

METROPOLITAN STUDENT CHAPTERS

TORONTO



PRESENTS

TAMMARA
TMUTAGA
TMUTAGA

PRESENTS

2023

TORONTO

METROPOLITAN STUDENT CHAPTERS

TMUTAGA

Technical Association of the Graphic Arts

Toronto Metropolitan University Student Chapters © 2023

Toronto is in the 'Dish With One Spoon Territory'. The Dish With One Spoon is a treaty between the Anishinaabe, Mississaugas and Haudenosaunee that bound them to share the territory and protect the land. Subsequent Indigenous Nations and peoples, Europeans and all newcomers have been invited into this treaty in the spirit of peace, friendship and respect.

No part of this publication shall be reproduced without permission and written consent from the author(s).

Published by TMUTAGA
www.tmutaga.com

School of Graphic Communications Management

Toronto Metropolitan University
125 Bond Street
Toronto, Ontario
M5B 1Y2 Canada
www.torontomu.ca/gcm/



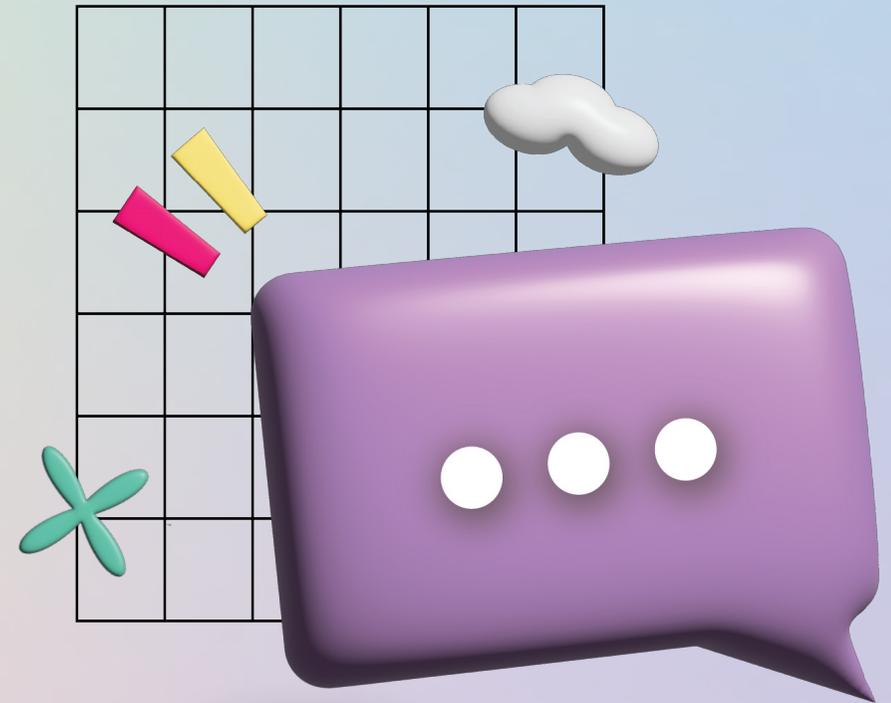
Scan the QR code to access an audiobook and a digital version of this year's papers.



OUR INSPIRATION

The 2023 TMUTAGA creative vision was to create a journal that can represent us and also bring an impact to our viewers. As we have rebranded ourselves with our new name and started this new journey, we wanted to show our viewers that we are still the same **great** student group from Toronto Metropolitan University (formerly Ryerson University). The journal's creative response is to mix the old with the new to create an impactful journal. This was done by incorporating the "4 somethings" concept throughout the journal: **(1) Something Old**, which is our hard work and perseverance, **(2) Something New**, which is our new name and theme, **(3) Something Borrowed**, which are the student papers created by students in our program and **(4) Something Blue**, which is our colour scheme and unique graphic elements that ties everything together.

A LETTER FROM...



OUR FACULTY ADVISOR

Dear TMUTAGA team,

I've lost count of how many TAGA conferences I attended with a student chapter. Each team has its unique character, and as the advisor, it is always interesting to observe the dynamics in each student chapter.

This year the team took lessons learned from the pandemic years and used them this year. The way this year's team worked is different from before the pandemic. We had our weekly meeting virtually, and also the various teams, like editorial and creative, worked virtually with their associates. Of course, the production of the journal still needs to take place in person.

The papers published in this year's journal reflect the very diverse interests that students have these days. I enjoyed reading all of them and learned something from them, which in turn broadened my horizon.

I can't wait to see what our fiercest competition from CalPoly came up with this year. May the best team win.

Enjoy the conference, make new friends and expand your knowledge and professional network!



Martin Habekost, Dr. rer. nat.
TMUTAGA faculty advisor



**MARTIN
HABEKOST** (he/him)

OUR PRESIDENT

Dear TMUTAGA team,

It is with my greatest pleasure that as a team, we can return to in-person practice and showcase our 2022/2023 Student Publication Journal. Though the past years have shown each of us how quickly time can change, we are so excited to bring you a journal that speaks on our experiences, our diversity and our strength to continue into the future – with a little extra sparkle in our vision.

On behalf of the team, we would like to thank everyone who has supported TMUTAGA to bring this project from a plan to production in every capacity. To our team, sponsors, GCM Faculty and staff, and family friends, the production of this journal wouldn't be possible without their support and generosity. A very memorable thank you goes to our faculty advisor Martin Habekost, for his leadership, guidance and reinforcement through every stage of the journal.

With every piece of the puzzle that went into this incredible project, we are so excited about what we have accomplished this year. With many new experiences, we can confidently walk away this year with a greater understanding of the Graphic Arts industry and push these experiences to our personal careers and journeys in the future. With many learning curves, trial and error and ultimately times where the creative spot seemed out of reach, we are proud to showcase this collective of research and technology through a journal – one that had each of our own experiences wrapped in it from conception to execution.



Samir Macklai
President, TMUTAGA



SAMIR MACKLAI
(he/him)

TABLE OF CONTENT



10

The Effects Of Dark Patterns On Reuse

Claire Cambridge

44

Analysis Of French Colonial Influences On Print Culture In Indochina Vietnam From 1890-1945

Hung Ngoc Truong

88

Thermal-oxidative degradation of single-use paper cups: PHA bioplastics as an alternative to traditional polyethylene film coatings

Hayden Mcgreal

120

Gate-to-Gate Life Cycle Analysis of Wide-Format Flatbed Inkjet Printing

Zuha Waqar

168

Visual Cues And Sustainability: An Analysis On Consumer Perception Of Potato Chip Packaging Artwork In Canada

