Contents

About the Author

Dr Camilla Pang holds a PhD in Biochemistry from University College London and is a Postdoctoral Scientist specialising in Translational Bioinformatics. At the age of eight, Camilla was diagnosed with Autistic Spectrum Disorder (ASD), and ADHD at 26-years-old. Her career and studies have been heavily influenced by her diagnosis and she is driven by her passion for understanding humans, our behaviours and how we work.

To my mother Sonia, father Peter and sister Lydia

Introduction

It was five years into my life on Earth that I started to think I'd landed in the wrong place. I must have missed the stop.

I felt like a stranger within my own species: someone who understood the words but couldn't speak the language; who shared an appearance with fellow humans but none of the essential characteristics.

In our garden at home I would sit in a multicoloured tent tilted sideways – my spaceship – with an atlas laid out in front of me, wondering what it would take to blast off back to my home planet.

And when that didn't work, I turned to one of the few people who maybe did understand me.

'Mum, is there an instruction manual for humans?'

She looked at me blankly.

'You know ... a guidebook, something that explains why people behave the way they do?'

I can't be certain – picking up on facial expressions was not, is not and never has been my forte – but in that moment I think I saw my mother's heart break.

'No, Millie.'

It didn't make sense. There were books on almost everything else in the universe, but none that could tell me how to *be*; none that could prepare me for the world; none that could teach me to place a comforting arm around the shoulder of one in distress, to laugh when others laughed, to cry when others cried.

I knew I must have been put on this planet for a reason and, as the years passed and my awareness of my conditions developed and my interest in science grew, I realized it was this. I would write the manual that I had always needed – one that explained humans to others like me who didn't understand, and which would help those who thought they understood to see things differently. The outsider's guide to life. This book.

It didn't always seem obvious, or achievable. I'm someone who was reading Dr Seuss while revising for my A levels. Reading

fiction actually makes me afraid. But what I lack in almost everything else, I make up for with the distinctiveness of how my brain works, and my overwhelming love for science.

Let me explain. The reason I never felt normal is because I'm not. I have ASD (autism spectrum disorder), ADHD (attention deficit hyperactivity disorder) and GAD (generalized anxiety disorder). Together, these might combine to make life as a human impossible. It's often felt that way. Having autism can be like playing a computer game without the console, cooking a meal without pans or utensils, or playing music without the notes.

People with ASD have a harder time processing and understanding events on an everyday scale: often we have no filter in what we see or say, get easily overwhelmed, and can display idiosyncratic behaviours that mean our talents can be overlooked and ignored. I'm someone who will tap the table in front of me a lot, make weird squeaking noises, and twitch constantly, nervous tics assailing me at random. I'll say the wrong things at the wrong time, laugh at the sad bits of films and ask constant questions through the important parts. And I'm never far away from a total meltdown. To get an impression of how my mind works, think of the Wimbledon tennis final. The ball – my mental state – is being rallied back and forth, faster and faster. It's bouncing up and down, side to side, constantly in motion. Then, all of a sudden, there's a change. A player slips, makes an error or outwits their opponent. The ball spins out of control. A meltdown begins.

Living like this is frustrating, but also completely liberating. Being out of place also means you are in your own world – one where you are free to make the rules. What's more, over time I have come to realize that my curious cocktail of neurodiversity is also a blessing, one that has been my superpower in life – equipping me with the mental tools for fast, efficient and thorough analysis of problems. ASD means I see the world differently, and without preconceptions; while anxiety and ADHD allow me to process information at rapid speed, as I pogo between boredom and intense concentration, and mentally envisage every possible outcome of each situation I find myself in. My neurodiversity created so many questions about what it meant to be human, but it also gave me the power to answer them.

I've sought those answers through the one thing in life that gives me the greatest joy: science. Where humans are ambiguous, often contradictory and hard to understand, science is trustworthy

and clear. It doesn't lie to you, mask its meaning or talk behind your back. At the age of seven, I fell in love with my uncle's science books, a source of direct, concrete information I simply couldn't find elsewhere. Every Sunday I would go up to his study and immerse myself in them. It was like a pressure valve being released – for the first time in my life I had found something to help explain the thing that confused me most: other humans. As someone who has constantly sought certainty in a world that often refuses to provide it, science has been my staunchest ally and most trusted friend.

