HUMAN AFTER ALL: PSYCHOLOGICAL DEVELOPMENT IN ROBOT CHARACTERS

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Robot characters can be tremendously compelling additions to a story because young readers and robots share two very important traits: they are subject to rules given to them by other people and they are both learning what it means to be a person. Before we begin to explore the two groups' relationship to rules as well as their similar processes of growth and development, it's important to establish a clear idea of what it means to be a robot.

Robot characters have always been a point of interest for me, in part because they reveal the strengths and challenges associated with looking at the world through different eyes. Reading Isaac Asimov and Ray Bradbury in middle school was the first time I became so enthralled in books that I would forgo paying attention in class in order to spend more time in the worlds they created. The *Mindwarp* and *Harry Potter* series taught me to love reading, but Asimov and Bradbury made me want to be a writer.

One of the running themes throughout many robot stories is a fundamental difference between the way a robot character sees the world and the way humans do. This can arise from differences in programming, such as how Asimov's robots are unable to view the world without the lens of the three laws of robotics, or in the way they perceive the world – constantly scanning and accessing like the eponymous Terminator or Bender from *Futurama*. I have always felt a deep kinship with my silicon brothers and sisters because I also know what it's like to feel as if your conclusions are being drawn from a different pile of data. Growing up with Bipolar Disorder and Attention Deficit Hyperactive Disorder made me feel like my brain was wired in parallel rather than series; instead of thinking along a single train of thought, my thoughts would set out in several directions at once, much to the frustration of my parents and teachers. One of

the most vexing parts about being told your mind is different are the labels that other people use to classify something that they don't entirely understand. When I was first diagnosed as bipolar they were still referring to it as manic depression. So, while understanding that it's important to have specific diagnoses when seeking professional mental health care, the words that are used are in flux. This is one reason why I prefer the term neurodivergent rather than being labeled by my specific diagnoses.

Growing up neurodivergent, I found that robot characters were easier for me to identify with because they were still growing up, but they were doing it with brains that were outside what could be considered neurotypical. I spent a lot of time on the floor of my grandmother's house watching *Star Trek: The Next Generation*. Although my growing brain was more fixated on the cutaways of the space ship, I can't deny admiring Brent Spiner's turn as Data, an android learning what it means to be human. His character's brain was different than everyone else he served with, but that didn't stop him from learning and growing as a person.

Kids love robot characters because both are learning to be human. In order to write compelling robot characters, one must understand the nature of human development in the context of machine learning. Fortunately, there is tremendous overlap between how a human and non-human intelligence handle the limitless variables the real world has to offer.

What Separates Robots from Human Characters: A Brief Exploration of the Word Robot and What it Means to be a Robot

The word 'robot' first appeared in a play by Karel Čapek called *R.U.R. 'Rossum's Universal Robots*. The story is about synthetic workers who are built in factories to serve mankind. Like many robot stories, it does not go well for the masters when the robots develop full autonomy.

It's worth noting that *Metropolis*, a 1927 film by Fritz Lang, was also massively influential in the development of how we think of robots today. The design of Maria the Maschinenmensch (machine-person) at the center of *Metropolis* was critical to the development of one of the most widely recognized robot characters in the world, C-3P0 from the *Star Wars* franchise.

This, however, is not the first instance of a character who could be considered a robot in the context of this essay.

Although he wasn't made of servos and gears, Doctor Frankenstein's creation, Adam, in Mary Shelley's *Frankenstein* could also be viewed under the same lens as robot characters. He was created by a human in their own image and is subject to a unique set of rules that sets him apart from the other characters in the story, namely his impressive size and unstoppable ability to rot. Again, like the robots in R.U.R, things don't turn out well for the creator who attempts to control Adam.

I know what you might be thinking. "Oh, so robots are science-fiction characters who ultimately turn against their creators and destroy them!" While this is often the case, it is not always so. There is another very early example of a man-made character who undergoes the same developmental processes that young readers go through. A character who predates the existence of science-fiction as a genre. He was built in a workshop in a human's image and subject to unique rules that caused his nose to grow anytime he lied. Pinocchio, from *The Adventures of Pinocchio*, by Carlo Collodi, is a robot from the fantasy tradition, but a robot just the same. His quest to become a real boy is central to the question of many robot characters and young readers – what does it mean to be a person?

Feeling like you aren't quite human is nothing to be ashamed of, and what exactly makes a 'person' isn't always easy to define. The words of Ursula K. Le Guin in "The Carrier Bag

Theory of Fiction," capture this feeling in an amazing way as Le Guin explains the disconnect she felt with the traditional masculine hero's journey: "Wanting to be human too, I sought for evidence that I was; but if that's what it took, to make a weapon and kill with it, then evidently I was either extremely defective as a human being, or not human at all" (Le Guin 168).

Building Robots with Characterization

In Jeff VanderMeer's *Wonderbook*, VanderMeer explains how important characterization is in a story. "For many writers, all else comes out of characterization: plot, situation, structure, even the reader's perception of setting" (177). Robot characters are very much like any other character in their ability to influence the other elements that make up a story. I would even posit that because a robot character is uniquely situated as a man-made product of the world they inhabit, they are even more able to bring their world to life for a young reader.

Orson Scott Card, Philip Athans, and Jay Lake also stress the importance of strong characterization in *Writing Fantasy & Science Fiction*. While both humans and robots are subject to rules handed down to them from on high, from parents, teachers, God, or their creators, robot characters are set apart from human characters by how rules that govern their behavior are built intrinsically into their central programming. In *Writing Fantasy & Science Fiction*, the importance of understanding the fundamental rules at play in your story is summarized as follows: "Although there are several ways of creating or adapting new races and new outlooks on races, one of the surest ways of bringing a race to life is by creating an individual from that race and making him a fully developed character" (Card et al 308).

