference Evolution (Trial 8)
×10^143
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Preference Strength
0
0.5
1
1.5
2
2.5
×10^4
Preference Step (τ)
Robot1
Robot2
Robot3




### 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 + 0.1*randn();
    phi2 = 0.8 + 0.1*randn();
    tau = 10 + randi(5);
    error_sd = 0.1 + 0.05*rand();
    warning('Using randomized default parameters');
end
```

```
Estimated Parameters:
phi1: 2.277
phi2: 0.8135
tau: 22027.4658
error_sd: 0.1301
Initial Preferences (from ASCs):
   -0.1321    0.0606         0
```

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