Accel World Agent Simulation, MATLAB Test Type

Goal: Analyze the formation of Brain Burst within the Accel World universe, and attempt to find what parameters allow such an acceleration game to stablize over time. What make BB2039 different from AA2038 and CC2040? Can we manipulate settings such that we are able to reach level 4 and unlock the Unlimited Neutral Field? What causes the system to break down?

Thus, the search for a simulation of Brain Burst began. The goal of this document is to explain my process and my code such that it is easier to understand and have more people participate in. I try to comment my code pretty well, but there's a lot more that can be said here, I think, so I'm going to expand it out as much as I can. This is written in MATLAB, so it is a bit weird and hacky at times.

This script will probably get super bloated if it is actually run as a live script, so all edits and actual simulations should be done in the script file, Mainsim.m.

Definition of Parameters

In the first section, we are going to define our parameters that we are going to mainly vary. We collect all of them here as to more easily be able to track them and their impact on the simulation. All of these parameters are recorded in the README file in each 'SavedSims' folder.

Global

These parameters affect global things. They are mainly the random number generator seed for reproducability, and the maximum number of rounds we will simulate. The goal of having a limit is to more effectively use our time, as longer simulations take a lot longer (no real surprise there). We can add other exit conditions later, but this is our most generic one.

```
seedy = 2039; %save for later
rng(seedy); %set the seed

roundLim = 10; %how many rounds to run of the simulation
```

makePlayer - Player Creation

This function creates new players, which is our main source of Burst Points before the UNF.

We have 2 methods for experience, a created parameter that states how good a player is at the game. This is a major factor in a player's win chance, and one of the more defining features for Brain Burst, so both the initial experience and its growth is important for how the simulation behaves.

The Continuous distrobution generates a random number between 0 and 1 and multiplies it by expMax. Because of the way MATLAB generates random numbers, there are 2^{52} possilibites, so when scaled from 0 to expMax (eg 10), there are more than are discernable by eye.

The Discrete distrobution generates a random integer on the interval expRange, which creates a much more noticeable gradient. I shift away from the discrete option because it looks less natural on a graph, and is not representative of the real world continuous levels of experience people have, nor the non-integer experience they gain over time.

valDistro and satDistro are for normalizing the color space, but that's another discussion. Basically, color is a 3 dimensional vector space, but the BB color wheel shown by Kuroyukihime is really 2 dimensional. More on that in the makePlayer function description section though.

Moral Booster isn't fully implemented into the simulation yet, but it is the morality of the player. A lower morality index would mean that they are more likely to commit immoral acts. The primary example of this would be IRL PK'ing, trapping someone and then direct dueling them until they lose all their points. The other example that would have a big effect in the early days was Originators who would install BB on a player and then duel them to completely exhaust their points without teaching them how to play the game. This could be a critical way to introduce points into the game, but hasn't been implemented yet because I'm too optimistic, and I'm not sure what the chance function for it should be yet.

```
% makePlayer
makePlayerPara.expVer = 'cont'; %or discr
makePlayerPara.expRange = [1 10]; %range of experience values ('disc')
makePlayerPara.expMax = 10; %max of continuous exp vals ('cont')
%adding options for continuous or discrete starting exps
makePlayerPara.valDistro = [7 6]; %A, B for beta distrobution
makePlayerPara.satDistro = [1.75 1.5]; %A, B for saturation (radius) distro

makePlayerPara.MoralBooster = 10; %multiplier for morality
```

duel - Simulate Duels

This is the bread and butter of Brain Burst, the battle. In terms of parameters, most deal with how points are distrobuted.

expMod is a modifier to how much each player learns from the battle and then supplements their own exp. This has to be kept small so that we don't see an explosion of exp for the higher level players that makes it impossible to break into the game if you start later. Another thing that helps to discourage that is that each player learns a percentage of the other's experience, since you would learn from how well the other person fights, and a huge mismatch in ability would not teach the more able player much.

drawTol is the tolerance for a draw, how close do the calculated win chance's need to be to consider it a draw? This is pretty small, since most win rates are relatively small, and the chance of a draw is pretty uncommon in Brain Burst as well, except when two players just make a duel to talk (@Haruyuki).