Anastasia Partserniak

234

Credits

248

Colophon

250

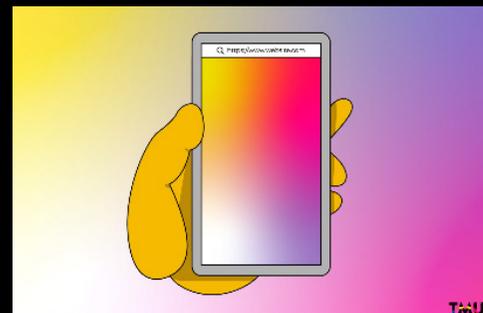
Sponsors

01



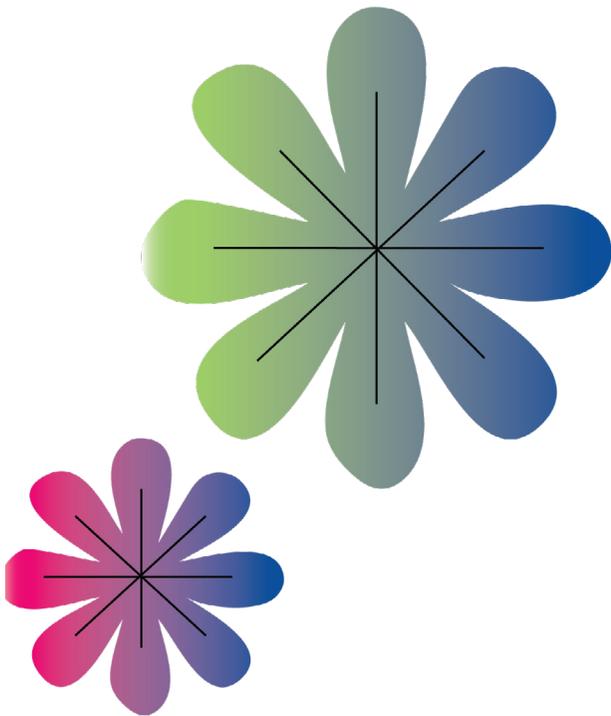
THE EFFECTS OF DARK PATTERNS ON REUSE

by Claire Cambridge



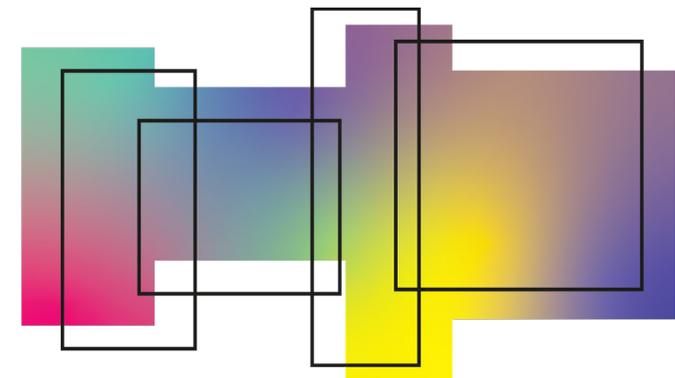
ACKNOWLEDGEMENTS

While writing my undergrad thesis, I received lots of support from my community. I would like to thank my supervisor, Rich Adams, for guiding me through the process. I would like to thank my professor, Ian Baitz, for creating a calming class environment that made me excited to start my thesis. Finally, I would like to thank my friends, coworkers, and my sister, Liv, for supporting me for the semester in and out of school.



ABSTRACT

Design is a powerful tool. Sectors of user experience (UX) design are made to ensure designs benefit its users. Other sectors of UX design aim to meet company goals of user attention, information, or profit. Furthermore, specific UX patterns have been discovered and are called dark patterns (DPs). A DP is a user interface (UI) design that intentionally changes the choice architecture in a way that benefits the company but not the user. This study adds to a small pool of research that describes the effects of using DPs. Specifically, if DPs affect whether people will use a website more than once (reuse) and what can affect reuse. A survey of 33 people was conducted to test the hypothesis that DP use decreases the reuse rate. The study found that reuse was affected by the type of DP (mild or aggressive), level of exposure, and participant mood. Results confirm that mild DPs have little backlash and found that users will continue to reuse them.



INTRODUCTION

Design is described as the “function, structure, and appearance of consumer-facing technologies” (Schreiber, 2020, p. 377). User experience (UX) design is a multidisciplinary field that aims to create an enjoyable experience with a product or service (Babich & Santos, 2020). UX designers look at all product or service functions from a humanistic perspective. This field is often mentioned in website design. User interaction (UI) design is a subset of UX design that looks solely at the interaction and visuals of a product or service. These terms are often used interchangeably despite the difference in definition (Babich & Santos, 2020).

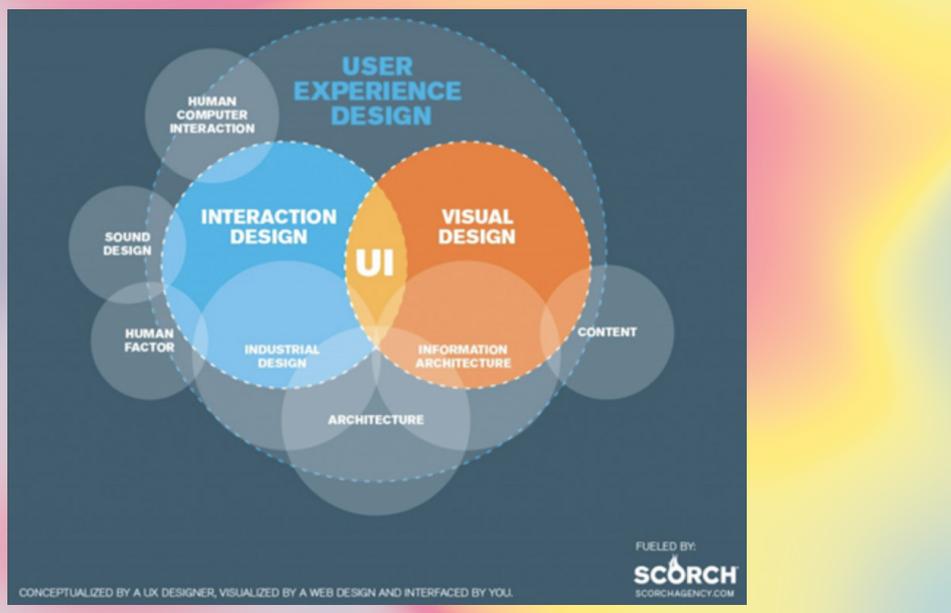


FIGURE 1. - SCORCH AGENCY, [PHOTOGRAPH]. RETRIEVED FROM [HTTPS://XD.ADOBE.COM/IDEAS/CAREER-TIPS/WHAT-IS-UX-DESIGN/](https://xd.adobe.com/ideas/career-tips/what-is-ux-design/)

Power of Design

UX design has the power to influence behaviour (Gray et al., 2018). Technology has become a significant portion of a person’s day (Di Geronimo et al., 2020). With this increase in technology use, UX design has a greater reach and stronger influence. By designing the functions of a website, UX and UI design has a direct influence on choice architecture. Choice architecture describes the way choices are presented, and the way choices are presented affects how people make decisions (Vedantam, 2022). In a study by Cornell University, a UI change increased doctors prescribing cheaper, generic brand medicine from 40% to 90% (Vedantam, 2022).

A field of design called human-centred design (HCD) created a framework to ensure designers stay user-focused (Di Geronimo et al., 2020). Despite this, designers’ focus still strays from the user to elsewhere. The shift is often from a user’s wants to a company’s wants, and is described as dark UX. Dark UX is made of specific UI choices called dark patterns (DPs). Common company goals include clicks, profit, or information.

This study adds to the small pool of research that uncovers the effects of DP use. A survey was conducted to discover the effects of DP use on participant reuse. This work adds to existing research by discovering the results and discussing how DPs affect reuse.

LITERATURE REVIEW

Taxonomy of Dark Patterns



DPs were defined academically in 2010 by Harry Bringull (Bringull, n.d.). Further research refined this original taxonomy. This wave of research defined DPs as a concept, increased awareness of this phenomenon, and showed that its use is problematic. The taxonomy used in this paper is shown below in Table 1.

TABLE 1 - (BRINGULL, N.D.; GRAY ET AL., 2018, 5)

TYPES OF DARK PATTERN	SUBTYPE	DEFINTION
Nagging		Redirection of expected functionality that can happen one or more times.
	Bringull's Roach Motel	The design is very easy to join, but hard to leave (e.g. a subscription).
Obstruction	Bringull's Price Comparison Prevention	A retailer restricts the use of or omits functions that allow users to compare the prices of items. Users become unable to make informed decisions.
	Intermediate Currency	Users spend real money to purchase a virtual currency which is then spent on a good or service.
Sneaking	Bringull's Sneak into Basket	When purchasing items, an additional item is snuck into a user's cart upon purchase. This is often done through the use of an opt-out radio button or checkbox on a prior page.
	Bringull's Hidden Costs	When unexpected charges appear during the last step of the checkout process (e.g. delivery charges, tax, etc.)
	Bringull's Bait and Switch	When a function has an unexpected and undesirable result (e.g. what is expected to be a "close" button is actually an add to cart button.)

