The Hearth Student's Journal

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Table of Contents

Letter from the Editor-In-Chief

The Hearth Student's Journal, Volume 2, Issue 1, 2025

Dear Colleagues,

It is my pleasure to welcome you to the second volume of *The Hearth Student Journal*.

Since our last issue, our team has been hard at work showing off THSJ to the world. On top of the same enthusiastic branches and writers we had last year, we've seen more people apply to edit, and our editorial quality, we hope, has correspondingly improved.

This volume reflects the incredible growth of our international community. What began as an ambitious idea has now scaled into a truly global platform, with our network expanding to encompass over thirty schools in more than ten countries. This broadened reach is vividly represented in the diversity, depth, and rigor of the research featured in this issue.

Our core mission remains steadfast: to provide a highly selective, interdisciplinary platform for high school students to engage in the peer-review process and share their academic passions. In the following pages, you will find papers that tackle complex questions across diverse fields, reflecting the profound intellectual curiosity of our peers. The rigorous review and revision cycles these authors endured stand as a testament to their dedication to scholarly excellence and scientific integrity.

I want to extend my deepest gratitude to our expanded editorial board and our dedicated design team, whose meticulous efforts have brought this volume to life. To our contributing authors: your commitment to academic inquiry is the driving force behind this publication.

We hope that the research presented in Volume 2 will challenge your perspectives, inspire your own academic pursuits, and continue to foster a vibrant, borderless community of young scholars.

Happy Writing!

Bui Thien Khiem
The American School Vietnam '28
Editor-in-Chief
The Hearth Student's Journal
Volume 2, Issue 1

What is Self-Deceit?

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The term "self-deceit" remains a highly controversial and debated matter among philosophers and sociologists. It involves acquiring a false belief despite evidence of the contrary (Deweese-Boyd et al, 2023). Numerous philosophers have debated the voluntary, moral, and evolutionary implications of self-deceit, revealing its underlying processes and belief systems. LAs Nietzsche once wrote in Ecce Homo, "How much truth does a spirit endure? How much truth does it dare?" When our emotions overcome our will, we tend to deceive ourselves. To delve into these underlying processes, we must consider the following: is self-deception moral, what drives it, and how it affects our interpersonal relationships. This essay argues that self-deception is necessary for psychological survival, but it undermines moral responsibility and personal freedom. To properly evaluate and analyze the factors of this argument, we must consider the topic through a neurobiological, philosophical, and sociological lens. The findings suggest that biological components are activated as defense mechanisms; however, self-deception poses a threat to our conscience.

Neurobiology provides a grounded understanding and empirical evidence of the cognitive functions of self-deception. The scientific models presented by functional magnetic resonance imaging (fMRI), PET, and tDCS in self-deception reveal an increase in neural activity in specific regions of the brain, facilitated by neuroprocessing networks (Chu, 2017). Before examining the role of anatomy as a survival mechanism, it is critical to explore the underlying neurobiological mechanisms of self-deceit. The evidence from patients with deceptive responses suggests that brain structure controls deception. In the first phase of this mechanism-" perceptual filtering"-the prefrontal cortex carries executive functions to mediate cognitive control, decision making, and emotional regulation, causing self-deceivers to rationalize unwanted truths (El Baba et al. 2023). The prefrontal cortex suppresses behaviors regulated by the motor, sensorimotor cortices, and limbic systems that indicate deception. Furthermore, it helps filter information to determine emotionally relevant data. During this phase, the anterior cingulate cortex is utilized to detect cognitive dissonance through conflict monitoring, making it essential for detecting tension and the perpetuation of biased attention (Buddington, 2012).

In the second phase of deception, "emotional valuation", the left ventrolateral prefrontal cortex (vIPFC) is activated during intentional lying by filtering distracting stimuli and suppressing inappropriate responses (Chu, 17). This actively perpetuates the neglect of a truthful narrative and the projection of new portrayals, facilitating self-deception. The amygdala, vmPFC, and hippocampus work together to assign values to perceptions. As a result, these neural structures are responsible for inhibiting truthful responses and serve as a defense mechanism by preventing the absorption of unwanted truths and confronting painful realities. In the third stage of self-deceit, the dorsolateral prefrontal cortex (DIPFC)o'contributes to deceptive processes by generating conflict responses and working memory adaptations, regulating episodic memory, and the production of deceptive responses. The phenomenon of cognitive rationalization describes the justification of behaviors that make them seem more reasonable (Beltranu, n.d).

A student who has just failed their exam could assert that they didn't fail because they were unprepared, but that the exam was unfair. Similarly, a person who has been diagnosed with depression could rationalize their lack of motivation by convincing themselves that solitude and emotional withdrawal are necessary.

These structures work together to construct false narratives to maintain a coherent self-image, reducing cognitive overload and enhancing self-perception. Its association with self-enhancement and emotional processing supports the [8] that self-concept maintenance could increase the likelihood of deception. Moreover, during memory distortion, the hippocampus, prefrontal cortex, and cingulate cortex modify the interpretation of past events to support current beliefs. A person who has failed their exam could construct a new narrative where they believe that their exam has "gone better than they thought it would."

Therefore, it could be reasoned that the "positive illusions" derived from self-dmeceit confer psychological benefits and social advancement, serving as coping mechanisms against threatening realities (Stanford, 2006). A notable example can be Ivan Illych's self-deceit, where the character is subsumed by his self-deception and constructs a new narrative to avoid confronting the unpleasant truth of his impending death (IJRISS, 2023). His denial of mortality and the formation of his false belief shields him from the harsh reality of his demise-yet serves as the primary source of his suffering, preventing him from finding true meaning. Similarly, survivors in concentration camps required a buffer for survival when the harsh realities proved otherwise. The deceit of this character and the resilience of survivors reveal how self-deceit shielded them from confronting difficult truths, serving as coping mechanisms. Their perception of this facet enabled them to maintain control over threatening circumstances.

A person who is in denial of climate change will construct false narratives to support false beliefs or consciously ignore the signs of global warming. Similarly, one can act under-confident to avoid the threats of predators. Through conjuring cognitive dissonance and rationalizing our deceptions, this demonstrates how self-deceit serves as a coping mechanism to maintain psychological stability in the face of existential threats and adversity.

Another psychological factor that contributes to the survival mechanism of self-deception is the evasion of others' detection efforts. Self-deception eliminates cognitive overload and the disruption of detection efforts by facilitating the persuasion of false information by first persuading oneself. (Butterworth et al., 2022) The facilitation of interpersonal deception minimizes the cognitive demands of truth, warranting coping mechanisms. Holmes notes that we are harder to detect when we believe in our lies (Robson, 2022). Self-deception acts as a hedonic tool that strengthens positive mood and self-esteem by allowing us to believe in what we want to be true.