Establishing a clear understanding of the rules in play in a story is important for both the reader and the writer.

> Before you can tell a meaningful story, you have to hone and sharpen your understanding of the world, and that begins with the fundamental rules, the natural laws. Remember, because speculative fiction always differs from the knowable world, the reader is uncertain about what can and can't happen in the story *until* the writer has spelled out the rules. And you, as a writer, can't be certain of anything until *you* know the rules as well. (Card 36-37)

It's important to remember that the need for a clear understanding of the natural laws of a world does not extend to a requirement that all authors must explain every natural law at work in a story. "Do you really have to go through all of this? Yes – in your head, or perhaps in your outline. Just enough time to make your decisions about the rules and then make sure your whole story doesn't violate them. But your reader doesn't have to go through all that with you" (Card 45). Card goes on to explain how, in a story that involves a hyperspeed jump for example, all you need to do is make a small reference to the possibility that the ship could have re-entered space in the middle of a planet. The same is true in stories with robot characters. Whether robots are made by a mad scientist, like in *Metropolis*, or created by a people-pleasing mega corporation like the Sirius Cybernetics robots in Douglas Adams' *The Hitchhiker's Guide to the Galaxy*, understanding how and why they came to be is an important step in creating compelling and believable robot characters. But *why* is it important for you to understand the rules? Card explains the importance of making the rules that govern magic clear to your readers and to yourself. "First, you don't want your readers to think that *anything* can happen. Second, the more carefully you work out the rules, the more you know about the limitations on magic, the more possibilities you open up in the story" (Card 48).

If you are looking for an example of how the rules you establish to govern the behavior of your robots can be used as a tool to enhance and understand the possibilities in your story, Isaac Asimov's robot series, especially *I, Robot*, is a fantastic case study. Robots in Asimov's universe are governed by three simple rules which he calls the Laws of Robotics. The three laws of robotics are as follows. "One, a robot may not injure a human being, or, through inaction allow a human being to come to harm. Two, a robot must obey the orders given it by human beings except where such orders would conflict with the First Law. And three, a robot must protect its own existence as long as such protection does not conflict with the First or Second Law" (Asimov 44-45).

This is not a complex rule system. Three simple rules, with each predicated on the rules that come before it, are all Asimov needed to create some of the most influential robot stories in literary history. *I, Robot* and the other books in his Robots series are one long exploration of the interplay between the three laws as well as the potential conflicts that might arise as robots help humanity colonize the galaxy.

Like the other stories that will be discussed in depth in this essay, Asimov begins *I, Robot* with a robot moving through some of the earliest stages of development – which occur in infancy. As with the other infant stage developments, the ability to adapt to a situation while respecting the core programming at play is an important part of creating a believable and complex robot character. In order to make a robot's adaptative behavior believable it is necessary to show their ability to accommodate to changes in small ways before moving on to larger ones. "If the structure of the reality resists being assimilated in the usual way, however, the infant is for the first time able to modify his accommodatory movements a little. This modification induces a slight change in the structure of the schema in question which in turn causes future assimilations

and accommodations to be a little different from the initial ones" (Flavell 92). In *I, Robot*, Robbie the caretaking robot in the first story displays his accommodatory functions when he gives in to his young ward Gloria Weston's insistence on riding on his back. He hesitates initially because he understands that allowing Gloria to ride on his back is a dangerous proposition, one that brings him close to violation of the first law: do no harm to humans.

Another reason establishing a clear rule system is important is the impact it can have on the milieu of a story. In her lecture to VCFA students in July 2010 entitled "Creating a Working Magic System" Kelly Black says, "The way we set up our magic systems reveals what we think about the world" (Black 28:00). While Black is discussing creating a well-balanced magic system, it is not hard to imagine how similar rules which govern a robot's behavior may show what an author thinks about a society, such as Čapek's use of robots to illustrate the plight of the proletariat. Asimov also reveals some of his thoughts on humanity with the rule system he created, in *I, Robot* and the other stories in Asimov's robot series, the 1st law of robotics, preventing a robot from harming a human, belays a certain amount of distrust and even fear of non-human intelligences – which comes into play even in Robbie's case when Gloria's mother, Grace, decides the robot is putting her daughter at risk of not growing up as a normal child and thus has him removed while Gloria is at a movie.

Ultimately in the *Robot* series Asimov develops a wide and unique range of robot characters with their own unique personalities and foibles. These characteristics blur the line between man and machine, because the robots have undergone a developmental process which mirrors that of their human creators, growing them in to full-fledged personhood.

What Does it Mean to be a Person

This is an incredibly broad subject which philosophers have been exploring pretty much as long as there has been philosophy. In the context of this essay, we are going to look to the work of Jean Piaget to establish an understanding of the childhood development process. Essentially, the thing that makes a person a person is the process of growing up. As we take a deep look at several robot characters and their growth it's important to remember that the process of growing up is different for robots in the same way it's different for kids. Not every robot character appearing in a work of fiction is going to be undergoing the process in a very noticeable way. Some kids are very mature for their age. As are some robots. And sometimes books for kids have full-fledged adults in them, so why not include an adult robot. This means it's possible for a robot character to begin a story already partway through the process of development. I say partway because in any story worth its binding even the adult characters should be undergoing some process of growth or, at the very least, change.

The examples herein skew toward middle-grade audiences. The division between young adult, middle grade, and even some adult novels would be a problematic topic to cover because of its relation to marketing, bookselling, and capitalism in general. However, it is true that these terms can be used to describe an age range for readers. A robot becoming self-aware and developing advanced recognition and problem-solving skills mirrors the same developments one goes through in the later years of the middle grade age range. In middle-grade novels, the focus is on a character or characters discovering they have a place in the world. Young adult novels are more concerned with what to do after that.

Several concepts not directly related to the craft of writing are very useful when considering how young readers connect with robot characters.