- RESULTS CONTINUE ON THE NEXT PAGE

	Bringull's Forced Continuity	After a free trial of a service ends, a user's credit card silently starts getting charged without warning. In some cases, this is made worse by making it difficult to cancel the membership.
Interface Interference	Hidden Information	Options or actions are relevant to the user but not made immediately or readily accessible.
	Aesthetic Manipulation	Any manipulation of the user interface that deals more directly with form than function.
	Preselection	Any situation where an option is selected by default prior to user interaction.
	Toying with Emotion	Any use of language, style, colour, or other similar elements to evoke an emotion in order to persuade the user into a particular action.
	False Hierarchy	Gives one or more options visual or interactive precedence over others, particularly where items should be in parallel rather than hierarchical.
	Bringull's Trick Questions	Questions that are phrased in a way that appear to ask one thing at a quick glance, however when read carefully, asks something else entirely.
	Bringull's Disguised Ad	Adverts that are disguised as other kinds of content or navigation, in order to get you to click on them.
	Bringull's Confirmshaming	The act of guiltling the user into opting into something. The option to decline is worded in such a way as to shame the user into compliance.
Forced Action	Bringull's Friend Spam	When a website asks for a user's email or social media permissions under the pretence that it will be used for a desirable outcome (e.g. finding friends), but then spams your contacts in a message that claims to be from you.
	Social Pyramid	Requires users to recruit other users to use the service.
	Bringull's Privacy Zuckering	When users are tricked into publicly sharing more information about themselves than they intended to. Named after Facebook CEO Mark Zuckerberg.
	Gamification	Describes situations in which certain aspects of a service can only be "earned" through repeated (and perhaps undesired) use of aspects of the service.

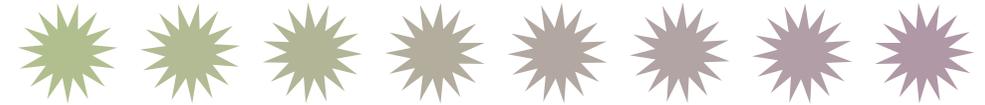
Research struggles to clearly define a DP. Some say DPs are merely “tricks” (Bringull, n.d.), where others describe them as intentional manipulation (Luguri & Strahilevitz, 2021).

Overall, definitions include some, or all, of these 4 topics:

1. The UI characteristics used
2. What it is that influences users
3. The role of the UX designer
4. The benefits and harms form the DP
(Mathur et al., 2021)

Researchers agree on the taxonomy and that DPs affect choice architecture (Mathur et al., 2021), but the role of the designer is less clear. When using DPs, designers are said to be aware of the manipulation present and intentionally use DPs (Di Geronimo et al., 2020; Gray et al., 2018; Luguri & Strahilevitz, 2021). It is possible that DPs can show up unintentionally, for example, by copying other designs. However, this is a result of poor design and is called an anti-pattern, not a DP (Gray et al., 2018). Moreover, it is difficult to study the intent of a designer. Some studies assume that any use of DPs, whether they are anti-patterns or not, are intentional to have a clear study. The benefits and harms of DPs are still currently being studied. It is clear that DPs are a strong tactic that helps a company reach their goals. Luguri & Strahilevitz (2021) discovered some short term effects of DP use. It is unclear what harms there

are in the long term. In this paper, DPs are UI designs that intentionally change the choice architecture in a way that does not benefit the user.



Power of Dark Patterns

DPs take advantage of human psychology to reach company goals (Luguri & Strahilevitz, 2021). It most often uses the fact that people follow the path of least resistance (Vedantam, 2022). As described previously, UI design affects the choice architecture, while DPs change the choice architecture to benefit a company’s goals. In other words, DPs ensure the option a company prefers is the easiest to choose.

On its own, making one option easier to choose than others does not mean an interface has a DP. In the generic medicine study by Cornell University, they made an interface that preferred the option that benefits the patient. An interface that includes DPs must push a user towards one or more choices and those choices must benefit the company. Pushing users towards certain choices has great strength. A study by Scott Halpern (2013) demonstrated how making one choice selected by default (preselection) informs people’s choices when making important decisions. Patients with terminal

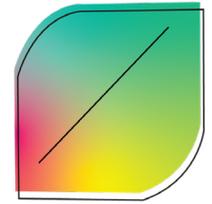
illnesses were asked to choose their preferred style of end-of-life care: life extension or comfort care. Compared to the control group, participants were more likely to choose the preselected option and less likely to choose against the preselected option (Halpern et al., 2013). After participants discovered that the preselected option was randomly chosen, only two participants changed their decision (Vedantam, 2022). Other studies show DPs increase the rate of accepting subscriptions (Voigt et al., 2021), sometimes doubling the acceptance rate (Luguri & Strahilevitz, 2021).

With the increased use of technology and smartphone access (Di Geronimo et al., 2020), DP use has steadily increased. It is present in e-commerce websites (Mathur et al., 2019), social media, and other mobile apps (Di Geronimo et al., 2020). Of the apps studied, Di Geronimo et al. found 95% used at least one DP. These apps included big brands such as Netflix and Spotify.

Studies on what happens to a user who is subjected to DPs is limited. Users become annoyed at different levels depending on the DP used (Luguri & Strahilevitz, 2021; Voigt et al., 2021). Mild DPs such as preselection are the most influential on the user and have little backlash (Luguri & Strahilevitz, 2021). Aggressive DPs, like roach motel or a long series of mild DPs, are less effective, more annoying, and users are less likely to continue to interact with the website (Luguri & Strahilevitz, 2021). Creating feelings of annoyance in customers is not beneficial for a business long-term as DPs decrease customer's

brand trust (Voigt et al., 2021), a key factor in continued use. What effect does DP use have on other factors to a long-term business relationship? Will DPs affect whether users use a website more than once? This paper aims to discover if DPs have an effect on users revisiting a website. In this paper, this action will be described as the reuse rate.

METHODOLOGY



Research Questions

How do the dark patterns preselection, hidden costs, and forced continuity affect a users reuse rate? Does level of exposure to DPs, user mood, and single-use rate affect the reuse rate?

To study the reuse rate of DPs, a 16 question survey open to the public was conducted using Google Forms. The following Likert scale questions were asked:

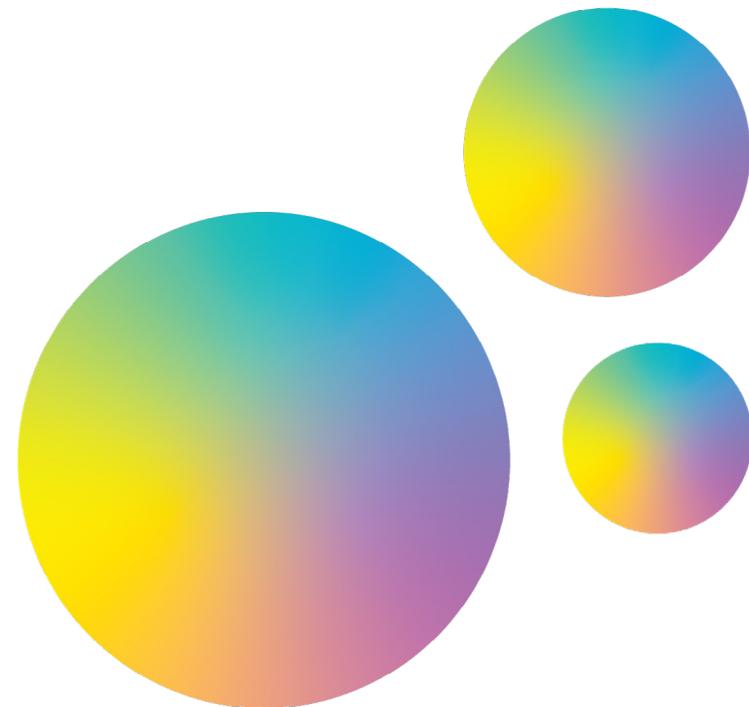
1. How often do you interact with similar interfaces / had similar experiences online?
2. How do you feel using this interface / with this experience?
3. How likely or unlikely would you use a website with this interface / experience one time?

