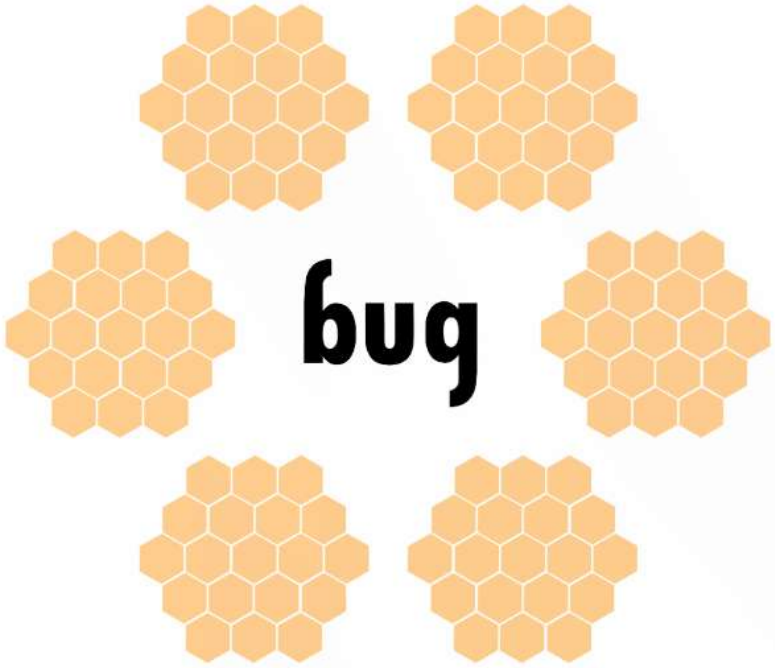
Bug – perceptual binding, identity and meaning in a new sort of polyomino game

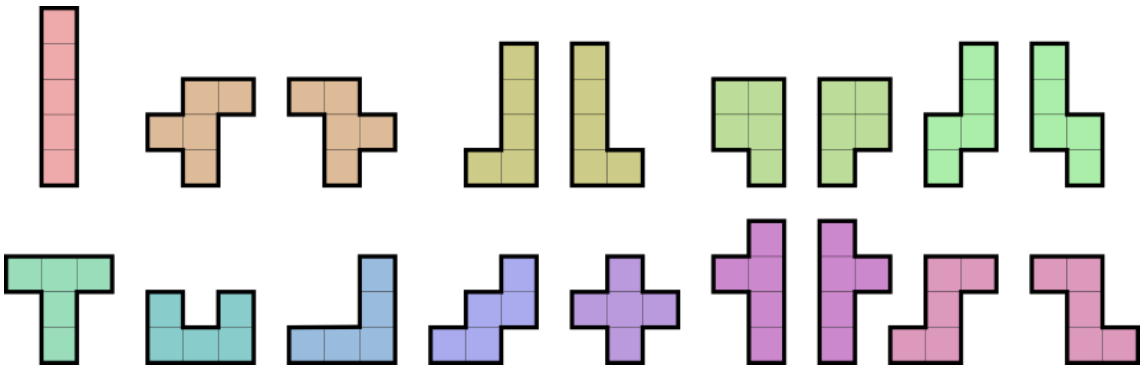
By Nick Bentley – November 25, 2017
[https://www.nickbentley.games/bug-polyomino-perceptual-binding]



This post is about a game I've invented called Bug. It's a 2 player game where you build shapes on a hexagonal board, which then eat each other. The shapes that survive grow into different, larger shapes until one player runs out of space to grow (and thus wins).

You can find the rules toward the bottom of this post, here. But first I'll discuss the game's origin. It involves concepts I've not seen connected with game design, so maybe I have something new to say. Here goes:

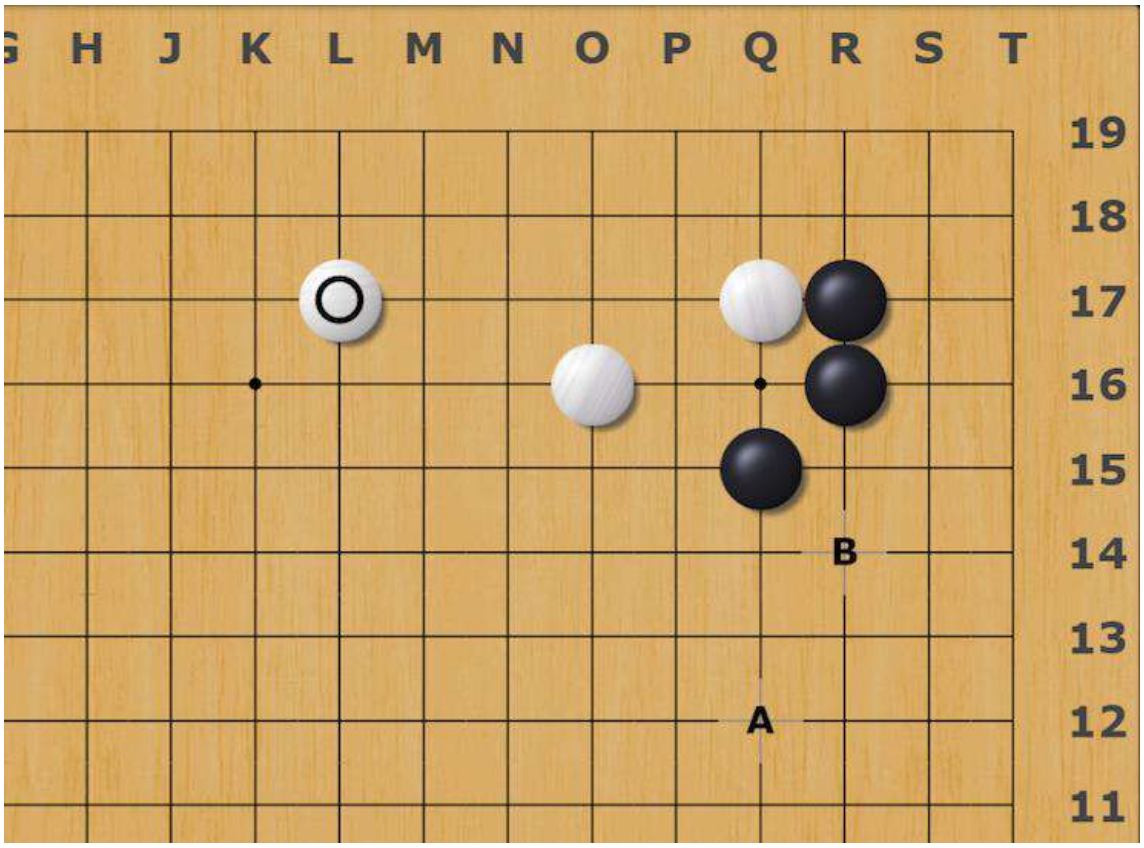
Perceptual binding, identity and meaning in a new sort of polyomino game



Bug was birthed from my belief that a class of polyomino games is waiting to be invented. There's no shortage of polyomino games already of course (here are more than 100), for at least two good reasons:

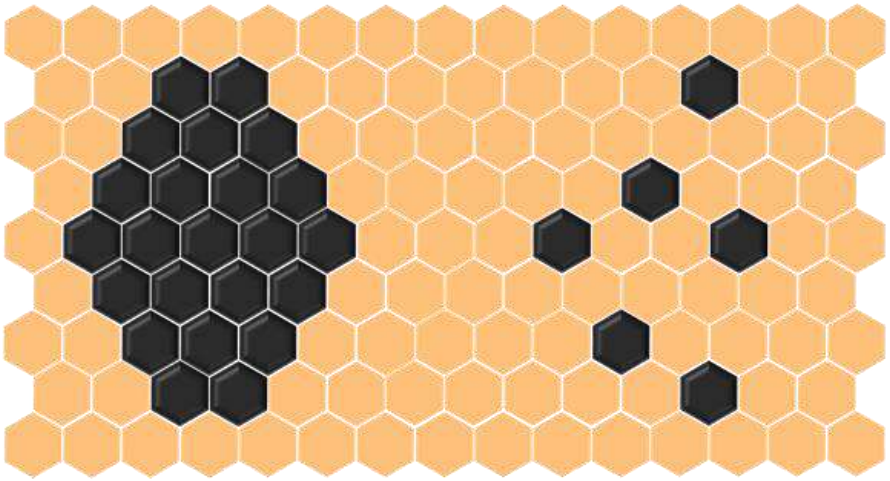
First, due to the variable way they fill space, polyominoes are champs at creating tactics.

Second, our brains handle polyominoes well. One key way we process spatial information is by dividing it into localized chunks and memorizing/operating on the chunks. For example Joseki in Go or Hex Templates or words in sentences.