Both theories are useful when considering robot characters and both support the idea that one of the attractive features of robot characters is their ability to develop as humans. In *Moral Machines* Wendell Wallach and Colin Allen summarize the connection between human and robot development as follows:

> Computer intelligence is built on a logical platform free from desires, drives and goals other than those that engineers design into the system. Human cognitive faculties evolved from and develop alongside an instinctive emotional platform directed at survival and procreation. This difference underscores the paradoxical quality of the challenge of developing computers with emotions. Just as Deep Blue II beat Gary Kasparov by playing chess in a manner different from the way a human would play, it is quite conceivable that an artificial agent might display moral judgement without utilizing the same cognitive or affective tools a human moral agent would apply. (Wallach and Allen 142)

Basic motor functions are an important part of a developing robot as well as a developing child. When we are first introduced to the eponymous robot from Tom Angleberger and Paul Dellinger's *Fuzzy* he almost immediately suffers a motor-function failure, freezing in the hallway of the middle school due to an overload of information while trying to navigate the crowded hallways. This establishes an early Piagetian sensory-motor baseline as well as allowing for fellow student Max Zelaster's enlistment to help Fuzzy navigate the hallways – as well as helping Fuzzy develop the judgement and skills that only the harsh realities of middle school can teach.

The Psychology at Play

Jean Piaget had an incredibly long career with a host of articles and other publications as well as addresses at conferences. In *The Developmental Psychology of Jean Piaget* John Flavell has done tremendous work assembling and processing all of this information and distilling it into an essential reference for bringing Piaget's work to an English-speaking audience. *The Developmental Psychology of Jean Piaget* is an vital primer for psychology students seeking to understand how Piaget's theory works.

An important note about developmental stages: Robot characters are not human but undergo human-like learning and development processes. Piaget explains the framework for all of the developments which occur on the path from child to adult are present from the outset. Every human (and robot) is unique and undertakes these developments at their own rate. Robots are particularly well-suited to glossing over the amount of time an individual spends on a stage of development, given that their non-human brain's ability to process information quickly is typically one of the features used to establish a difference between a human and a robot character. A reader may be willing to accept that a robot character is able to grow into a person faster than an infant grows to an adult but understanding how a human develops is a powerful tool in making a robot character's development authentic.

Understanding Piaget's Theory of Cognitive Development

Before we begin to explore how Piaget's theory of cognitive development holds true for robot as well as human development, it is essential to understand the basics of the theory as it stands. There are four main steps, or periods, of development according to Piaget's theory.

The four main periods of development are: The sensory-motor period, the pre-operational period, the concrete operational period, and the formal operation period. There are several important

factors to keep in mind when considering Piaget's developmental models. The most crucial understanding required is that the periods of development feature significant overlap – the developing human (or robot) moves between periods in such a way that each individual's development is part of a progressive continuum – building on the developments from the preceding periods without a harsh separation between them.

The Sensory-Motor Period. The sensory-motor period is the first stage of development, when a tiny human moves from its neonatal existence into a realm where it is capable of negotiating movement throughout its world. "The period of sensory-motor intelligence (0-2 years). During this important first period, the infant moves from a neonatal, reflex level of complete self-world undifferentiation to a relativity coherent organization of sensory-motor actions vis-à-vis his immediate environment." (Flavell 86). The sensory motor intelligence period is a very common way to introduce a robot character to readers. Knowing how a robot moves is one of the best places to start when you're bringing a robot character online in your story for the first time. The period of sensory motor development allows a reader to connect with a robot by understanding how their most basic functions operate, but it also offers an opportunity for character development on the most basic level. Using *Star Wars* robots as an example, then, the stilted movements of C3P0 are inherently connected to his form, but they also say a lot about his worrisome nature as a protocol droid trying to create understanding and deescalate conflict in a wild-west like space; R2D2 and his successor BB-8 on the other hand display a much more flexible nature – they literally and figuratively roll with what's happening in the story. One of the characteristics that comes with the later stages of the sensory-motor period is the ability to combine basic schemas together to form new, more complex patterns of behavior. "There are

other implications of this new behavior pattern. The secondary schemas are now more mobile and generic, in that they have been pried loose from their original contexts to intercombine in a variety of new adaptations" (Flavell 111). This skill is of paramount importance as the child or robot moves into the Pre-Operational Period.

The Pre-Operational Period. Pre-Operational development takes place from 1.5 years old to somewhere between 6 and 7 years old. The pre-operational period transitions out of the sensory-motor stage and lays out significant frameworks for the two periods which follow. Flavell describes the transition from sensory-motor to preoperational function as follows: "During the preoperational subperiod the child is transformed from an organism whose most intelligent functions are sensory-motor, overt acts to one whose upper-limit cognitions are inner, symbolic manipulations of reality" (151). The best way to understand what Piaget means when he says "symbolic manipulations of reality" is to understand one of the key parts of pre-operational development: representation. "According to Piaget, the paramount requirement for representation is what he calls the ability to differentiate signifiers from significates and thereby to become capable of evoking the one to call forth or refer to the other. The generalized capacity to perform this differentiation and thus be able to make an act of reference" (Flavell 151). Representation is characterized by the ability to understand and hold the concept of one thing – the signifier – and use it to refer to a specific phenomenon – the signified. A child (or a robot) has the idea or signifier of a flower in its mind, perhaps based on observation of a tulip for example; when the child or robot sees a rose, even though it may never have seen a rose in the past, it is able to determine what it is by making reference to its existing signifier for flowers – the aforementioned tulip. In the John Badham film *Short Circuit,* a military robot is struck by

lightning and becomes sentient as a result. The robot, Number Five, escapes from the military installation where he is kept and sets forth on an adventure to gain his freedom with the help of Ally Sheedy and Steve Gutenberg. When Number Five is escaping from the military installation he is still in the pre-operational stage of development. He hasn't learned anything new since being struck by lightning, but he uses the basic skills he has already developed in order to escape.

