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Zoetrope Blues

Andrew Tetz

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Under the Direction of Jason Snape, MFA

ABSTRACT

Zoetrope Blues surveys the zoetrope style of animation from its inception to its contemporary practitioners, discussing both the unique charms of the medium and the technical elements that make it work. This paper delineates the process behind zoetrope creation while also investigating the effects made possible by modern technology.

The zoetrope was the world's first motion picture format, using the flicker of a handheld carousel to transform a spinning disc into the illusion of a moving image. This Victorian parlor trick changed our understanding of vision and laid the foundation for cinema, but was largely forgotten with the invention of the film projector.

Despite being a "dead medium," the zoetrope has seen recent applications as varied as turntablism, sculpture, and augmented reality. Its quirks give it a careworn aesthetic which stands out against the glossy sheen of digital design, and its mandala-like polar grid gives it a psychedelic edge.

INDEX WORDS: Zoetrope, Animation, Pre-Cinema

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DEDICATION

For Melissa, my family, & Bonnie. Thank you for keeping me going.

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Deepest thanks to all the friends, artists, & educators who assisted or encouraged me throughout this writing process. Special gratitude to all of the animators who agreed to be interviewed about their own work.

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1 INTRODUCTION

1.1 A Note on Analog Animation

The birth and growth of animation is a deep and fascinating story closely tied to the history of film and photography. As these topics are their own fields of study and have been covered extensively by other researchers, I will not spend too much time retelling this familiar origin story, choosing instead to focus on pre-cinema formats. Even within this narrow field of study, "analog animation" comprises a vast range of techniques for tricking the eye, including stereography, kineographs, thauamatropes, zoetropes, praxinoscopes, phenakistoscopes, and all manner of other "-tropes" and "-scopes."

While these formats have their own charm and there is conceptual overlap between them, this paper will focus on the circular loops of zoetropes and phenakistoscopes. There are technical distinctions between the two (phenakistoscopes are flat discs which predated the cylindrical zoetrope), but the design considerations and technical constraints are fairly similar. For simplicity's sake, the term "zoetrope" will be used in this paper, but assume that the same design concepts and considerations can be applied to both.

1.2 Me and My Zoetrope

Analog animation is an endlessly fascinating topic. I'm captivated by the challenge of capturing the magic of cinema in a physical object and devoted to pushing the medium to (or beyond) its practical limits. In my research and professional practice, I've personally created over 1,000 zoetropes. These range from personal experiments with the format to commercial work for brands such as Maison Valentino, Ray-Ban, and Vans.

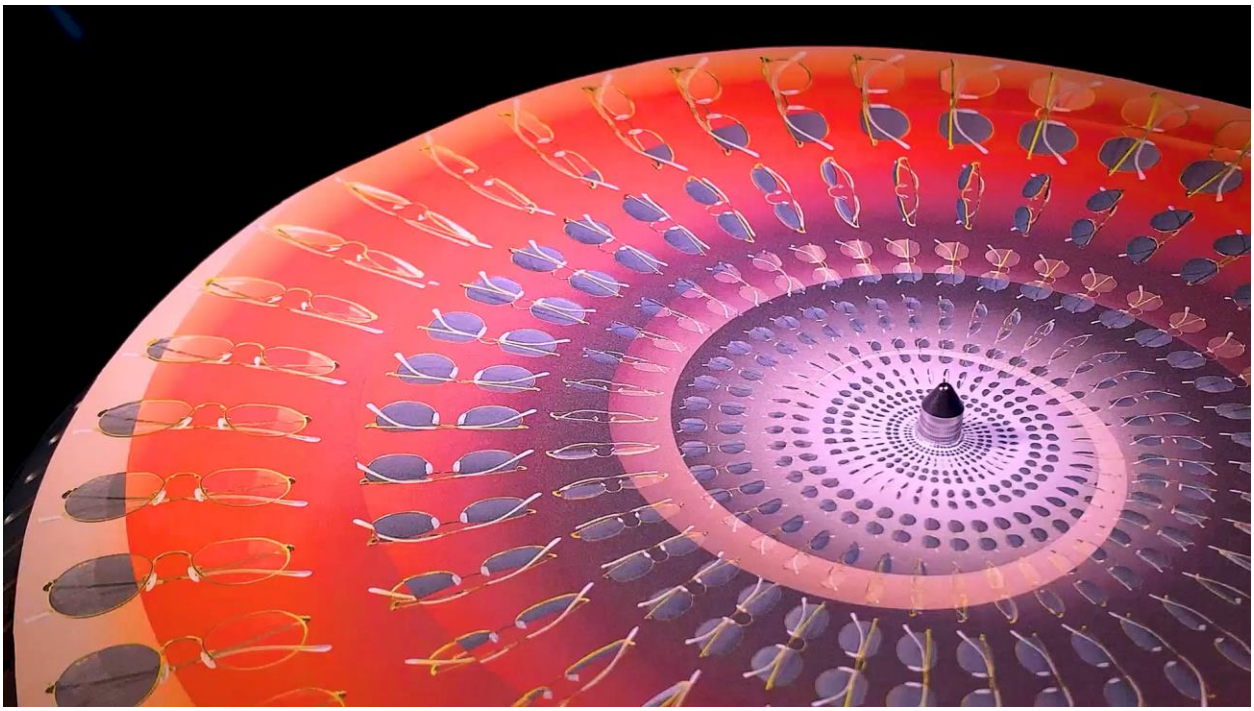

Figure 1 "You're On" Campaign, Drew Tetz for Vans, 2021.

As I use a traditional record player and its corresponding playback speeds as a foundation for my work, I've found synergy in working with bands and record labels on animations for phonograph records. This has become a professional niche for me, giving me the opportunity to design for clients including Santana, Flying Lotus, and the Grateful Dead, while building up a personal "discography" of almost a hundred releases over the past four years.

In an era where most people have a decent quality camera phone and the turntable has resurfaced as a household symbol of cool, zoetropes are arguably more accessible than they have been in a century. Despite this, actually crafting a zoetrope is still a niche skill with only a small number of self-taught specialists worldwide. Through this paper, I hope to illuminate the creation process behind this mystifying medium and to share a glimpse of the spinning world that I have found so entrancing.

1.3 Formatting

Writing about animation without being able to show the actual motion is always a challenge, especially when detailing advanced techniques, so I have inserted diagrams to clarify the denser information.

I have tried my best to give a comprehensive survey of the zoetrope medium. In the interest of capturing the appeal of analog animation, I have reached out to contemporary artists working in the field asking what makes the medium so magical to them. These responses (along with a short profile of the artist's work) can be found in the section "Why Zoetropes?" which may serve as introduction to the field through modern practitioners with less technical jargon.

2 HISTORY

2.1 The Prehistory of Cinema

As with any history of the motion picture foundations exist in early visual storytelling. The sequential imagery found in cave paintings, illuminated manuscripts, and ancient Greek vessels have all featured series of images which suggest the passing of time and the sensation of motion. This is not to say that hieroglyphics are a proper film. For the same reason, we will not be discussing shadow puppets, automata, etc.; we'll be defining animation as a series of still

images which create the illusion of movement when shown in quick succession.

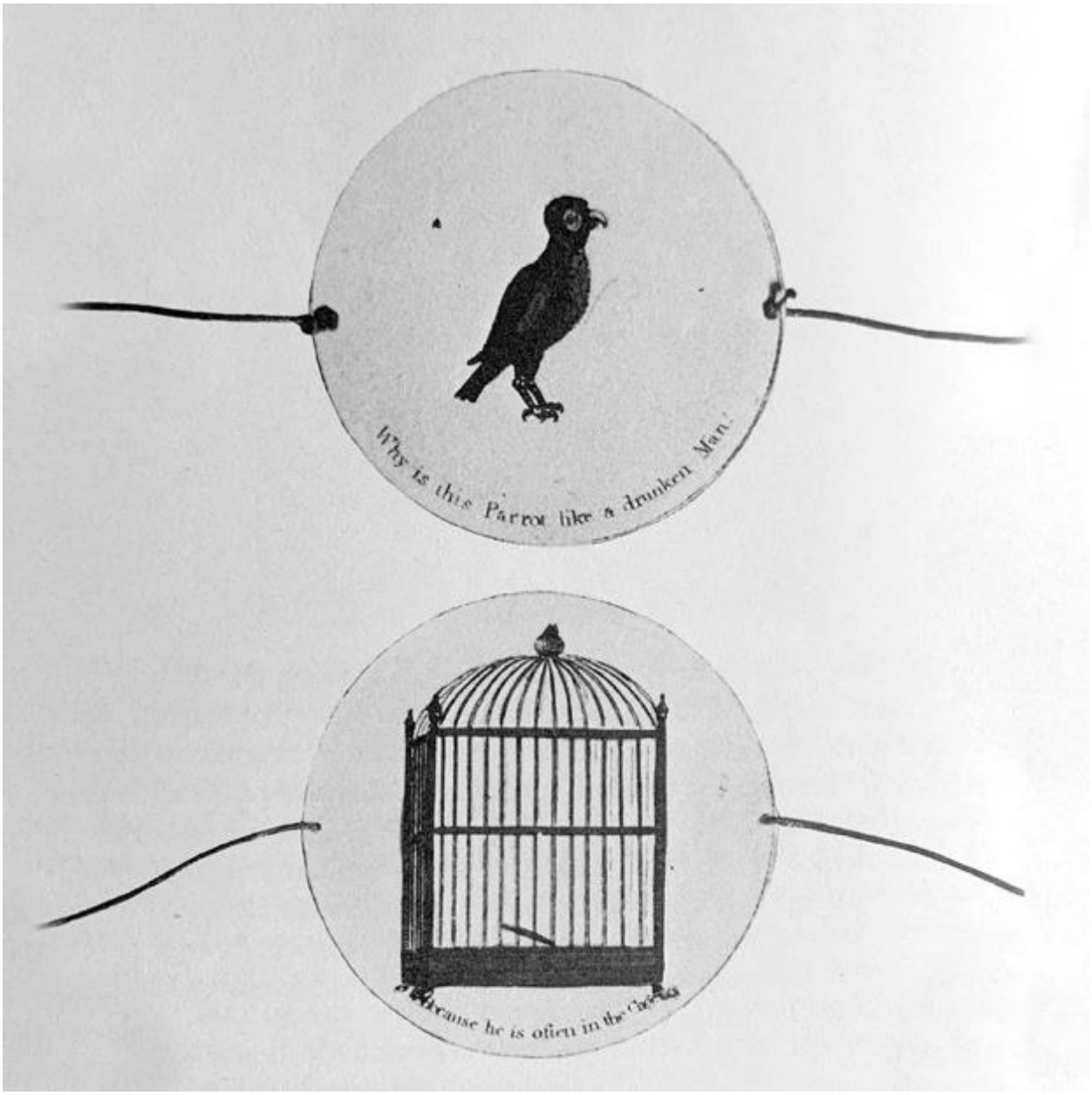

Figure 2. A 19th Century thaumatrope. Photograph by Philip Freeman Sayer and Caroline Freeman Sayer. Victorian Kinetic Toys and How to Make Them. Evans, 1977.

One potential exception to this ancient cinema skepticism is the thaumatrope. The thaumatrope is an optical toy featuring a coin attached to a string. When the string is twisted, the rapid spinning of the coin blurs the images printed on either side into the illusion of a single

composite image—one of the most commonly known examples is a bird flying out of a cage. Whether or not you consider two frames to be a proper animation, it was a moderate commercial success when it first appeared in 1825 and helped set the stage for the zoetrope craze.