Joseki – a local pattern in Go constituting a balanced position between the players

Polyominoes are particularly easy for us to handle this way, thanks to a phenomenon called perceptual binding. We automatically perceive certain spatial patterns, including polyominoes, as unified objects. When we perceive a pattern as an object, we can more easily remember it, distinguish it from others, and manipulate it in imagination. Try closing your eyes and rotating a polyomino in your mind, and then try rotating some random, non-contiguous spackle of cells in your mind. Most people find rotating the spackle harder:



Thanks to perceptual binding, it's easier to mentally rotate the contiguous group of same-color cells (left) than the non-contiguous group (right).

Perceptual binding is a key reason polyominoes feel friendly to many people. Tetris would be harder if it were played with spackle-patterns instead of polyominoes.

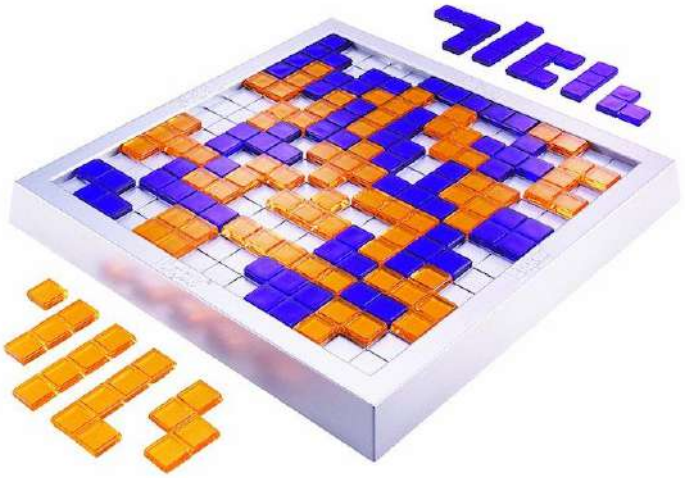
Why are polyominoes subject to perceptual binding?

The condition allowing the brain to bind a polyomino into a perceptual object is spatial contiguity of color. In life, regions of contiguous color in the visual field have a statistical tendency to be part of the same object, so our brains evolved to *assume* such regions belong to the same object (visual perception is Bayesian! – it's why camouflage is an effective defense).

an owl and a tree, perceptually bound

Polyominoes are composed of contiguous, like-colored cells, so we see them as objects, in contrast to joseki, Hex templates, and other spatial patterns that appear in games.

That's probably why most polyomino games come with pre-built polyominoes. We perceive polyominoes as objects, so we create polyomino game pieces which ARE objects. Hence Blokus and Tetris.



Blokus

A Missed Opportunity

Here's where I think the opportunity has been missed. I can imagine a class of games where players build and modify polyominoes as they go, and the collective interplay of their changing shapes define the terms of a board-spanning geometrical conflict.

Go-moku (above) and its many descendants (like Renju, Connect 4, Pente, Pentago, and Connect6) are indeed polyomino-building games, but they focus on trying to build one pre-chosen polyomino: a line segment. These games feel

strategically limited to me, and considering how big the universe of polyominoes is, tactically limited too. What if we could create a strategic game, where a wide range of polyominoes matter and interact (and different polyominoes matter depending on context)?

I think that would be swell, not only because the idea itself is cool (according to me, arbiter of cool), but because, thanks to perceptual binding, it offers a path to solving a sticky design problem:

Specified vs. Natural Powers

Consider Chess, Magic, and Go, three hall-of-fame games. Chess and Magic are generally more accessible than Go. But the reason isn't obvious. Go has the simplest rules of the three, after all.

Here's where I think the difference lies: The rules of Chess and Magic *specify units of play with differing powers*, and Go's don't. I'm referring to Chess' piece-powers and Magic's card-powers here. The pieces and cards have specified identities (the rules tell us what they are), and specified meanings (the rules tell us what they do). Because they're explicit, they act like big flashing arrows, pointing players toward tactics and strategy.

Go has units of play with differing powers too, but they're not explicit. For example, the aforementioned joseki, or the opening patterns called fuseki. These powers aren't in the rules; instead they're a natural property of gameplay. I call these *natural powers*. All good strategy games have them: they're just heuristics, but I'm calling them natural powers to highlight that their role in gameplay shares a key function with specified powers: they comprise a collection of tools, and figuring out how to use those tools offers a bunch of interacting puzzles that drive gameplay.