highWinTrans and lowWinTrans are both functions of how many points are transfered at the end of a duel. Since we only deal with integer points, we round them. If a higher level player wins, this is the expected outcome so there is a smaller number of points transfered. This decreases from 10, the standard to basically just one. I think if the level difference is more than 6 or so, no points are transfered at all (from Silver Crow and Aqua Current's adventure), but that hasn't been implemented yet since there are no tag-team duels or players getting to level 6 or 7 yet. If the lower levelled player wins, this is the unexpected outcome, so the lower levelled player gets more points. From Crow's first fight against Ash, this seems to scale with level difference, as outlined below. If the players are equal level, they just exchange 10 points, and if there is a draw, no points are transfered.. To summarize, $P_{\text{high}} = \frac{10}{1+\text{lvlDiff}}, P_{\text{low}} = 10(1+\text{lvlDiff})$. This functions are continuous at all points.

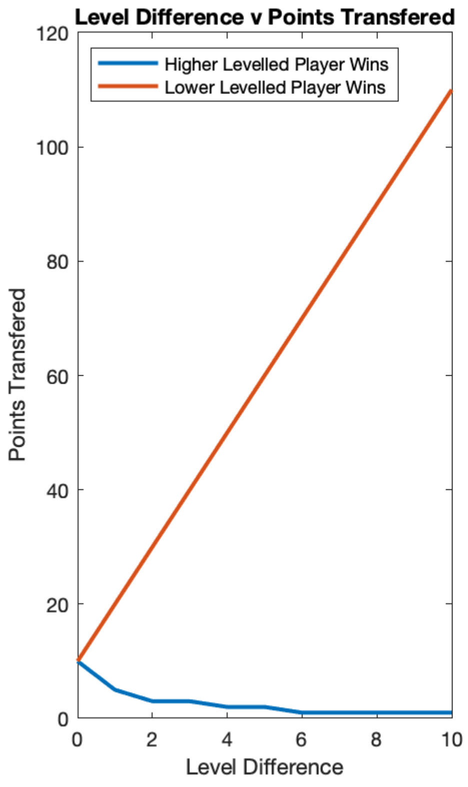
lvlGain is a modifier of how much level affects win chance. This parameter was added because higher level players would start losing streaks and be unable to recover their BP for some very talented level 1'ers. This is an actual mechanic though, as each level up grants the player a bonus which makes them stronger in combat. This solved the problem, but the exact value of the function is still up for debate.

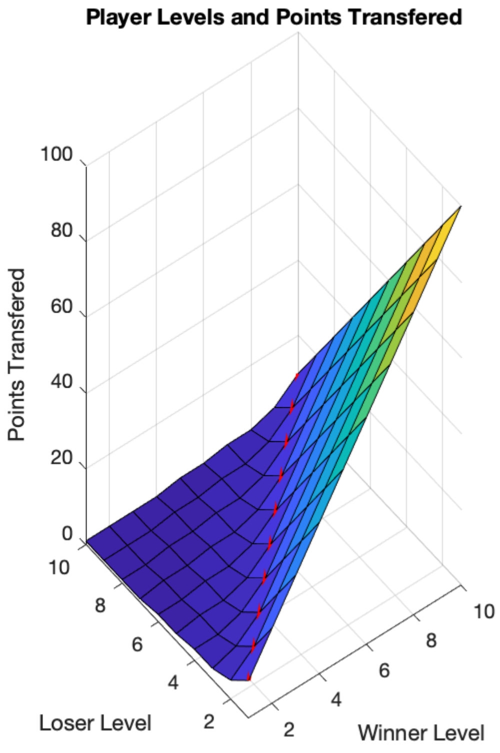
```
%duel
duelPara.expMod = .05; %modifier for experience gain
duelPara.drawTol = 5e-5; %tolerance for considering a draw
duelPara.highWinTrans = @(lvlDiff) round(10/(1+lvlDiff)); %points
%transferered when player with the higher level (is expected to) wins
duelPara.lowWinTrans = @(lvlDiff) (10*(1+lvlDiff)); %points transfered
%when player with lower level (unexpected) wins
duelPara.equalWinTrans = 10; %points to transfer at the same level
duelPara.drawTrans = 0; %points to transfer for a draw
duelPara.lvlGain = @(lvl) lvl.^2; %how does your level win chance?
```

