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The Pathology of addiction

Janis Dougherty

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A Thesis Submitted to the Faculty of
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In Candidacy for the Degree of
Master of Fine Arts
in Medical Illustration

The Pathology of Addiction

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Abstract

The field of addiction has grown exponentially in the last 60 years with abundant research and results. Today we understand that addiction is less of a disease and more of a choice, however, it continues to be a perplexing disease.

The focus of this thesis project is to condense the theories presented in Dr. Ronald Ruden's book *The Craving Brain* into a 7 minute animated film. The film illustrates three major topics outlined in the book: “Landscaping the Brain”, stress, and neurotransmitters. The conclusion ties it all together showing how each individual piece contributes to the makeup of the addictive brain.

This is a 2-dimensional animated film with accompanying voice over and sound track. There is no dialogue, only narration explaining the animated visuals on screen. This film is not a slide show of illustrations, however; but a twofold and comprehensive exploration of filmmaking and the pathology of addiction.

This film is intended to supplement Ruden's book *The Craving Brain*. It can stand alone as a teaching tool, but it is not a deep and thorough explanation of addiction. Like Ruden's book, it is intended for a variety of audiences from little to no knowledge of science and medicine to professionals in the field.
Introduction

Addiction medicine is a relatively young discipline in the medical world, yet in the last sixty years the discoveries have been tremendous. Since the 1950s, with the establishment of organizations such as the American Society of Addiction Medicine and the National Institute of Drug Abuse, physicians and other medical health care professionals have fine-tuned their approach to addiction in order to better explain the disease and treat those afflicted. Naturally, through research and experiment, various theories have surfaced explaining the pathology of addiction. One book in particular, titled *The Craving Brain*, by author Dr. Ronald Ruden, presents a compelling theory of the physical manifestation of addiction.

According to *The Craving Brain*, addiction stems from the primitive part of our brains that governs survival. This is the same part of our brain that tells us to eat when we are hungry or run when we are scared; without it, humans would be extinct. However, this area of the brain can sometimes malfunction and the result is mental illness, most notably addiction. Addiction is analogous to a computer infected with a virus. The computer still does what it is programmed to do while simultaneously destroying itself.

I chose to work with this topic for my Medical Illustration thesis simply for the challenge of illustrating something intangible, imprecise and not easily measured. Medical illustration has historically been an artistic discipline of precision and accuracy and I enjoyed the dichotomy of practicing those principles with such an abstract subject matter.

The final deliverable is a 6 to 7-minute animated film with voice over and animated sequences illustrating the science behind the research. This film is a supplemental piece to *The Craving Brain*, to be used as a teaching tool or for anyone seeking answers about addiction. With success, after watching the animated short, people will have gained a fundamental understanding of how addiction works and the mechanisms behind it. Those without prior
medical or scientific knowledge would be able to identify some of the key contributors to the addictive brain, and those with general or specialized knowledge would understand specifically how the neurotransmitters, our genes and our environment all interact to foster an addictive personality.

**Research**

The literature in the field of addiction medicine is plentiful but disjointed and it quickly became apparent that I needed a subject matter expert beyond my thesis advisor to focus my research and develop a story. Through online resources, I located the Bowles Center for Alcohol Studies at the University of North Carolina at Chapel Hill and contacted the director, Dr. Fulton Crews, suspecting he could be of help. Dr. Crews graciously lent his time and recommended *The Craving Brain*, which turned out to be exactly what I was looking for.

The book is written for both laymen and specialists, mixing scientific terms with simplified explanations. The explanations are also linear and therefore ideal material for a script. *The Craving Brain* tells the entire story of the cascading events that turn a “normal” brain into that of an addict.

After finishing the book, scribbling all over the inside and “dog-earring” every other page, ideas for a treatment started to manifest. The largest challenge was condensing multiple years and 300 pages of research into a seven-minute film. Additionally, the final deliverable had not been decided and I was conflicted between making an animated short or an interactive website. This indecisiveness continued throughout the entire pre-production phase and slowed progress down considerably. Before starting a large project like this one, it is necessary to lay out all the pieces to see what there is to work with.