However, natural powers don't offer the guidance Chess' piece-powers or Magic's card powers do, because you must discover them before you can use them. You have to train yourself to see them, and after you do, they can be harder to remember because you perceive them as *situations* rather than *things*.

Does that mean game designers should always specify some powers? I hope not. Specified powers have their own problems: they add rules, they feel inelegant and often arbitrary (to me), and they tend to make a game feel opaque before you've memorized them.

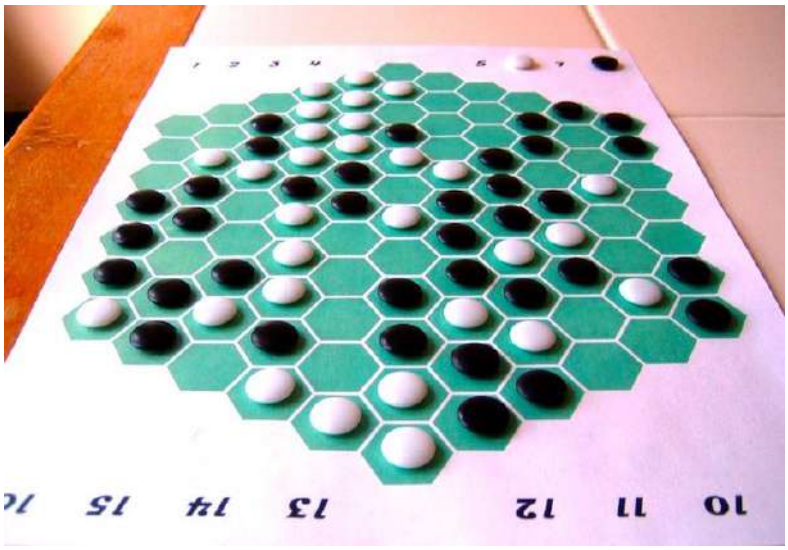
Contemplating this, I've wondered if I could create naturalish powers that needn't be specified individually, but which are nonetheless recognizable and thingish like specified powers. Here's where polyominoes come in: because they're

perceptually bound, we see them as distinct things, which could have, with the right rules, distinct meanings.

So my goal is to create a polyomino-building game where building a polyomino grants you a power particular to that polyomino, but I don't have to spell out the powers individually. I now have several designs that approach this idea from different angles, with varying success. Below I discuss three.

- The first, Papagra, sort of embodies the idea, but not really.
- The second, Carnivores, is one of my favorite games, but it has specified powers and doesn't meet the objective.
- The third, Bug, which I'm presenting for the first time here, seems to succeed.

First, Papagra



Papagra was my first polyomino game. The goal is to create pairs of groups of empty spaces with identical shapes – sort of negative polyominoes (in Papagra the polyominoes are hexagonal, so they're called polyhexes). The player who constructs the biggest pair first wins.