For example, we can graph the point exchange versus level difference and player level.

```
figure;
subplot(1,2,1)%lvldiff
x = -0:10;
plot(x,round(10./(1+x)),'LineWidth',2)
hold on
plot(x,10*(1+x),'LineWidth',2)
xlabel('Level Difference'); ylabel('Points Transfered');
title('Level Difference v Points Transfered');
legend({'Higher Levelled Player Wins','Lower Levelled Player Wins'},...
    'Location','northwest')

subplot(1,2,2); %for all levels
lvlWinner = 1:10; lvlLoser = 1:10; %levels of winners/losers
[WW, LL] = meshgrid(lvlWinner,lvlLoser); %meshgrid
points = zeros(10); %preallocate
for indW = lvlWinner
    for indL = lvlLoser
        lvlDiff = indW-indL;
        if(lvlDiff > 0 ) %W expected
            points(indW,indL) = round(10/(1+lvlDiff));
        elseif(lvlDiff == 0) %same level
            points(indW,indL) = 10;
        elseif(lvlDiff < 0) %upset, L expected
            points(indW,indL) = (10*(1-lvlDiff));
        end
    end %loser lvl
end %winner lvl
surf(WW,LL,points);
hold on
plot3([1, 10], [1 10],[10 10],'r','LineWidth',2)
hidden off
xlim([1 10]); ylim([1 10])
title('Player Levels and Points Transfered');
xlabel('Winner Level'); ylabel('Loser Level');
zlabel('Points Transfered');
```





killEm

Function to kill players, but there are no parameters here.

```
%killEm
%none here, nothing to change yet
```

lvlUp

Function to level up players who are elgible.

points is the number required to level up from each level. These are from the JP wiki, which seems like the most reputable source. We can't level up from 9->10 yet, but this simulation is not built to simulate that much life out of Brain Burst.

margin is how much of a buffer a player has to have before they level up. Since leveling up eats that number of points, players need to have enough to continue playing afterward. This used to be 1.25, but a couple players died shortly after reaching level 3, so it was increased. It would vary by player, but keeping it constant makes the simulation simpler.

(As a thought, this could have a random component, maybe...)

```
%lvlUp
lvlUpPara.points = [300 400 600 900 1500 3000 6000 10000]; %from JP wiki
%number of points needed to increase in level
lvlUpPara.margin = 1.5; %total safety margin to level up
```