After reading through the book once, I narrowed it down to four major topics and a script started
to unfold. The four main topics are “Landscaping the Brain”, stress, neurotransmitters, and the conclusion tying the three previous elements together.

The first theme, “Landscaping the Brain”, was borrowed from Ruden’s own verbiage and explains how our hormones play a key role in the development of our minds and psyche. The brain is built upon a foundation that the genes determine, but our experience helps to shape our thoughts and behaviors. If a person is brought up in a relatively stable environment excluding major trauma, physical or emotional, normal growth and development occurs for the first 10 – 12 years. When adolescence begins, the individual hits a turning point developmentally. Elevated levels of hormone secretion introduce many new variables and the body begins to experience extremes. If the original “foundation” of the brain is unstable due to genetics, stress, or an insecure upbringing, the individual at this point may exhibit addictive behaviors. When these addictive patterns start to surface, Dr. Ruden refers to the brain as “maladapted”.

The second theme and major factor lending itself to the maladaptive brain, is stress. Stress is very commonplace term and a phenomenon everyone in the known world is familiar with. Stress can be fairly benign and fleeting, but it can also linger and cause much damage.

There are two kinds of stress. The first is acute stress and comes on as an immediate response to something the body is against doing or feeling such as momentary anxiety before delivering a speech or concern that a final exam will be too difficult. This type of stress comes in the form of anger, fear, frustration, anxiety, etc. and is not normally dangerous, however, it can linger. When it lingers, it is called “Chronic Inescapable Stress” (Ruden 2000).

Chronic inescapable stress, the second kind of stress, is detrimental to our health on a mental, emotional and physical level. This kind of stress comes from long term exposure to stressful situations such as abuse, low self esteem or major losses. Chronic stress causes a certain chemical to be released in the body from the adrenal glands above the kidneys called
glucocorticoids. Glucocorticoids travel to the brain and affect the pleasure center of the brain. In addition, there is the limbic-hypothalamic-pituitary-adrenal (LHPA) axis, one of the body's major stress response pathways and also a part of the pleasure center of the brain, that plays a large role with chronic stress. It seems that the LHPA is overactive within chronically stressed individuals and these same individuals exhibit addictive behaviors ranging from food to drugs (Buffington 2004). Overall, within the pleasure center there is a delicate balance of neurotransmitters that when disrupted, results in a dysfunctional brain, thus breeding addictive behavior. Chronic inescapable stress is a major contributor to this phenomenon.

The third theme in the linear sequence focused on neurotransmitters, particularly dopamine and serotonin. These two neurotransmitters play a distinct role in our daily lives for both the “normal” functioning brain (non-addictive) and the maladaptive brain (addictive or propensity for). Steven Johnson said it best in his book *Mind Wide Open*: “at any given time, your background moods and foreground emotions are a measure of the various chemicals swirling around in your head” (Steven 2004).

Dopamine is found in the reward pathway of the brain and is released into the nucleus accumbens. Dopamine helps drive the basic desires that keep us alive; it is the reason we seek out food when we are hungry, a mate to procreate, or shelter when we are scared. Conversely, serotonin is what helps us recognize we’ve had enough to eat or no longer need to be scared. Serotonin is associated with satiety. In fact, low levels of serotonergic activity creates unrelenting cravings in an individual so much that they feel they are dying for a drink or their drug of choice (Streett 2005). Serotonin and dopamine are designed to work in harmony with one another to keep our needs and wants in balance; however if the brain is maladapted, it misuses these neurotransmitters and this imbalance can lead to addictive behaviors.