And it's provided the lens through which I now see the world, explaining many of the most mysterious aspects of human behaviour that I have encountered during my adventure on Planet Human. While science may seem abstruse and technical to many, it can also illuminate the most important things in our lives. Cancer cells can teach us more about effective collaboration than any team-building exercise; the proteins in our bodies offer a new perspective on human relationships and interaction; and machine learning can help us to make more organized decisions. Thermodynamics explains the struggle to create order in our lives; game theory provides a path through the maze of social etiquette; and evolution demonstrates why we have such strong differences in opinion. By understanding scientific principles, we can better understand our lives as they really are: the source of our fears, the basis of our relationships, the functioning of our memory, the cause of our disagreements, the instability of our feelings and the extent of our independence.

Science has been the key to unlocking a world whose door was otherwise closed to me. And I believe the lessons it has to teach are important for all of us, whether neurotypical or neurodivergent. If we want to understand people better, then we actually need to know how people work: the functioning of the body and the natural world. The biology and physical chemistry that most of us have only glimpsed as diagrams in a textbook actually contain personalities, hierarchies and communications structures all of their own – reflecting those we experience in everyday life, and helping to explain them. Trying to understand one without the other is like reading a book with half the pages missing. A better understanding of the science that underpins our humanity, and the world we live in, is essential to a clearer understanding of ourselves and those around us. Where we normally rely on

instinct, guesswork and assumptions, science can bring clarity and provide answers.

I was someone who had to learn people and human behaviour as a foreign language. By doing so, I have recognized that those who claim to be fluent have gaps in their vocabulary and understanding too. I believe this book – the instruction manual I had to create for myself through necessity – can help everyone to better understand the relationships, personal dilemmas and social situations that define our lives.

Since I can remember, my life has been dominated by one question: how do you connect with other people when you're not wired to do so? I'm someone who doesn't instinctively know what love, empathy and trust feel like – but I desperately want to. So I have become my own living science experiment: testing the words, behaviours and ways of thinking that will allow me to become, if not completely human, then at least a functioning member of my own species.

In this quest I've been fortunate to have the love and support of my family, friends and teachers who looked out for me (contrasted with others, who you will read about, who did the opposite). Because of all the privileges I have had in life, I want to share my experiences of what is possible, and what can be achieved from a starting point of difference. With my Asperger's syndrome, often referred to as a high-functioning form of autism that makes you too 'normal' to be stereotypically autistic, and too weird to be neurotypically normal, I see myself as an interpreter between both worlds in which I have lived.

I also know that what changed my life was being aware that I was seen and understood. Realizing that I was a person, and had the right to be myself: in fact the duty to be. Everyone has the right to human connection – to be heard and taken seriously. Especially those who, by nature and instinct, struggle to connect. I hope through all the experiences and ideas I share in this book, I will be able both to emphasize the importance of common ground between us as people, and to offer new thoughts on how to achieve it.

So I invite you to join me, on this journey into the strange world of my Aspergic, ADHD brain. It's an odd place to be, but certainly never dull. As well as a notebook, pack your headphones – mine rarely leave my ears, a useful barrier between me and the sensory

overload of the outside world. And with that, you're ready. Let's go.

1. How to (actually) think outside the box

Machine learning and decision making

'You can't code people, Millie. That's basically impossible.'

I was eleven, and arguing with my older sister. 'Then how do we all think?'

It was something I knew instinctively then, but would only come to understand properly years later: the way we think as humans is not so different from how a computer program operates. Every one of you reading this is currently processing thoughts. Just like a computer algorithm, we ingest and respond to data – instructions, information and external stimuli. We sort that data, using it to make conscious and unconscious decisions. And we categorize it for later use, like directories within a computer, stored in order of priority. The human mind is an extraordinary processing machine, one whose awesome power is the distinguishing feature of our species.

We are all carrying a supercomputer around in our heads. But despite that, we get tripped up over everyday decisions. (Who hasn't agonized over what outfit to wear, how to phrase an email or what to have for lunch that day?) We say we don't know what to think, or that we are overwhelmed by the information and choices surrounding us.

That shouldn't really be the case when we have a machine as powerful as the brain at our disposal. If we want to improve how we make decisions, we need to make better use of the organ dedicated to doing just that.