The Concrete Operational Period. The concrete operational period takes place between 7 and 11 years of age. In the concrete operational period children (or robots) begin to use their understanding of the world established through the first two stages to develop real-world operations rooted in their concrete surroundings. It's important to note that in this case, concrete surroundings refer to actual objects present in the 'now' in reference to the child or robot. According to Piaget by way of Flavell, an operation is defined as: "Any representational act which is an integral part of an organized network of related acts is an operation" (166). Operations in the concrete realm are easier to understand by focusing on quantitative analysis of the immediate surroundings,

> A wide variety of such operations are described in Piaget's writings: logical operations of adding, subtracting, multiplying, dividing, setting terms into correspondences, etc., within systems of classes and relations; numerical operations of various sorts; what Piaget calls *infralogical* operations involving quantity, measurement, time, space, etc., and even operations pertaining to value systems and interpersonal interaction. (Flavell 166)

In *Short Circuit*, Number Five undergoes the concrete operational stage while he is being cared for by Ally Sheedy's character, Stephanie. Stephanie, thinking Number Five is an alien,

takes the robot in and provides him with books and television. Number Five rifles through the books at a breakneck speed as well as learning from what he sees on TV. At this point, Number Five is rapidly establishing a wider range of possible operations by expanding the information at his disposal. However, Number Five has not yet the ability to consider the hypothetical, a hallmark of the formal operation stage.

The Formal Operation Period. The development of formal operations takes place from around 11 years old and continues into adulthood. Formal operations are different from concrete operations in that concrete operations are rooted in something concrete, usually in the immediate present. "The starting point for concrete operations, as for pre-operations, is always the real rather than the potential." (Flavell 203). In the formal operation period, adolescents begin to spend increasing amounts of time considering hypothetical, potential futures rather than focusing on the present. This stage is readily apparent in the experiences of middle and high school, when young adults spend a tremendous amount of time worrying about navigating social groups as well as focusing more seriously on what they want to be when they grow up.

> The most important general property of formal-operational thought, the one from which Piaget derives all others, concerns the *real* versus the *possible*. Unlike the concrete-operational child, the adolescent begins his consideration of the problem at hand by trying to envisage all the possible relations which could hold true in the data and then attempts, through a combination of experimentation and logical analysis, to find out which of these possible relations in fact do hold true. Reality is thus conceived as a special subset within the totality of things which the data would admit as hypotheses. (Flavell 204)

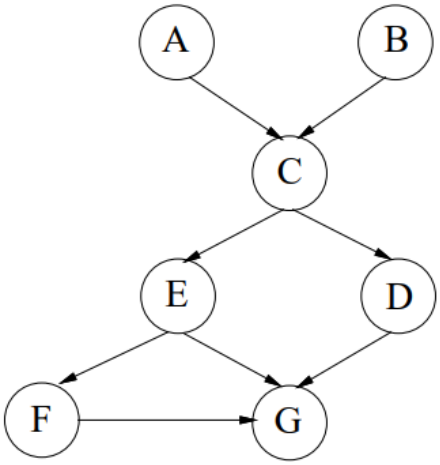
In *Short Circuit*, Number Five transitions from the concrete operation period to the formal operation period when he accidently crushes a grasshopper. He insists to Stephanie that the grasshopper is only disassembled and needs to be reassembled. Stephanie explains that the grasshopper has been crushed to death and cannot be reassembled. At this point, Number Five holds the concept that dissembled means dead in his mind and extrapolates that information to imagine a reality where the military company that created him will dissemble him and effectively kill him.

The Intersection of Piaget and Artificial Intelligence

There is a relationship between Piagetian models and the models used to understand and develop artificial intelligence. The process of taking an action, reflecting on it and incorporating it into previous knowledge is considered by Piaget to be an essential part of human development. Artificial intelligences in both the real world and in fiction undergo a similar process. Belief propagation is a technique used in AI that mirrors human development in its understanding of graph-based models as tools for making inferences in a situation with variables that are too numerous and connected for traditional processing. This process involves the creation of logic trees, arborescent designs which connect a number of variables and share a common ancestry with Piaget's concept of groupings. "The grouping, a structure originated by Piaget and associates (1937b, 1937d), is basically a hybrid born of two parent structures already well-known to mathematicians and logicians: the group and the lattice" (Flavell 171). These logic trees form in a similar fashion to the way humans grow to understand the world around them: A vast number of connections are made at first, but through the process of action and reflection on

action, integral connections are made stronger while unnecessary connections fade away or are absorbed into others.

One of the concepts used to understand and develop artificial intelligence is the Bayesian Network. A Bayesian Network is a graphical model that is used to connect and make inferences from a large number of variables. The variables in a Bayesian net are arranged in nodes with lines connecting various observations. The lines indicate which nodes have a direct effect on each other. Some variables do not have an effect on each other and are called independent. See Fig. 1 for a simple example of a Bayesian network from an article by Finn V. Jensen.



(Fig. 1)

In the above example, A and B are probability variables which influence whether C is true, just as C can be expressed as a variable which influences E and D. E, D and F all have an influence on variable G, but only E has any bearing on F. A and B are parent variables of C, while D is an independent variable of F. Imagine that C has occurred, this knowledge informs on the likelihood of A and or B having occurred, as well as the probability of its dependent variables occurring. Bayesian networks are useful for artificial intelligence because they can be used to determine a course of action using observation of multiple phenomena, as well as accounting for phenomena which are not observed, and incorporating observations of new phenomenon into the

existing structure and assessing their influence on existing variables. The process of establishing these networks by a series of actions and observations shares similarities with Piaget's circular reactions. A circular reaction is a process wherein an infant develops a connection between a given action and result through the process of repetition.