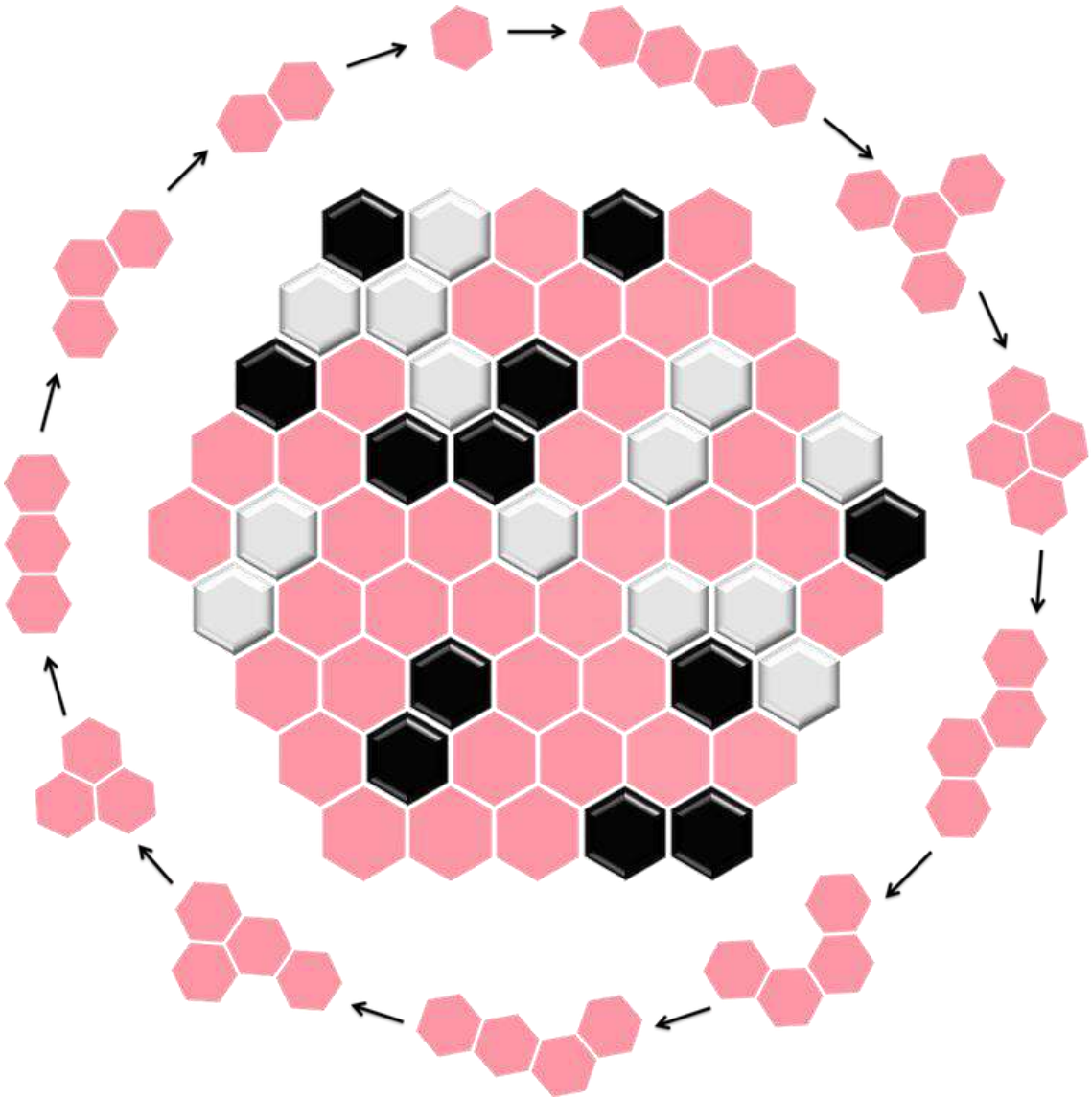
When you see a polyhex has formed or will form, it gives you a goal and a lens through which to see the rest of the board. The power of a polyhex is it gives you an opportunity to win by making a matching polyhex.

However, groups of empty spaces don't feel like "things" and they aren't as perceptually bound as normal polyhexes, so your brain can't handle them well. That defeats the purpose. Plus the "power" you get from building a polyhex doesn't feel much like one, not in the least because you don't own it and the other player can use it too. In sum: blah.