Furthermore, self-deception contributes to self-enhancement by modifying our perceptions of others; we do not merely deceive ourselves to believe what we want to be true, but to believe what we want to persuade others to be true (Von Hippel et al., 2011). Festinger's social comparison theory postulates the inherent human drive to evaluate ourselves through the comparison of others, providing an incentive for self-deceit and maintaining a favorable self-image (Social Comparison Theory, 2024).

The internal narratives that we form during this process aren't solely driven by wishful thinking but by a desire to project a certain image of ourselves to fulfill our self-esteem; self-deception would be regarded as a defensive response to uncongenial societies and the propensity of portraying ourselves in a favorable light (Farrow, et al., 2015). Freud's exploration of psychoanalysis explores defense mechanisms, navigating our internal drives and the external reality (Nash, 2024). The defense mechanisms of denial, projection, and regression serve as tools of self-deception, where we unconsciously distort or deny aspects of reality to cope with anxiety.

Moreover, his structured model of the human mind comprising Id-the motor of our two instincual drives, Ego-the filter that acts as a conduit for our internal drives, and superego-our "conscience" where our morality and values reside, reveals how self-deceit maintains the balance of our ego by keeping truths unconscious, thereby ensuring psychological equilibrium (Nash, 2024). This demonstrates that self-deceit mitigates internal conflict by maintaining psychological balance.

Having now proven that self-deception is necessary for survival by constructing false belief systems and the evasion of others' detection efforts, we pose the following question:

Is self-deceit adaptive, and how does it impact our interpersonal relationships? There are three ways in which self-deceit could be adaptive: by deceiving others for our mutual benefit, reaping psychological benefits, or gaining social rewards. For instance, when there is a disequilibrium in social hierarchies, lower-status individuals tend to rationalize their deceptions to obtain a desirable impression of themselves in achieving social desirability (Chu, 2017). This allows them to acquire greater equanimity.

However, while self-deceit comes as a coping process to satisfy our false belief systems, neurobiology indicates the maladaptive processes associated with self-deceit and the detrimental consequences on our well-being.

Biological research shows the lack of dissociable neural activations in neuroplasticity when "faking good" or self-deceiving, demonstrating poor differentiation between emotional states; the brain would treat two distinctive neural patterns as the same (Farrow et al., 2014). Thus, a person experiencing self-deceit will struggle to differentiate between their perceived happiness and true emotional well-being. To further emphasize this, neural signatures of deception conducted through the Implicit Association Test reveal how deception fuels alterations in neural activations (Schindler et al., 2015). During faking, it was discovered that increased activity in the right inferior frontal gyrus (between 150 and 200 ms) related to the suppression of automatic responses. The findings suggest increased cognitive overload was required to override automatic processes, culminating in cognitive dissonance or self-deception.

In addition to neurobiological influences, it is critical to observe self-deceit through a philosophical and sociological standpoint. The concept of "hedonism" measures the morality of our actions based on the pleasurable or painful outcomes. While self-deceit could act as a coping mechanism by instilling false narratives per our beliefs, the paradox of hedonism asserts that these serve as temporary happiness and that the "overly conscious pursuit of happiness through these self-deceptive mechanisms culminates in our self-defeat."(Paradox of Hedonism | Internet Encyclopedia of Philosophy, n.d.).

Examining the moral implications of self-deception, we could thus reason that self-deception, while beneficial in the short run, could pose a threat to our moral knowledge. By facilitating harm to others, many consider self-deceit objectionable (Butterworth et al., 2022). Furthermore, Joseph Butler's sermon, "On self-deceit", emphasizes how self-love drives self-deceit, corrupting conscience and the agent's ability to change. Self-deceit could be salutary at the expense of our values and sense of self. Carl Rogers' theory of congruence perfectly encapsulates this phenomenon of identity maintenance: for healthy psychological development, the “ideal version of ourselves” and our real self must be closely aligned with each other (Pt-Prince, 2025). This suggests that self-deceit could exacerbate incongruence by instilling falsified versions of ourselves, thereby increasing psychological tension and distress.

To properly define “self-deceit”, we must also consider its interpersonal implications and consequences. Robert Trivers’ book on self-deception hypothesizes that “our ability to deceive ourselves evolved to deceive others.” When we deceive ourselves into believing our falsified beliefs, we eliminate the idiosyncratic deceptive cues that reveal our deception (Butterworth et al., 2022).

Considering this, we beg the following: Should a self-deceiver be held morally accountable? Before we evaluate the diverging perspectives of self-deceit and its moral implications, we must concede that the morality of self-deceit remains a highly multifaceted issue debated by philosophers. According to the traditional view of self-deception, there are two categories of thinkers pertaining to its voluntary prospect: non-intentionalists and intentionalists.

Intentionalists argue that self-deceit is a deliberate attempt to deceive oneself by intentionally believing in something false, rendering the act as morally problematic (Deweese-Boyd, 2012). For instance, a parent could believe that their child is not struggling despite contrary evidence, to appear as a “successful parent.” Conversely, non-intentionalists posit that self-deceivers are aware of the biasing effects but exert self-deceit without conscious intention (Self-Deception (Stanford Encyclopedia of Philosophy/Fall 2023 Edition), 2023). It is believed that self-deception could be derived from cognitive biases and systematic processing, reducing the need for blame. Neurobiology proves the suppression of automatic responses to undesirable truths. The right inferior frontal gyrus, bilateral middle occipital gyri, and temporoparietal junction coordinate to suppress automatic responses and cognitive workload (El-Baba & Schury, 2023). This shows us that cognitive processes are required to reach intentional deception.

By examining self-deception through neurobiological, philosophical, and interpersonal perspectives, it serves defensive and adaptive functions; however, it often results in long-term psychological and moral dissonance. Its moral implications-whether intentional or unconscious- shape the person’s interpersonal relationships and profoundly

influence their capacity for self-awareness, accountability, and self-actualization.

Provided that neurobiological mechanisms are activated during self-deception, we conclude that self-deception evolves as a coping response to emerging threats but impedes moral responsibility. Our findings suggest the factors constituting self-deception include rationalization, denial, and projection through the activation of neural activities.

Sociological and philosophical influences substantiate the claim that self-deceit could result in psychological conflict and moral dissonance. But are we willing to sacrifice comfort at the expense of truth?