As an interesting historical sidenote, in a 2010 *Antiquity* article, researchers postulated that some ancient rondelles (discs carved from bone) with markings of animals may have been intended to function similarly to thaumatropes, displaying a running deer when spun.[1] While there is no way to know for sure whether this was the true purpose of these enigmatic coins, it is an interesting theory, and romantic to think that motion pictures could be millennia older than previously believed.

2.2 The Development of the Projector and the Downfall of the Zoetrope

The booming new world of film made zoetropes obsolete and the technique quickly receded into the cultural consciousness as an antiquated parlor trick: interesting as a gimmick but paling in comparison to full length screen stories.

[1] Marc Azéma and Florent Rivère, "Animation in Palaeolithic Art: A Pre-echo of Cinema," *Antiquity* 86, no. 332 (2012): |PAGE|, doi:10.1017/s0003598x00062785)

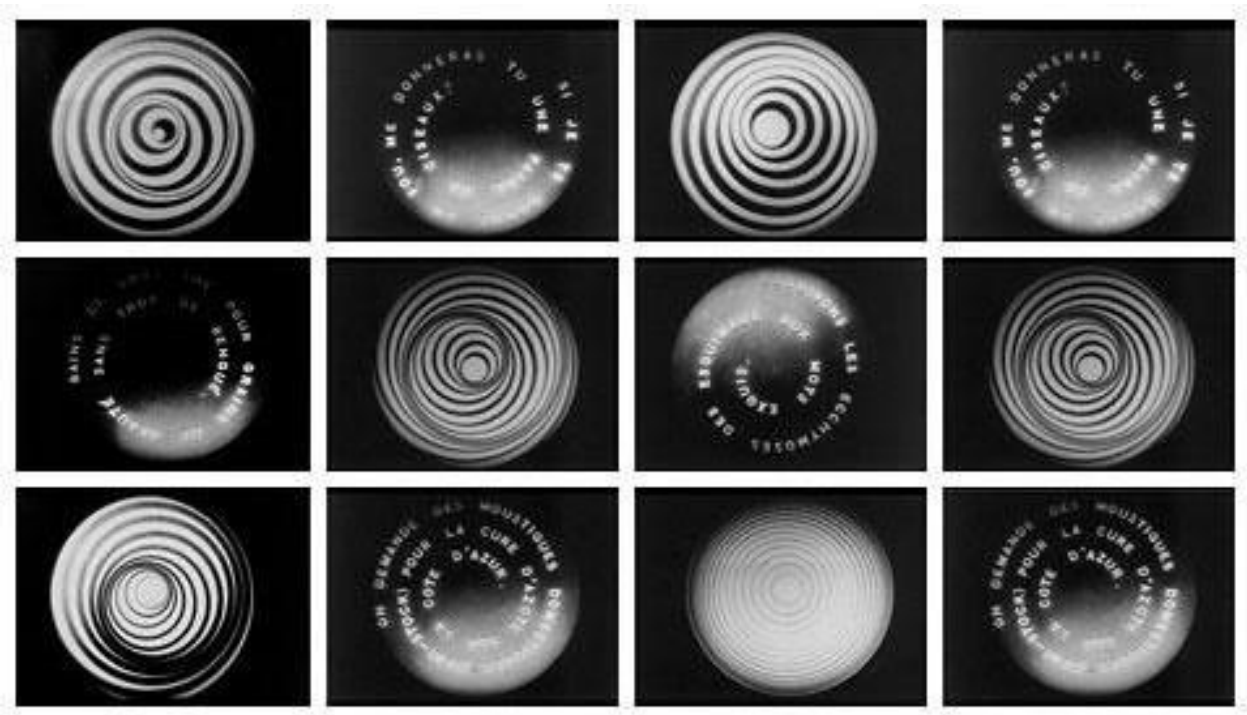

Figure 3. Stills from Duchamp's Anemic Cinema. Marcel Duchamp, Anemic Cinema, Paris, France, 1926.

While no longer a household name, there were still those in the 20th century who found value in this strange photographic novelty. Marcel Duchamp, never one to turn away from a good gimmick, took inspiration from the zoetrope in creating his 1926 "Rotoreliefs," a set of circular prints intended to be placed on a phonograph and watched. These were later collected in his experimental film *Anemic Cinema*, made in collaboration with Marc Allégret and Man Ray.[2] While none of the discs created a proper animation per se—and were even a commercial flop on release—they have come to be understood as an important part in the story of op art and an ancestor to the turntable zoetropes seen today.

[2] *Anémic Cinéma*, dir. Marcel Duchamp, Man Ray, and Marc Allégret).

Figure 4. A "Movie Record" praxinoscope by Red Raven. Red Raven Orchestra. Peter Cottontail Magic Mirror Movie, Morgan Development Laboratories, USA.

Praxinoscopes—the zoetrope's lesser-known cousin which relied on faceted mirrors to create the illusion of motion—saw a brief revival in the late 1950s through an ingenious toy called the "Red Raven Magic Mirror," produced by the Red Raven Movie Records label. This

plastic carousel accompanied a set of children's records which had illustrated characters printed on the label. When the carousel was placed on top of the record and played at 78RPM, the 16 frames would spring to life in the mirrors, the cartoon acting out the story or song on the album.[3] While the mirrored carousel is arguably a smoother viewing experience than other zoetrope formats, the praxinoscope format remains relatively obscure. This may be due in part to the added expense of producing the faceted mirror, but the challenges of a significantly reduced scale/framerate also hinder integration with common applications such as 33RPM records, which confines it more to specialized toys and novelties.

[3] Red Raven Orchestra. *Peter Cottontail Magic Mirror Movie*, Morgan Development Laboratories, USA.

3 SIGHT, SPIN, AND SCIENCE

3.1 Flicker Methodologies

One point of consistency for every motion picture device ever created is the necessity of a flicker. In most cases (film projectors and computer screens, for example) this takes the form of a rapidly flashing sequence of static images. Quick bursts of darkness between the frames trick our brains into perceiving the series as a single moving unit rather than a blur of light. This rapid flicker is necessary to separate the pieces and create the illusion of motion, whether it's tied to a pixel refreshing, a movie projector, or the flash of a strobe light.

The psychophysics of vision is its own field of study, and the nuances of flicker fusion rates far exceed the scope of this paper, but it is worth mentioning for a few unique considerations tied to the zoetrope format. First, there is the flicker rate, which usually takes the form of a camera's frame rate or the speed of a strobe's flash.

3.2 Revolutions Per Minute versus Frames Per Second

The speed of the turntable and the framerate of the camera directly inform the number of frames to create a static zoetrope loop. Fortunately, because most turntables operate at three consistent speeds and most consumer cameras shoot at 30FPS, it's fairly easy to commit these three numbers to memory and work from there.

Table 1: Turntable Speed vs. Zoetrope Frame Count

Turntable Speed:	33RPM	45RPM	78RPM
Zoetrope Frames:	54	40	23

While these three speeds allow for a range of effects, there will inevitably be times where you need a different playback speed—for example: syncing the animation to a beat, using a

smaller number of frames for easier fabrication, or working with a larger sculpture that must spin slower. There is a formula for solving cases like this: for a camera shooting at 30FPS, divide 360 by (RPM*0.2) and you will find the necessary number of frames.

3.3 Variable Speeds

Most modern zoetropes assume the luxury of a turntable or some other motor set to a consistent speed, but this has not always been the case, and early versions were spun by hand. As a result of the uneven RPM, the animation rings that sync with the frame rate will appear to rotate backwards and forwards as a zoetrope speeds up or slows down. If the spin of the object is too fast or not steady enough, it can create an uncomfortable blur rather than a satisfying animation. This can be managed by setting the various layers to sync at different speeds, creating a gentler transition between tempos and a more cohesive effect overall.

Figure 5. Still from video of a throwing disc dyed by Robert Whetsell, using the "Ribbit Ring" zoetrope design by Drew Tetz. 2017. https://www.instagram.com/p/BWvTM4vA70p/

While designing for variable speeds has its challenges, it also opens up new possibilities. Certain applications (such as bicycle wheels or throwing discs) are natural fits for the zoetrope medium, having consistent enough spins to create a lasting loop while also staying within practical RPMs. The fact that they are almost always used outside makes them ideal for filming,

as the sun replaces the need for extra lighting. Additionally, consumers are used to circular designs embellishing these objects. These simplified viewing conditions give the artist a great deal of freedom, as they can work from basically any number of frames they want and know that they'll hit the correct RPM at least some of the time.

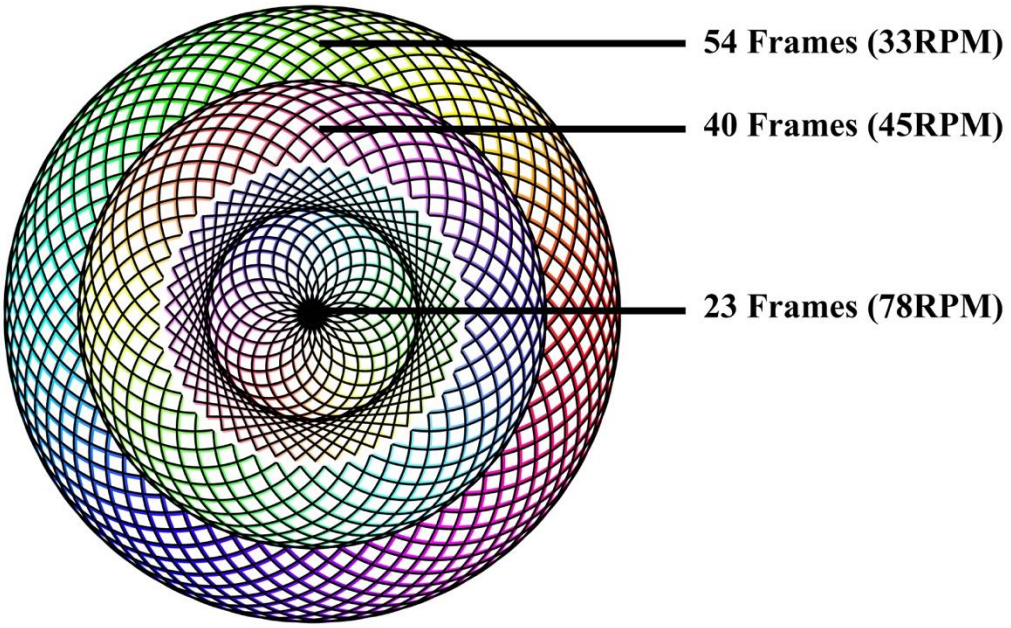

Figure 6. Drew Tetz, Sacred Spinner 2020, 2020. This disc contains three separate patterns which appear to freeze in place when played at their corresponding speed.

There's also the option of designing for multiple RPMs on the same zoetrope. This can seem counterintuitive, considering that the portions not in sync with the turntable will be wildly out of focus, but the ability to switch between speeds and punch in different loops is a powerful visual effect. This is one of the easiest ways to demonstrate the relationship between the number of frames and the RPM, as dialing the speed up and down shows immediate feedback from the distinct loops on the record.