makeBabes

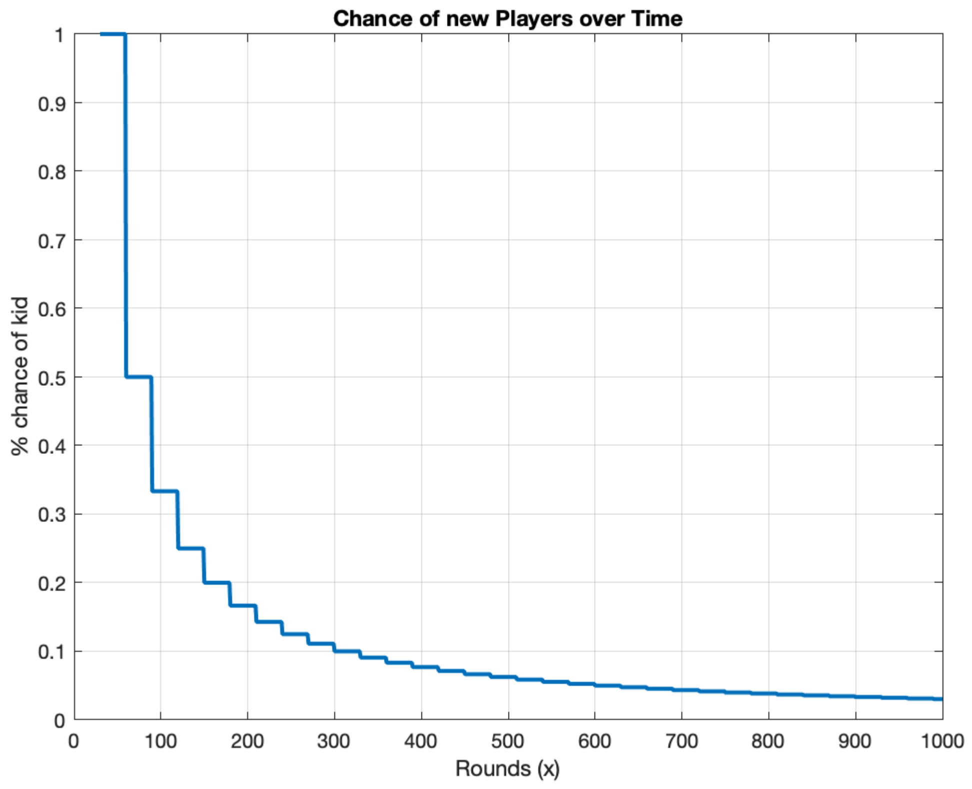
Function to create new players (babies). This function just calls makePlayer, so it's basically only a frequency and elgibility checker.

chanceFcn is the probability that a new player will be created as the child of an elgible player. When it is equal to itself, a new child is born. This decreased over time, since logically it would be harder and harder to find new compatible kids IRL. Basically, it generates a random integer with a maximum of $\left(\frac{\text{rounds}}{30}+1\right)$. As the simulation runs for longer, rounds gets larger and larger. We add 1 so that we never get a max value of zero, but it essentially is always equal in the early rounds, not that they can make kids at round 30 though. We can graph the chance that it is equal to itself as well.

Since we usually don't get players to level 2 until around round 100, it might be worth modifying the function to $\left(\frac{(\text{rounds}-100)}{30}+1\right)$ or some variation therein.

```
%makeBabes
makeBabesPara.chanceFcn = @(x) randi(floor(x/30)+1, 1); %chance function
%if it is equal to itself, BB player has a child.  Should be decreasing
%in frequency over time because the random range gets bigger
```

```
figure
x = 1:1000; %round range
plot(x,1./floor(x/30),'LineWidth',2)
hold on; grid on;
xlabel('Rounds (x)'); ylabel('% chance of kid')
title('Chance of new Players over Time')
```



Pure Colors

This section defines the traits of 6 of the 7 Kings of Pure Color. We know Kuroyukihime has a parent, so she isn't an originator and was created later, and we only have confirmation of Blue, Green, and White being originators. However, it doesn't seem like that far of a stretch to say most, if not all, of the other Kings were also originators. The other purpose is to create some players who have more exp and are therefore more interesting to track.

By artificially inflating their exp level, by multiplying the normal player expMax by 1.1, we ensure that these players will likely live and prosper, so we can use them as a guage of the leading edge of Brain Burst play.

There are some problems with colors, but to keep it consistent, they all fit into the HSL color scheme. Again, more on that in the makePlayer function description itself. White is cyan colored in terms of color wheel assignment, since she has to have a value, and there isn't a Cyan king, even though there should be one based on the color wheel theory I have here.

However, it is likely that rather than using pure HSL colors and an angle assignment on the color wheel, Brain Burst might use another color standard, like HTML or another list of named colors. These can still be standarized for displaying on screens (and hopefully brains through full dive), and are more representative of what we think of when we see colors. The main instance of this is Purple, since the assignment based on color angles would actually be magenta (like the printer ink color), instead of an actual Purple. Besides the fact that there is a different purple for every color standard, this makes the graphs look better since it's a darker color, like we expect from Purple. Magenta Scissor is a very different character after all.

```
%Pure Colors
PureColors = struct('color', {0 60 120 240 275 180}, 'sat',...
{100 100 100 100 100 0}, 'light', {50 50 50 50 37 100});
%What colors will they be?  White Cosmos is "cyan" ...
PureColorPara.exp = makePlayerPara.expMax*1.1; %super high
%set it so they are always more powerful
```

Simulation Preface

This is basically here to save the data to a file. A dialog box is used so that you have to actively choose what to call it. Also displays a warning if you are going to overwrite data. If no name is entered, it auto-assigns "noName" so that we can still graph trends without pulling errors.