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Identifying the flywheel shape that maximizes Angular Momentum in Orbiting Satellites

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The aim of this project is to identify and replicate the shape that maximizes the angular momentum generated by a spinning flywheel in an orbiting satellite. When a satellite is in the vacuum of space, moving the satellite can be difficult. Traditional propulsion systems don't work in small satellites as space becomes a big limiting factor, while turbines also don't work as there is no air to push back against. The solution, then, comes through the form of conservation of angular momentum. In a vacuum, as there are no external forces, angular momentum must be conserved. If angular momentum is generated in the internal structure of a satellite, then the satellite itself must rotate in the other direction, to conserve angular momentum.

This project aims to replicate this phenomenon through a custom-3D-printed Satellite with dimensions 10cm x 10cm x 10cm, attached to a 3W micro-servo motor. We also custom-designed a special hanger dedicated to holding up the satellite, with the tension force cancelling out the force of gravity. This project also aims to emulate the dimensions of a CubeSat, a standardized satellite unit used often to reduce costs of sending satellites to space. This project also aims to do a significant portion of the calculations required to emulate the realities of a satellite like this, using simple Newtonian Mechanics with rather generalized scenarios for ease of understanding.

As mentioned before, satellites in orbit do not use air resistance to generate force, nor do they burn fuel to generate thrust. Instead, the use a rotating flywheel. In a vacuum, absent of external forces, and thus, external torque, angular momentum must remain conserved. This action, the conservation of momentum, forces the satellite itself to rotate in the opposite direction.

The key relationship is simple, written by the equation:

$$L = I \cdot \omega$$

Where L is the Angular Momentum, I is the rotational inertia, and ω equals the angular momentum. Considering the fact that this is generated by a wattage for a set period, we can also formulate the following equation:

$$Pt = W = \frac{1}{2} I\omega^2 = \frac{1}{2} L\omega$$

Rotational inertia depends on how mass spreads relative to the axis. Mass located far from the center contributes much more than mass near the center. If you move the same amount of material outward, inertia increases quickly, a concept that can be easily tested by holding a long bar away from the axis of rotation-you will notice that it takes a lot more force (or more accurately, torque) to generate the same change in angle. We can create a formula for rotational inertia like so:

$$I = \int_0^R r^2 dm$$

This matters a lot for small satellites, as CubeSats and similar platforms have strict mass budgets. Every gram must justify itself. If your flywheel stores more angular momentum without adding mass, you improve the amount of control you have, resulting in faster reorientation, better pointing accuracy, and more stable operation during disturbances. A flywheel with higher inertia changes speed more slowly for a given torque. That can improve stability but reduce responsiveness. Designers need to balance these effects. For this report, we focus on maximizing stored angular momentum, assuming the motor can still reach the required speeds.

We should also consider the context of torque, a concept that will appear often in this paper, and is found through the following equation:

$$\tau = \mathrm{I}\alpha = F \times R = FRsin(\theta)$$

In order to find what flywheel shape is the most optimal, we need to understand that changing the flywheel shape, assuming it has a set mass, changes its rotational inertia:

$$P \cdot t = \frac{1}{2} I\omega^2$$

Through some simple algebra:

$$P \cdot t = \frac{1}{2} L \cdot \omega$$
$$\frac{2P \cdot t}{\omega} = L$$

Through this derivation, we can see that in order to maximize Angular Momentum, we must aim to minimize angular velocity. We can bring in Inertia by coming back to our original formula (note that KE = Kinetic Energy, which we are assuming is Constant, as we are running the motor, with set power, for a set period of time):

$$KE = \frac{1}{2} I\omega^2$$
$$\sqrt{\frac{2KE}{I}} = \omega$$

We can see from this formulation that in order to minimize angular velocity, we must maximize rotational inertia, a concept that's rather intuitive. But by extrapolating this, we can see the following:

$$L = I \cdot \omega = I \cdot \sqrt{\frac{2KE}{I}} = \sqrt{2KEI}$$

Via this extrapolation, we can see the following identity:

$$L \propto \sqrt{I}$$

This identity is actually rather interesting and counterintuitive for two reasons. Firstly, you would assume that since $L = I\omega$, you would assume that having a higher angular momentum plays just as big a role as higher rotational inertia (they both have linear correlation). But this is not the case, as rotational inertia also affects ω through the relationship $\omega \propto \frac{1}{\sqrt{I}}$. What's far more interesting is that we see the correlation $L \propto \omega$ when only 2 lines above we see the equation $L = I\omega$. Although after spending some time with this finding, it would make sense, as in this situation, we are assuming KE is a constant.

With that said, we should also note the following equation:

$$\alpha = \frac{\tau}{\mathrm{I}}$$

Since torque itself is limited, changing the rotational inertia affects its angular acceleration, causing the satellite to be less responsive. As a result, maneuvering becomes more difficult and the satellite becomes more clunky. But nevertheless, this is still a relatively unimportant trade-off for the increased efficiency.

Hence, after all this formulation, we can see that our aim for this project is to maximize rotational inertia for a given mass. We need to keep in mind that we are working with a set mass, as in conventional satellites, mass would be a huge limiting factor. Therefore, our next aim would be, for a given mass, what flywheel shape would maximize the rotational inertia?

At a first glance, a circle would be a really common and simple flywheel shape that would be easy to attach. From a performance standpoint, the circle provides a reliable baseline, storing a moderate amount of angular momentum for its mass. However, the issue is that not all of its material contributes equally. The inner regions, close to the axis, add relatively little to rotational inertia. That means some of the mass does not work as efficiently as it could.

The Derivation for the rotational inertia of a solid circle is rather simple. We first have the density of the disc itself:

$$\sigma = \frac{M}{\pi R^2}$$

We know the formula for rotational inertia:

$$I = \int_0^R r^2 dm$$

Since we don't have dm, we can attempt a quick substitution by recognizing that mass = σ · area

$$m = \sigma \cdot A$$
$$dm = \sigma \cdot dA$$

Since dA is just 2πrdr, we can simplify the following equation:

$$dm = \left(\frac{M}{\pi R^2}\right)(2\pi r dr)$$
$$I = \int_0^R r^2 \cdot \frac{M}{\pi R^2} \cdot (2\pi r) \cdot dr$$
$$I = \frac{M}{\pi R^2} \cdot 2\pi \cdot \int_0^R r^3 dr$$
$$I = \left(\frac{2M}{R^2}\right)\left(\frac{1}{4}R^4\right)$$
$$I = \frac{1}{2}MR^2$$

Still, the disk has a few advantages. Structurally, it is the strongest of all the flywheel designs proposed in this paper. The continuous material distributes stress evenly, allowing it to handle high speeds without complex reinforcement. Additionally, it also mounts easily onto a motor shaft, which, for a micro-servo motor, this simplicity matters; this reduces alignment issues and minimize vibration.