3.4 High/Low RPMs

While record players are a comfortable range of RPMs for the zoetrope, they are far from the end-all be-all for the medium. Naturally, there will be times when a different speed is called for, and design decisions to make accordingly. For lower speeds (for example: a carousel or moving walkway) the number of frames needs to be increased, with speeds below 15RPM requiring over 100 frames per loop. This smaller frame size is slightly balanced out by the fact that such applications would also allow for a significantly larger scale. Inversely, faster speeds require fewer frames, meaning that the actual animation length is much shorter. For this reason, high speed applications (such as tires or gyroscopic toys) are usually more effective with abstract treatments than with conventional figure animation.

3.5 Harmonics & Multiples

As already established, the number of frames around a zoetrope is tied to the playback RPM. In an interesting parallel to sound, these frame counts seem to follow the same principles as the harmonic series, with positive integer multiples of the count also syncing with the RPM. This opens up a world of animation techniques, both practical and experimental; being able to double up on small elements with very slight number variations adds a subtle movement. Knowing this, we can update our previous framerate chart as follows:

Table 2: Multiples in Zoetrope Frame Counts

Turntable Speed:	33RPM	45RPM	78RPM
Zoetrope Frames:	54 (108, 216…)	40 (80, 160…)	23 (46, 92…)

The astute animator will notice a connection between doubling frames and animating “on the twos,” a classic time-saving technique of having every other frame be the same. While the

parallel is an interesting coincidence, it is not a direct analogue to doubling frames for a zoetrope, as the zoetrope rings gain the extra strength of being able to drop down to 50% playback speed with no perceived drop in “resolution.”

Halving the RPM for the lowest multiple has an interesting effect in creating a stuttering slow motion. Unfortunately, this is less practical, due to a “flash” from interpreting the space between frames. There is a theoretical form of pseudo-interlacing where the artist overlays frames by 150% and then plays the zoetrope at half speed for a double length loop, but the poorer image quality makes it less than practical. These experiments with playback speed are some of the most tactile ways to understand the relationship between speed and frame rate, as they offer immediate visual feedback. They also account for satisfying visual effects through physical manipulation of the playback, subverting expectations for the way an animation should behave.

3.6 Zoetrope as Data

Analog recording formats have the distinction of encoding information into physical objects. Just as the grooves of a phonograph record represent the vibrations of a soundwave, the circular filmstrip of a zoetrope is a tangible version of vision over time. This concept has interesting implications: can analog animation techniques be used to layer information in a way that’s more efficient than image sequences? Could a full-length film ever be packed into a record? What’s the maximum amount of data you can encode into a zoetrope?

Engineer Jozef Bogin took the audio version of this question to an absurd-yet-brilliant conclusion when he managed to boot a PC from code he had written and recorded as sound on a 10” vinyl record. These anachronistic experiments with form can occasionally skirt dangerously close to existing technology—we must remind ourselves that audio CDs, DVDs, Blu-Ray and

Laserdiscs are all also discs which use light to process information—but this dedication to doing things the hard way could be argued to be a charming earmark of the analog animation mindset.[4]

[4] Jozef Bogin, "Booting from a Vinyl Record," Booting from a Vinyl Record, November 22, 2020, accessed March 20, 2021, http://boginjr.com/it/sw/dev/vinyl-boot/

4 ZOETROPE DESIGN PHILOSOPHY

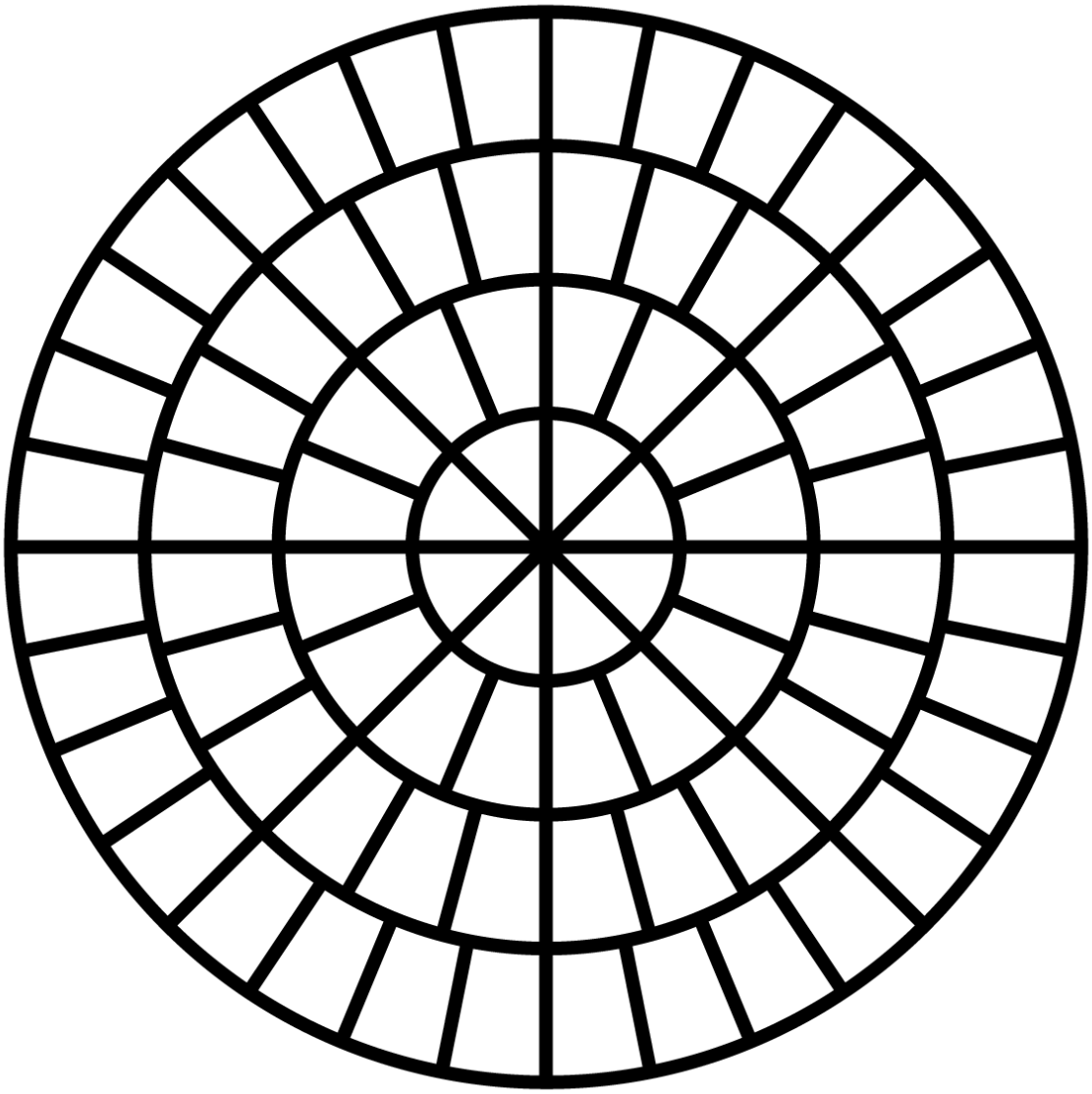

Figure 7. A circle divided into a polar grid four ways. From outer to inner, the rows have 32, 24, 16, and 8 cells.

4.1 The Polar Grid

Zoetropes have naturally circular compositions, which means they have special design considerations distinct from a traditional rectangular grid. While some of these can be confusing

(for example, accepting that half of your piece will always be upside down), universal design concepts such as hierarchy still ring true. Understanding the unusual rules of the polar grid unlocks techniques unique to the medium, as well as how best to emphasize different pieces of the animation.

Here are some of the considerations for working with a polar grid:

- Unlike a rectangular grid which is generally read from top to bottom or side to side, the polar grid very easily becomes a multi-directional whole. The eye is frequently drawn in towards the center of the piece rather than from edge to edge, which can be a challenging focal point to contend with.
- There is very rarely a “true north” to indicate orientation. Without this keystone, its origins or intended direction are left ambiguous, which is further compounded when the piece is set in motion and the loops move independent from one another.
- Because it lacks a strictly defined orientation, it can be inverted or rotated without losing its sense of meaning.
- There is more room in the outer edges than there is in the inner circle, which greatly affects the sense of scale and the perceived hierarchy of the loops. The most important information will almost always occupy the outer rim, as his allows for the highest detail, while the innermost rings will most likely be simple shapes.
- The sense of moving in or out of the circle can be greatly emphasized through varying line quality or spiraling shapes. The combination of the two can even create the illusion of dimensionality.
- The lack of corners in a circular design challenges the concept of rule of thirds. Even cropping into a rectangle is not enough to break the circle, as spinning the shape will lead to a ghostly implied circle drawn by the corners.
- The visual rhythm of the animation largely determines the gestalt of the overall disc; it’s not uncommon to see large bursts of color tied to dramatic movement in the frames.

- Asymmetric layouts develop dramatically different rhythms when rotated— that is to say, offsetting the center of the composition from the true center rotation point introduces a "swing" that changes the timing as well as the motion of the animations. Small amounts of swing can feel more dynamic or human than a perfectly ordered composition, and so intentionally introducing some variation can be desirable.
- Polar grids frequently contain many more divisions than rectangular grids, with 50 or more divisions per ring.
- Rotational symmetry is heavily emphasized (as compared to lateral symmetry.) Zoetropes lack the luxury of orienting elements to a cardinal direction to force the viewer to interpret image from a single viewpoint, being instead constantly viewed "in the round."
- Repetitive visual elements in a polar grid must either decrease in size or number as they move towards the center. Decreasing in number is generally not practical for zoetropes with strict frame counts, so they have to get smaller for the inner rings.
- The centermost area in polar grid compositions is frequently reserved for a single focal point. Zoetropes often abandon animation in the center area in favor of a static illustration or information.

4.2 What kind of motion works well on a zoetrope?

Due to the reduced individual frame size and short amount of animation time, zoetrope loops are most effective when they have a single dramatic action. This tends to naturally develop into a natural rhythm as the record spins, so it's good to consider the context of surrounding loops and adjust accordingly. Whether selecting clips or animating from scratch, it's important to choose a motion that will be understood easily even when seen as a tiny silhouette, thus placing a

larger emphasis on big movement than subtlety. This can lead to a balancing act between finding a compelling motion for the timeframe and taming an unruly loop that becomes distracting.

4.3 Dynamic Motion

A unique consideration of the stroboscopic effect is the way that the RPM relates to the frame rate. The number of steps in a rotating object will determine whether those steps appear to be rotating forwards, backwards, or perfectly stationary when viewed under the right conditions. While this has practical roots in mechanical analysis for quickly and accurately measuring the speed of a part, it can also be utilized to artistic effect in zoetropes.