The last part of the film is the conclusion where everything is tied together starting with our genetic precursors, followed by the stress-induced state of an addict’s mind, and finally the
imbalance of serotonin and dopamine. In summation, a brain with a nucleus accumbens hypersensitive to dopamine as a result of the glucocorticoids released because of chronic inescapable stress, in conjunction with low baseline serotonin levels is an equation for addiction.

**Script and Storyboard**

With the four major topics outlined, a story unfolded leading a straightforward path to the script and storyboard. Helping me get there in every step of the way, was the work of Ruden. Ruden's writing is very visual and he uses key words that clearly illustrate his points. For example, by explaining the development of our brains in the formative years as "landscaping the brain", immediately a tractor tilling and preparing the soil came to mind. Similarly, when he discussed how puberty changes the landscape of the brain, a harsh thunderstorm wreaking havoc seemed the perfect illustration. From the start, the purpose of this project was to clarify the disease of addiction in a light and entertaining way so that the audience could not only grasp all the information being shared with them, but also enjoy themselves in the process.

The initial script was three pages of evolving content. As production progressed, new skills were learned and the script adapted. I found that my 2D animation skills were stronger than my 3D, therefore I concentrated on what I was more proficient with. Additionally, as I learned new applications such as Adobe After Effects, suddenly I was able to create layouts and effects that I couldn't earlier in the process. Because of this, the approach I took towards some of the scenes changed, and therefore so did the script. Continuously, new lines for the voice over were added while others were omitted. Overall, the open-ended nature of this script writing proved detrimental to the progress of the film. With so many changes, rewrites and new concepts introduced, production moved very slowly and completion seemed impossible.

The storyboard was equally unpolished, roughly sketched with scenes that were loosely

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1 For script see Appendix
blocked. The storyboard could have been more detailed and used as an animatic for the final piece. In fact, a safe number for allocating time in a production pipeline is 80% devoted to preproduction, and 20% to production (Bieman 2007). Lack of understanding the workflow, plus the eagerness to get started created a very haphazard workflow. In retrospect, more time should have been focused on developing a coherent script, followed by a fully developed storyboard and a properly timed animatic.

I have a great respect for anyone who works in the film and animation industry because it takes much discipline to adhere to the production pipeline and there are many detailed steps to follow. The process works and eventually I learned it – just backwards.

The Art

Initially, the scope of a Medical Illustration thesis involved the incorporation of medical illustrations. However, I ultimately decided to take an unconventional route and tell the story without the aid of traditional medical drawings. The disease is one which is based within the mind, which is abstract and vague and moreover, very difficult to capture in a schematic drawing.

After finishing *The Craving Brain*, it was clear that a new approach would need to be considered and the concept of using characters and their environments instead of detailed illustrations made the most sense. Once I settled on the idea of creating a film, I was firm in my decision not to make it just another slide show even though the story was narrated and there was no dialogue. Instead, the characters needed to interact with one another and their environment to help tell the story.
The main character that appears throughout the film is “Dopa”. She came from a random doodle in a sketchpad and shortly thereafter became the film’s main character. Her simplified but expressive face is quirky and memorable and she adds personality to an otherwise dry topic.

After creating Dopa, the general palette was defined. Saturated and robust colors were chosen because despite the content, the film needed to be somewhat light and entertaining to keep the interest of the audience. Past masters such as Walt Disney and Chuck Jones provided much inspiration.
At its conception, the film was originally a mix of both 2D and 3D animation. The 3D elements illustrated the heavy medical and scientific pieces of information, and the 2D elements carried the story. In theory, the mix of 2D and 3D worked well, but my ultimate decision that I made two years after starting the thesis was to discard the 3D parts entirely. The reason for this change was mostly because the 3D elements looked rudimentary and interrupted the general flow of the imagery. The loss of coherence in mixing the two mediums was enough of a problem inspiring me to throw away half the work I had already done.
Technical Difficulties

The whole process of creating an animated film was a learning experience. For the most part, the job was an exciting one with so many new avenues to explore both with creative techniques and technology. Generally, the artist has far more control over creative techniques and execution, but is often at the mercy of the technology. I found this obstacle to be true on multiple occasions.
The first challenge was with the voice over. The voice over for this film was recorded multiple times and always on low-grade equipment. With very limited knowledge on sound and sound equipment, the film's narration was very weak and distracting. The amateur voice over truly detracted from the graphics it was paired with and the overall product was substandard.