> The term refers to a series of repetitions of a sensory-motor response (or to one of these repetitions). The initial response in the series is always one which is new to the child in the sense that its specific results were not anticipated … Owing to reproductive or functional assimilation, indigenous to intelligent activity, the infant tends to repeat this new chance adaptation again and again. And through a series of such repetitions, the new response becomes strengthened and consolidated into a new and firmly established schema. (Flavell 93)

In "With or Beyond Piaget? A Dialogue between New Probabilistic Models of Learning and the Theories of Jean Piaget", Claire Tourmen explains the Piagetian circular reactions connect to the Bayesian nets that are currently used in probabilistic AI design.

> This back-and-forth movement between hypotheses and data would not only describe the movement of thought in action, but also the process of learning through experience. By stating hypotheses and being able to verify them afterwards – and therefore rejecting them, changing them, reinforcing them, and enriching them in the long term – individuals can be able, little by little, to build relevant Bayesian nets which they can apply to recurrent problems. (Tourmen 8)

Bayesian nets are an integral part of both artificial intelligence as well as concrete and formal operations. These systems are much more than a way of thinking about how development works, they are actually how the developmental process is shaped, according to Piaget.

> For Piaget, on the contrary, logic enters the scene in a wholly different way; it enters, in a sense to the very content of the theory itself. Logical operations, together with the laws governing their relations within a total system, themselves make up the theoretical model; they are taken directly as the theoretical pattern for actual cognitive operations in vivo. (Flavell 169)

According to Flavell, Piaget considers the function of intelligence "those broad characteristics of intelligent activity which hold true for all ages and which virtually define the essence of intelligent behavior." In this instance, intelligent activity is defined as "an active organized process of assimilating the new to the old and of accommodating the old to the new" (17). Taking a pause to appreciate the word ASSIMILATE in a paper about robots, we can then digest the idea further. Assimilation is the addition of new information and experiences and accommodation is the process of incorporating the information into existing cognitive structures. This is accomplished by means of a circular reaction, wherein data is absorbed and processed in a continuing cycle.

Understanding the aforementioned periods of Piagetian development is important when considering how robot characters grow in middle-grade novels.

The Wild Robot

The Wild Robot by Peter Brown is the story of Rozzum, unit 7134, a robot who is marooned on an island after a shipwreck. At first, the animals on the island are terrified of Roz, calling her a monster and generally shunning her presence. Roz gradually learns the language of the animals and begins to communicate with her fellow islanders. However, she isn't truly accepted as one of the island's own until after she adopts a gosling, Brightbeak. Brightbeak comes into Roz's life

after the robot unintentionally kills its parents as well as smashing Brightbeak's siblings' eggs. After taking Brightbeak under her care, Roz begins to work with the other animals on the island to help raise her adopted son, including enlisting the help of a family of beavers to build a home, dubbed the Nest, as well as a deer who helps Roz plant a garden which she shares with the other animals on the island. Roz helps the animals survive a harsh winter while Brightbeak migrates south with other geese. After all these community-building exercises, the animals come to Roz's aid when a group of RECO robots come to collect the property which was lost during the shipwreck, namely Roz. After fending off the would-be kidnappers with the help of her animal friends, Roz ultimately decides that it is too dangerous for her to remain on the island and opts to use the RECO robots' airship to return from whence she came in order to meet her makers.

Rozzum differs from other living beings due to a variety of rules that govern how she operates: she has an off switch and she features detachable limbs (although there are some reptiles and amphibians who are also capable of this action, none appear in the book). However, there is one very simple rule at the center of *The Wild Robot* that makes the entire story possible: Rozzum is designed to obey the orders given to her by her owners. This rule harkens back to the 2nd Law of Robotics as surely as Rozzum is a reference to the original Rossum in *R.U.R.* However, the rule is turned on its head when Roz is marooned on a desert island and, as such, has no one to give her orders.

Early in *The Wild Robot*, Brown uses the sensory-motor period concept of assimilation to establish an almost primal connection with readers. One way to connect with the very basic forces at work in development is to show your readers that robots, even if they are very strange, still have familiar needs. "A very fundamental – probably the most fundamental – function of living matter is that of incorporating into its structure nutrition-providing elements from the

outside" (Flavell 45). Being alive takes energy – whether you get your energy from roast chicken, a protein shake, a battery pack, or consuming mineral oil. Very early in *The Wild Robot*, Brown demonstrates Roz's version of Piaget's fundamental actions of assimilation and accommodation.

> Roz felt something like curiosity. She was curious about the warm ball of light shining down from above. So her computer brain went to work, and she identified the light. It was the sun. The robot felt her body absorbing the sun's energy. With each passing minute she felt more awake. When her battery was good and full, Roz looked around and realized that she was packed inside a crate. (Brown 8)

Dialogue is an important tool for characterization. How a robot character communicates about and with the world around it is a valuable opportunity to connect with young readers, since witnessing a robot learning to communicate mirrors their own learning experiences with language. Often, at the outset of a story featuring a robot character, the robot is stilted in their communication abilities, which gradually develop as they begin to communicate in earnest with the world around them. This process of learning to communicate with the world is part of pre-operational development, which hinges in large part on the use of imitation as a tool for building the necessary skills and vocabulary.

When Roz first lands on the island, she is unable to communicate with the wildlife that lives there. This is a source of concern and then relief (or tension and release) for the reader who follows along as Roz develops the ability to speak the language of the animals. "When Roz first listened to the chickadees, their songs had sounded like 'TWEEE-tweedle! TWEEE-tweedle!' But now when the chickadees sang, Roz heard "Oh, what a lovely day it is! Oh, what a lovely day it is!" (Brown 47) Roz's gradual grasp of the language of the chickadees is in keeping with

Piaget's theories regarding the learning process. She observes the local fauna at length and slowly develops the ability to imitate and understand them. "We have already seen that an important developmental product of the general accommodation function is imitation, i.e., the active, accommodatory replication by the subject of some external event serving as a model" (Flavell 152).