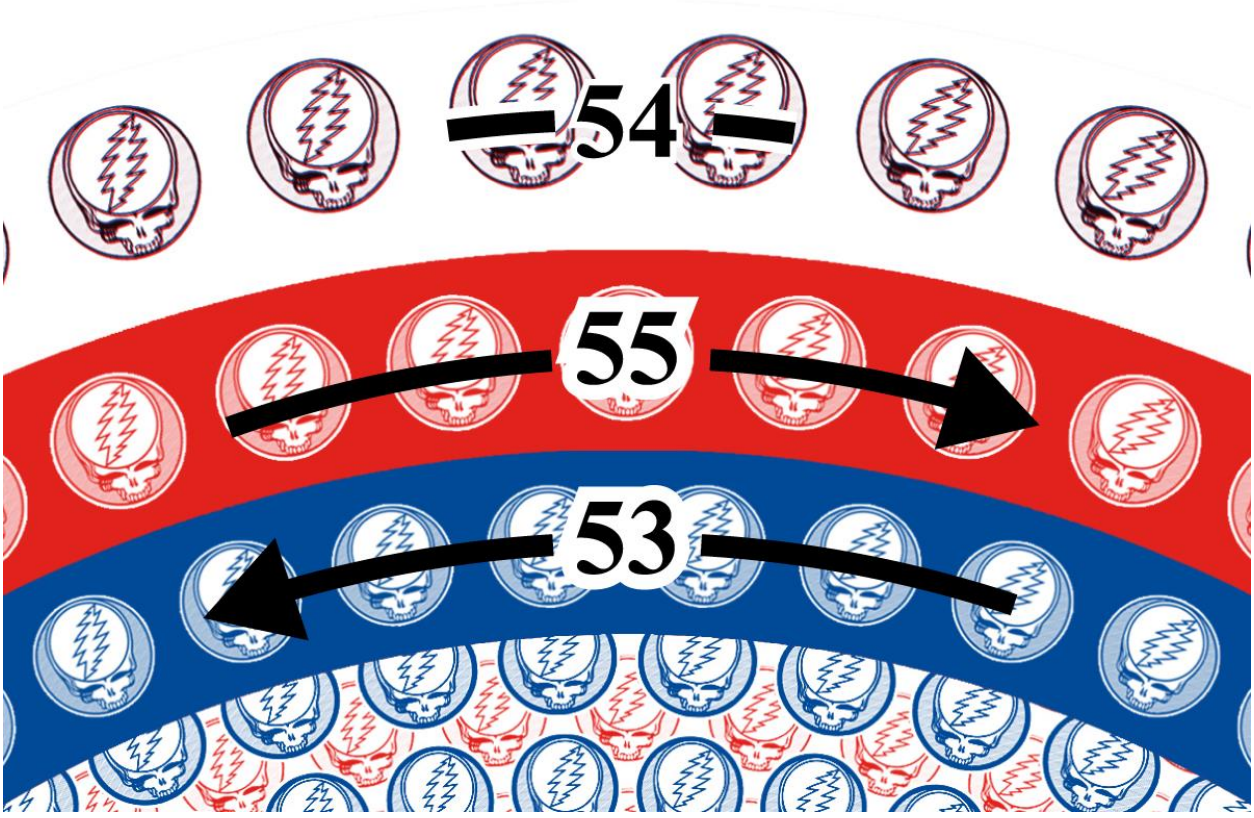

Figure 8. Drew Tetz for the Grateful Dead, The Story of the Grateful Dead slipmat Side A, 2020. Assuming a turntable speed of 33RPM, the outermost ring (which is set to 54 frames) will appear to animate in place. The row below it will appear to rotate forwards, because it has 55 frames. Finally, the bottom row will appear to move backwards, because it has 53 frames.

It's easiest to focus on a steady image, so the primary content of a zoetrope will most likely be set to a number of frames rendering it stationary in the overall canvas. However, adding a slight bit of forward or backward movement to a ring can help separate it from its surroundings, and adds visual interest when juxtaposed with other speeds. For this reason, it can be beneficial to add or subtract a frame on alternating rows in order to develop a more robust visual hierarchy. It is worth noting that at most practical zoetrope speeds, things start to move too quickly for the eye to comfortably track if they're more than two frames off of the recommended count, but even a single frame's difference can improve a composition.

While this is easiest to learn in the standardized cells of a polar grid, slightly staggering the spacing—for example, splitting a circle of 40 frames into 22 frames on one half and 18 on the other—allows you to create this dynamic tension within a single ring. As with single speed rings, context greatly affects how dramatic the difference will look, so it's important to consider where these flourishes sit in relation to the rest of the piece.

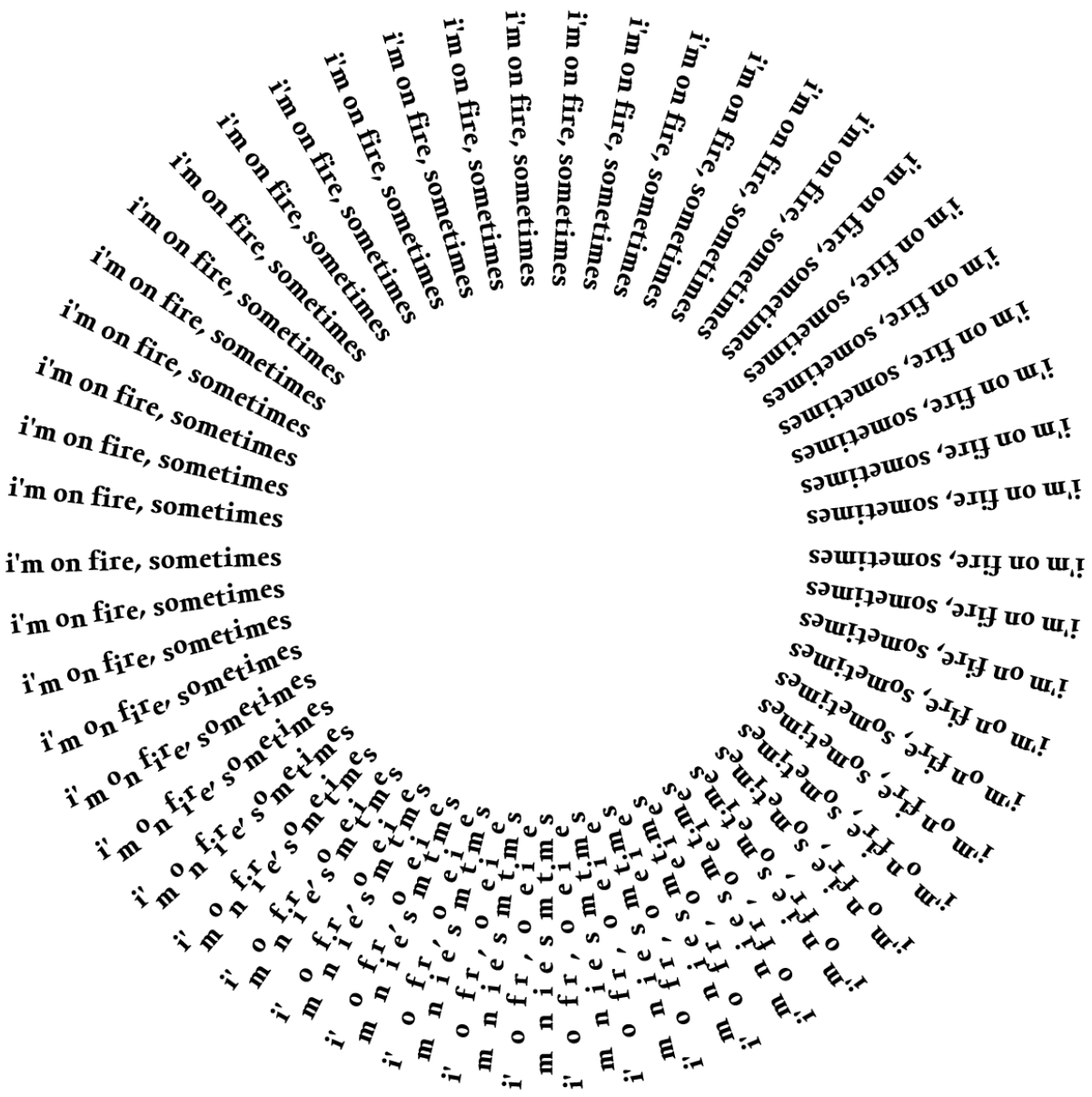

Figure 9. Drew Tetz, unused design for Reader's Engrams, 2019. The top half of the composition is set to a consistent polar grid of 54 frames; the bottom splits every other letter into a grid of 53 or 55, making them appear to rotate counter to each other's motion.

As an aside: combining an animation of perceived forward motion while also subtracting a frame for backwards motion led to the motions canceling each other out, resulting in a very small increase in frame size. It's difficult to think of a situation where this would be useful, but it

is a neat mathematical phenomenon, and these tiny quirks ultimately make for a more robust technical vocabulary for pushing the medium.

4.4 Fills and Patterns

Since any stationary element in a zoetrope has to be repeated on the grid, background elements frequently form unintentional symmetric patterns. In many cases, this is a good thing: having a pattern helps ground the overall gestalt of the piece, and having the ground stationary for the animation is fairly necessary, as the motion of pieces not linked to the polar grid can be distracting. In areas too small for proper animation, abstractions made of repeated elements from the main composition can make for compelling filler that fits the overall feeling, and some rudimentary motion effects can result simply by overlaying alternate frame counts.

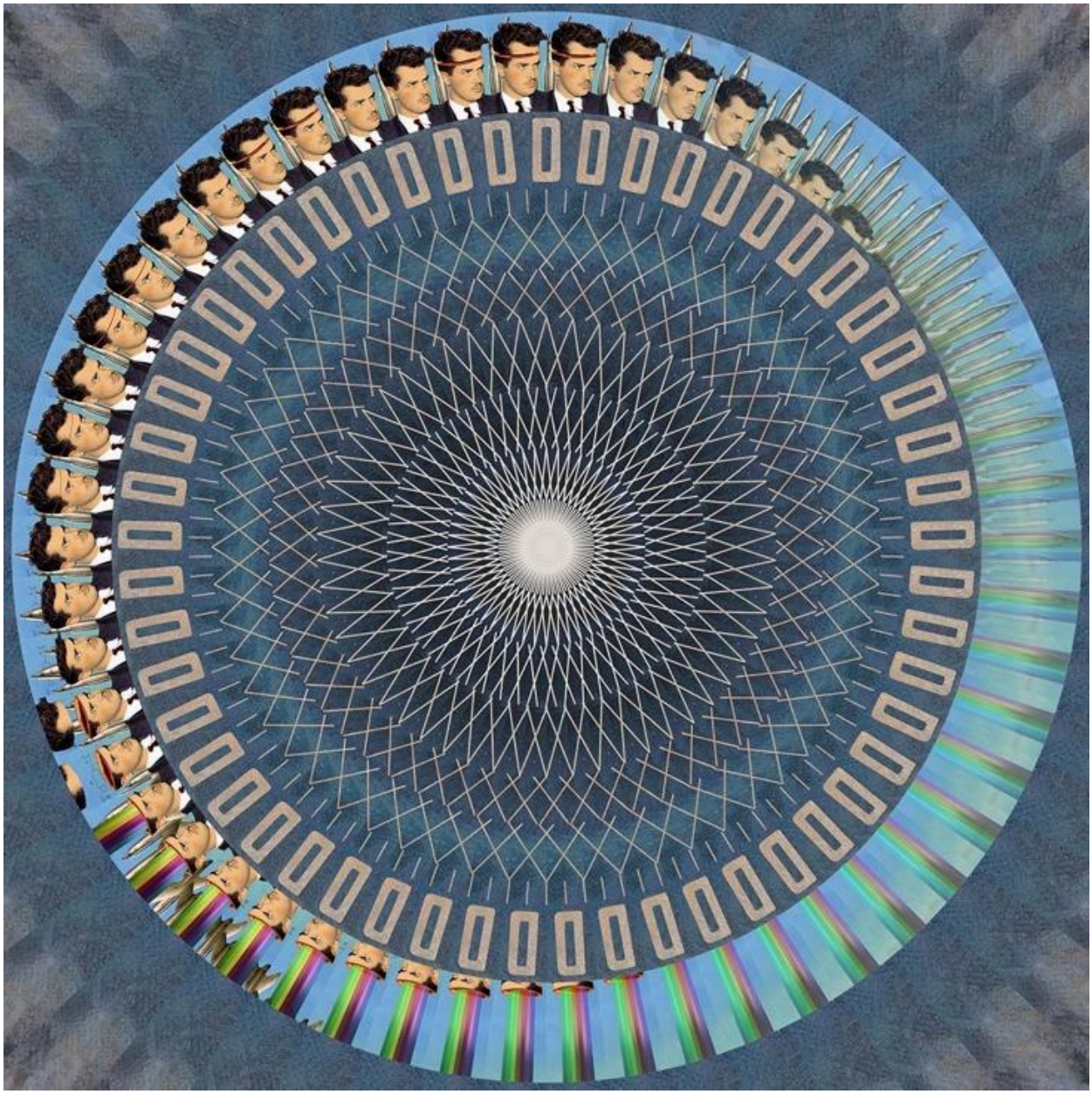

Figure 10. Drew Tetz for the Claypool Lennon Delirium, South of Reality, 2019. The center area contains a geometric pattern which is overlaid on a repeated sample of the album's cover painting, which creates a gentler foundation than a background untethered to the polar grid.