Another benefit is the predictability; the disk behaves in a straightforward way, allowing for control algorithms to rely on consistent performance, making it a good starting point for testing and calibration. This increased predictability and simplicity is one of the main reasons why a circular flywheel is so popular.

But if your goal is to maximize angular momentum per unit mass, the disk is not ideal. As mass closer to the center of the disc affect rotational inertia very little, it makes the system inefficient for angular momentum per unit mass. Hence, we must explore to see what other options are more effective to maximize this rotational inertia.

Unlike the previous example, the plus shape rotor minimizes wasted inertia by removing a significant portion of the wasted mass. By spreading out 4 arms very far, this design, at first glance, seems like a very efficient way of generating angular momentum.

In practice, the situation is more mixed. The plus shape reduces total mass, which, although it can be useful in tight budgets, removes material from intermediate radii, not just the center. That means you lose a substantial portion of your rotational inertia as well.

But to prove this, we must go through the following derivation, where R is the radius from the center point of the servo to the outer end:

$$\lambda = \frac{M/2}{2R} = \frac{M}{4R}$$

Since r = x in this context, we can make the following assumption:

$$dM = \lambda dr$$

$$I = \int_{-R}^{R} r^2 dM = \lambda \int_{-R}^{R} x^2 dx$$

$$I = \frac{2\lambda}{3} R^3$$

$$I = \left(\frac{M}{4R}\right)\left(\frac{2}{3}R^3\right) = \frac{1}{6}MR^2$$

Considering that there are 2 arms of the motor, we must add up the inertia:

$$I' = I_{cm} + Md^2$$

$$I_{total} = \frac{1}{6}MR^2 + \frac{1}{6}MR^2 = \frac{1}{3}MR^2$$

In fact, if we plug this back into our original equation:

$$L = \sqrt{2KEI} = \sqrt{\frac{2}{3}KE \cdot MR^2}$$

Compared to this equation for the previous mass:

$$L = \sqrt{2KEI} = \sqrt{KE \cdot MR^2}$$

We can see that there is an 18% decrease in efficiency when we switch to this new flywheel design.

The major 'advantage' of this particular design is that you get a much faster ω, which in turn results in more responsive behavior. But calling that an advantage would be quite generous. The gaps between the arms reduce the overall mass distribution, meaning compared to a full disk of the same outer radius, the plus shape typically stores less angular momentum if both spin at the same speed. Having that slight nudge for an 18% decrease in overall efficiency is quite a serious drawback.

There are also structural concerns, as the arms experience higher stress because they are not supported by continuous material. Even when connected to a micro servo motor, this can lead to bending or failure if the material is not strong enough. For a this particular setup, where materials may be lightweight or 3D-printed, this becomes important.

Overall, the plus shape offers some improvement in efficiency compared to a full disk only if it removes mostly low-value central mass. But in many practical cases, it ends up reducing total angular momentum due to lost material at useful radii, an is generally not applicable nor that useful.

The third design combines an outer circular ring with a plus-shaped internal support. This shape directly targets the key idea behind rotational inertia, by concentrating the mass at the largest possible radius. It comes directly from the following theoretical principle of rotational inertia in a thin hoop:

$$I = \int r^2 dm$$

But since we treat this as all the mass in on the outside of the ring (treating this as one thin hoop), the radius is an unchanging constant:

$$I = \int R^2 dm = R^2 \int dm = MR^2$$

The outer ring carries most of the mass. Since it sits far from the axis, it contributes strongly to inertia while minimizing wasted mass, making it highly efficient for storing angular momentum. For the same mass, a ring can outperform a solid disk because it avoids placing material near the center.

Unfortunately, while a thin hoop is theoretically the best, it is also impossible as a the thin hoop can't just be randomly floating in the air, and not be connected to the servo. Hence, we must add something to connect to the servo motor and add it's inertia through the parallel axis theorem:

$$I' = I_{cm} + Md^2$$

To minimize wasted mass, we can use the plus shape from the previous derivation to add onto the outer thin hoop, making the design actually possible to be used. Luckily, all the math that we've done for the past two sections, we can reuse. To achieve a general result, note that:

$$M = M_r + M_p$$

Recall that:

$$I_{plus} = \frac{1}{3}MR^2 = \frac{1}{3}M_pR^2$$

$$I_{ring} = M_rR^2$$

$$I_{total} = \frac{1}{3}M_pR^2 + M_rR^2 = R^2(\frac{M_p}{3} + M_r)$$

Now since:

$$M = M_r + M_p$$

We can rewrite into a cleaner general equation:

$$I = R^2(M - \frac{2}{3}M_p)$$

$$I = MR^2 - \frac{2}{3}M_pR^2$$

We can interpret this general equation as, in the ideal scenario, where $M_p = 0$, the Inertia is just that of the outside ring. But since that's not technically possible, by adding this particular Mass-plus variable, we can adjust the rotational inertia calculations accordingly.

Mounting this design onto a micro-servo motor is slightly more complex than a solid disk, as we will need a secure connection between the shaft and the support structure. But this is manageable with proper design.

Looking at the performance of this design, it looks extremely promising. Setting the following equation:

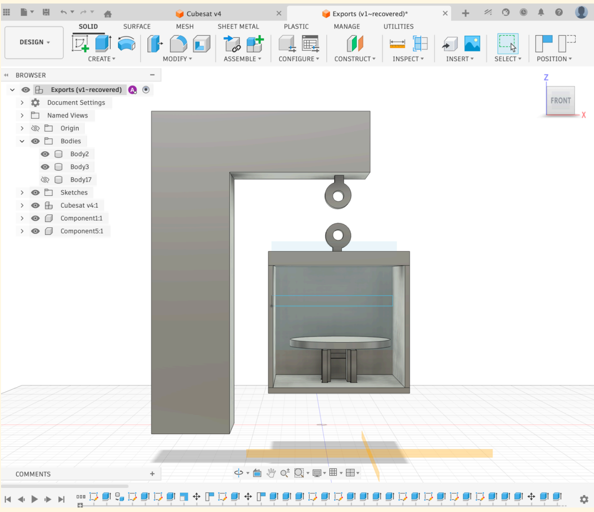
$$MR^2 - \frac{2}{3}M_pR^2 > \frac{1}{2}MR^2$$

We can see that with some basic algebra, as long as $M_p < 75\%\ M_{total}$, the rotational inertia for this design would be more efficient than a full circle. Even setting an arbitrary $M_p = 50\%\ M_{total}$, a very reasonable expectation, we can see that this design yields a result that is 33% more efficient than the circle we first designed.