Machines may be a poor substitute for the human brain – lacking its creativity, adaptability and emotional lens – but they can teach us a lot about how to think and make decisions more

effectively. By studying the science of machine learning, we can understand the different ways to process information, and fine-tune our approach to decision making.

There are many different things computers can teach us about how to make decisions, which I will explore in this chapter. But there is also a singular, counter-intuitive lesson. To be better decision makers, we don't need to be more organized, structured or focused in how we approach and interpret information. You might expect machine learning to push us in that direction, but in fact the opposite is true. As I will explain, algorithms excel by their ability to be unstructured, to thrive amid complexity and randomness and to respond effectively to changes in circumstance. By contrast, ironically, it is we humans who tend to seek conformity and straightforward patterns in our thinking, hiding away from the complex realities which machines simply approach as another part of the overall data set.

We need some of that clear-sightedness, and a greater willingness to think in more complex ways about things that can never be simple or straightforward. It's time to admit that your computer thinks outside the box more readily than you do. But there's good news too: it can also teach us how to do the same.

Machine learning: the basics

Machine learning is a concept you may have heard of in connection with another two words that get talked about a lot – artificial intelligence (AI). This often gets presented as the next big sci-fi nightmare. But it is merely a drop in the ocean of the most powerful computer known to humanity, the one that sits inside your head. The brain's capacity for conscious thought, intuition and imagination sets it apart from any computer program that has yet been engineered. An algorithm is incredibly powerful in its ability to crunch huge volumes of data and identify the trends and patterns it is programmed to find. But it is also painfully limited.

Machine learning is a branch of AI. As a concept it is simple: you feed large amounts of data into an algorithm, which can learn or detect patterns and then apply these to any new information it encounters. In theory, the more data you input, the better able your algorithm is to understand and interpret equivalent situations it is presented with in the future.

Machine learning is what allows a computer to tell the difference between a cat and a dog, study the nature of diseases or estimate how much energy a household (and indeed the entire National Grid) is going to require in a given period. Not to mention its achievements in outsmarting professional chess and Go players at their own game.

These algorithms are all around us, processing unreal amounts of data to determine everything from what film Netflix will recommend to you next, to when your bank decides you have probably been defrauded, and which emails are destined for your junk folder.

Although they pale into insignificance to the human brain, these more basic computer programs also have something to teach us about how to use our mental computers more effectively. To understand how, let's look at the two most common techniques in machine learning: supervised and unsupervised.

Supervised learning

Supervised machine learning is where you have a specific outcome in mind, and you program the algorithm to achieve it. A bit like some of your maths textbooks, in which you could look up the answer at the back of the book, and the tricky part was working out how to get there. It's supervised because, as the programmer, you know what the answers should be. Your challenge is how to get an algorithm to always reach the right answer from a wide variety of potential inputs.

How, for instance, can you ensure an algorithm in a self-driving car will always recognize the difference between red and green on a traffic light, or what a pedestrian looks like? How do you guarantee that the algorithm you use to help diagnose cancer screens can correctly identify a tumour?

This is classification, one of the main uses of supervised learning, in which you are essentially trying to get the algorithm to correctly label something, and to prove (and over time improve) its reliability for doing this in all sorts of real-world situations. Supervised machine learning produces algorithms that can function with great efficiency, and have all sorts of applications, but at heart they are nothing more than very fast sorting and labelling machines that get better the more you use them.

Unsupervised learning

By contrast, unsupervised learning doesn't start out with any notion of what the outcome should be. There is no right answer that the algorithm is instructed to pursue. Instead, it is programmed to approach the data and identify its inherent patterns. For instance, if you had particular data on a set of voters or customers, and wanted to understand their motivations, you might use unsupervised machine learning to detect and demonstrate trends that help to explain behaviour. Do people of a certain age shop at a certain time in a certain place? What unites people in this area who voted for that political party?

In my own work, which explores the cellular structure of the immune system, I use unsupervised machine learning to identify patterns in the cell populations. I'm looking for patterns but don't know what or where they are, hence the unsupervised approach.

This is clustering, in which you group together data based on common features and themes, without seeking to classify them as A, B or C in a preconceived way. It's useful when you know what broad areas you want to explore, but don't know how to get there, or even where to look within the mass of available data. It's also for situations when you want to let the data speak for itself, rather than imposing pre-set conclusions.