If the resulting pattern becomes distracting, it may be worth considering a solid color fill instead, as the contrasting motion of the new piece may pull viewers out of the zoetrope. However, this is not a hard and fast rule, and it could be argued that these untethered pieces help

reinforce the rest of the illusion through contrast. Non-animated elements can also be overlaid on top of the animated rings used to hide the restart points on not-quite-perfect loops.

4.5 Perfect Loops

Besides their shared roots of being linked to a turntable, zoetrope design and hip-hop production have an unlikely bond in the form of "loop digging." Loop digging is a term used in audio sampling which refers to editing down found material to a single seamless loop that can be played back on repeat or mashed together with other sources. Processing clips and animating for zoetropes can be a similar process, as the short length of the individual animations quickly settles into a steady rhythm, and many zoetropes are made from sampled material. Moreover, an improperly looped clip can be as jarring as a skipping record. While all animation practices face the danger of spending hours tweaking individual frames for less than a second of motion, there are several tried and true tools (such as duplicating frames) for making a loop stretch to the time requirements, and zoetropes even have added flexibility through slightly altered frame counts.

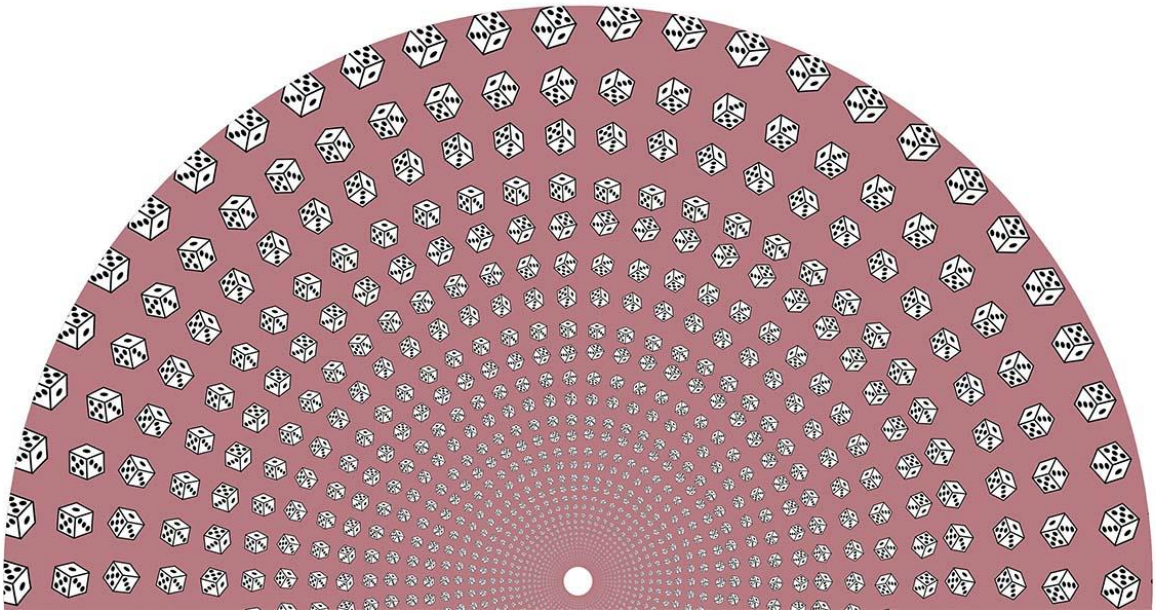

Figure 11. Drew Tetz for Midland, Let it Roll, 2019. The tumbling dice spiral outward from the center, adding dynamic motion and lengthening the dice roll loop to 7.5 seconds.

4.6 Linking Loops through Spirals

One of the largest limitations of the zoetrope medium is the short running time. A zoetrope on a turntable spinning at 45RPM only gets 40 frames (or about 1.3 seconds) per loop, scarcely enough time for a single motion. This can be managed through a technique which breaks away from the nested concentric circles approach and instead spirals a longer filmstrip to create a continuous sequence.

While there are additional challenges to the spiraled form—for example, the spiral means that the focal point of the animation is moving outwards within the grander composition—this is nevertheless an invaluable tool for lengthening loops. Spirals also dodge the standard loop requirement, allowing you to "fade out" a clip rather than feeding it back into itself—although a spiral also works wonders for lengthening or adding dynamic motion to loops. Finally, even if you stick to a single short loop, spiraling it by adding some outward motion is a great way to stretch a pattern and fill in large spaces.

4.7 Overlapping Frames for a Larger Picture

Fighting for canvas space is a constant issue in zoetrope design, as many practical speeds have such high frame counts as to prevent much individual detail. Fortunately, this can be assuaged through the overlapping of frames. Animations with transparent backgrounds allow you to slightly overlay figures on top of each other which tightens up the horizontal space and can lead to an up to 140% increase in scale. This is an essential tool for zoetrope designers, especially when facing speeds of 33RPM or below.

Figure 12. Drew Tetz for EELS, Earth to Dora side 3, 2020. The detectives overlap each other horizontally by 25%, allowing for a much larger individual frame size.

5 WHY ZOETROPES? INTERVIEWS WITH CONTEMPORARY ANALOG ANIMATION ARTISTS

5.1 Tee Ken Ng

Figure 13. Tee Ken Ng for Tim Minchin, still from Leaving LA, 2020. https://www.youtube.com/watch?v=kX-ly8VxhLY

Australian animator Tee Ken Ng has made some of the most innovative zoetropes in recent history, skillfully blending motion design with three-dimensional experimentation to create eye-popping turntable carousels. He also has the distinction of generally designing for 78RPM and 24FPS, which results in a larger picture size and smaller number of frames, a great complement to his bold style. Ng sees analog animation as a way to reconnect with the beautiful mystery of motion pictures for audiences burnt out on CGI bells and whistles:

> I have a fascination for in-camera practical effects and I love to create and devise my own. Practical effects still has that magic-like quality that I feel VFX and CG have lost as audiences feel anything is possible now digitally. Returning to old-forms of analog animation, such as zoetropes, is in a way saying or pointing out how intrinsically magical the moving image is as a medium.

5.2 Dina A. Amin

Figure 14. Dina A. Amin, Kaan Ya Ma Kaan, 2020.
https://www.instagram.com/p/B9IJNXXHVMh/

Dina A. Amin is an artist and maker from Cairo who uses her Industrial Design background for a detail-oriented approach to stop-motion animation. Her work takes a microscope to the world around us, exploding household machines and leading their inner

workings in a whimsical dance before they magically reassemble to restart the loop. This mechanical mindset informs her interest in analog animation:

> I fell in love with the analog animations because of the amount of making involved. It has a bit of industrial design to it, which appeals to me. But also the illusion of stop-motion, specifically, it is realistic. The objects are all there in front of you, but when you see the way it moves, it's like 'How is this happening? Is my brain tricking me?'
>
> I also like that until the analog animation moves, you can kind of see the steps of it— you say "Okay, is this someone running?" But once it starts to move, it's much more than that. So maybe that's something that makes it very special. For some of these more abstract pieces, you can't even tell that it's an animation until it enters the motion, and I think that's really the wow factor of it.

5.3 Kevin Foakes (DJ Food)

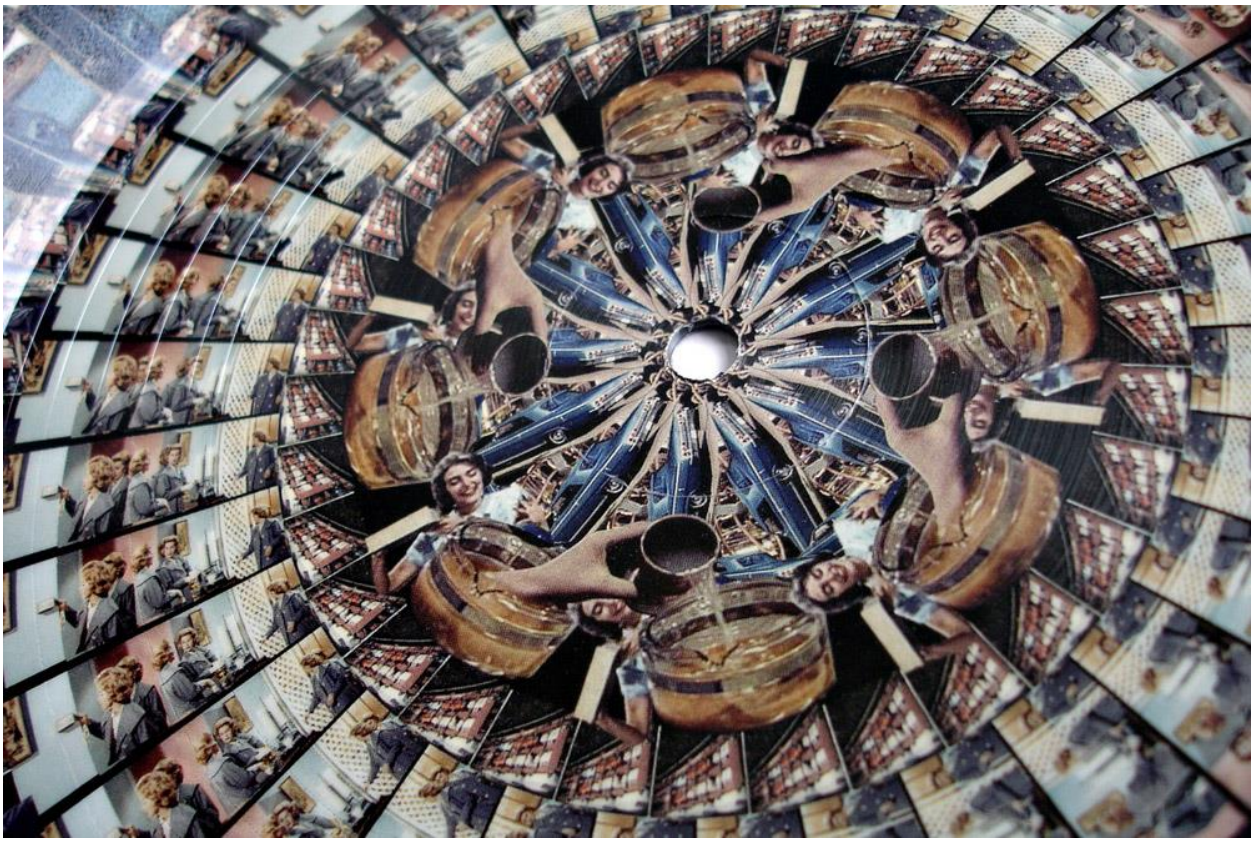

Figure 15. Kevin Foakes for Bonobo, Cirrus, 2013. https://www.youtube.com/watch?v=K-jg5VimYNM