Then, Carnivores

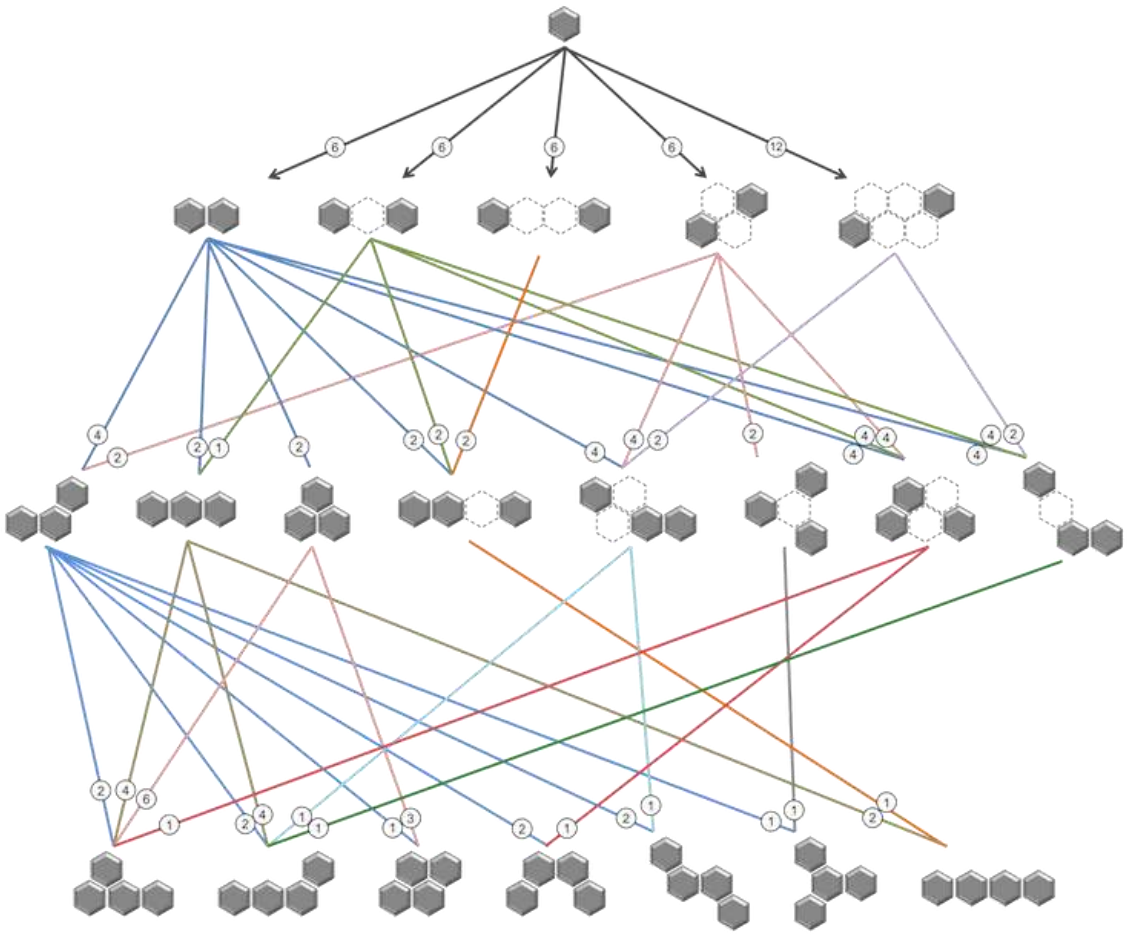
After a long polyomino vacation, a notion rekindled my interest. I dreamt of adjacent polyominoes capturing each other. It was simple, intuitive, and embodied a cool metaphor: the polyominoes would be like an ecosystem of creatures, eating each other and struggling for survival.

So I started building polyomino-capture games and hit on Carnivores, which the abstract games community on BoardGameGeek voted Best Combinatorial Game of 2015. In Carnivores, differently-shaped polyhexes eat each other according to a diagram around the board, called the Circle of Life, which includes all polyhexes size 4 or smaller:



Each polyhex can eat only one other polyhex, as indicated by the arrows in the Circle of Life – if an arrow points from polyhex A to polyhex B, then A can eat B when A and B are adjacent on the board.

Obviously, these powers are specified. But they're not arbitrary. The Carnivores are arranged on the Circle of Life according to how difficult they are to build. If I could say in the rules "each Carnivore eats the Carnivore that's the next-easiest to build (and the easiest of all eats the hardest)," then the powers would be closer to what I'm looking for. But no one can "see" how hard it is to build a polyhex. It took major ergs just to figure out how to do the "hardness" calculations, which required constructing this nutty diagram:



As specified powers go, Carnivores' are cool: they're naturally ordered, they're a complete set, and the Circle of Life conveys them in a compact, easy-to-reference, pictorial way. Carnivores has twice the specified powers as Chess, but you don't have to look up the rules or puzzle over what they do because you just look and see as you play.

They're about as natural as specified powers get, and Carnivores remains one of my favorite games, but it doesn't meet the objective. So I kept thinking.

Now, Bug

I thought for 2 more years. Then one day I got stoned and Bug came to me. It's like Carnivores but with more natural powers: each polyhex's power is to eat polyhexes of the same shape, so the shape implies the power.

Why didn't I just do this in the first place? Well, if nothing else happens after a polyhex eats an identically-shaped one, you can easily get infinite tit-for-tat eating cycles, including from the first turn when single stones eat each other recursively forever. I didn't know how fix that in a way that felt right. But eventually I saw: after a polyhex eats, it should grow. Growth eliminates cycles and ensures the game will end. Bug fell right into place after that.

