# Optimizing Candy Land "House Rules": Reducing parental toddler-bedtime-routine-induced distress

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**Children are wonderful. However, there are situations in which parents must minimize the amount of time spent on an activity while maximizing a child's enjoyment of the activity. Here, we analyze the problem of a bedtime routine that involves playing the game Candy Land with a toddler who does not take kindly to losing. We examine variants of the rule sets to create "house rules" that optimize the probability of the toddler winning while minimizing the amount of time playing. We find that adopting a "Youngest Forward-Only" set significantly improves the probability of the toddler winning with minimal impact on duration of play. A "All Best Choice" set produces the shortest games but does not substantially improve the winning probability of the toddler. Lastly, a "Youngest Best Choice" set nearly ensures toddler victory while still providing the same or shorter game duration as the Standard set of rules.**

mental health | child development | monte carlo simulation | game theory

## Introduction

Bedtime routines are a critical aspect of daily life for millions of American families. Not only do good bedtime routines ensure a well-rested child, they also play an important role in preserving the mental health of parents. Often, bedtime routines consists of screen-time-minimizing activities such as solving puzzles, building couch forts, or playing board games.

Toddlers do not have fully developed brains. As such, their sense of fairness is rarely accurate. In addition, toddlers may be hyper-competitive, believing they deserve to win every game they play. While there is a time and place for parents, educators, and other adults to help elucidate these matters as children grow — bedtime is not it. For millions of parents, the only single, overriding priority during bedtime routines is to get the toddler into bed as quickly, quietly, and calmly as possible.

Here, we explore the statistical properties of Candy Land, a game frequently played during bedtime routines. We discuss the practical implications of these properties and explore variations of the game rules in relation to two objectives: (1) maximize the probability of the toddler winning while (2) minimize the amount of time playing.

## About Candy Land

Candy Land, created in 1949, is a simple, non-strategic racing game. It is a favorite among toddlers because it requires only minimal counting ability (up to two) and rudimentary recognition of six colors and eight candies. The components of Candy Land consists of a board, four player markers, and a deck of 64 cards.

Fig. 1 shows the standard Candy Land board with every tenth space enumerated by a field researcher's hand-written (post-it) notes. On the board, play begins in the lower left corner and terminates in the top middle castle. The board follows an approximately repeating pattern of red, purple, yellow, blue, orange, and green, with special pink squares interspersed throughout for a total of 132 spaces. Two green squares have licorice icons and two squares "teleport" players forward (but never backwards).


**Fig. 1.** Candy Land board game with notes enumerating every ten spaces. Play begins in the lower left and continues along the paths until a single player reaches the top middle castle.

Each player is represented by a marker (Fig. 2) — the standard fourth marker in this specific specimen was lost to the ravages of toddler-time and replaced by a dinosaur. The accompany deck consisting of 64 cards (Fig. 3). Cards can be single-color, double-color, or one of seven pink specialty candy locations (see For any given bedtime routine, the ideal rule set will vary. Text S1).

Game play in Candy Land is non-strategic, with deterministic rules for each card. Because the outcome is predetermined by the order of cards in a shuffled deck, the only way to manipulate Candy Land outcomes is by changing the rules.

### The Rules of Candy Land.

The **Standard** set of rules are:

1. Each player (starting with the youngest) takes turns, drawing a card.
2. If a card has one red, purple, yellow, blue, orange, or green square, the player moves **forward** to the nearest square of corresponding color.
3. If a card has two red, purple, yellow, blue, orange, or green squares, the player moves **forward** to the second nearest square of corresponding color.
4. If the card has a candy icon, the player moves **forward** or **backward** to the corresponding square.