Kevin Foakes (AKA Strictly Kev/DJ Food) has secured a place in music design history through his stint as the in-house designer at influential electronic label Ninja Tune, but he is also notable for producing some of the best known (and best executed) zoetrope records of the 21st century, such as the 12" picture disc for Bonobo's "Cirrus." No stranger to the flutter and wow of vinyl records, he cites that extra fuzz as a huge draw for the medium:

> …I'm drawn to the analog in things, even if there's digital elements used to create it (I'm not a purist). Whether it's someone like Julian House or Rueben Sutherland resurrecting old techniques and processes, it's the soft focus, the grit and the puzzle of figuring out how they achieved it that intrigues me.
>
> I like the fact that it's not a crowded field and there seems to be much new ground to be explored. Despite the time it takes to a achieve a zoetrope animation, it's when you give it that first spin, a bit like lifting the screen on that third layer on a screen print, you don't know how it's going to react or look. Maybe you've tried something new, shifted some parameters and it's all changed. There's still so much to learn and it's hard to predict. Coupling zoetropes with turntables and records is just a match made in heaven for me.

5.4 Raymo Ventura

Figure 16. Deuxwave, still from Cheat Sheet for the Voting Booth, 2020.
https://deuxwave.com/Ilana-Glazer-Cheat-Sheet-for-the-Voting-Booth

Philadelphia studio Deuxwave's off-kilter take on animation touches on everything from CRT feedback to zoetropes to flipbooks. This hands-on approach distinguishes Deuxwave from the digital sterility of many modern motion graphics studios and has had them making psychedelic visuals for artists such as Tierra Whack and Bad Bunny. Studio lead and animator Raymo Ventura enthusiastically explains the appeal of experimenting:

> What excites me the most with analog animation is its freestyle potential for discovering happy accidents! Embracing imperfection, organic movements and textural warmth that digital plug-ins can't really replicate.
>
> Whether we use light-boxes, printers and scanners for frame by frame doodles or daisy-chaining feedback loops with hi-8s, mixers, and video synths, the loose off-'puter workflow hits all those handcrafted tactile feels!

5.5 Reuben Sutherland (Sculpture)

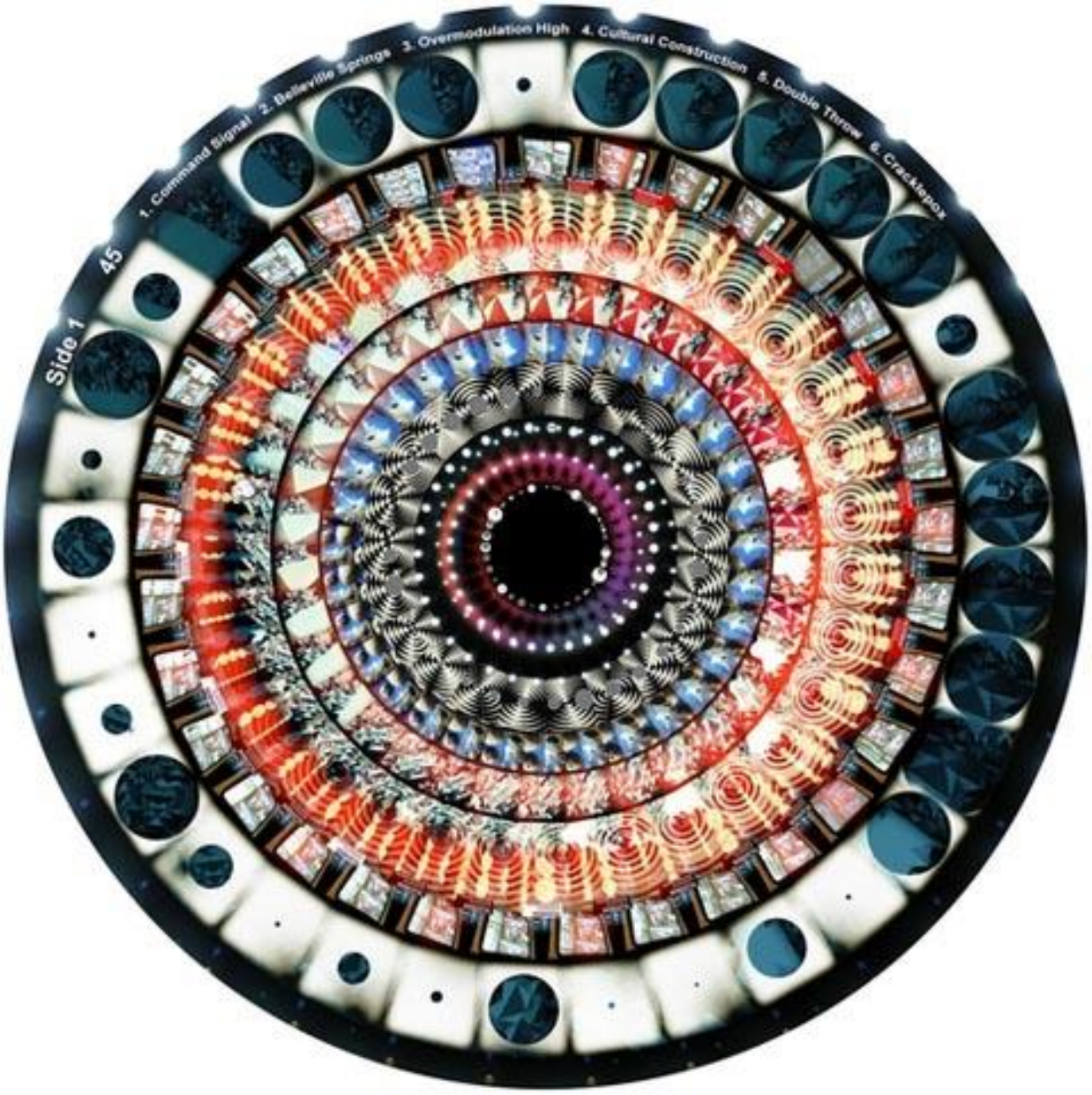

Figure 17. Ruben Sutherland/Sculpture, Rotary Signal Emitter, 2010. https://www.youtube.com/watch?v=J3lGS27kfAQ

Reuben Sutherland represents the visual half of UK audio/visual duo Sculpture, known for their cut and paste approach to sampling media from every imaginable format. These madcap collages take the form of tape loops, experimental film, and notably zoetropes. Sutherland's

turntablist-inspired performances and artistic picture discs have made him one of the strongest vanguards in the modern zoetrope movement.

> I find analog animation interesting because of lots of different reasons that have changed over time. One thing to be aware of is that only part of our animation process in analog, and that is the live delivery which is the camera and turntable and disc part.
>
> animations are mostly made in the computer, then output to the zoetrope disc and played on the turntable. so it looks way more analog than it is in some ways.
>
> I find all live animation interesting and the computer stuff is and can be amazing but analog have so much potential to never ever be the same which makes it more suitable for improvised music
>
> in a way the tech is so simple not much can go wrong
>
> Lots of unexpected surprises is always good for excitement levels mistakes that end up looking good or going with the sound
>
> it's great that other people can up and play with the same tools and discs and invent some new way of doing it
>
> Oh yeah, and it's well quick to set it up on stage

6 ZOETROPE BLUES

Zoetrope Blues was a thesis exhibition of four original printed slipmats paired with four resin-cast bangles, all animated in the zoetrope style, with each demonstrating principles unique to the medium and "signature techniques" I have developed. I personally illustrated, animated, modeled, printed, molded, cast, filmed and edited each piece entirely from scratch, so it serves as an introduction to my research though a 100% original display without the constraints of clients.

The sets of prints and sculptures were each mounted on their own turntables, along with a pedestal LED spotlight and instructions to watch the pieces through a phone camera. This encourages viewers to experience the piece from multiple angles at their own pace. Additionally, a screen in the center of the gallery played a selection of longer form zoetrope videos I have worked on. The videos were not only a way to show a broader variety of designs, but also to present them in their idealized (edited and processed) form.

This highlights an interesting exercise in the way that a designer controls the viewpoint for these archaic art forms: a foundational characteristic of the zoetrope is its physicality, the sense that it must always be perceived in the round (or, at least, that the viewer must choose their own perspective.) The turntable offers no prescribed starting point, & all of the pieces can be understood from multiple angles, so the viewer is left to discover them at their own pace. In contrast, the video version forces the pieces into a linear (if abstract) narrative, with each shot deliberately controlling the viewer's experience. This is especially important to note because far more people saw the show via online video than they did in the gallery.

The videos also served a third purpose— or rather, their soundtracks did. As each piece in the show was set to run at 45RPM, they all naturally synced up visually with the rhythms of a 90BPM song. As any sound effect artist or film composer will tell you, a well-placed thump can

greatly increase the impact of an onscreen motion, and this principle applies for zoetropes as well. One of the most thorough explorations of this idea is *The LOVE Mix,* a 2019 project made in collaboration with Daedelus, a LA beat scene legend and Berklee music professor. Set to a continuous 90BPM mix specially created for the piece, *The LOVE Mix* runs though 25 original zoetrope prints in a longform kaleidoscopic DJ routine, each card's animation syncing perfectly to Daedelus' driving soundtrack. These sounds coming from the gallery television speakers served to create a background texture which heightened the effect of the pieces even when not specifically filmed in tandem.