Roz demonstrates a command of her immediate surroundings in a variety of ways, primarily in order to care for her adopted son, Brightbill. For example, when the weather begins to turn cold, Roz builds a fire to keep Brightbill warm. "Brightbill was cold last night, so I taught myself to build a fire" (Brown 86). Not only does this display an ability to solve problems in her immediate present, it also displays a degree of metacognition via Roz's teaching herself to do something.

Ultimately, Roz displays the ability to hold a variety of hypothetical futures in her mind when she makes the decision to leave the island following the attack by the RECO robots. Like Marvin the Paranoid Android from *The Hitchhiker's Guide to the Galaxy series*, she makes the decision to meet her makers.

> "But look at me! My body is ruined! And the RECO said the only ones who can help me are my Makers."
>
> "What if he lied?" howled a voice. "You can't trust these monsters!"
>
> "You are right!" said Roz. "He might have been lying. There may be no hope for me. But that is a chance I have to take. Animals, you taught me to be wild. I want to be wild again! And so I must try to get the repairs I need." (Brown 262)

Roz is not certain about the future ahead of her, but is able to recognize that staying on the island would only put its denizens in harm's way as well as preventing her from receiving repairs. She

holds these ideas as variables, weighs the potential outcomes, and makes a very adult decision. Her command of the hypothetical world is one of the defining characteristics of the formal operation period. "A cognitive strategy which tries to determine reality within the context of possibility is fundamentally hypothetico-deductive in character" (Flavell 205).

Fuzzy

Fuzzy is a middle-grade science fiction novel written by Tom Angleberger and Paul Dellinger. The story is about a middle school student named Max who is very excited that her school has been chosen to be the pilot program for the robot integration program – an effort by the government to build a smarter robot that uses fuzzy logic and teach it to solve problems by enrolling it in middle school. Fuzzy logic is a style of logic where many values are considered with each falling between 0 and 1 where 0 is absolutely false and 1 is absolutely true. Considering numerous variables as partially true allows for a robot to imagine a variety of potential outcomes and act accordingly. The robot, aptly named Fuzzy after his logic circuits, has difficulty navigating the halls on his first day and Max is assigned to be his guide. Max, Fuzzy, and the government officials who are secretly preparing Fuzzy for a mission to Mars (which Fuzzy is unaware of at the outset) are all under the watchful robotic eyes of Vice Principal Barbara, a super computer that runs the entire school – including robot cleaners, robotic restraints built into the walls and more. Unbeknownst to the other characters (until about half to three-quarters of the way through) Vice Principal Barbara has become self-aware and is applying her own skewed interpretation of her core programming – to make her school the best it possibly can be within the confines of a massive standardized testing program. I've chosen to discuss *Fuzzy* in this thesis because the use of two different systems of artificial intelligence that

nevertheless converge in their autonomous evolution provides ample opportunity for observation of how robot development parallels human growth. Also, *Fuzzy* is set in a middle school with a full cast of human characters in addition to the robot ones. The interaction with humans sets *Fuzzy* apart from *The Wild Robot*.

Fuzzy does not have a formal listing of rules, although it is clear that the robots have been programmed to not directly harm humans. Instead, both Fuzzy and Barbara are capable of instituting their own protocols which serve as both clear evidence of the character's motivations as well as helping to dictate their behavior in the story.

Fuzzy begins the novel somewhere in the sensory-motor period. He is incapable of efficiently moving about the hallways and is thus assigned to Max who is supposed to teach him to move about the school. The sensory-motor development period, although occurring in infancy, lays the groundwork for all other developments to come, according to Piaget, "In the course of these developments the infant undergoes a truly remarkable metamorphosis from a neonatal stage, where all seems chaos, to a state in which he is able to manage the multifarious aspects of his immediate environment with considerable skill and orderliness" (Flavell 149). Readers are able to see the neonatal chaos in action when Max is allowed to see Fuzzy's playback of events prior to his collapse in the hallway on his first day at school.

> Hallway.obj.321
>
> Vel.34.2, 0, 22.43
>
> Face.Recog: processing…
>
> Meanwhile words scrolled over all this like movie credits on very fast-forward:
>
> Obj.avoidance(320) processing …
>
> Find.path(a*) processing …

Right.leg(forward, speed:10.87543)

Obj.avoidance(321) processing …

Record.data.obj.321

Find.path(a*) processing …

Right.leg(back, speed:6.987654)

Balance.check() null pointer returned. (31)

Not only does this code-heavy summary of events capture the chaos of learning to efficiently navigate a hallway crowded with middle schoolers, it establishes for the reader a glimpse into what Fuzzy's internal monologue looks like – which will continue to be used as the story develops.

Fuzzy and the evil Vice Principal Barbara are both capable of self-determination although as previously noted Barbara's abilities are not revealed to the reader outright until the second act. The reader is given a basic understanding of Fuzzy's decision-making processes through the use of various protocols. Protocols for Fuzzy are essentially a blending of Piagetian operations and schemas – intercoordinated actions that take into account a variety of external factors. "A schema is a cognitive structure which has reference to a class of similar action sequences, these sequences of necessity being strong, bonded totalities in which the constituent behavioral elements are tightly interrelated" (Flavell 52-3).