Of course, there are certainly tradeoffs with this design, not the least of which is that manufacturing becomes slightly more complicated, and attaching becomes more difficult and easy to break. With that said, even with an arbitrary 50%, which can easily be much lower, there is already an insane 33% increase in efficiency from our first design!

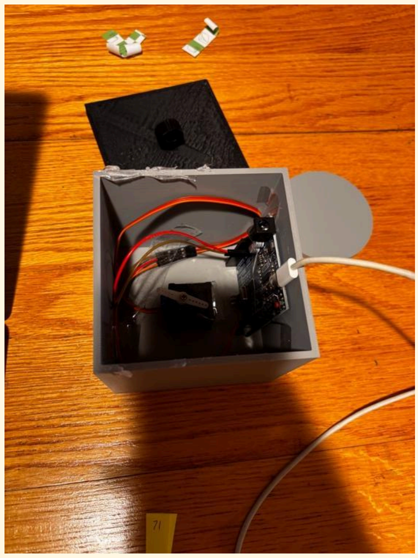
Hence, from the calculations, it is clear that the best, most efficient way to maximize angular momentum is through a thin hoop connected to a plus in the middle, maximizing used rotational inertia while minimizing any wasted mass that will not affect the rotational inertia that much. With all this theory in mind, let's attempt to apply it into the real world.

The prototype was built around a custom-designed 1U CubeSat structure, following the standard 10 × 10 × 10 cm form factor used in small satellite systems. The frame was 3D printed to allow rapid iteration and easy integration of internal components. A mounting bracket was included to secure a micro-servo motor at the center of mass, with the shaft aligned along the primary rotation axis.



The control system used an Arduino Uno, which provided a simple and reliable platform for generating PWM signals to drive the servo. Wiring was kept minimal to reduce clutter and avoid interference with the rotational motion. Power was supplied externally during testing to ensure consistent voltage and eliminate battery limitations.

A custom clamp was fabricated to attach and hold the micro servo motor in more securely, especially when it has to undergo high amounts of angular velocity. To suspend the satellite, a custom hanger was designed and mounted above the structure. This hanger held a thin string, allowing the CubeSat to rotate freely about a vertical axis while remaining constrained in space.



The system relies on conservation of angular momentum. When the flywheel accelerates in one direction, the satellite body should rotate in the opposite direction. The effectiveness of this interaction depends on how much angular momentum the flywheel can generate, given by the formula $L = I\omega$.

However, unexpectedly, running the system yields very minimal results. The satellite appears to spin for an estimated <10° before abruptly stopping. There is clear and visible motion, although for a very short time and for a very short distance. This form of motion suggests other forces have been acting on the cubesat satellite.

Theoretically speaking, even if we were to generate any amount of angular momentum in a vacuum, absent of all other forces, the system should be able to rotate and spin. Unfortunately, the problem is, it does not. From our testing, there appears to be a few initial movements but then it stops. The key question, then, is why? Can the flywheel generate enough angular momentum to produce a visible rotation of the 1 kg satellite body?

We can begin with the following estimates:

Flywheel mass ≈ 0.2 kg
Radius = 0.037 m
Satellite mass ≈ 0.7 kg
Cube side length ≈ 0.1 m

Motor power ≈ 3 W

From our measurements, we can detect that the flywheel is spinning at around a rate of 120 RPM, which we can convert to 12.6 rad/s. We can also calculate the following values:

$$I_{wheel} = \frac{1}{2} \cdot 0.2 \cdot (0.037)^2 = 1.36 \times 10^{-4}\ kg \cdot m^2$$

Which we can plug in for the following calculation:

$$L \approx 1.36 \times 10^{-4} \cdot 12.6 \approx 1.71 \times 10^{-3}\ kg \cdot m^2 \cdot s^{-1}$$

Now, to verify our estimates, we need to calculate our satellite's rotational inertia. We can work through this by first finding the rotational inertia of a single face, and then integrate that through the entire volume. If we take surface density (note that a in this context means 1 side):

$$\sigma = \frac{m}{a^2}$$

Since the area of a strip is just $Area = a \cdot dx$, we can take the derivative and subtitute the following:

$$dm = \sigma a dx$$

The rod at a center has the following rotational inertia (in terms of full length now instead of radius):

$$I = \int_{-\frac{L}{2}}^{\frac{L}{2}} r^2 dm$$

Recall that:

$$\lambda = \left(\frac{M}{L}\right)$$

And that:

$$dm = \lambda dr \rightarrow dm = \left(\frac{M}{L}\right) dr$$

$$I = \left(\frac{M}{L}\right) \cdot \int_{-\frac{L}{2}}^{\frac{L}{2}} r^2 dr = \frac{1}{12} ML^2$$

Now that we have the rotational inertia of a rod, we can sort of treat our surface as an infinite number of infinitely small rods. Since every strip simply is just $dm \cdot x^2$, we can write the following computation. Also, for this equation, we will assume the satellite is fully filled:

$$I = I_{center} + mr^2$$

$$dI = \frac{1}{12} dm \cdot a^2 + dm \cdot x^2$$

Which, when we substitute in some values:

$$dI = \frac{1}{12} \sigma a^3 dx + \sigma a x^2 dx$$

Since $I = \int dI$, we can do the following computation from range $x \in [-\frac{a}{2}, \frac{a}{2}]$:

$$I = \int dI = \frac{1}{12} \sigma a^3 \int dx + \sigma a \int x^2 dx$$

$$I = \frac{1}{12} \sigma a^4 + \frac{1}{12} \sigma a^4 = \frac{1}{6} \sigma a^4$$

We can substitute in the original density of sigma:

$$\sigma = \frac{m}{a^2}$$

$$I = \frac{1}{6} \cdot \frac{m}{a^2} \cdot a^4 = \frac{1}{6} ma^2$$

Now that we know the inertia of a single slab, we can calculate the rotational inertia of the whole cube by integrating it with the z-axis.

$$\rho = \frac{M}{a^3}$$

Since $dV = a^2 \cdot dz$, we can restate:

$$\rho = \frac{mass}{volume} \rightarrow dm = \rho\, dV \rightarrow dm = \rho a^2 dz$$

Considering the fact that we are treating this as many thin sheets, we can do the following calculations:

$$I_{sheet} = \frac{1}{6}(mass) \cdot a^2$$
$$dI = \frac{1}{6} \cdot dm \cdot a^2$$
$$dI = \frac{1}{6} \rho a^4 dz$$

And then we integrate from $z \in [-\frac{a}{2}, \frac{a}{2}]$:

$$I = \int dI = \int_{-\frac{a}{2}}^{\frac{a}{2}} (\frac{1}{6} \rho a^4 dz) dz$$
$$I = \frac{1}{6} \rho a^5$$

We can substitute in our density formula from the beginning to get:

$$I = \frac{M}{a^3} \cdot \frac{1}{6} a^5 = \frac{1}{6} M a^2$$

That was a very long detour. All of that is to say, when we estimate the rotational inertia of the flywheel through the following derivation:

$$I_{sat} = \frac{1}{6}(0.7)(0.1)^2 = 1.17 \times 10^{-3}\, kg$$

Theoretically speaking, the rotational inertia of a cubesat satellite should not actually matter in a vacuum, as absent of all other forces, conservation of angular momentum must be preserved. Unfortunately, this is not the theoretical world, and there are plenty of other forces at play.