A subfunction called here is `saveInfo`, which basically just writes down a list of every parameter defined above, but in a mostly easy to read format.

```
simTitle=inputdlg('Sim Title, hit cancel to not save', 'Save Simulation?');
if(~isempty(simTitle)) %are we saving?
simTitle = simTitle{1}; %to string
direc = ['SavedSims/' simTitle '/']; %concat for ease
while(isfolder(direc)) %overwritting
simTitle1 = inputdlg(sprintf(['Warning: Directory "%s" already'...
' exists, and will overwrite old data.\n  Do you wish to'...
' re-title the simulation?\n  Press Cancel to continue and'...
' overwrite existing data.'],simTitle),...
'Warning!  Overwritting Data');
if(isempty(simTitle1)) %we'll overwrite
break;
else
```

```
simTitle = simTitle1{1}; %for new data
end
end
saveInfo; %save information, now in separate script
% Things to do
% make iterative version?  click through and analyze?
else %there's no value
simTitle = 'noName'; %filler so it still graphs
end
```

Create Structs (Players)

This next section creates the first 100 players, the Originators. We care so much about these players because they can create unlimited children, and are basically the only fuel for Burst Points until the Unlimited Neutral Field appears. This has been recently reworked to actually work backwards (make 100th player first) so that preallocates the variable for the 100 spaces, and works a bit faster. There are separate sections for the Pure Colors, who have more parameters controlled, while the other players are randomized.

```
%% Create structs
% gen - which generation are they?
% color - what is their color 1-360
% sat - saturation 0-100
% rounds - which rounds did they play in [start end]
%        if end != 0, they are dead
% BP - burst points, starts at 100, if hits 0 --> dead
% exp - personal experience, increments through battles
%players = struct('gen','','color','', 'sat','','rounds','','BP','', 'exp','');

clear players; %start clean
players(100) = makePlayer(0,0,1, makePlayerPara); %start at end

%make Pure Colors and follow them
for numPures = 1:6
newPlayer = makePureColor(PureColors(numPures),PureColorPara);
%create pure colors, only varying color, keeping Exp, etc const
players(numPures) = newPlayer;
end
%make Normal players
for numOrig = 7:99
newPlayer = makePlayer(0,0,1, makePlayerPara);
players(numOrig) = newPlayer;
end
```

Run Simulation

This is the bulk of the simulation itself. Many of the actual actions are broken up into functions, but the fight selection still happens here. We are going to break it up into sections to be more clear.

Initialization

It might seem like there are a bunch of initializations here, but this is one of the last ones. Here, we close out other figures for clarity (and avoid getting 20 open if we run a bunch of simulations), and start up some variables. For the first round, no one is dead, and everyone is alive, so we create `deadlist` and `livelist` to store who is dead and alive, respectively. This speeds up other functions as it has to operate on a much smaller list. These are basically just arrays of the indices of which players are still kicking. `bigData` is a round to round tracker of information, it basically stores things of interest so that we can graph them at the end.

`graphImmediate` is our round to round plot of the simulation, so we start it by creating a figure and starting a movie and gif file to record.

```
%% Run sim

close all;

deadlist = []; %no one's dead yet
livelist = 1:100; %everyone's alive
bigData = struct; %empty, no data yet

[stateFig, movie] = graphImmediate(players, 0, livelist, 0, {0, simTitle}); %initialize
```

Start of Each Round

This includes our for loop statement, where we just loop until we decide to end. We reset two variables, `numsPicked` and `fights`. The first tracks who has already fought in this round, and the other counts how many total fights. This is important for our fights loop, so that we keep having battles until 80% of all players have fought. It's lower because not everyone will fight every round, and when we get to very few people, percentages are weird (ie less than 10).

```
for rounds = 1:roundLim %loop the simulation
numsPicked = []; %zero out picked duelers
fights = 0; %reset counter
while fights < .8*((size(players,2)-size(deadlist,2))/2)
%set number of duel
```