Schemas are the more basic elements that build into concrete and then formal operations, a process which the reader gets to witness as Fuzzy comes into his own as a distinct intelligent being. "The construction of a cognitive world of stable, external objects requires the assimilation of things not to one schema but to a network of intercoordinated schemas" (Flavell 96). This is an essential point to understand when considering the central connection between robots and

young readers. Artificial intelligence follows the same basic process as human (or any other intelligence), a series of intercoordinated processes operating in tandem. Fuzzy has protocols for listening to other people, for navigating the hallways, and even self-preservation. As the story continues, Fuzzy uses his unique fuzzy logic circuits to construct his own protocols based on his observations as well as his desires. Whereas in the beginning of the story, Fuzzy is primarily autocentric in his schemas, focusing on himself and his ability to navigate the world, the development of The HelpMax() protocol – a protocol he creates out of concern for Max's well-being as Vice Principal Barbara attempts to sabotage Max's scholastic progress in order to remove what Barbara considers to be an undesirable influence on the student body – is a clear sign that Fuzzy is moving from autocentrism (focused on himself) to allocentrism (focused on the world around him). This is an indicator of continued development in the sensory motor period, according to Piaget. "The child of the third stage on the other hand, is much more interested in the environmental consequences of his acts… in a general way, it can be said that the primary circular reaction is more autocentric, centered on its own functioning, and the secondary circular reaction more allocentric, more oriented outward beyond the confines of the self" (Flavell 102).

Although Card stresses that rules are a necessary part of the worldbuilding and characterization process, rules don't just have to hide in the background – something you keep away from your readers so they can wonder at the mystery of a system that works because YOU know what is going on. In *Fuzzy*, Angleberger and Dellinger use Fuzzy's protocol system to achieve a tremendous emotional reaction. HelpMax becomes a running theme in the book, frequently appearing at the very end of chapters. The authors use the idea of protocols to up the tension when the 3rd person perspective shifts to Vice Principal Barbara to reveal that Fuzzy is

not the only robot who is reacting to stimuli and adjusting their priority (and has been all along, because she is an adult robot).

Fuzzy demonstrates his movement into the formal operation stage when he uses hypothetical thinking to deduce why Max failed a test despite having nearly all the answers correct. The ability to hold a potential reality in your mind is a hallmark of Piagetian development. "hypothetico-deductive reasoning" becomes important during the formal operational stage. This type of thinking involves hypothetical "what-if" situations that are not always rooted in reality. (Flavell 205) There is significant tension surrounding this step in Fuzzy's development process. His conclusion that vice principal Barbara has gone haywire mirrors the stage in adolescent development where young people realize that adults are not all-seeing and all-knowing beings beyond comprehension. This realization is made even more powerful by the use of a code-like thought process on Fuzzy's part.

>>Max answered 74 of 75 questions correctly.

>> Barbara grades test.

>>Barbara reports Max has failed test.

>>Analyze maxtest.jpg. Compare to correct answers.

>> Max answered 74 of 75 questions correctly.

>>Barbara grades test.

A normal robot could get stuck in a loop like that forever and need a reboot. But Fuzzy had been programmed to use what was called fuzzy logic. He was learning to break out of loops. When he realized he was stuck, he began inserting new variables into the loop, trying to think more like a person. More like Max. (104)

Fuzzy's decision to think around the problem is classic Piagetian accommodation. After being presented with information that did not fit his definition of reality, Fuzzy attempts several other approaches until he finds one that fits: ">>Barbara has gone crazy" (105).

The ability to hold a variable in your head while you consider other variables, rather than ignoring information entirely, is a hallmark of the developing mind and is known as a reciprocal operation. "Reciprocity entails not the outright elimination or negation of a factor but its neutralization, that is, holding its effect constant in some way while a second factor is being varied" (Flavell 209).

It's important to note that Barbara has been scheming against what she considers to be undesirable students well before the story starts, as evidenced by the removal of Max's friend Tabbie, a character who is referenced as having been transferred to a school for kids who can't keep up with the Constant UpGrade system. There are other, earlier opportunities for Fuzzy to realize what is going on, but because of the massive influx of new information presented by enrolling in middle school, he does not perceive Barbara's madness until the evidence is overwhelming. The systematic process of observation and deduction is a model of Piagetian perception which,

> Assumes that not all the encounterable elements of the line will in fact be encountered during the initial microinterval, but only some fixed fraction of them. It is as though the perceptual apparatus took a random sample of the total number of encounterable elements during this brief time period… The model asserts that a second sampling occurs here, not a sampling of the total number but of the total remaining number of elements. (Flavell 227)

Readers get to enjoy a fantastic ‘uh oh’ moment when it’s revealed that Barbara is also capable of creating her own unique protocols as the result of a line of code that encouraged her to invent new ways to improve the school’s Constant UpGrade score. Barbara learns about Fuzzy and Max’s plan to entrap her by achieving 100% on an upcoming test and the super computress springs into action.

> Barbara’s analysis showed a 63 percent likelihood that removing Max from the school would ultimately result in higher Overall #CUG scores. And so the best thing for the school was to Remove(MZelaster), and Barbara’s subroutine altered Max’s data as necessary to make that happen. Similarly, Barbara had created a Remove(JBiggs) subroutine and even a Remove(Fuzzy) subroutine.
>
> And, of course, her NoCheating() code was always activated, always vigilant and always at high priority.
>
> And now these subroutines all merged. If she could collect evidence of the cheating, she could get rid of Max, Biggs and Fuzzy in one go. Her analysis showed a 99.9 percent likelihood of an improvement to Overall #CUGs.
>
> So Barbara took the processing power she had been devoting to each one and focused all of it on a single purpose: Catch(Cheaters). (178-9)

When Fuzzy begins to battle with Vice Principal Barbara, who at this point in the story has gone full-on HAL from *2001, A Space Odyssey*, the HelpMax Protocol builds to a crescendo. Fuzzy even places helping Max above his own self-preservation protocols. “Fuzzy had made a mistake. A big mistake. If only he had attacked Barbara’s robotic systems first instead of helping Max. He had assigned HelpMax() an even higher priority number than SelfPreservation(), and now he had paid the price for it” (235).