We have taken into account 3 main forces, or more accurately, torques:

The torque of the motor (τ_{motor})

The torque of the string, due to torsion ($\tau_{str} = - k\theta$)

The torque of gravity ($\tau_g = - mgd\theta$)

Which when combined, leaves us with the general equation:

$$I_{sat}\alpha = \tau_{motor} - \theta(k + mgd)$$

Note that we can treat α as $\frac{d^2\theta}{dt^2}$, after some time, α and ω equals 0 due to the other forces. We can identify the point where which these other forces cause acceleration to turn 0 with a simple re-arrangement.

$$\tau_{motor} = \theta(k + mgd) \rightarrow \theta = \frac{\tau_{motor}}{(k+mgd)}$$

Assuming a 3 cm distance between the point of contact of the string and the cubesat satellite's center of mass, we can form the following calculation:

$$KE_g = (0.7)(9.8)(0.03) = 0.21N$$

Adding an estimated, albeit arbitrary, 0.1 Newtons for the string torsion force, and having a conservative assumption of the motor-torque as 0.02Nm and we can see that:

$$\frac{\tau_{motor}}{(k+mgd)} = \frac{0.02}{0.206+0.1} = 0.065\, rad \approx 3.7°$$

Unfortunately, from our calculations, https://news.mit.edu/2024/aeros-cubesat-launches-study-ocean-health-0520

it appears that our observations were in fact, correct. The issue within the design comes not from the fact that it doesn't work theoretically, but from the fact that we have not succeeded in removing all external forces.

Conservation of Angular Momentum generates very little acceleration, something that can only realistically be measured in the vacuum of space. When other forces, such as string torsion or the torque from gravity is present, the movement from the conservation of angular momentum becomes very minimal, almost to the point of undetectability.

From our calculations, we have concluded that, if your aim is to maximize angular momentum for an orbiting satellite with the minimum possible mass, then the best flywheel shape for that optimization would be a hoop with a plus shape in the middle, as that minimizes wasted rotational inertia in the center. While the solid disk remains useful for its simplicity and reliability and works well as a baseline, it is not as efficient as the thin outer hoop, as there will always be wasted mass that could've been used to increase rotational inertia.While we initially set out to test and run our calculations out in the real world, we unfortunately found very little luck with getting enough torque to support the orbiting satellite. Though our aim was to use a custom clamp to eliminate all external forces, there were still many forces acting on the satellite, resulting in minimal detectable motion. With that said, theoretically speaking, our calculations show that this CubeSat design would theoretically be possible in a perfect vacuum.

Looking forward, if one wishes to improve upon this experiment, the first aim would most certainly be to attempt to eliminate any and all external forces. Consider using a ball bearing, as that is likely the most efficient way to eliminate the external forces caused by string torsion. Additionally, it may be worth adding an IR receiver, in order to fully close the lid without having the wire go through a small section of the lid. Though this was the original plan, to connect the servo to an IR receiver, we found that it was too troublesome with our time constraints, especially with getting the signal to pick up.

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The Absurdity of Human Reasoning / Trying to Find Meaning

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It began in a field. He was flat on his back, drunk, and slightly miserable. With no plan and nothing but a bottle of alcohol and a copy of The Hitchhiker's Guide to Europe. Douglas Adams stared up at the night sky and let his thoughts wander. Somewhere between hopelessness and starlight, a strange idea hit him: "someone should write a hitchhiker's guide to the galaxy." That weird, directionless moment became the unlikely origin of one of the most iconic science fiction books of all time. The Hitchhiker's Guide to the Galaxy wasn't born from a grand vision or a careful plan, it came from a half-conscious thought in the mind of a man who was drunk. And yet, in hindsight, there's something oddly fitting about it. That bizarre moment captures the very thing the novel would go on to explore: the absurdity of human reasoning and their relentless urge to create meaning. After all, what is the human mind best at if not turning chaos into patterns, accidents into meaning, and nonsense into story. The Hitchhiker's Guide to the Galaxy doesn't just laugh at the randomness of the universe, it laughs at the way humans try to make sense of it.

Douglas Adams reveals that the human impulse to find meaning, even in the most irrational situations, isn't based on logic but rooted in psychology. A clear example of this is seen in the absurd scene where a missile, through a random Improbability event, transforms into a sperm whale. What's most absurd is that it immediately begins naming things and questioning its environment. Like the whale, humans are brought into existence without a clear reason or purpose, and to soothe the anxiety that comes with that, they begin constructing meaning as a form of mental survival. As the whale thinks aloud, "I suppose I'd better start finding names for things if I want to make any headway in what, for the sake of argument, I shall call the world," it's clear that this act of naming is less about understanding the world and more about achieving a sense of control. The word "headway" implies progress, but Douglas Adams uses it ironically, as this sense of progress becomes nothing more than a "diversion" from confronting the sheer vastness and absurdity of existence. This act of naming serves as a mental detour, pulling attention away from big questions like "Why am I here?" and "What is the point of all this?" Instead, it turns to the more manageable task of identifying and categorizing, shrinking the vast unknown into miniature details. In this way, naming becomes a temporary relief and something for the mind to fixate on, soothing anxiety without ever addressing the overwhelming scale of the unknown. But that comfort is short-lived as the whale's naming session comes to an abrupt stop. The whale's sudden death turns the scene into a punchline that exposes the "futility" of constructing meaning where none exists. Adams uses this to highlight how humans, like the whale, attempts to rationalize the world but in return gain only a temporary sense of direction with no real payoff in the end. This tendency to project meaning onto the meaningless rooted in human psychology reappears in the scene where Arthur is left alone with Marvin to guard the passageway. As he gazes at the alien sky, Arthur finds beauty and familiarity in his surroundings, saying "Look, robot, the stars are coming out… I've never seen anything like it in my wildest dreams... The two suns! It was like mountains of fire boiling into space.... great wide rolling blue oceans..." Arthur's reaction reflects the human's psychological need to "romanticize" the unfamiliar in order to make it emotionally bearable. He doesn't simply describe the sunset, he makes it seem more special and meaningful by calling it "mountains of fire boiling into space" turning a random and meaningless event into something beautiful and symbolic. This instinct reveals how, when faced with uncertainty or fear, people often beautify and sentimentalize their surroundings as a coping mechanism. By projecting meaning onto indifferent environments, humans create a sense of reassurance and purpose even if it's only temporary. Beautifying the world becomes a way to soften its chaos, to transform the unknown into something that feels known, and therefore, safe. But Marvin undercuts this effort with blunt dismissiveness "Wretched, isn't it?...It's rubbish…I can't bear oceans." These responses serve as a harsh "disillusionment" that breaks the illusion of meaning Arthur tries to create. Each line Marvin delivers deflates Arthur's emotional projection. Where Arthur sees awe-inspiring beauty, Marvin sees only emptiness and irritation. His comments don't just disagree, they reject the very idea that beauty or meaning are worth acknowledging. This exchange acts as a reality check, revealing how humans often try to make sense of the unfamiliar by turning random sights into something meaningful. But Marvin's blunt rejection reminds us that not everything carries hidden significance. Adams uses this contrast to expose the absurdity of human reasoning driven by a psychological need to create meaning, even when none exists.