Making decisions: boxes and trees

When it comes to making decisions, we have a similar choice to the one just outlined. We can set an arbitrary number of possible outcomes and choose between them, approaching problems from the top down and starting with the desired answer, much like a supervised algorithm: for example, a business judging a job candidate on whether they have certain qualifications and a minimum level of experience. Or we can start from the bottom, working our way upwards through the evidence, navigating through the detail and letting the conclusions emerge organically: the unsupervised approach. Using our recruitment example, this would see an employer consider everyone on their merits, looking at all the available evidence – someone's personality, transferable skills, enthusiasm for the job, interest and commitment – rather than making a decision based on some narrow, pre-arranged criteria. This bottom-up approach is the first port of call for people

on the autistic spectrum, since we thrive on bringing together precisely curated details to form conclusions – in fact we need to do that, going through all the information and options, before we can even get close to a conclusion.

I like to think of these approaches as akin to either building a box (supervised decision making) or growing a tree (unsupervised decision making).

Thinking in boxes

Boxes are the reassuring option. They corral the available evidence and alternatives into a neat shape where you can see all sides, and the choices are obvious. You can build boxes, stack them and stand on them. They are congruent, consistent and logical. This is a neat and tidy way to think: you know what your choices are.

By contrast, trees grow organically and in some cases out of control. They have many branches and hanging from those are clusters of leaves that themselves contain all sorts of hidden complexity. A tree can take us off in all sorts of directions, many of which may prove to be decisional dead ends or complete labyrinths.

So which is better? The box or the tree? The truth is that you need both, but the reality is that most people are stuck in boxes, and never even get onto the first branch of a decision tree.

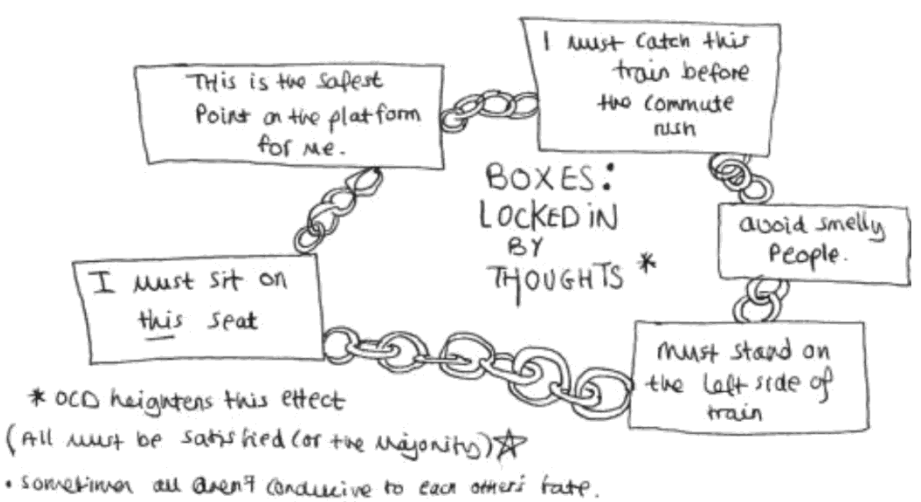
That certainly used to be the case with me. I was a box thinker, through and through. Faced with so many things I didn't and couldn't understand, I clung to every last scrap of information I could get my hands on. In between the smell of burnt toast on weekdays at 10.48 a.m. and the sound of schoolgirls gossiping in cliques, I would engage within my recreational equivalent – computer gaming and reading science books.

Night after night, throughout the years of boarding school, I would revel in my solitude by reading and copying selective bits of texts from science and maths books. My trusty instruction manuals. I took great pleasure and relief from doing this over and over, with different science books, not knowing why but only to reach the crescendo of pinning down some gravitational understanding of the reality before me. My controllable logic. The things I read helped give me rules that I set in stone, from the 'right' way of eating to the 'right' way to talk to people and the 'right' way to move between classrooms. I got stuck in a rut of

knowing what I liked and liking what I knew – regurgitating a series of 'should's to myself because they felt safe and reliable.