4. How likely or unlikely would you use a website with this interface / experience more than one time?

These four questions were asked under four different DP conditions: control, preselection, hidden costs, and forced continuity. These DPs are shown in order, imitating the experience of a subscription service. This order and choice of DPs were chosen for three reasons: popularity of DPs used, increased immersion, and isolation of singular DPs. Subscription services are becoming increasingly popular online. The DPs chosen are ones that many people have experienced before and continue to be implemented. Secondly, when studying user experiences, participant immersion is key to receiving accurate answers. Recreating the flow of a standard subscription service increases immersion and accuracy. Lastly, the survey aims to see the effects of one DP. Subscription services have less complicated UIs compared to e-commerce. Using less complicated UIs makes it easier to isolate and study one DP.

Most questions were presented to the participant on 5-point Likert scales. Questions 3 and 4 showed the scale from “Very likely” to “Very unlikely.” Question 1 used a 6-point scale that ranged from “I have not seen similar interfaces within the last month” to “Multiple times per day”. Question 2 then asked participants to rate how they feel using this interface on a scale from 1 (“Happy and relaxed”) to 5 (“Aggravated and annoyed”) similar to Luguri & Strahilevitz (2021).

Statistical analysis using Google Sheets was used to reach conclusions based on the responses. To calculate data, responses were converted to numerical values. For each survey question, the averages and modes were calculated to understand the responses. Next, an ANOVA was conducted to determine if there is a relationship between the reuse rate and other survey questions. For significant relationships, a bonferroni post-hoc test was performed to see which specific relationships are significant. For the reuse rate, the post-hoc was calculated for all pairs of DPs. Other post-hoc tests compared the reuse rate and another variable (e.g. mood) of the same DP, for each DP.



Limitations

There are many limitations with this study. Due to time restraints, the survey was only available to the public for one week. This limits the number of participants to a small sample size of 33 people. The methods used to share the survey also limited its outreach. It was shared to the public using the researcher’s social media (e.g. Instagram), and personal outreach to friends.

Another limitation of this survey is its lack of interaction. When studying UX, researchers need to know what users will actually do by getting participants to interact with their website. In a survey, there is no interaction between participants and a website. Because of this, the results are limited to what participants say they would do. However, what participants say they would do may not align with what they would actually do. Despite this limitation, due to time and resources, a survey was the best way to collect data.

A final limitation of this study is that it is difficult to fully isolate results to a singular DP. Although precautions were taken, it is possible the rate of reuse may be affected by the culmination of DPs, rather than individual ones. This limitation is more prominent in interactive studies. While this study is not fully interactive, presenting the DPs similar to a subscription service may affect participants’ answers.

RESULTS

After a week, the survey reached a total of 33 participants. Almost all respondents answered all questions. One respondent missed question 14 and one respondent dropped-off at question 13. During calculation, the 3 blank responses were filled with the average answer.

Reuse Rate and Dark Pattern

It was hypothesised that DPs decrease the reuse rate. Participants were most likely to reuse the control example (4.15). The aggressive DP, forced continuity, showed the lowest rate of reuse (2.25).

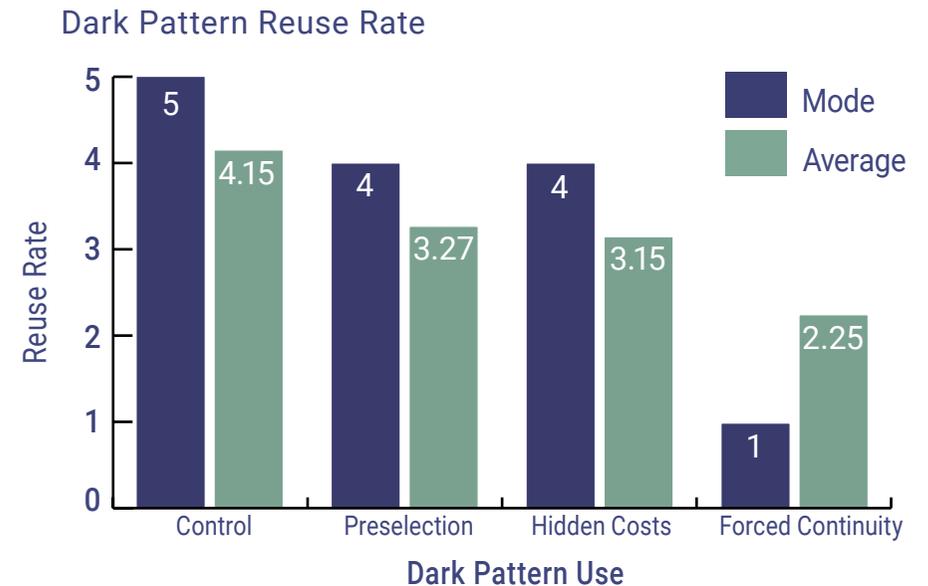


FIGURE 2. - ONLINE SURVEY, "HOW LIKELY OR UNLIKELY WILL YOU USE A WEBSITE WITH THIS INTERFACE / EXPERIENCE MORE THAN ONCE?". [BAR CHART].

A one-way ANOVA was used to test the hypothesis that DP use affects reuse rate. This test revealed that DPs have a significant relationship with reuse rate ($F(3, 128) = 14.11, p < .001$). This confirms the hypothesis that DPs affect reuse rate. The post-hoc t-test was performed to confirm which DPs affect the reuse rate. Relationships between all DPs except preselection and hidden costs showed statistical significance ($p < .0083$).

TABLE 2 - ONLINE SURVEY, PREVIOUS INTERACTION AND REUSE RATE (T-TEST). [TABLE].

	Control	Preselection	Hidden Costs	Forced Continuity
Preselection	t (32) = 3.58 p = .0011			
Hidden Costs	t (32) = 3.31 p = .0023	t (32) = 0.47 p = .0011		
Forced Continuity	t (32) = 6.54 p = 2.3e-7	t (32) = 3.69 p = 8.3e-4	t (32) = 3.21 p = .0030	

Single-Use

It was hypothesised that single-use rates would be similar to reuse rates and have an effect on the reuse rate. The survey found participants were most likely to use the control (3.94) and least likely to use preselection (2.61) one time. This differs from the reuse rates. A two-way ANOVA was used to find a relationship between single-use rate and reuse rate. The

two-way ANOVA found no relationship between single-use, and reuse ($F(3) = 1.23, p = .30$). This data did not confirm the hypothesis that single-use rates affect reuse rates.

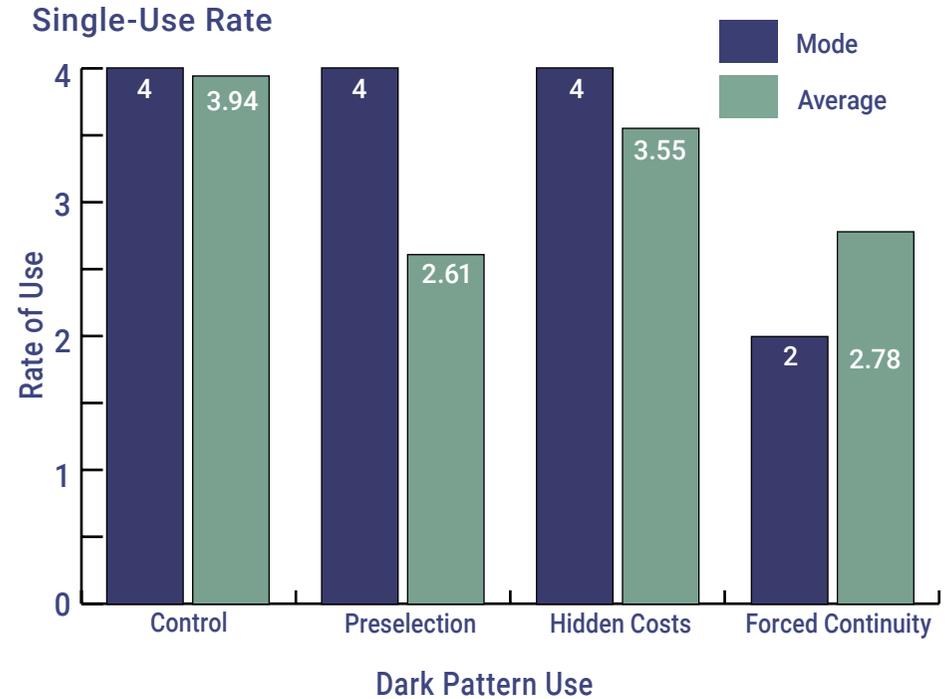


FIGURE 3. - ONLINE SURVEY, "HOW LIKELY OR UNLIKELY WILL YOU USE A WEBSITE WITH THIS INTERFACE / EXPERIENCE ONE TIME?". [BAR CHART].