In addition to the original voice over, I also took it upon myself to record custom sound effects, also known as Foley sound. A few of the ways in which this was accomplished involved a stack of textbooks, a bag of sand and a whistle. The recording equipment was the same apparatus used for the initial voice over and therefore, the results were highly unsatisfactory. This was a very complicated and timely job that was not worth the commitment for this particular project, but it was clear my film needed sound effects somehow.

After several months of attempting to record sound and a voice over, it became apparent that this part of the project was very involved. I had a choice to either learn a new discipline and invest in proper sound equipment, or find someone to outsource this work to. This was a large lesson and realization in that films are a collaborative process. Until this point I had created everything myself but it was clear my knowledge was limited and I needed the expertise of someone else.

A fellow filmmaker, Morgan Schultz, who had excellent sound skills and access to professional equipment, took the latest recording and fixed it to where it was decent and useable. To add further production value to the film, Morgan added sound effects and a musical score. I was amazed to see how some simple music and sound effects carried the film and made it more engaging. On the outside, audio seems the least complicated part of a film, but sound design is a true art form that alone, I just could not master.
Another major issue that surfaced was the timing of the graphics. Despite the major transformation sound design made on the film, there were still a few strange pauses and awkward transitions. These issues were invisible at first due to my lack of knowledge, however, the work experience gained in a post production house trained my eye to notice such subtleties. Clearly, some editing needed to be done.

I began by revisiting some of the older animations such as the girl and boy in the playground. By adjusting the timing and exaggerating the spacing between frames, the animation seemed more smooth and fluid. Next, since the character animation was created in Adobe Flash, it needed to be exported as an image sequence to be composited in Adobe After Effects. Initially, the sequence was exported at 12 frames per second, which is completely unusable for film and needed to be redone at 24 frames per second. This required doubling the amount of frames and the addition of more movement. Thankfully, only a handful of scenes needed this attention.

The choppy animation was not the only noticeable problem. Likewise, the film had strange pauses and awkward scene transitions that significantly hampered the flow of the content. With all the animated sequences fixed to satisfaction, the transitions and final tweaks were handled in a proper editing program such as Final Cut Pro. From After Effects, a full, uncompressed, Quicktime movie was exported and then imported into Final Cut Pro. The edits were small, such as closing the gap from 25 frames of black between scenes to 10 frames of black between scenes, but it helped to balance everything, increasing the film's production value.

**Lessons Learned**

The major lesson learned was the simple notion that making a film requires much preparation and thought. With the excitement of starting a new endeavor, it was easy to neglect the more tedious parts of the process and focus on the more pleasurable parts. Experimenting with character animation and design was more gratifying than storyboarding and blocking scenes;
however each of those individual steps are crucial to the success of any film. My personal idealism of filmmaking clashed with the reality of it and I learned through the mistakes made.

Another big lesson learned is that filmmaking is a collaborative process and involves the use of many ingredients. For assured success, the filmmaker must not only have a clear vision, but must also be surrounded by the right resources such as books, other experts, the right equipment, and know how to use them. I learned a great deal from those who are better than me because I was not afraid to ask questions or take criticism. On the other hand, the more personalities there are working together, the more organization and communication there must be. The lack of communication leads to frustration and dampens creativity.

One major mistake made early on in the development of this project was having the mindset that this thesis film needed to be perfect. This is a fundamental problem because it was a setup to fail. The real lesson was in the process and not in the product. I believe with the lack of clarity came the loss of focus and attention and the gain of insecurity causing much delay in the making of this film. Clearly, by staying on task, setting milestones and conquering them, this film would have been done sooner and other endeavors would have followed.