When it comes to power, humans have a limited grasp of just how little they truly possess, yet they continue to operate under the illusion that they hold far more influence and control than they actually do. One striking illustration of this misguided belief is seen in how humans perceive themselves as the most intelligent species, as shown through their relationship with dolphins. Douglas Adams captured this, writing "humans had always assumed they were more intelligent than dolphins because they had achieved so much—the wheel, New York, wars, and so on..." This passage illustrates the flaw in the way humans measure intelligence and power, as they grant themselves a false sense of "preeminence". The list of things they classify as achievements "the wheel, New York, wars" moves from invention to civilization to literal destruction, this glorifies mechanization, industrial dominance, and violence traits as if they are signs of intelligence. By including wars as part of humanity's proudest achievements, Adams critiques the entitlement with which humans view their place in the world. War, a destructive force responsible for suffering and loss, becomes framed as a marker of intelligence. In contrast, "the dolphins had long known of the impending destruction of the planet Earth," showing real foresight and awareness, yet they are still considered less intelligent simply because they lack human-style accomplishments. This reversal highlights the absurdity of human reasoning and how they cling to a distorted sense of logic, believing they are the ones with power and that the world revolves around us. Adams continues this critique in the next scene, where Arthur asks Ford to show him what The Hitchhiker's Guide to the Galaxy says about his home planet, Earth. when Ford finally reveals the updated entry: "Mostly harmless," and Arthur immediately shouts, "Mostly harmless?!" This reveals the "hubris" that underlies much of human reasoning.

Arthur's disbelief stems from the assumption that Earth with all its culture, history, and influence must hold cosmic relevance. Yet that belief is dismantled by the Guide's two-word entry, reducing the planet to a mere afterthought. By framing Earth as barely worth mentioning, Adams critiques the anthropocentric mindset that leads humans to believe they are powerful and central. Arthur's reaction highlights the flaw in humans constructing meaning around themselves and assuming they hold power in the universe not because they actually do, but because it preserves their illusion of control. What humans mistake for power is just self-importance reflected back at them, and in the vast scale of the cosmos, that illusion falls apart. showing that humans' sense of importance comes not from actual influence, but from the flawed reasoning they use to convince themselves they hold power in a universe that barely notices them.

Through exaggerated policies and disturbingly compliant characters, Adams reveals the strange logic that emerges when authority goes unquestioned and where governments impose absurd rules, and people, rather than challenge them, end up accepting them as perfectly reasonable. This dynamic plays out clearly on the planet Bethselamin, where the government, concerned about environmental damage, believes that tourists are slowly eroding the planet by eating food and leaving with it in their bodies, has enforced an absurd rule: "any net imbalance between the amount you eat and the amount you excrete while on the planet is surgically removed from your body weight when you leave." This reveals the "preposterousness" not just in the rule's content but in the logic that attempts to justify it. The policy reflects a warped sense of environmental responsibility, as if cutting fat from someone's body somehow provides geological stability. By treating digestion as planetary theft, the government minimizes a complex issue like erosion into a bodily equation, reducing the planet's survival to a digestive math problem. But what's more absurd than the rule itself is the unquestioned "adherence" to it. Tourists, instead of challenging the logic or demanding change, submit to surgery as if it were a civic duty. This reflects how humans comply with structure, no matter how illogical, simply because it comes from an authority. In this way, Adams not only satirizes the government of Bethselamin but uses it as a mirror, reflecting the ways humans rationalize nonsense when it comes from the government and everyone is expected to follow it. This same pattern resurfaces when Arthur and Ford enter a bar for a drink, he casually reveals that Earth is going to be destroyed in a matter of minutes. After the initial shock wears off, the barman begins to accept the news but with lingering hesitation. His doubt doesn't come from believing that Earth is too important or culturally rich to be destroyed, but rather from the fact that it doesn't unfold the way he imagined."I thought that if the world was going to end we were meant to lie down or put a paper bag over our head or something… That's what they told us in the army." This reflects a government effort at "pacification" with a ritual designed not to save lives, but to reduce panic. It reveals how even institutions meant to protect the public often reason in absurd ways, offering empty displays of action instead of actual solutions. What deepens the critique is the barman's response. Rather than questioning the usefulness of the advice, he hesitates because reality doesn't match the procedure he was told to expect. His sincere question "Will that help?" highlights the "gullibility" of ordinary people who believe and normalize these hollow instructions. It's not just that the government promotes absurd logic, but that people are willing to accept and reenact it, confusing performative action with actual safety. Ford's blunt "No" highlights how absurd it is that people would seriously consider such meaningless instructions. In both cases, Adams shows how absurd ideas become accepted as normal when governments create illogical rules and people, rather than question them, passively accept these absurdities as part of reality.

Ultimately, The Hitchhiker's Guide to the Galaxy isn't just about the randomness of the universe, it's about the randomness of humans. Adams's real subject isn't space, but the strange reasoning humans use to survive uncertainty. From romanticizing alien sunsets to obeying nonsense rituals, his characters cope not through logic, but through stories and illusions of control. That's why it's so fitting that the idea came to him drunk in a field, staring at the stars with no plan. That random moment didn't just inspire the book, it became the book. The same way Adams turned an absurd thought into a full-blown galactic satire is the same way humans turn emptiness into meaning. He didn't mock that instinct, he exposed it with humor, inviting humans not to give up on meaning, but to see its absurdity, laugh, and move forward a little more aware.