Level of DP Exposure

It was hypothesised that previous exposure to DPs affect the reuse rate. Participants were exposed the most to hidden costs (3.67). On the scale used, this is between once a week and every other week. Participants were exposed to forced continuity (2.25) the least. This was about once a month.

Previous Interaction with Dark Pattern

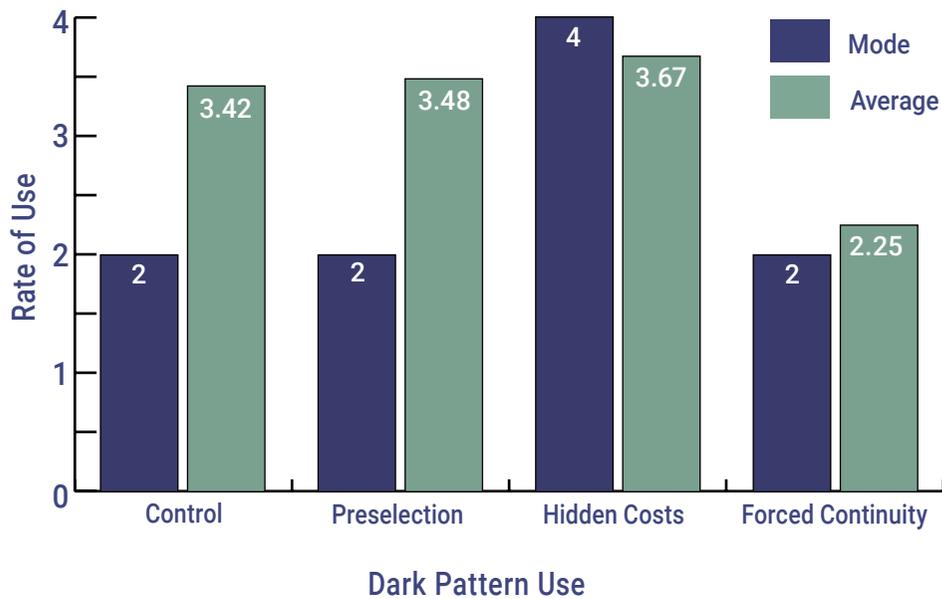


FIGURE 4. - ONLINE SURVEY, "HOW OFTEN HAVE YOU SEEN SIMILAR INTERFACES / HAD SIMILAR EXPERIENCES ONLINE?". [BAR CHART].

The two-way ANOVA found there is a relationship between participants' level of exposure to DPs and reuse rate ($F(3) = 2.67, p = .048$). This data confirms the hypothesis that level of exposure affects the reuse rate. The post-hoc test was used to confirm which relationship between level of exposure and reuse is significant. Only the control and hidden costs showed a significant relationship ($p < .0125$). For forced continuity, the averages for interaction and reuse were the same, resulting in a p-value of 1.

TABLE 3 - ONLINE SURVEY, PREVIOUS INTERACTION AND REUSE RATE (T-TEST). [TABLE].

	Control	Preselection	Hidden Costs	Forced Continuity
t-value	2.67	-0.96	-2.78	0
p-value	0.0119	0.34	0.009	1

Participant Mood

It was hypothesised that participant mood would have an effect on reuse rate. Participants reported feeling somewhat annoyed and aggravated when seeing forced continuity (3.90). The participants felt somewhat happy and relaxed when seeing the control (1.97).

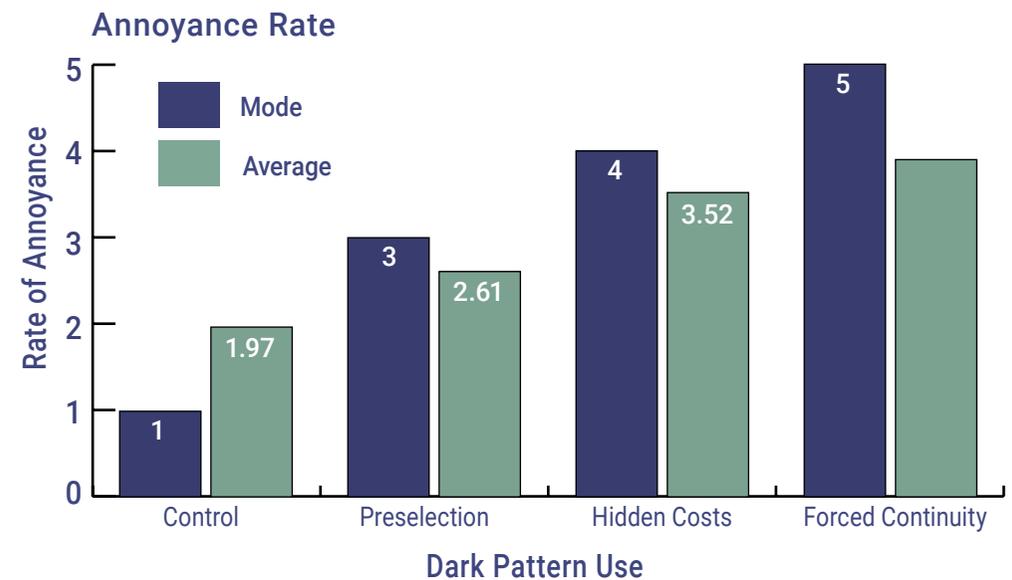


FIGURE 5. - ONLINE SURVEY, "HOW DO YOU FEEL WHEN SEEING THIS INTERFACE / HAVING THIS EXPERIENCE?". [BAR CHART].

TABLE 4 - ONLINE SURVEY, MOOD AND REUSE RATE (T-TEST). [TABLE].

	Control	Preselection	Hidden Costs	Forced Continuity
t-value	6.56	2.11	-1.05	-3.92
p-value	2.18e-7	0.04	0.3	4.3e-4

DISCUSSION

The survey aimed to answer two research questions: How do the dark patterns preselection, hidden costs, and forced continuity affect consumer reuse? Does the level of exposure to DPs, participant mood, and single-use rate affect the reuse rate? Results from the study found that reuse was affected by DP, participant’s level of DP exposure and mood, but not the single-use rate.

What Affects Reuse?



Dark Pattern

As hypothesised, participants were least likely to reuse forced continuity and were most likely to reuse the control. These findings add to the results found by Luguri & Strahilevitz (2021). Participants are more likely to stop using aggressive DPs (e.g. forced continuity) (Luguri & Strahilevitz, 2021). On

average, participants were neutral about reusing the mild DPs; preselection and hidden costs. This confirms that there is little backlash when interacting with mild DPs (Luguri & Strahilevitz, 2021) and users will continue to interact with them. The ANOVA found that a relationship exists between all DPs except for preselection and hidden costs. It is believed that there is no relationship between these two DPs because they are both mild DPs. This finding suggests that the type of DP, mild or aggressive, is more impactful on reuse than the specific DP.



Level of Exposure

Confirming the hypothesis, hidden costs had the highest level of exposure. Hidden costs is the only DP chosen that can be used outside of subscription services. With the boom in e-commerce (Mathur et al., 2019) and popularity of service apps such as Uber, the high level of interaction was not surprising. Similarly, forced continuity had the lowest level of exposure. Forced continuity requires users to sign up for a subscription service, while other DPs can be seen without user action. Research found that level of previous exposure only affects reuse in the control and hidden costs. The existence of a relationship between level of exposure and reuse aligns with the hypothesis. It is unexpected that this relationship only exists in the control and hidden costs. With the current data, it is unclear why the relationship is present. The post-hoc t-test

for forced continuity was inconclusive because, by chance, the averages were the same. This resulted in a t-value of zero. When all three DPs have different results, it is unclear why this relationship is present.