Figure 18 Still from The Love Mix, *Drew Tetz and Daedelus, 2019. https://www.youtube.com/watch?v=qNPaUgvvkMg*

6.1 Pharaoh's Eyes

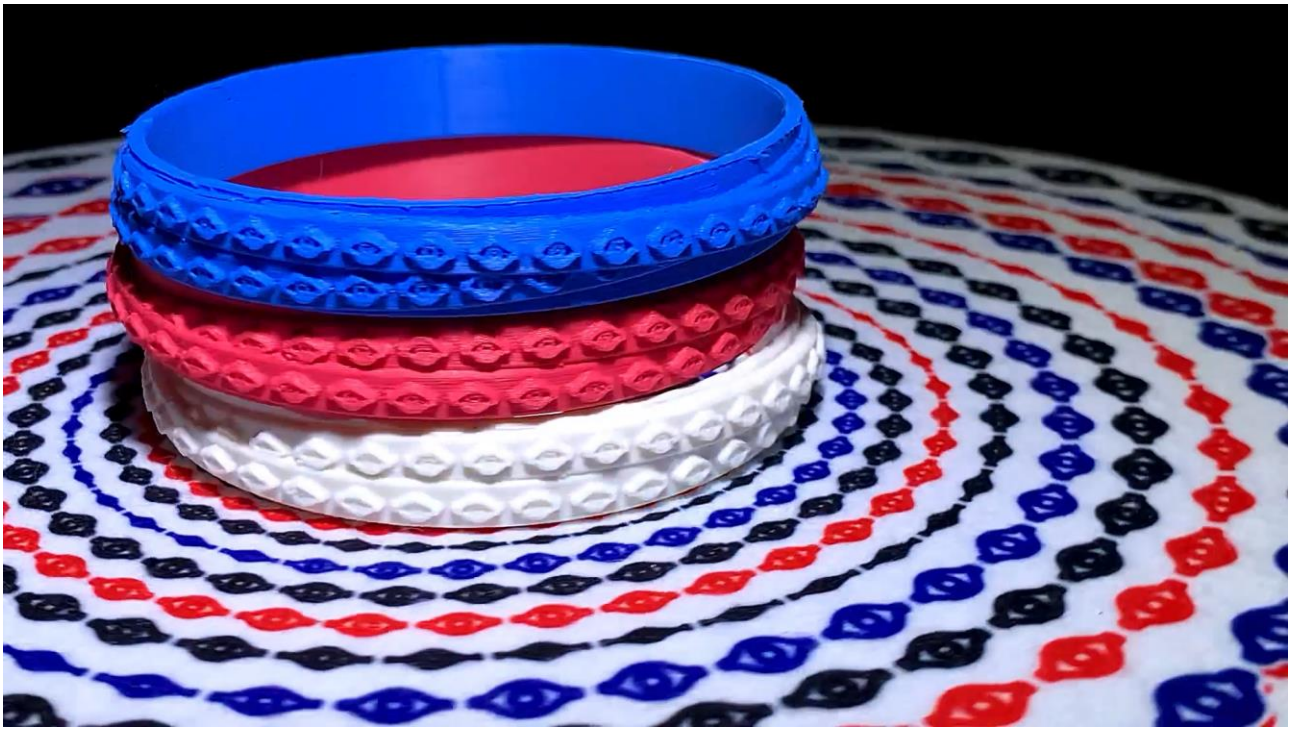

Figure 19 Drew Tetz, Pharaoh's Eyes, 2021. https://www.instagram.com/p/CNRTD5UAyqZ/

Pharaoh's Eyes demonstrates a number of compositional techniques which I have pioneered and refined, with the primary focus being a sequence of interlocking loops forming a rolling knot. I learned that by overlapping two loops (separated here into red and blue for greater clarity), offsetting them from the center axis, and then cutting them at the intersection to heighten the impression of being interlocked, a much greater impact is created than the loops seen on their own. The gentle sway of the two circles becoming as much a part of the motion as the animation itself, and can be intensified by moving them further away from their original center points, widening out their orbits to a dizzying swing until only the outermost action becomes legible. (I chose a more conservative tightly woven knot for the sake of clarity.)

The animation in question, a blinking eye, gains significant emphasis when expanded into a larger array, forming an ominous wall of eyes gazing out from the turntable. Simply copying &

scaling down the pattern can be less than ideal, as stacked elements can create visible seams in the disc, and so it becomes beneficial to rotate subsequent rows to avoid rivers through the composition. The first rotation is simply moving forward half a frame, which obfuscates the grid and allows for a tighter fit. The second rotation (which is much more important to the visual effect) is to turn each new row 90 degrees, which effectively makes each eye blink one “beat” after the one above it. Grouping four of these rows together establishes a 1-2-3-4 rhythm which is significantly more satisfying than all the blinks happening in unison—especially when linked with a corresponding soundtrack.

The bangle takes the concept of the knot and pushes it into the third dimension, opting for a twisted nest of two thin bands rather than the print on the flat disc. Turning the eyes onto their side does not drastically affect their presentation, but the ability to offset the loops on multiple axes creates a stunning effect, as the addition of a third dimension also means further freedom to push the designs off-kilter. I took advantage of this by separating them by 3 millimeters on the z-axis, as well as giving them a 5 degree tilt away from each other, with the two resulting bands appear to push back and forth past each other as they spin. In addition to the hypnotic quality added by these sculptural twists, this piece represents a method I have developed for converting 3D animations into “filmstrip” sequences before bending them into a circle for proper zoetrope motion. While this eye animation is a fairly simple example of the technique, the physicality of

the lid and the pupil being separate layers as they jut out from the bracelet does wonders to add visibility to the single color plastic.

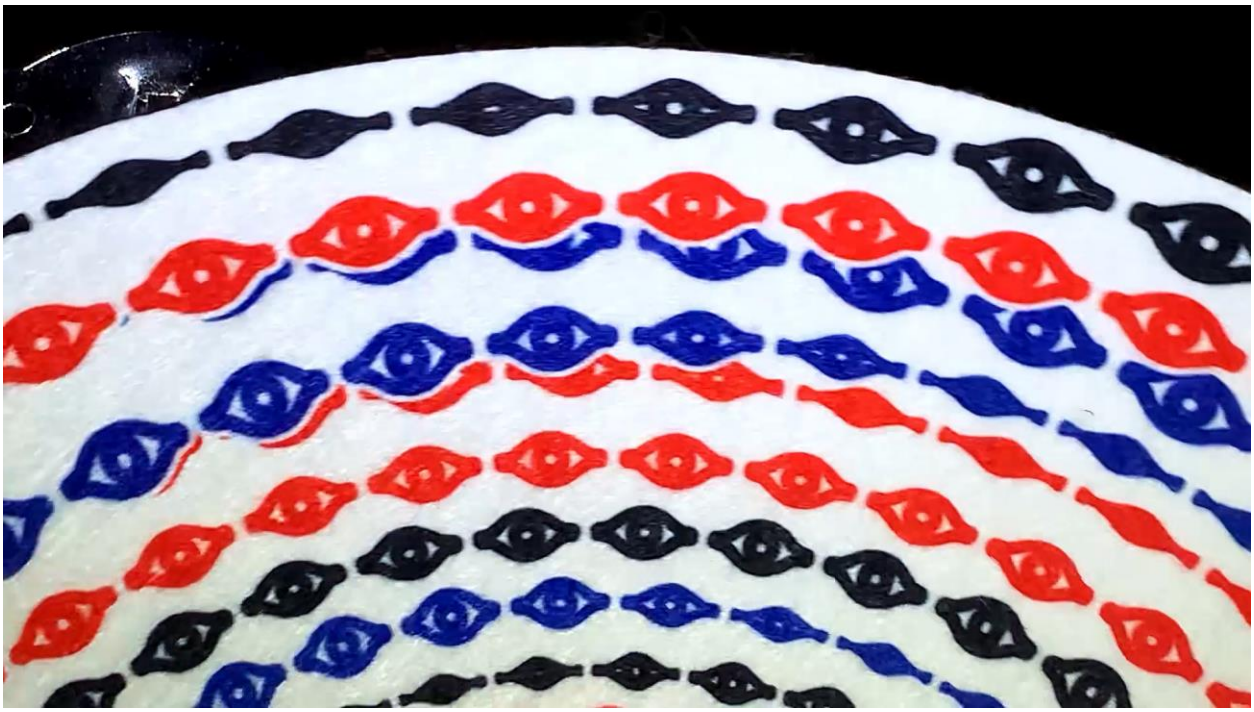

Figure 20 Drew Tetz, Pharaoh's Eyes, 2021. Detail of "knot" technique. https://www.instagram.com/p/CNRTD5UAyqZ/

6.2 Face Melt

The foundation for *Face Melt* was a 2018 exploration on color blending and overlaying slightly different loops for a glitchy effect, with the subject of the animation being that universal symbol of raves, the smiley face. The modern rendition has been rebuilt from scratch for a more consistent beat, as well as a matching, three-tiered bracelet.

The rhythm of this piece is distinctly more unified than *Pharaoh's Eyes*, with every single loop hitting on the second and fourth beat for a warehouse-ready thump. As mentioned before, this "all together now" approach often leads to rivers of blank space, a challenge which

was mitigated here by overlapping certain rows with an additional layer set to a different frame counts. The resulting overlap is reminiscent of a VHS tape with the tracking gone wrong, with individual portions of the frame flitting into view as the colors dance past each other. Mixing frame counts in a single row is often just as chaotic as it sounds, but with careful color management, it remains legible while creating a uniquely dynamic analog effect.

Figure 21 Drew Tetz, Face Melt, 2018/2021. https://www.instagram.com/p/CNTi85OAYNe/

The *Face Melt* bangles consider the effects of frame counts and z-axis offset on zoetropes when brought into 3D, and especially the relation those two variables have on each other. The rows are arranged from top to bottom at 41, 40, and 39 frames, which would usually display as a modest stack with rows that appear to spin forwards, in place, and backwards respectively. However, I chose to offset all of the rows from the “true” center of the center hole, which creates a strange effect on the perceived motion, giving an elastic feeling to the animation. Rather than

moving at a static pace, the rows appear to swing in and out of focus, their outermost points tracing a gentle oval as the faces pulse. In addition to this offset bands technique, this piece demonstrates a system I have developed for transferring 2D animation filmstrips onto 3D surfaces through displacement. This allows for loops created though traditional means to be applied to 3D shapes and brought into the physical world.

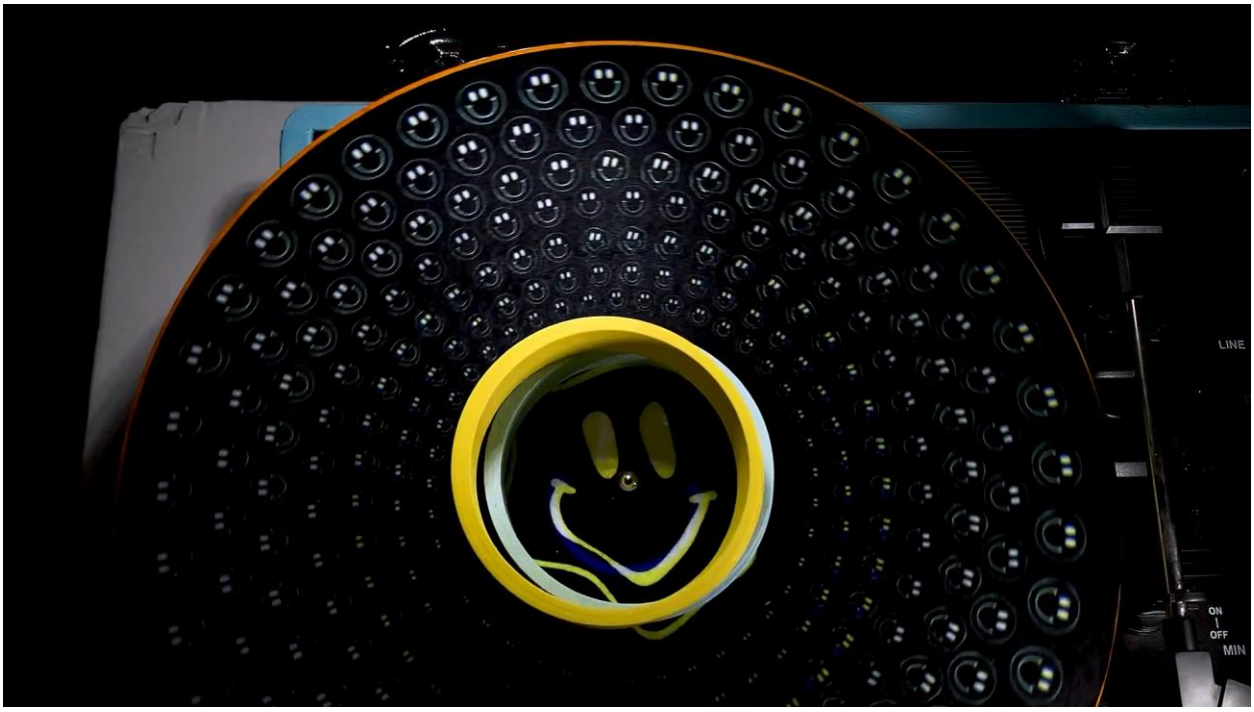

Figure 22 Drew Tetz, Face Melt, 2018/2021. https://www.instagram.com/p/CNTi85OAYNe/

6.3 Slime Time

Figure 23 Drew Tetz, Slime Time, 2021. https://www.instagram.com/p/CNeHdq0gjx0/

Slime Time emphasizes color and simple dramatic motion to create a drippy spectral rainbow, emphasizing a few of my favorite original color blend techniques. The primary action (a large viscous bead lazily rolling in and out) is rotated 180 degrees and inverted, sliding past each other twice for every rotation, with the resulting overlaps creating bright highlights. These bright patches are particularly interesting, highlighting the intersections of the opposing loops but also forming a solid barrier separating the individual rows.