**Fig. 2.** Player markers. A fourth traditional marker has been replaced by the nearest appropriate item.

**Fig. 3.** The deck is composed of 64 cards which can be single-color, double-color, or special candy location cards.

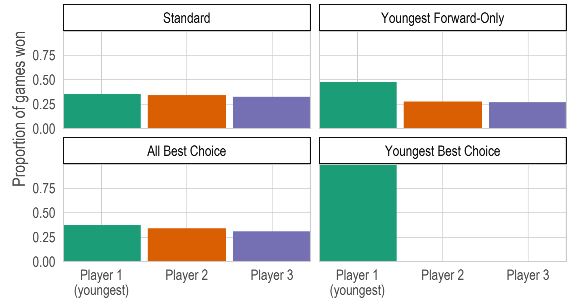


**Fig. 4.** Proportion (y-axis) of games won by each player (x-axis) by rule set (facets).

5. If a player lands on a green licorice square, they lose a turn.
6. If a player lands on Peppermint Pass or Gumdrop Pass, they proceed on the indicated path to the corresponding square.

In addition, the instructions provide two variations of the Standard set of rules.

First, called the "**Youngest Forward-Only**" set, all Standard rules apply except Player 1 (the youngest player) never moves backwards. If Player 1 draws a pink card and the location is backwards, they do not move.

Second, in a Choice set, all players draw two cards and choose one card before moving. Here, we provide two variations of the Choice set called the "All Best Choice" set and the "Youngest Best Choice" set. In the **All Best Choice** set, every play draws two cards and always picks the card that advances their marker the furthest. In the **Youngest Best Choice** set, all players draw two cards and the youngest player always selects the card that advances their marker the furthers (with help from parents, if necessary); however, all other players select the card that advances their marker the nearest.

## Results

For each of the four rule sets described above, we ran 100,000 Candy Land simulations using `R 4.0.2` (see **Methods** for details). Each simulated game features three players and, in accordance to Candy Land regulations, Player 1 is always the youngest player.

Below, we present the statistical properties of Candy Land. We first discuss the probability of Player 1 winning (Objective 1), then the distribution of game duration (Objective 2). We then discuss both Objective 1 and Objective 2 simultaneously. Lastly, we discuss patterns of mobility in Candy Land.

**Player 1 wins nearly all games under the Youngest Best Choice set.** In Fig. 4, we plot the proportion of games won by each player in each rule set. We note that even in the Standard set, Player 1 has a first-move advantage winning slightly more games than Player 2 who in turn wins slightly more games than Player 3 (34.7% vs 33.3% vs 31.9%). As expected, the Standard set and the All Best Choice set yield similar win proportions because they do not restrict the movement of Player 1. Conversely, Player 1 wins nearly half of all games in the Youngest Forward-Only set (47%) and over 99.5% of all games in the Youngest Best Choice set. In 100,000 simulated games, Players 2 and 3 won only 96 and 112 Youngest Best Choice games, respectively.

**Game duration is shortest under the All Best Choice set.** In Fig. 5, we show the duration of games (as number of moves required by