Participant Mood

According to the hypothesis, participants would feel happy and relaxed with the control and aggravated and annoyed with forced continuity. The results matched the hypothesis. These results also matched those found by Luguri & Strahilevitz (2021). In that study, aggressive DPs (e.g. forced continuity) caused the most emotional backlash, whereas mild DPs (preselection and hidden costs) had little emotional backlash (Luguri & Strahilevitz, 2021). It is likely that forced continuity is the most annoying because it regularly spends large amounts of user's money. Hidden costs, the second most annoying DP, still spends user's money, but at a smaller scale. It is also possible that these results were due to exposure to multiple DPs (Luguri & Strahilevitz, 2021). Studies discussing what affects participant mood will clarify this relationship. This study adds to previous research by confirming that strong moods affect reuse. A relationship between mood and reuse was found in the control and forced continuity. It shows positive moods increase reuse, and negative moods decrease reuse. Neutral moods of mild DPs do not affect reuse. This increases

the power mild DPs hold. They double the rate of acceptance, do not have an emotional backlash (Luguri & Strahilevitz, 2021), and people will continue using them.

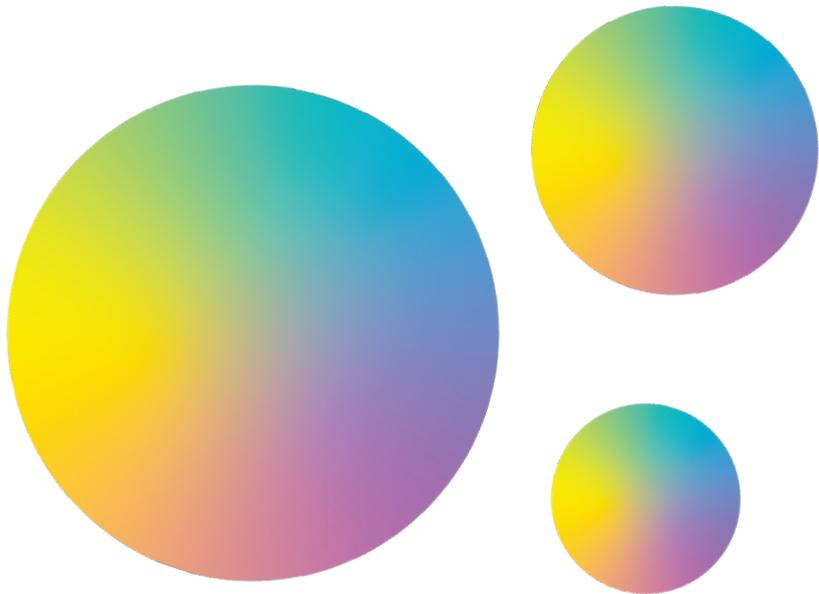
What does not Affect Reuse?

Single-Use



Contrary to the hypothesis, participants were least likely to interact with preselection one time. This result is believed to be because of the nature of the DPs. When experienced once, preselection requires users to take more action than forced continuity. Users need to be aware of preselected options, then if there is follow through, users may want to change or cancel their subscription. Forced continuity only requires action when users want to change or cancel their subscription. There is no relationship present between single-use and reuse. This result shows that users interact differently depending if they will use a website once or multiple times. This goes against the original hypothesis. It is believed that users have different criteria when stating if they would use a DP once or reuse it multiple times. For example, it is less likely that a user would interact with preselection multiple times on one website. This makes the impact of the one time a user interacts with preselection stronger. Results highlight the importance of considering multiple viewpoints in design.

More research is needed to discuss why relationships between reuse and the variables studied exist. Studies could explore the cause and effect of each relationship studied in this paper or discover new relationships with reuse. Further research should clarify the strength of the relationships present to further show why the results are important.. If the relationships present are strong, it highlights the effects of DP use further. Further study on other effects of DP use is needed. For example, studying the relationship between DPs and brand trust. Due to the limitations discussed in the methodology, it is recommended to study larger samples and use immersive studies.



CONCLUSION

This study aimed to discover the relationships between reuse and DPs, level of exposure to DPs, participant mood, and single-use rate. This study found that users choose to use an interface more than once based on the type of DP they encountered, how encountering a DP affected their mood, and how often they had encountered the DP before. If a DP is more aggressive, a user is less likely to reuse an interface. If encountering the DP affects a user's mood negatively, they are less likely to reuse an interface.

DPs are still a new topic of study. To understand the full implications of DP use, further studies should be conducted. Studies could clarify the results found in this paper or discover new relationships. This study adds to the small pool of research that discovers the effect of DP use.

Becoming aware of the effects of DP use highlights the dangers or benefits of using them. This study confirms the dangers of using mild DPs. Users are affected by aggressive DPs, but have no problems reusing mild DPs. When considering their strength, this is dangerous for potential users. As long as they are in use, mild DPs will continue to trick users. Businesses may benefit from DPs, but at what cost?

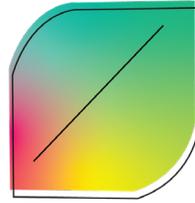
REFERENCES

- Babich, N., & Santos, A. (2020, November 24). What Is UX Design? User Experience Definition | Adobe XD Ideas. Adobe XD | Fast & Powerful UI/UX Design & Collaboration Tool. Retrieved March 1, 2022, from <https://xd.adobe.com/ideas/career-tips/what-is-ux-design/>
- Bringull, H. (n.d.). Dark Patterns. Retrieved February 12, 2022, from <https://www.darkpatterns.org/>
- Di Geronimo, L., Braz, L., Fregnan, E., Palomba, F., & Bacchelli, A. (2020, April). UI Dark Patterns and Where to Find Them: A Study on Mobile Applications and User Perception. Proceedings of the 2020 CHI conference on human factors in computing systems, 1-14. <https://dl.acm.org/doi/pdf/10.1145/3313831.3376600>
- Gray, C. M., Kou, Y., Battles, B., Hoggatt, J., & Toombs, A. (2018, April). The Dark (Patterns) Side of UX Design. Proceedings of the 2018 CHI conference on human factors in computing systems, 1-14. <https://dl.acm.org/doi/pdf/10.1145/3173574.3174108>
- Halpern, S. D., Loewenstein, G., Volpp, K. G., Cooney, E., Vranas, K., Quill, C. M., McKenzie, M. S., Harhay, M. O., Gabler, N. B., Silva, T., Arnold, R., Angus, D. C., & Bryce, C. (2013). Default options in advance directives influence how patients set goals for end-of-life care. *Health affairs (Project Hope)*, 32(2), 408–417. <https://doi.org/10.1377/hlthaff.2012.0895>

- Luguri, J., & Strahilevitz, L. (2021). Shining a Light on Dark Patterns. *Journal of Legal Analysis*, 13, 43-109. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3431205
- Mathur, A., Acar, G., Friedman, M. J., Lucherini, E., Mayer, J., Chetty, M., & Narayanan, A. (2019, November). Dark Patterns at Scale: Findings from a Crawl of 11K Shopping Websites. Proceedings of the ACM on Human-Computer Interaction, 3(CSCW), 1-32. <https://dl.acm.org/doi/10.1145/3359183>
- Mathur, A., Mayer, J., & Kshirsagar, M. (2021, May). What Makes a Dark Pattern... Dark? Design attributes, normative considerations, and measurement methods. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1-18. <https://arxiv.org/pdf/2101.04843.pdf>
- Schreiber, A. (2020). Privacy's Blueprint: The Battle to Control the Design of New Technologies. By Woodrow Hartzog. (79th ed., Vol. 2). The Cambridge Law Journal. doi:10.1017/S0008197320000355
- Vedantam, S. (2022, January 3). Choose Carefully [Audio podcast]. Hidden Brain. <https://hiddenbrain.org/>
- Voigt, C., Schlögl, S., & Groth, A. (2021, July). Dark Patterns in Online Shopping: Of Sneaky Tricks, Perceived Annoyance and Respective Brand Trust. *International Conference on Human-Computer Interaction*, 143-155. <https://arxiv.org/abs/2107.07893>