**Experimental Results**

In deciding to make a film based on the pathology of addiction, the intention was to have it used as a supplemental teaching tool for those affected by the disease or those working in the field. It was designed it to be light-hearted and easy to understand while delivering some heavy information. I used a range of audience members and received many varying responses.

To professionals working in the field, including the author of the book himself, Dr. Ronald Ruden, the overall response was that this piece could be very helpful and influential in the education of addicts, family and friends of addicts, and healthcare professionals. Additionally, the information
was accurate and very easy to understand.

A large panel of professional and student animators at the School of Film and Animation at RIT viewed it with mixed responses centered primarily on the execution of the visuals. Basically stated, their feedback declared that the animation was decent however a little stiff and very two-dimensional. For example, there was plenty of action, but not enough reaction, such as when the bulldozers traverse the brain there should have been dirt building up on the sides, as if they were truly digging a path. That said, my layout and compositional skills were acknowledged to be very strong and the overall pacing of the film was excellent.

Finally, the film was viewed by a mixed group of individuals. This group consisted of those without any education in addiction medicine, as well as those with limited experience in the field but with enough scientific background to understand the terminology. Those without experience were able to reiterate some of the key themes presented in the film, such as the two neurotransmitters that play a large part in the disease, the role of stress, and how puberty is often the turning point in a person's life psychologically. Those with a mild scientific background were surprised to learn just how dopamine and serotonin contribute to addiction as well as glucocorticoids and Chronic Inescapable Stress. Many of these professionals asked about Ruden's book and wanted to read further on the subject. Although the film was limited in its scope, there was something valuable in it for everyone who saw it.

Conclusion

This project has been the longest, most difficult, but most rewarding project I have ever completed. Through this film I was able to find my own voice and follow it down whatever path it wanted to lead me. I was on a four-year-long journey of personal research and development and was wrong to think the fieldwork ended when I finished reading the book. In fact, the research had only just begun when I closed The Craving Brain.
The lessons learned through this process are invaluable, and I have gained new confidence as a graphic artist and as an animator. I am also hopeful that the work put into this film will not be wasted but utilized for something greater. The field of addiction is continuously expanding and the information available on the topic is endless. Perhaps this film can be another element for anyone interested and willing to learn.
References


Appendix

Script

Voice over:

Scene: "Dopa" walking through crowd.
So what makes us who we are? Why, though, each of us has one heart, two lungs, one nose, two legs, why are all so different from each other? Perhaps its our chemistry. Perhaps on a scale the human eyes can't see little molecules exist in various amounts. And these molecules in these various amounts are what makes each individual just that, an individual.

Scene: Brain illustration.
Many factors make us who we are. Everyone is familiar with the age-old argument of nature versus nurture. Our personalities, are they genetic, or manufactured by our environment?

It's Both.

Scene: Brain and tractors; houses popping up; thunderstorm.
Our genes initiate the process by creating the foundation that everything else will build upon. Imagine tractors tilling the soil and preparing it for growth.

Next, our personalities shape the land, like growing trees and building houses shape the land. So for the first decade of our lives, our brain is nurtured into a quaint little neighborhood ready to house our thoughts and grow with the things we learn.

But then puberty hits and our hormones rage like a hurricane. Our brains naturally adapt, however in some cases maladapts.
So, what exactly do we mean by “maladapt”? Does nature take a wrong turn somewhere?

It's not so much that nature goes wrong, but rather modifies things for our survival. One factor largely responsible for altering our minds and our bodies is Stress. Stress can be very damaging. If Stress lingers indefinitely, it is called “Chronic Inescapable Stress”. Chronic Stress may come from abuse or low self-esteem.

Scene: Close up of body, kidneys and brain.

So when the body is stressed, it starts to produce certain substances that will help balance itself out.