And when I wasn't sitting with my books, I was observing: memorizing number plates on car journeys, or sitting around dinner tables contemplating the shape of people's fingernails. As an outsider at school, I would regularly use what I now understand to be classification to understand new people entering my world. Where were they going to fit into this world of unspoken social rules and behaviours that I struggled to understand? What group would they gravitate towards? Which box could I put them in? As a young child I even insisted on sleeping in a cardboard box, day and night, enjoying the feeling of being cocooned in its safe enclosure (with my mum passing biscuits to me through a 'cat flap' cut in the side).

As a box thinker I wanted to know everything about the world and people around me, comforting myself that the more data I accumulated, the better decisions I would be able to make. But because I had no effective mechanism for processing this information, it simply piled up in more and more boxes of useless stuff: like the junk that hoarders can't bear to throw out. I would become almost immobilized by this process, at times struggling to get out of bed because I was so focused on what exact angle I should hold my body at. The more boxes of irrelevant information piled up in my mind, the more directionless and exhausted I became, as every box in my mind started to look the same.



My mind would also interpret information and instructions in a

understand – and then decide – if we explore, question and reconcile things that don't fit neatly together. If we want to be more scientific about how we make decisions, that means embracing disorder before we can detect patterns and hope to draw conclusions. Which means we need to think more like trees. Let me show you what that looks like.

Thinking like a tree

Tree thinking has been my salvation. It is what allows me to function in everyday life, doing what might seem normal tasks to most of you – like commuting to work – but which could easily be insurmountable barriers for me. I can be sent into meltdown by anything from an unexpected crowd, noise or smell, to something that doesn't turn out as I had planned.

But while my ASD means I crave certainty, it doesn't mean that simplistic methods of making decisions are helpful for me. I want to know what is going to happen, but that doesn't mean I am prepared to accept the most straightforward route from A to B (and from experience and perpetual anxiety, I know the route is never that easy). It's the opposite, because I struggle to stop my mind racing through all sorts of possibilities based on everything I see and hear around me. In my world, appointments get missed, messages are left unanswered and my sense of time disappears because I've spotted something like a blackbird sitting on a roof, and wondered how it got there, and where it's going next. Or I've become distracted because I noticed the pavement was smelling like raisins after a rain shower, only to then experience a close shave with a lamp post.

What you notice is only the half of it. My mind is a kaleidoscope of future possibilities about what I observe and experience. This is why I have a whole bunch of coffee-shop loyalty cards, all fully stamped, but never yet used. I can't decide which is the greater risk: that there will be a time in the future when I need them more than I do now; or that the chain in question will cease to exist before I get the chance to use them. The net effect is that nothing at all happens. (But note: I don't consider any of these far-out projections as wrong. They are things that haven't yet happened, but still might.)

Add to that my ADHD, which means my perception of time is squished and stretched, and can sometimes disappear completely.

Because information is flying through your mind at high speed, leaving your legs restless and shaking, it can feel like you are living a week's worth of thoughts and emotions all within an hour: oscillating wildly from euphoria to despondency, thinking things are going to be brilliant one moment, and a catastrophe the next. Not ideal for making to-do lists.

For the same reason, I rely on a chaotic working environment to be productive. I will spread paper everywhere, make notes on anything that comes to hand, and simply let the material pile up around me, embedded within the white noises of the room. This 'chaos' is something I find stimulating, a weed whacker to cut through the non-stop noise within my mind, enabling me to focus. In contrast to what we are taught at school, I find silence doesn't help me focus, but instead creates a pressure that simply stops me from doing anything.

My brain is craving certainty and feeding on chaos all at the same time. To keep myself functioning, I have had to develop a technique that satisfies both my need to think through everything, and my desire for an ordered life in which I know exactly where and when I am going to be. Which is where the trees come in.

A decision tree allows me to reach a certain end – which might be one of several potential outcomes, but at least I know what they are – through sometimes chaotic means. It provides structure to what I know my mind will do anyway, which is race through endless possibilities. But it does this in a way that leads me to something useful: a conclusion about what decisions I can make that give me something representing certainty. It also allows me to avoid putting all of my eggs in one basket, a process which at times gives me an outwardly cool edge of slight indifference.