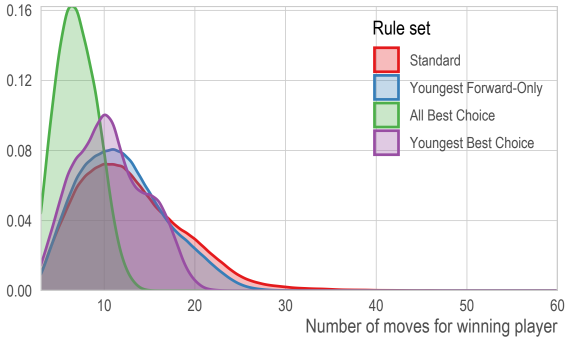


**Fig. 5.** Distribution of number of moves per game for the winning player.

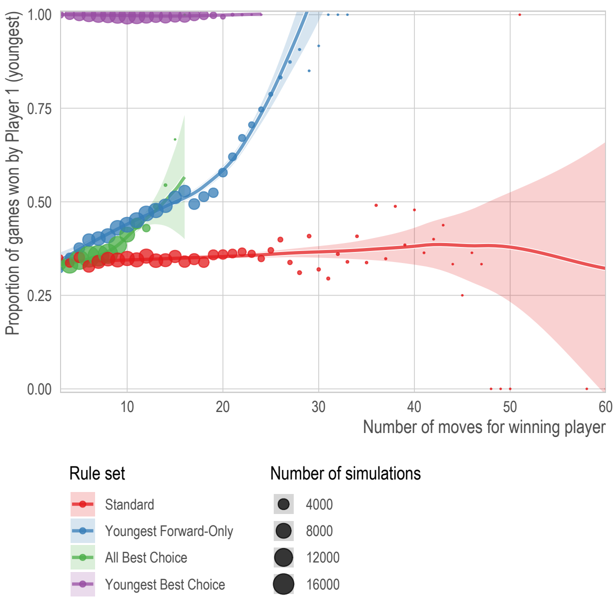


**Fig. 6.** Number of moves required to win (x-axis) relative to the probability of Player 1 winning (y-axis) by rule set (color). The size of each point is the number of simulations. Each line is the loess regression line weighted by the number of simulations.

the winning player) under each rule set. All variants reduced the number of moves required to win relative to the Standard set. In the Standard set, the winning player required an average (SD) of 13.0 (5.82) moves before winning compared to 12.0 (4.80) moves in the Youngest Forward-Only set. The All Best Choice (mean: 7.0; SD: 2.21) and Youngest Best Choice (mean: 10.7; SD: 3.93) sets reduced variation while also lowering game time.

**Probability of Player 1 win as a function of game length.** In Fig. 6, we plot the game duration (in number of moves for the winning player) on the x-axis compared to the proportion of games won by Player 1 on the y-axis for each rule set (color). The size of each dot represents the number of simulations.

As expected, the Standard set shows no correlation with game length. However, for all restricted game sets, we see that as games get longer, Player 1 is more likely to win relative to the baseline expected win percentage of 34.7%.

**Potential player locations quickly diffuses over time.** In Fig. 7, we show the potential locations for Player 1 in the first (top), third (middle), and seventh (bottom) move for each of the four rule sets. (See the digitized game board as a stylized grid in For any given bedtime routine, the ideal rule set will vary. Fig. 9.)

As expected, in the first move, the location probabilities are identical across the rule sets. However, diffusion of probabilities across the board quickly occurs. By the third set, nearly the entire board is a potential location in the Standard set; however, early squares are less likely in other sets where backward movement of Player 1 is restricted. As sets become increasingly restrictive of backward Player 1 movement, earlier squares are less likely to be available by move 7.

**Different rule sets impact transition probabilities.** In Fig. 8, we plot the probability of transition from position $i$ to position $j$ under each rule set. That is, given a player is located in position $i$, what are the probabilities of transitioning to any other position $j$. We note, the isolates at 46 and 72 are self-loops due to losing a turn. Horizontal bands represent the two shortcuts. Vertical bands represent special candy locations, which can send players forwards or backwards from any board position.

## Discussion

In any given bedtime routine, the ideal rule set will vary. For Objective 1, maximizing the probability Player 1 wins, the Youngest Best Choice set is the optimal rule set. Under this set, Player 1 wins over 99.5% of all games played. For Objective 2, minimizing the game duration, the the All Best Choice set lasts about half as long as the Standard set (7 moves vs 13 moves) while also reducing variability in game duration (SD of 2.2 vs 5.8). While the Youngest Forward-Only set is not optimal for either objective, it is the most likely to achieve high compliance by younger players and still provides substantial improvements over the Standard set.

**Ethical considerations.** With great power comes great responsibility. Household policymakers must acknowledge the risks and consequences of employing the implications of our paper in the real world for prolonged periods of time. As any academic knows, losing, rejection, and backwards movement are inevitable, necessary parts of life. Similarly, a basic understanding of elementary probability is critical for life success. Trade-offs between parent mental health and potentially skewing the world view or limiting the ability to deal with probabilities of young children must be thoughtfully weighted. We leave this exercise to the reader.