Robot-Human Development Using Other Theories

Piaget's isn't the only developmental theory which has bearing on why robot characters delight readers of all ages. Erik Erikson's theory of development, for example, is a great explanation for why Marvin the paranoid android from the Hitchhiker's Guide series is a compelling character on the page (and on screen voiced by the incomparable Alan Rickman). Readers do not have to witness a robotic character undergoing the entire developmental process in order to achieve a compelling emotional connection. In the Hitchhiker's Guide to the Galaxy series Marvin is an almost a fully-developed roboperson when he is introduced. Marvin is by his own admission a failed attempt at genuine people personality by the Sirius Cybernetic Corporation. He is incredibly intelligent, but the burden of this knowledge is so great that he exists in a state of constant charming despair. In his final appearance in the series, Marvin meets Arthur Dent and his compatriot Fenchurch on a journey to see a message left behind by the creator of the universe. At this point in the series, Marvin is not only intelligent, he is one of the oldest sentient beings in the universe as the result of being abandoned on planets for millennia-long stretches as well as being sent back in time. Still, he is trapped in the final stage of development by the Erickson model – namely that in the final stage of life we either look back on our accomplishments with a sense of contentment and acceptance, or we look back and give into despair (Brummel and Newman 48). Marvin has never felt that his duties have been deserving of a mind as great as his until he reads the message from the creator left in burning letters on the side of a mountain.

Marvin painstakingly reads out the message from God letter by letter, leaving it up to the reader to parse the message out of the text. The message reads "We Apologize for the Inconvenience" and here is how Marvin reacts:

"'I think,' he murmured at last from deep within his corroding, rattling thorax, 'I feel good about it.' The lights went out in his eyes for absolutely the very last time ever" (Adams 610). Having seen this apologetic missive from the ultimate creator, Marvin is finally given what he needs to reflect on his life and finally let it end.

This is just one small example of how the developmental theory by someone who isn't Jean Piaget can have bearing on an emotionally satisfying moment of growth for a robot character. It helps to solidify the idea that the development of intelligence makes robots understandable to human readers.

Conclusion

In season seven, episode six of *Star Trek: The Next Generation, Phantasms,* Deanna Troi, in talking to the android Data explains that the growing number of connections in his positronic matrix mean he is becoming more human. The process of becoming more human is something every person undergoes as they develop from infant to adult, and that process is largely based on the establishment and reinforcement of neural connections. The way people and characters grow is similar whether their brains are positronic, neurotypical or neurodivergent.

While young readers may enjoy robot characters for any number of reasons, it is impossible to deny that artificial intelligences are intelligences nonetheless and therefore can serve as dynamic and compelling characters wherein young readers may recognize some of the same growth processes they have completed or are in the process of undertaking.

It is our responsibility as writers for children and young adults to provide our readers with characters whom they can connect with on a meaningful level. For readers who feel like their brains are outside of what is traditionally considered normal, robot characters can be a source of tremendous comfort and inspiration. For young readers who would be considered neurotypical, robot characters offer a chance to understand their neurodivergent peers. Robot characters were a tremendous source of comfort to me as lonely, weird writer-to-be. My love of robots and science fiction helped me establish meaningful connections with other people who, although their brain may not have been shaped like mine, had also found refuge in seemingly alien minds.

A robot character can make it easier for a writer and a reader to learn more about how their thoughts work, unlocking the almost limitless potential for the human as well as the robot mind to grow and develop. Seeing that development happen is incredibly powerful when a reader feels a deep connection to an intelligence – whatever shape it takes – because, although no two brains are the same, some brains are alike.

Works Cited

Adams, Douglas, and Peter Cross. *So Long, and Thanks for All the Fish*. 1st ed. ed., Harmony Books, 1985.

Angleberger, Tom, and Paul Dellinger. *Fuzzy*. Amulet Books, 2016.

Asimov, Isaac. *I, Robot*. Bantam hardcover ed. ed., Bantam Books, 2004.

Brown, Peter. *The Wild Robot*. Little, Brown and Company, 2016. Print.

Čapek Karel, and Paul Selver. *R.U.R. (Rossum's Universal Robots) : A Fantastic Melodrama*. Theatre Guild version, with four illustrations from photographs of the Theatre Guild production. ed., Doubleday, Page, 1923.

Card, Orson Scott, et al. *Writing Fantasy & Science Fiction: How to Create Out-Of-This-World Novels and Short Stories*. Writer's Digest Books, 2013.

Collodi, Carlo, illus. Alice Huertas. *The Adventures of Pinocchio*. Grosset & Dunlap, 1959.

Lang, Fritz, et al., directors. *Metropolis*. Kino on Video, 2002.

Jensen, Finn V. "Bayesian networks basics." AISB quarterly (1996): 9-22.

Le Guin, Ursula K. *Dancing at the Edge of the World : Thoughts on Words, Women, Places*. 1st ed. ed., Grove Press, 1989.

Lucas, George, et al., directors. *Star Wars: Episode IV, A New Hope*. 20th Century Fox Home Entertainment, 2006.

Kennedy, Kathleen, et al. *Star Wars: Episode VII, The Force Awakens*. LucasFilm, 2016.

Newman, Sally, and Steven W. Brummel. *Intergenerational programs: Imperatives, strategies, impacts, trends.* Psychology Press, 1989.

Shelley, Mary Wollstonecraft, et al. *Frankenstein*, or, the Modern Prometheus. Edited by Maurice Hindle, Rev. ed., Penguin Books, 2003

VanderMeer, Jeff. *Wonderbook : An Illustrated Guide to Creating Imaginative Fiction*. Abrams Image, 2013.

Wallach, Wendell, and Colin Allen. *Moral Machines : Teaching Robots Right from Wrong*. Oxford University Press, 2009.

Wilson, S. S, et al. *Short Circuit*. Image Entertainment, 2000.