Fight Selection

This next section is how two players are picked to duel. We first start out by selecting a random player from `liveList`, so we know that they do have nonzero BP and can fight. We have to switch from a `liveList` index to a `players` index, which is what the first two lines do. We then check to see if they have already fought, and appear in the list of players who have already battled. If we see them, we continue and repeat the loop and start selection anew. If they don't appear, we place them into a miniture list of everyone picked.

```
per1Ind = randi(size(livelist),1); %pick a player
per1 = livelist(per1Ind); %assign them the actual number
if(any(find(numsPicked == per1))) %already picked
continue;
end
numsPickedMini = [numsPicked, per1]; %include per1 now
```

We then repeat the process for the second player, this time checking that they are also not the first player picked to fight. We then store the mini fight list back into the main one, but with the addition of both players, and increment our number of total fights. The details of `duel` will be explained later, as that's actually the interesting part here.

```
per2Ind = randi(size(livelist),1); %pick a player
per2 = livelist(per2Ind); %assign real number
if(any(find(numsPickedMini == per2))) %already picked
continue;
end
```

```
numsPicked = [numsPickedMini, per2]; %now include both pers
players = duel(players,per1,per2,rounds, duelPara); %FIGHT
fights = fights +1;
end
```

Administravia

This section just handles what happens to each player after the duels and battles. `killEm` eliminates and "uninstalls" BB from players with zero points, `lvlUp` handles level ups for players, and `makeBabes` creates new children for eligible players. These operate directly on the `players` struct and basically replace it with their additions.

We also add to `bigData` with the information from that round. This allows us to easily create graphs at the end. We also create the intermediate figure of each player as a scatter plot. This is displayed, as well as saved in a movie and gif format.

```
[players, deadlist, livelist] = killEm(players, rounds); %eliminate dead players
players = lvlUp(players, rounds, lvlUpPara); %do level ups
players = makeBabes(players, rounds, makeBabesPara, makePlayerPara); %add players
bigData = recordTrends(players, rounds, livelist, bigData); %record info
%Graph each round's state
[stateFig, movie] = graphImmediate(players, stateFig, livelist, movie, rounds);
```

Second Exit Condition

This is the other exit condition. If we have only 1 player, we can't duel, so we exit out to avoid an infinite loop. Realistically, it should probably be like 3, but this is the bare minimum. This is also the condition that happened for Accel Assualt in one of the special episodes of the anime.

```
if(size(livelist,2)  <= 1)
%can't duel any more
break;
end %if out of players
end
```

Graphs and Pretty Pictures

This is the section that generates all the good looking graphs. We pass in `-1` to `graphImmediate` to tell it to terminate and close up the movie files, as well as create a second figure of all our trends at the end of the simulation.

The final section saves everything into our folder, which makes record keeping easy. This saves the player data, as well as the information needed for trend graphing and the figure itself. This is useful as MATLAB figures let you use the data cursor to pull info much more accurately than just eyeballing it. But at the end of the day, this is about general trends, so we also save the graphs to a png to display on github.

```
%% Graphing and Analysis
%Analyze what happened, hopefully

bigData(1).simmy = simTitle; %save it to pass in for graphing
[stateFig, movie] = graphImmediate(players, -1, livelist, movie, rounds); %initialize
fig = graphTrends(bigData, players); %graph what's happening

%still check if saving
if(~isempty(simTitle)) %are we saving?
filepath1 = sprintf('SavedSims/%s/data.mat', simTitle); %for data
```

```
filepath2 = sprintf('SavedSims/%s/trendsFig.fig', simTitle); %for figure
filepath3 = sprintf('SavedSims/%s/trendsPic.png', simTitle); %for image
save(filepath1, 'bigData','players'); %save data and players struct
savefig(fig, filepath2); % save the figure
print(fig, filepath3, '-dpng');
end
```