## Materials and Methods

**Data.** We simulated data using `R 4.0.2`. All code is available in an online repository. See **Supplemental Materials**.

**Model.** We used standard Monte Carlo methods to simulation 100,000 Candy Land games consisting of three players each under each of the four rule sets. All code is available in an online repository. See **Supplemental Materials**.

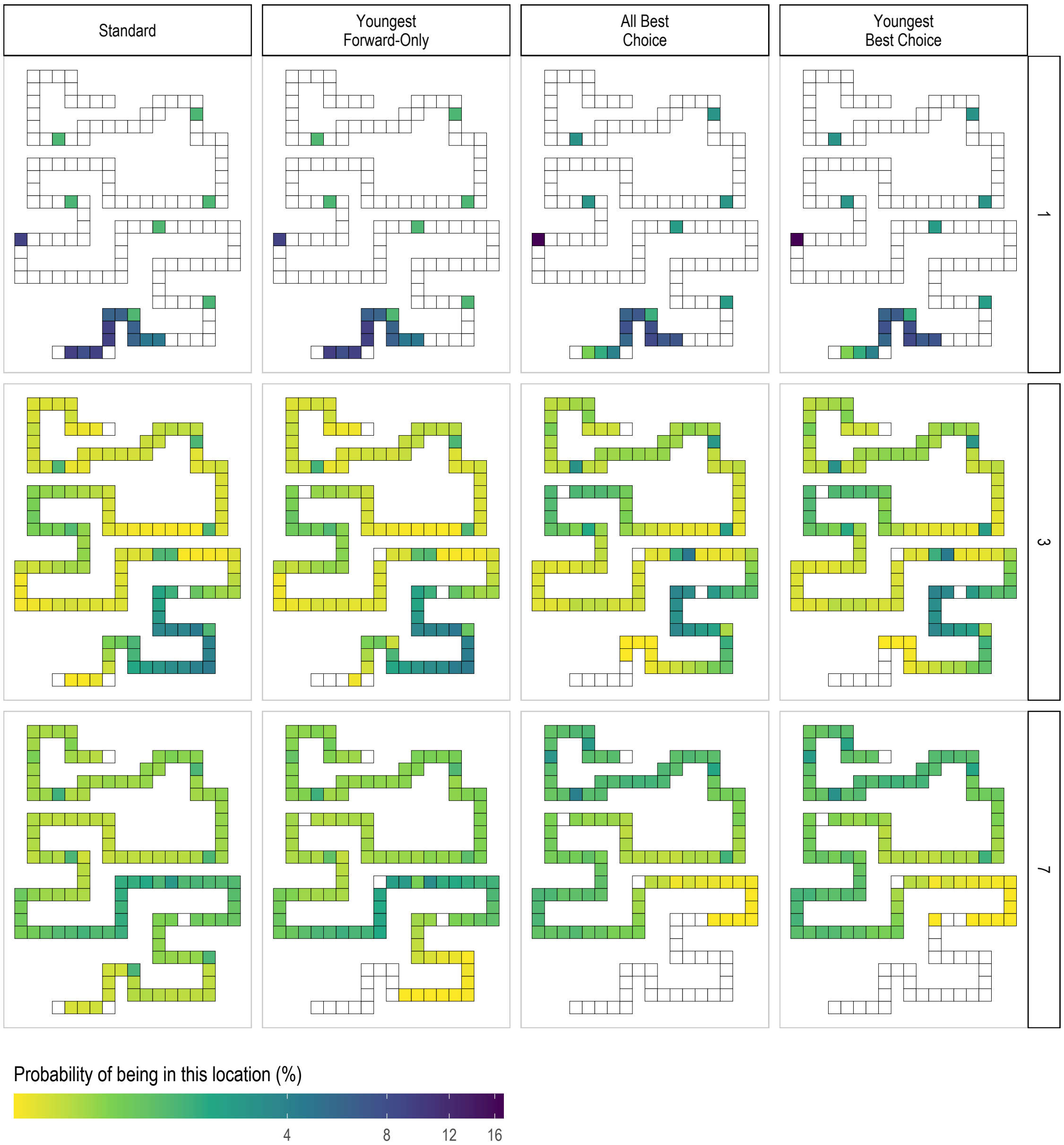


**Fig. 7.** We show the probability of Player 1 board locations for the first (top), third (middle) and seventh (bottom) move by rule sets (columns). In all sets, the first