Here's a bunch of stuff I like about it:

1. it has a natural win condition that doesn't require counting or calculation
2. it's fundamentally strategic (you can't win locally) but there are lots of tactics and lots of signposts along the way (like securing an uncapturable shape or forcing your opponent to clear bunch of your stones at once so that you have the placement freedom to make a strong counterattack)
3. it's finite (each game is guaranteed to end)
4. game-length is variable, which creates tension and variety.
5. ties are impossible, but...
6. it's hard to prove which side has the theoretical win, and the game seems quite balanced for the two sides.
7. thanks to some piece-cycling, you can play interesting games on small boards, but...
8. it scales well to larger boards as you gain experience.
9. it doesn't play like other games I know (Carnivores is closest, but there are big differences and Carnivores itself is fairly unique)

After much ado but without any further, the rules:

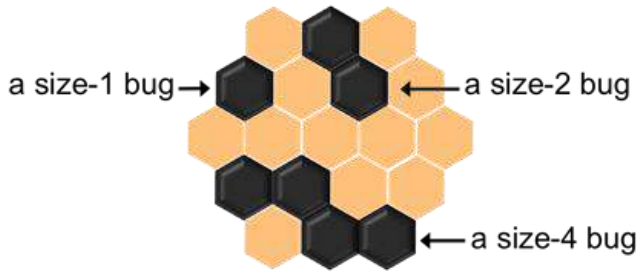
Rules of Bug

Bug is for 2 players, played with white and black stones on any hexagonal tiling. I strongly recommend starting with the board pictured in the images below (here's a PDF – it prints on a regular sheet of paper, for full size Go stones). Once you've grown skilled, try this larger board.

Definitions

1) A ***bug*** is an entire group of connected, same-color stones on the board. A single stone is also a bug.

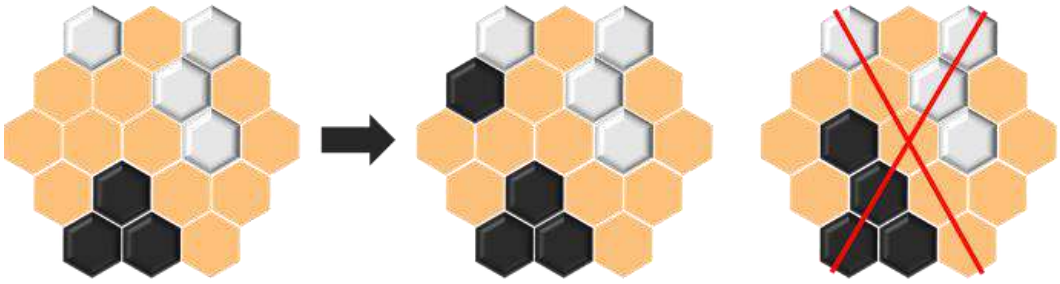
2) The ***size*** of a bug is the number of stones it contains.



Play

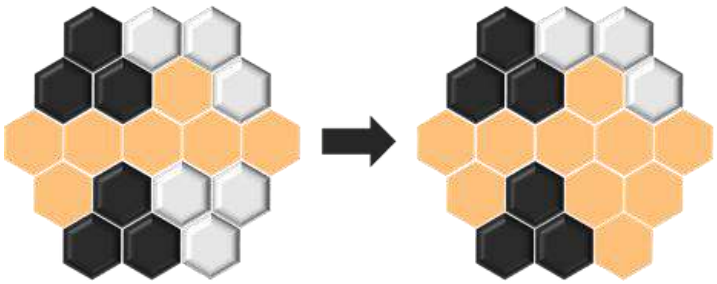
The board starts empty. Black begins the game by placing one black stone on any empty space. Then, starting with White, the players take turns. Each turn has 3 steps, taken in order: **1) Grow, 2) Eat, 3) Bonus Grow**

1) Grow: Place a stone on an empty space to either start a new bug or grow one of your preexisting bugs by one stone. You may not merge bugs, and you may not grow a bug to be larger than the largest bug on the board (regardless of color) prior to placement. Example:



It's Black's turn in this example. The placement on the far right is illegal because it would create a size-4 bug, larger than the largest bug on the board prior to placement (size-3)

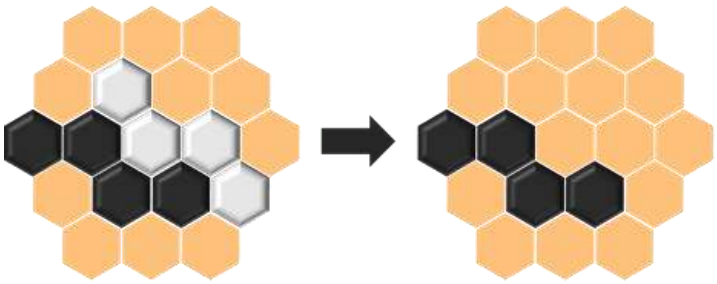
2) Eat: All your bugs which are adjacent to one or more enemy bugs of the same shape (but not necessarily the same orientation) must eat (capture) those enemy bugs. Return eaten bugs to your opponent. Example:



It's Black's turn in this example. Black's bug in the lower-left is adjacent to an identically shaped white bug. Therefore, the black bug eats the white bug.