APPENDIX

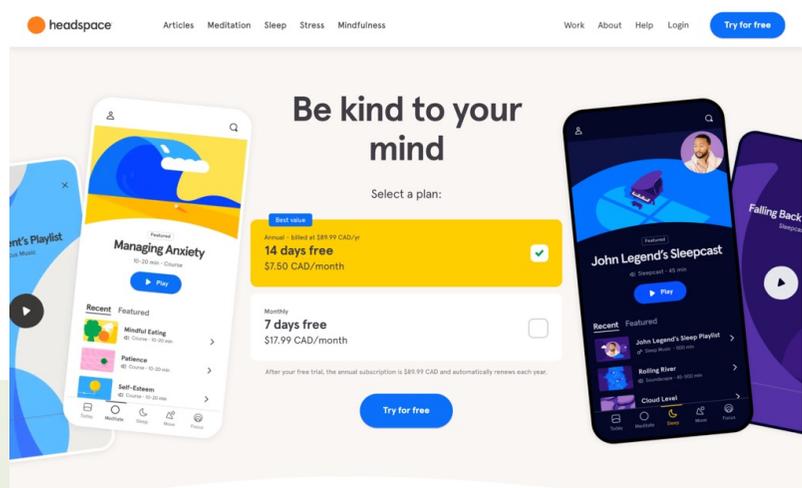
DP Conditions



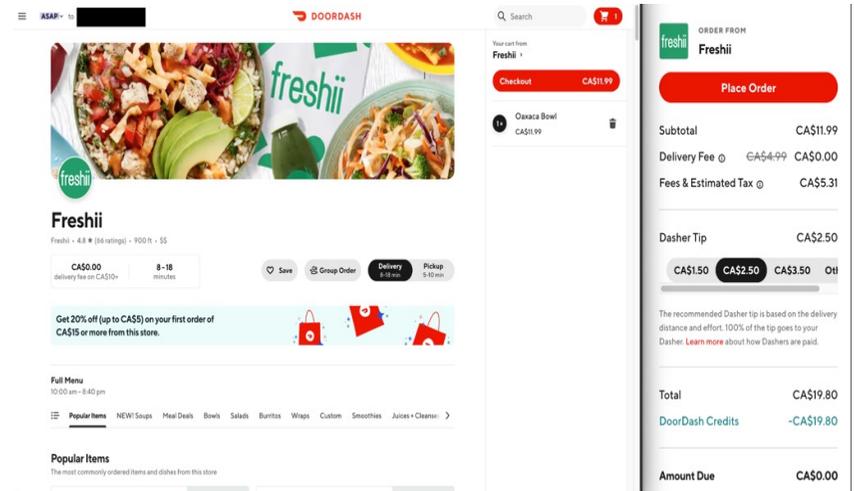
Control



Preselection



Hidden Costs



Forced Continuity



STEEZY

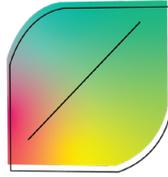
Your subscription is now active

Hey there,

Your STEEZY subscription has started and your payment method has been charged.

Survey Results

Section A: Control



HOW OFTEN DO YOU INTERACT WITH SIMILAR INTERFACES?

Multiple times a day	About once a day	About once a week	About 2 times per month	About once a month	I have not seen similar interfaces within the last month
12.1%	15.2%	21.2%	15.2%	27.3%	9.1%

HOW WOULD YOU FEEL USING SIMILAR INTERFACES?

1 (Happy and relaxed)	2	3	4	5 (Annoyed and Aggravated)
39.4%	36.4%	12.1%	6.1%	3%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE ONCE?

Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
36.4%	36.4%	12.1%	15.2%	0%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE MORE THAN ONCE?

Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
48.5%	30.3%	9.1%	9.1%	3%

Section B: Preselection

HOW OFTEN DO YOU INTERACT WITH SIMILAR INTERFACES?

Multiple times a day	About once a day	About once a week	About 2 times per month	About once a month	I have not seen similar interfaces within the last month
15.2%	9.1%	24.2%	18.2%	27.3%	6%

HOW WOULD YOU FEEL USING SIMILAR INTERFACES?

1 (Happy and relaxed)	2	3	4	5 (Annoyed and Aggravated)
12.2%	27.3%	48.5%	6.1%	3%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE ONCE?

Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
24.2%	33.3%	18.2%	21.2%	3%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE MORE THAN ONCE?

Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
12.1%	39.4%	18.2%	24.2%	6.1%

Section C: Hidden Costs

HOW OFTEN HAVE YOU HAD SIMILAR EXPERIENCES?

Multiple times a day	About once a day	About once a week	About 2 times per month	About once a month	I have not seen similar interfaces within the last month
12.1%	6%	48.5%	12.1%	12.1%	0%

HOW WOULD YOU FEEL WITH THIS EXPERIENCE?

1 (Happy and relaxed)	2	3	4	5 (Annoyed and Aggravated)
3%	15.2%	12.1%	54.5%	9.1%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE ONCE?

Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
18.2%	48.5%	21.2%	9.1%	3%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE MORE THAN ONCE?

Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
12.1%	36.4%	12.1%	33.3%	6.1%

Section D: Forced Continuity

HOW OFTEN HAVE YOU HAD SIMILAR EXPERIENCES?

Multiple times a day	About once a day	About once a week	About 2 times per month	About once a month	I have not seen similar interfaces within the last month
3.1%	0%	15.6%	12.5%	37.5%	0%

HOW WOULD YOU FEEL WITH THIS EXPERIENCE?

1 (Happy and relaxed)	2	3	4	5 (Annoyed and Aggravated)
6.5%	6.5%	22.6%	12.9%	38.7%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE ONCE?

Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
9.1%	27.3%	12.1%	30.3%	18.2%

HOW LIKELY OR UNLIKELY WOULD YOU USE A WEBSITE WITH THIS INTERFACE MORE THAN ONCE?

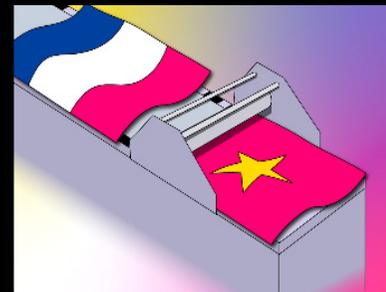
Very Likely	Someone Likely	Neither Likely or Unlikely	Somewhat Unlikely	Very Unlikely
6.1%	18.2%	12.1%	18.2%	42.4%

02



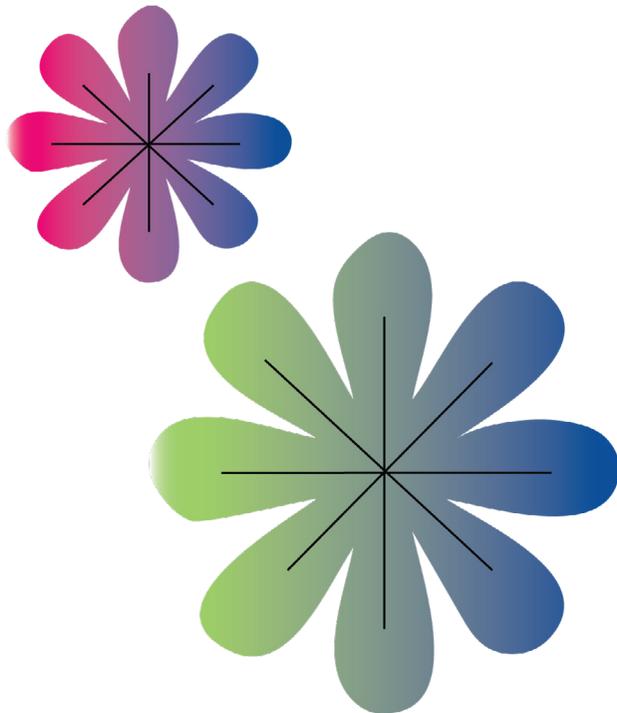
**ANALYSIS OF FRENCH
COLONIAL INFLUENCES
ON PRINT CULTURE IN
INDOCHINA VIETNAM
FROM 1890-1945**

by Hung Ngoc Truong



ACKNOWLEDGEMENTS

I would like to extend my gratitude to Prof. Ian Baitz for helping and guiding me through my undergraduate thesis. In addition to in-class materials, Prof. Ian Baitz was always available after class hours for support. Prof. Ian Baitz helped me frame a conceit and clear research question and research methodology. Finally, I would also like to thank my friends and family for their support throughout my time at Toronto Metropolitan University.