move is identical; however, as backward movement is restricted, the distribution of locations concentrates towards the end of the board with early locations being impossible to return to.

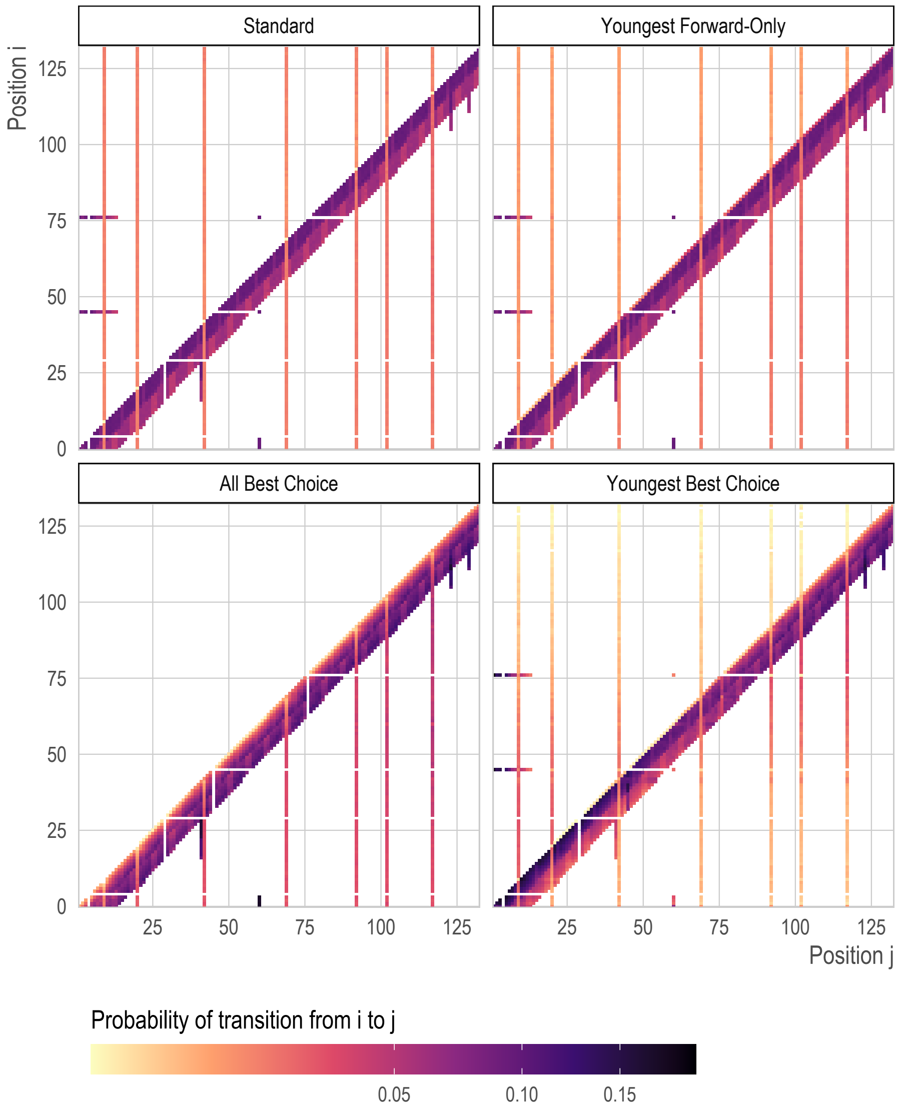


**Fig. 8.** For each pair of board positions $i$ and $j$, we show the probability of transitioning to $j$ from $i$ for all 132 board pieces. The isolates at 46 and 72 are self-loops due to losing a turn. Horizontal bands represent the two shortcuts. Vertical bands represent special candy locations, which can send players forwards or backwards from any board position.