Think about your morning commute. Mine is across London by train. That, for me, is an anxiety attack waiting to happen. The crowded carriage, the noise, the smells, the pressured spaces. A decision tree helps to minimize the potential for all those things to trigger a meltdown. I know what train I am going to catch, and then I consider what I'll do if it's late or cancelled, or I get delayed. I know where I want to sit, and what I will do if those seats are occupied, or if it is too loud. I think through all the things I need to ensure a meltdown-free journey – the right time, before the commuter crush; the right seat, away from the smelliest parts of the train; the right place on the platform to stand – and then I shimmy up the branches that stem off each, for when any of those

things might become impossible. I am a puppet on strings of probability, which guide me forward like a harness, allowing me to manoeuvre between branches. Rather than having a fixed routine, something brittle that will break under stress, I have multiple decision trees for my commute. I have lived in my mind all sorts of scenarios, most of which will never come to pass, in the hope that I won't encounter one that hasn't occurred to me, and which is likely to freak me out.

Before I get to any decisions, the ones that reassure me it's safe to travel, I have to go through this messy mental planning. The apparent chaos of the decision tree is necessary to help get me towards the sense of certainty I need to function.

To you that probably sounds like a lot of hassle (you'd be right!) and, to be clear, I'm not suggesting that you start war-gaming your morning routine as I would. I need to do this, otherwise I would get too overwhelmed and just not leave the house. But I do think this method has a place when it comes to the more complex decisions – the ones that neurotypical instinct and methods tend to fall down on.

While the challenge for my ASD/ADHD brain is not getting paralysed by overthinking, the opposite of this is also a problem. If you don't delve deeply enough into the data set that surrounds every major decision, allowing yourself to consider the different possibilities and outcomes, and the branches of the tree that different decisions will simultaneously close off and open up, then you are effectively making your choice while blindfolded. We can't predict the future, of course, but for most situations we can cluster enough data points and plot enough possibilities to give ourselves a decent map. What I do to reassure myself and tamp down anxiety on an everyday basis could be useful for you in working through the difficult decisions in your life. With a decision tree, you can reach from the things that you know, to grasp onto the decisions you are seeking – not in a prescriptive way, based on fixed outcomes, but by letting the evidence guide your conclusion, and allowing yourself to consider multiple outcomes and their implications.

Trees are also necessary to make sense of the confusing, open-ended questions that people are so fond of asking. If someone asks me, 'What do you feel like doing today?' my instinctive response will be, 'I don't know, maybe.' I need some specific options – branches of a tree – to offer a route from the chaos of total freedom towards the restriction of a decision, one which still leaves open alternative routes to divert down. A tree turns the multitude of underlying events and variables inherent in any decision into something like a route map. It might make every conversation into a jungle trek, but at least it allows me to find a way through.

By contrast, when we make decisions based on box thinking, we are usually doing so through a combination of emotion or gut instinct. Neither can be relied upon, and you can take it from me: there's nothing like ADHD to help you understand what making immediate decisions after emotion has slapped you in the face is like. Good times.

Good decisions don't generally emerge from an assumption of certainty, but out of the chaos otherwise known as evidence. You need to start from the bottom, building upwards towards the conclusion rather than starting with it. And to do that, you need a tree to climb up.

So how do I decide?

A tree is all very well in theory, you might be thinking, but with so many branches how do I actually make a decision? Isn't there a risk of getting lost in all the wonderful complexity we have visualized around us?

Yes, there is (welcome to my world!) but don't worry, machine learning has your back again. Algorithms also have a lot to teach us about how to sift through large amounts of data and draw conclusions – exactly what you need to do to make the tree method work for you in everyday circumstances.

Any machine-learning process essentially begins with what we call feature selection: filtering the useful data away from the noise. We need to narrow down our evidence base and focus on the information that can lead us somewhere. This is about setting the parameters of the experiments you will then undertake.

How is this done? There are different methods, but one of the most common in unsupervised machine learning is known as 'k-means clustering'. This is where you create indicative clusters within a data set based on how closely related they are. Essentially, you group together things that look similar, or have certain features in common, to create a certain number of clusters, and then use those to test and evolve your assumptions. Because you don't know what the outcome is meant to be, you are open-minded about the conclusions, and initially focus only on what can be inferred from the data: letting it tell its own story.

Is that really so different from the decisions we have to make all the time? Whether they are insignificant or life-changing choices, we always have data points that we can examine and try and cluster together. If it's choosing an outfit, we know what makes us feel good, what is appropriate for the occasion, and what others might think. If it's deciding whether to take a job in a different country, the data points might range from the salary on offer, to lifestyle, proximity to friends and family, and career ambitions.