Scene: Glucocorticoids destroying the brain.

One of the key substances released is called Glucocorticoids. They are released from the Adrenal Glands above the kidneys and directly affect the brain. Glucocorticoids seem to appear almost immediately in the presence of a stressor. They are interesting because do not linger for long, however, are potent chemicals in shaping the brain landscape. Rather than using a tractor to prepare the land, its more like using a jackhammer.

Scene: Schematic image of the brain and Nucleus Accumbens.

How these Glucocorticoids work in the addiction equation is this: it is believed that these Glucocorticoids make the Nucleus Accumbens sensitive to Dopamine. A Nucleus Accumbens that is sensitive to Dopamine is more likely to release high levels of Dopamine easily. Dopamine is a necessary substance for our survival, but like most things, must exist in moderation.

Scene: Synaptic Cleft.

So what is Dopamine? Dopamine is a neurotransmitter found in the reward pathway of the brain.
that is directly connected to the pleasure centers. Dopamine is also responsible for driving the primitive survival mechanisms and is particularly important when it comes to motivation and feeling good.

**Scene: Dopa in her bedroom.**

So Dopamine translates our bodily needs into physical action. Dopamine makes us do things like run and hide, skip and jump, make a peanut butter and jelly sandwiches.

Dopamine also causes us to be alert, like at night if we hear a noise and are scared. This is one of the primal survival mechanisms that keeps us from being preyed upon.

Now low levels of Dopamine can also cause us to be moody and irritable, but dopamine is replenished in the brain while we sleep. So when we wake, things always look bright and more cheerful than they did the night before. That's why they say to “sleep on it”.

**Scene: Playground with boy and girl**

So how does Dopamine come into addiction?

Because it is the ever propagating motivator to have us want more and continue wanting more. Sounds Addictive, doesn’t it?

And for someone who is an addict they continue to want and want. Often the desire becomes so strong, it can make them do some drastic things.

Why is it, though, that an addict keeps wanting? Why is enough NEVER enough? Thats a good question...

**Scene: Schematic of Serotonin.**

And brings us to another part of our addiction equation. Serotonin.
Serotonin's job is to put the breaks on Dopamine. It controls the amount of information the brain processes at a given time. It basically tells us when enough is enough. It tells us when we are satiated.

**Scene: Dopa driving.**

Without Serotonin to tell us we’ve had enough to eat, to drink, have spent enough money; the maladaptive brain would continue it its compulsive manor to quench the cravings. The brain is basically in overdrive and there are no breaks on the car.

**Scene: Dopa looking between "Evil Dopamine" and "Heavenly Serotonin". Followed by illustrations of Dopa as hungry, thirsty and scared.**

Serotonin sounds good where Dopamine sounds bad. Such is not necessarily the case, however. Without Dopamine to remind us that we’re hungry, thirsty, or scared, humans would have never made it into existence.

Dopamine’s purpose is for survival, so, Craving CAN be good. The problem happens when our wires get crossed and our maladaptive brains get confused on what to crave.

Here is a good example.

**Scene: Mr. Blue and Mr. Red at a bar.**

Take Mr. Blue and Mr. Red. Red has a relatively normal brain terrain with the right levels of Serotonin and Dopamine. Blue, on the other hand, is an addict. He has a Nucleus Accumbens hypersensitive to Dopamine AND low baseline Serotonin levels. The two crave an ice-cold beer after work. At this point, both are craving in exactly the same way.

The difference, we see, is after each gets what they want. Blue, with low Serotonin never feels satiated. So even when he has beer after beer, there is not enough serotonin to tell him he’s had enough. On the other hand, Red wanted one beer and one beer was enough. He had
enough Serotonin to make him feel satiated.

**Scene: Conclusion with illustrated equation.**
The conclusion here, based on neurological and clinical research, is that a brain with a Nucleus Accumbens hypersensitive to Dopamine, plus, Low baseline Serotonin levels, equals addiction.