## Supplemental Materials

**Break down of cards.** There are a total of 64 cards in a standard Candy Land deck. The card types are single-color, double-color, and special location. For single-color cards, there are six red, orange, blue, green, and yellow cards as well as five purple cards. For double-color cards, there are four red, blue, yellow, and purple cards as well as three orange and blue cards. There are seven pink cards, each designating a specific location on the board. In our version of Candy Land (see Fig 3.), the cards are as follows:

```
create_deck(n_decks = 1, shuffled = FALSE)
```

```
#   [1] "purple_2"      "purple_2"
#   [3] "purple_2"      "purple_2"
#   [5] "purple_1"      "purple_1"
#   [7] "purple_1"      "purple_1"
#   [9] "purple_1"      "orange_2"
#  [11] "orange_2"      "orange_2"
#  [13] "orange_1"      "orange_1"
#  [15] "orange_1"      "orange_1"
#  [17] "orange_1"      "orange_1"
#  [19] "red_2"         "red_2"
#  [21] "red_2"         "red_2"
#  [23] "red_1"         "red_1"
#  [25] "red_1"         "red_1"
#  [27] "red_1"         "red_1"
#  [29] "yellow_2"      "yellow_2"
#  [31] "yellow_2"      "yellow_2"
#  [33] "yellow_1"      "yellow_1"
#  [35] "yellow_1"      "yellow_1"
#  [37] "yellow_1"      "yellow_1"
#  [39] "green_2"       "green_2"
#  [41] "green_2"       "green_1"
#  [43] "green_1"       "green_1"
#  [45] "green_1"       "green_1"
#  [47] "green_1"       "blue_2"
#  [49] "blue_2"        "blue_2"
#  [51] "blue_2"        "blue_1"
#  [53] "blue_1"        "blue_1"
#  [55] "blue_1"        "blue_1"
#  [57] "blue_1"        "cupcake_1"
#  [59] "icecream_1"    "gummystar_1"
#  [61] "gingerbread_1" "lollipop_1"
#  [63] "popsicle_1"    "chocolate_1"
```

**Reproducible code.** All code required to re-run, modify, or inspect this paper is available online at http://github.com/mkiang/optimizing_candyland. We note that this code simulates Candy Land under the current regulations; however, previous iterations of the game had different card ratios and potentially different board spaces. We provide convenience functions for changing each as `create_deck()` and `create_board()` in the `./code/utils.R` file.