If two of your bugs could eat the same enemy bug, you decide which of them will eat it.

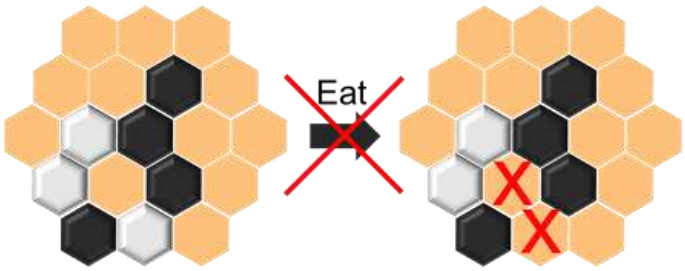
Note mirror-image bugs count as the same shape. For example, the black bug eats the white bug here (assuming it's Black's turn):



3) Bonus Grow: Increase the size of each of your bugs that ate, by exactly 1, by placing a stone of your color on any empty space adjacent to each such bug. Example:

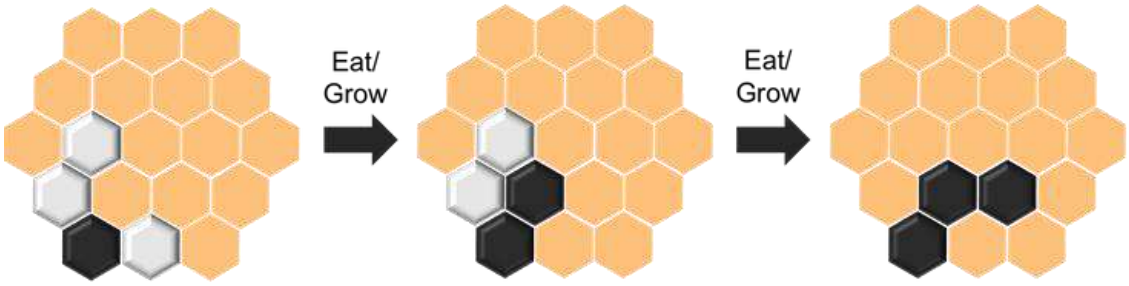
In this example, the black bug in the lower-left eats the white bug in the lower-right, and then grows by 1 stone.

If eating would unavoidably force a bug to grow by more than 1 through a merger with another bug of the same color, no eating occurs. Example:



It's Black's turn in this example. Normally, the size-1 black bug would eat the size-1 white bug adjacent to it. However, there's no way for the black bug to grow without merging with another black bug after eating. Therefore, the black bug doesn't eat.

If, after growing, a bug is adjacent to an identically-shaped enemy bug, it must eat the enemy bug (and grow again) if possible, and so on. Example:



In this example, a size-1 black bug eats a size-1 white bug, then grows to size-2, then eats a size-2 white bug, then grows to size-3, all in one turn.

End of the Game

The first player who CANNOT place a stone in the placement step WINS. That is: you win if you've filled the ecosystem with your bugs so much you can no longer expand.

Final Remarks

In a former life I was a neurobiologist. A key lesson I carry from that life is that we don't see reality; we see whatever was evolutionarily useful for us to see. Consequently our "reality" is sculpted and contorted in a thousand ways of which we're mostly unaware.

Perceptual binding is one of those contortions, and knowing about it offers fruitful avenues for thinking about game design. But this is just one example among many. I invite game designers to learn about the quirks of perception and to exploit them to make better games. I'm certain game design would improve if such knowledge was more widely dispersed.

Since this post is about spatial strategy games, I recommend this book about the quirks of visual perception to start. But since our biases aren't limited to spatial vision, I also recommend a study of more general cognitive biases. Here's a good starter list of such biases in wikipedia. Behavioral economists have discovered a load of valuation and prediction biases waiting to be exploited in economic games.

In any case I hope you got something from this. I'm in love, resolutely, endlessly, pointlessly in love with combinatorial games. I've adored being witness to their quiet renaissance, and it's been the signal thrill of my intellectual life to take part in it. I'm greedy to contribute more. I'd be overjoyed if someone stumbled into this post and it helped them see a little of the beauty I see in these games.

– NB