The slime runs through the full spectrum of colors as it continues towards the center, with alternating layers being flipped to drip inwards, and mismatched frame counts once again coming into play for an undulating counter-directional wrap. This piece is less representational than the others, and so questions like orientation and viewing angle are secondary to the overall

impression of the swirling lines, inviting the viewer to see it as a whole rather than focusing on the individual loop.

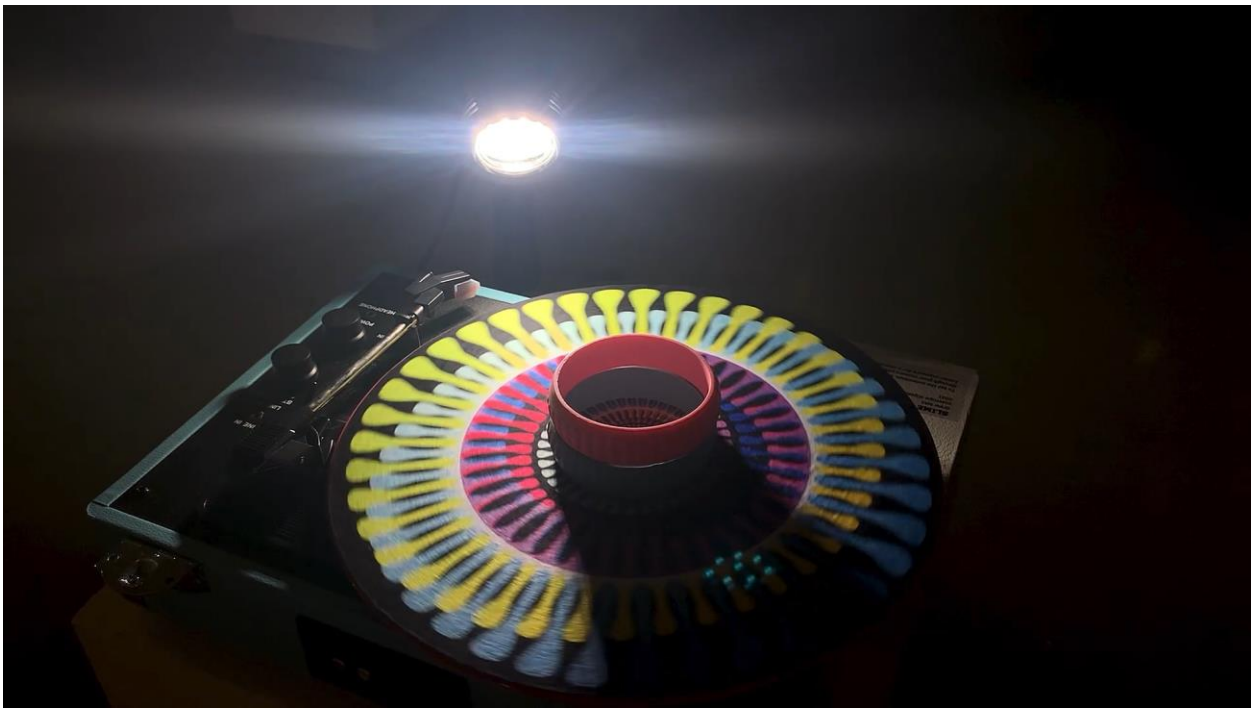

Figure 24 Drew Tetz, Slime Time, 2021. Installation photo. https://www.instagram.com/p/CNeHdq0gjx0/

The sculptural component of *Slime Time* is comparatively simple, being a single repetition of the animation loop extruded from a slightly curved bangle. This straightforward punch is made especially compelling when matched up with another piece placed on top but rotated to a different angle, as their two rhythms play tug-of-war with each other. This modular/stacking concept is a good way to echo the repetitions seen on the slipmats while also fully benefiting from the replicability of the resin casting process, so it featured heavily across the show, but this was perhaps the most obvious parallel to its printed companion.

6.4 Venus de la Void / LOVE ‘21

This set represents the culmination of much original research, so I am especially proud of the techniques it uses. The slipmat, *LOVE ’21*, features a 39/41 frame count split on every other innermost letter, creating an ever-shifting counter-directional vortex. (This technique in particular, which I have fondly nicknamed “text rivers,” has become somewhat of a trademark move for me, and so I am always glad to feature it.) The outer half of the print is a cascading spiral with both an overlapping spiral pushing outwards and a rhythmic bounce. The spiral is a compelling motion on its own, but is also an enormously helpful discovery from a technical standpoint, as linking together multiple frames through outward movement across the canvas is a fantastic trick for maximizing space and lengthening animations. Small details like the rainbow shadows help ground the fast-moving animation to the piece, while also linking to the overall rhythm with a subtle bounce.

Figure 25 Drew Tetz, Venus de la Void / LOVE '21, 2021.
https://www.instagram.com/p/CNiaGEegcGs/

The sculptural component, *Venus de la Void*, also works with the concept of splitting an individual composition into multiple frame counts. However, instead of typography, it warps a 3D scan of a classical sculpture into an array of slices that split into unsettling tracking static halfway around the bracelet, making for a satisfying twist on my “text rivers” signature.

It is important to note that this is not a consistent 39/41 split like the center of *LOVE*, choosing instead to break the composition into two halves. One half is set to a stable 20 frames of the full face, producing the illusion of a static image. The other half is broken up into 12 vertical slices and mixed between 19, 20, and 21 frames, creating a sudden but logical transition from the complete face to the fractured glitch. This method of splitting a composition into multiple frame counts within the same loop is unique to me, and so finding a way to extend it into sculptural work was important to me.

Figure 26 Drew Tetz, Venus de la Void / LOVE '21, 2021.
https://www.instagram.com/p/CNiaGEegcGs/

7 CONCLUSION: THE FUTURE AND POSSIBILITIES OF ZOETROPES

7.1 Analog in Digital Spaces

After so much philosophizing about the charm of analog errors and with digital animations being easier to create than ever, the idea of bringing an obsolete animation technique into a computer environment may seem absurd. However, many of the peculiar charms of zoetropes persist even in cyberspace, and the juxtaposition of a pre-cinema format with cutting edge technology can make for some surreal stuff. The inherent contradiction of "digital analog animation" draws the important distinction between the actual zoetrope device itself and the zoetrope animation technique, which has stylistic value even outside the "real world."

The absolute simplest example of this is using an animation program to rotate a zoetrope image. This is a natural step in the digital zoetrope creation process, as it's an easy way to check your work before manufacturing, but it's also technically the cleanest version of the animation. Naturally, not having the wobble of a turntable or the slight warp of a printed copy, this perfect rendition will be missing the textural jazz that many find so charming in the physical version.

While there are certainly ways to introduce artificial grain or skew the rotation for a more organic touch, the purity of the digital form in a vacuum allows the hypnotic qualities to really shine through. The fractal psychedelia of the polar grid makes it a natural fit for large scale projections, especially when given the boost of live editing tools; while some might argue that actively modifying a zoetrope loop in action defeats the purpose of the form, it would nevertheless be extraordinarily trippy.

3D animation, virtual reality, and augmented reality all offer the chance to create supersized zoetropes without worrying about cost or material challenges, a particularly exciting

possibility for sculptural works. Untethered from the physical constraints of manufacturing, virtual zoetropes can harness the power of procedural generation, motion capture technology, and texturing techniques to create intricate motion structures too complex for IRL production. On a smaller scale, it can also be used in a more restrained way with AR filters to place a zoetrope in space or use it as a virtual selfie accessory.

7.2 Large Scale

Turntable-based zoetropes are generally confined to being 12” or less. However, this is only a limitation of the equipment, not of the medium. For example: Peter Hudson’s *Charon* is a sculptural ferris wheel zoetrope standing 32 feet tall, and in 2008 Sony commissioned a 10-ton “BRAVIA-drome” with images of a footballer.

While large-scale zoetropes carry correspondingly large manufacturing costs, they do offer a few distinct advantages. Smaller zoetropes in a physical setting face the challenge of only allowing a small number of viewers at a time; when you’re working with the spectacle of a 3-storey strobe-lit carousel, that’s not really a problem. A bigger canvas also leads to bigger individual frames, which allows for more freedom when determining the RPM of the piece, as well as the length of the animation loops. In theory, an artist could fill an entire wall with filmstrips on looping motors so that viewers could see every frame in motion at once. Of course, at that point the question becomes “isn’t that just a deconstructed movie theater?” –which of course it is, but that doesn’t take away from the analog hipness of doing things the hard way. Slightly less anachronistic/more commercially viable applications might be internally lit pillars (not unlike a giant barber’s pole) which could theoretically achieve compelling motion without the need of a screen.

7.3 Long Format

The presentation of a zoetrope is often as important as the zoetrope itself: how will the audience be seeing it? Is it being presented to them, or are they interacting with it on their own? If they're experiencing it in a physical setting, they're free to approach it at their own pace, and they determine how much time to spend focusing on the individual elements of the piece. This additional level of interaction is fascinating for curious viewers, but it is up to them to interpret the structure of the piece beyond the ~2 second loop.

The alternative is a presentation of the zoetrope, most likely in the form of an edited video. Naturally, this gives the creator a tremendous amount of additional creative control over how the piece is understood. The camera angle, the frames being focused on, the duration of the shots—all of these cinematic tools are essential in guiding the viewer through the zoetrope and shaping the experience. It also allows for the critical addition of a fully synced and focused soundtrack. The rhythmic nature of the zoetrope loops (along with the conceptual grounding of the turntable) means the visuals get a huge bump when backed by a tune moving at the same tempo, so being able to properly sync to music is a huge benefit of the filmed approach.

A compromise between the live spontaneity of the physical zoetrope experience and the control of the edited film could exist in the form of a live presentation. The artist would use a traditional DJ setup of two turntables, but playing zoetropes instead of records, switching between camera feeds rather than audio channels. This would allow for an extended "VJ set" spanning multiple zoetropes. The preparation involved in such a set would be considerable to say the least, but if properly executed the effect would be phenomenal.

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