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Playing the Part: Gender, Performance, and Power in "The Kiss"

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Erving Goffman's concept of the "character contest" suggests that everyday life mirrors dramatic narratives, where individuals not only shape but also defend their social identities in front of an audience. In these contests, people must present and defend a desirable version of themselves, turning interaction into a negotiation of self-worth and control. Kate Chopin's short story "The Kiss" offers a vivid case study of this dynamic. The story follows Nathalie, a woman torn between financial security and romantic desire, as she navigates two suitors: Brantain, a wealthy but awkward man, and Harvy, a passionate but unsuitable lover. Brantain becomes the primary audience for her performance of respectability, while Harvy serves as the threat who could expose her hidden desires and unravel the performance entirely. In "The Kiss," Chopin critiques the social pressures that force women to perform conflicting identities by portraying Nathalie's calculated manipulation of appearance and emotion as a necessary but ultimately hollow path to power. This character contest, shaped by Goffman's theory, reveals how rigid social scripts demand suppressing personal truth.

Nathalie initiates the character contest between her true self and her external persona by deliberately shaping others' perceptions of her to advance her own goals. From the start of the story, she is aware of her appearance and how it can be used to her advantage. The initial depiction of Nathalie shows her beauty when the narrator describes her as "very handsome, with a certain fine, rich coloring that belongs to the healthy brune type" (Chopin 19), yet it also reveals her awareness of its power. This awareness is made explicit in the line "she knew that he [Brantain] loved her" (Chopin 19), which highlights that her attractiveness is something she actively performs, not merely possesses. The narrator goes on to say that "she was confidently waiting for him to declare himself and she meant to accept him" (Chopin 19), a detail that reveals Nathalie's calculated effort to secure Brantain's proposal – him being her intended audience – as she performs a carefully crafted persona designed to meet his expectations of stability and respectability. This dynamic exemplifies Goffman's theory of self-presentation, in which individuals like Nathalie strategically manage their behavior in the front stage of social life to create and sustain a desired impression.

The contest intensifies when the performance is disrupted by the titular kiss, a moment that threatens Nathalie's orchestrated identity.. When Harvy, the obstacle to her desired image, kisses her in Brantain's presence, Nathalie risks losing control over Brantain's perception of her and the image she has worked to maintain. Expectedly, Brantain is visibly shaken, and Nathalie momentarily falters. The narrator observes that "her [Nathalie's] presence of mind had not completely deserted her; but she could not have trusted herself to speak" (Chopin 20). This reveals the internal dissonance Nathalie experiences as her masquerade begins to crack; she must pause to calculate her next move. Only after this hesitation does she regain composure and attempt to restore control by telling Brantain, “When I thought how you might have misinterpreted it... it makes so much difference to me what you think” (Chopin 20). Here, she is not simply expressing regret – she is strategically framing the kiss as an unfortunate misunderstanding and herself as a victim of misrepresentation. This highlights how crucial Brantain’s perception is to Nathalie’s social survival and self-worth; his opinion directly impacts her identity, and therefore she must reaffirm the boundaries of her carefully managed image. She needs Brantain to see the kiss not as a betrayal but as a misread moment. The scene underscores the pressure Nathalie faces to keep her conflicting identities – lover and wife, desire and respectability – from collapsing into one another. Her self-definition depends on compartmentalizing these roles, and when they suddenly converge, she must quickly reassert control.

Nathalie turns to performance as a means of regaining the upper hand, a move that aligns closely with Erving Goffman’s theory of face-work. As Goffman explains, “face-work” refers to “the actions taken by a person to counteract… events whose effective symbolic implications threaten face” (Goffman 178). Nathalie’s shift from silence to explanation is a clear act of face-work – less about emotional honesty than about preserving Brantain’s perception of her as respectable and innocent. In Goffman’s terms, character contests require adaptability and performance management. For Nathalie, maintaining control is essential to protect her claim to both love and status. Though her actions may seem manipulative, they reflect constrained agency within a patriarchal society, where financial security is tied to marriage and respectability defines a woman’s social worth. Thus, Nathalie’s manipulation becomes less a choice than a survival strategy. From a feminist perspective, her dual identity – romantic and respectable – exposes the impossible expectations placed on women, who must be both desirable and virtuous, strategic yet submissive.

The resolution of the contest suggests that while Nathalie “wins” in material terms, the victory comes at the cost of emotional authenticity. After Brantain proposes and Harvy prepares to exit her life, Chopin writes, “She felt like a chess player who, by the clever handling of his pieces, sees the game taking the course intended” (Chopin 20). This line confirms that her strategy worked – she has secured the financial and social status she desired. Yet the tone is chilling, marked by cold calculation. Rather than expressing joy, love, or even relief, Nathalie reduces the emotional drama to a tactical game she has mastered. What matters is the preservation of her constructed identity as a proper, desirable woman worthy of marriage. This metaphor of a chess player also hints at the emotional detachment required to “win” such a contest. In contrast, the men around her move freely, unconcerned with maintaining appearances. When Harvy, after the wedding, tells Nathalie, smiling, “Your husband has sent me over to kiss you” (Chopin 20), he turns the earlier scandal into a private joke. His light tone trivializes the very moment that nearly unraveled Nathalie’s painstakingly organized “face”, displaying how little his disruption affected his own social standing. His identity remains intact, untouched by scandal, while Nathalie had to manage a complex performance to recover her respectability. This gendered contrast further illustrates the costs of character contests: for women like Nathalie, success requires tightly controlled self-presentation, while men like Harvy can afford to be flippant without repercussion. Nathalie’s victory, then, is a double-edged sword, exposing how mastering one’s social performance may secure power – but only by sacrificing authenticity in a world that demands so much more of women than of men.

Through “The Kiss,” Chopin illustrates the psychological and social stakes of Goffman's character contests for women in particular, revealing how identity becomes a performance shaped by the expectations of others. Nathalie's identity is not a fixed essence but a strategic construction – one she manipulates to secure Brantain's proposal. Her calculated performance reflects a form of agency, but one tightly constrained by the gender roles of her time. Unlike men, whose presentations often align with autonomy and desire, women like Nathalie must present themselves as alluring but dignified, navigating a narrower set of social rules. By using Harvy to threaten the carefully curated image Nathalie performs for Brantain, Chopin invites us to consider what happens when identity is entirely instrumental – when every gesture is designed to achieve social validation. The real drama, as Goffman's theory clarifies, lies not in romance but in how far individuals will go to win approval – and at what personal cost. Nathalie may have succeeded, but her victory exposes the emotional cost of self-performance in a society prioritizing image over authenticity.

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