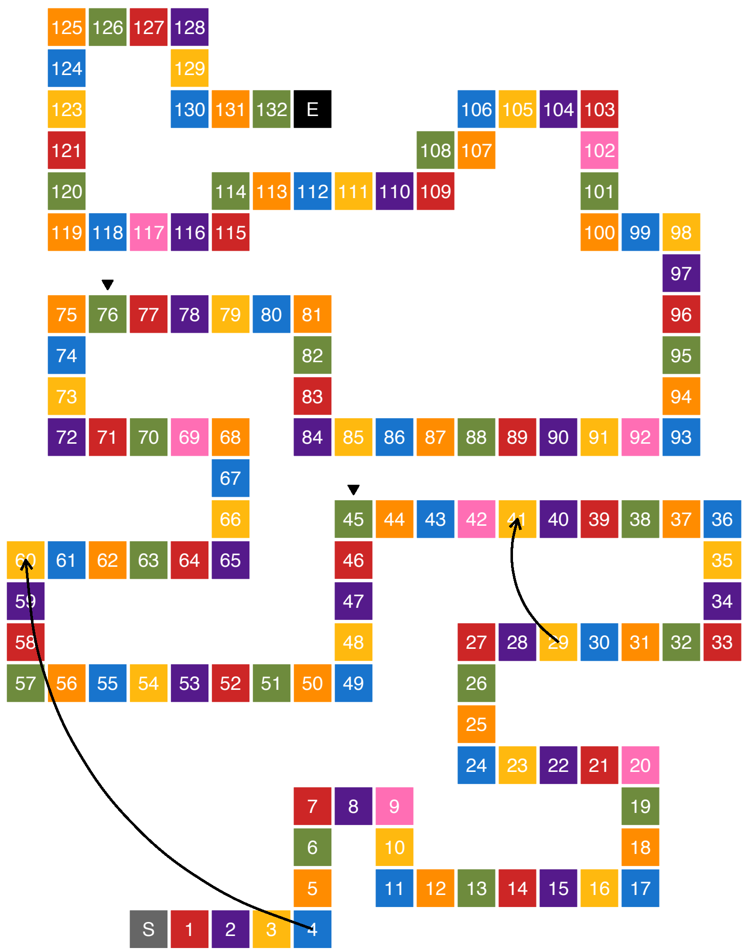


**Fig. 9.** Digitized, stylized Candy Land board. The triangles represent licorice (i.e., lose a turn) squares. The arrows represent paths. Play begins at S in the lower left and ends at E in the top middle.

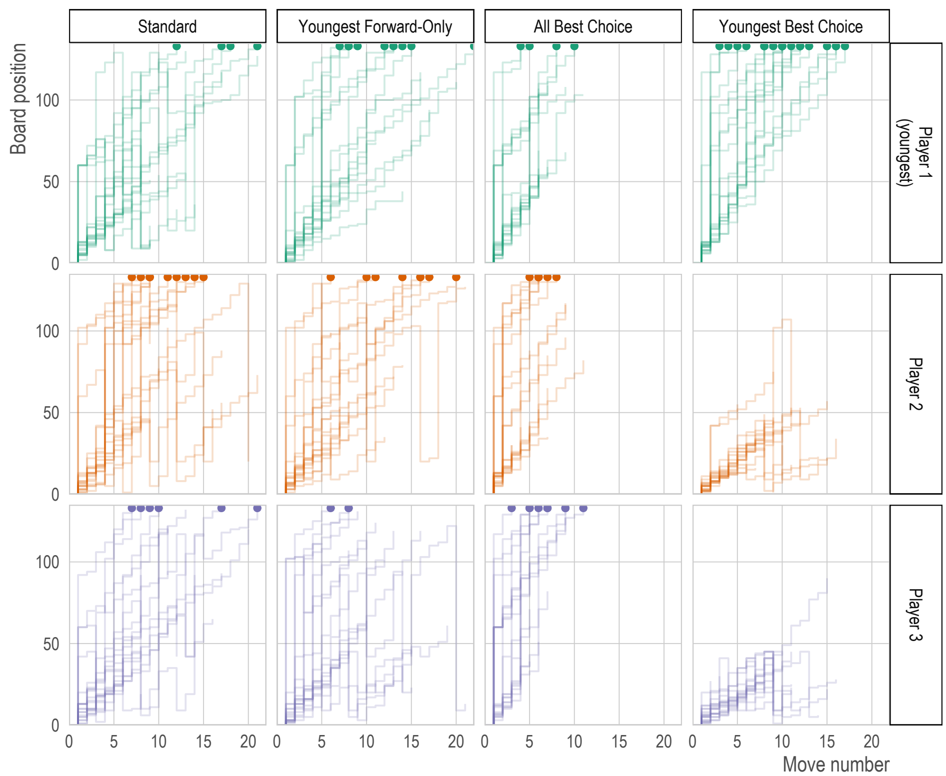


**Fig. 10.** Trajectories for three players (rows) across 20 simulated rounds of Candy Land by rule set (columns). Trajectories that terminated in a victory are marked by a point.