ABSTRACT

The colonial period was an important international event that introduced new technologies to developing colonies. France's expansion in Southeast Asia, specifically Vietnam, is the primary focus area of the thesis. The introduction of the printing press revolutionized Vietnamese technology and how people communicate on a larger scale. Multiple perspectives and qualities of life were considered in assessing the success of Vietnam's print culture during the French occupation. Even though the suppression of freedom of speech and the press were present, the print culture continued to thrive, setting the foundation for Vietnam newspapers and modern publications. Newspapers were the pinnacle of print culture and Vietnamese adaptation from existing French technology. It allowed Vietnam to publish and circulate patriotic prints while evading censorship. The thesis examined the chronological development of Vietnam print culture through multiple phases and sources, starting from primitive woodblock technology, to lithography and letterpress, and finishing with the modern printing process and the mass production of newspapers. Secondary sources, such as newspapers from different publications, are presented to showcase the content and print quality. The results demonstrated how the French occupation was essential for the development of Vietnam's print culture. Despite the struggle for political power and the initial purpose

of spreading French propaganda through printed matters, education and literacy improved gradually and had a long lasting impact on patriotism and anti-colonial ideologies.

TABLE 1 - TRANSLATION FOR KEY INFORMATION IN VIETNAMESE, CONTEXT PROVIDED

ORIGINAL VIETNAMESE	ORIGINAL FRENCH	ENGLISH TRANSLATION
Trung Kỳ	Annam	Mid-Central Region of Vietnam
Bắc Kỳ	Tonkin	Northern Region of Vietnam
Nam Kỳ	Cochinchina	Southern Region of Vietnam
Quốc Ngữ	L'alphabet	Romanized Alphabet
Nhà Nguyễn	N/A	Nguyễn Dynasty
Cảng Đà Nẵng	Tourane Port	Tourane Port
Việt Nam Độc Lập Minh Hội	Viet Minh	Viet Minh Communist Party
Nguyễn Ái Quốc/Hồ Chí Minh	Nguyễn Ái Quốc/Hồ Chí Minh	Leader of Viet Minh Communist Party, a key figure in revolutionary timeline
Mô Làng	N/A	Local messenger, primary oral communications
Vua Tự Đức	Empereur Tu Duc	The fourth emperor of Nguyễn Dynasty, a puppet government for France

RESEARCH QUESTION

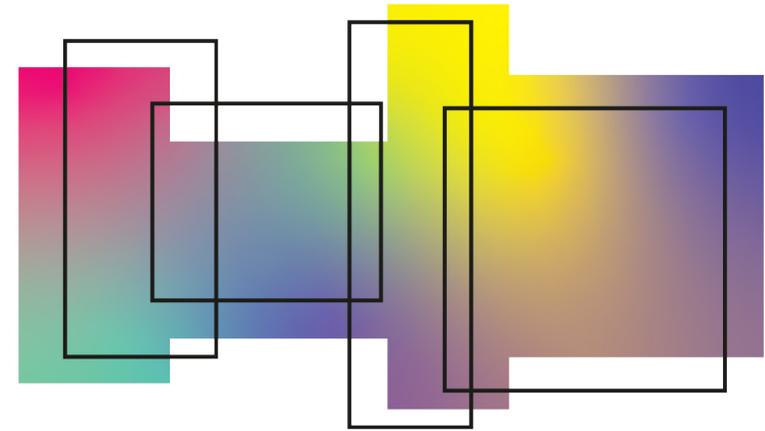
How Did French Colonialism Impact Vietnam’s Print Culture and Print Sustainability from 1890 to 1945?

INTRODUCTION

Colonialism was a result of the expansion and greed of Western capitalism; their impacts can be seen vividly in the development of 35 Asian colonies between 1850 –1945. France invaded Vietnam in 1857 through orders of Napoleon III. It went beyond missionary to become “the upsurge of French capitalism, which generated the need for overseas markets and the desire for a larger French share of the Asian territories conquered by the West” (Turley, p.5). This thesis focused specifically on Vietnam’s print culture and social history through the use of print, and compared the sustainability of print culture under the French administration and Việt Minh Communist movements. It is important to note that the majority of secondary sources are newspapers because other printed matters such as short books, flyers, or propaganda before 1945 were lost due to long periods of war.

The print culture created “public and clandestine” (McHale, p.9) spheres in Vietnam which increased the circulation of Quốc Ngữ and information to the illiterate lower classes. Keeping the idea of accessibility in mind, languages and complex theories were simplified for the appropriate audiences. All printed matter existed in one of four stages: “the creation and publishing of printed matter, through its control by the state, to its circulation and appropriation” (Mchale, p.10). All four stages were considered and examined to determine the impacts and successes of all printed matters. The thesis further examined the overall public sphere, the audiences of the print culture, how well they understood the information, and how censorship impacted the circulation of patriotic materials. Both the literature review and research methodology examined the diversity and challenges of printing in a censored print culture. When political critiques were censored, religious and Confucianist books and tracts covered this gap and continued to sustain the printing industry. Previous research of the colonial period often only examined the economic, social, or political turmoils, emphasizing the results of censorship but not the actual content being written and their intended audience. This paper will attempt to fill this gap and further examine the development and localization of Vietnamese newspapers. The chronological timeline of printed materials in Vietnam should demonstrate their adaptation to evade censorship and the ability to promote anti-French colonialism.

The ultimate goal of this thesis was to dismiss the notions that French administrators dominated the print culture throughout their occupation with studies and sources suggesting that the Vietnamese were able to adapt and evade censorship.



LITERATURE REVIEW

Throughout the modern history of the 20th century, France’s influence can be seen through the progression and development of their respective colonies. Vietnam is arguably one of France’s most profitable colonies, which led to a large influx of investments. The country experienced rapid social reforms within 60 years of occupation. This thesis will specifically focus on the development of communication and information as a result of the printing press. Three areas of focus to explore are:

1. The transitional period from woodblock printing to lithography

2. The development of newspapers, printed books, and propagandas throughout the country
3. The overall impact on education, the spread of information, and quality of life

Introduction to Colonial Setting

“The conquest and colonization of Vietnam began gradually but accelerated through the mid 1800s” (Llewellyn, Southey, Thompson, p.3). Historical data recorded the earliest presence of Catholic missionaries in the 1600s and French traders in the 1700s in Vietnam. Part of their colonization agendas included assimilating the local population to French customs to gain their full support. “The Nguyễn emperors, nervous about the effects of Catholicism on their people, attempted to nullify missionary activity” (Llewellyn, Southey, Thompson, p.4). The Nguyễn’s anti-Western policies ultimately hindered their social and technological progress. Most progressions came from China and sparked the invasion of Tourane Port. The French invaded Tourane Port in 1857 and pressured the Nguyễn government to seek a peace treaty and become a colony of France. The Treaty of Saigon signified an upcoming transitional period in Vietnamese history with social and technological reforms. “In this treaty, Tự Đức ceded control of Saigon and Vietnam’s three southernmost provinces including Biên Hòa,

Gia Định and Định Tường to the French administrator. Together these territories were to form the French colony of Cochinchina. France was also given sovereignty over Poulo Condore, an island off the southern coast of Vietnam, and full access to the ports of Tourane and Huế.” (Llewellyn, Southey, Thompson, p.20). According to The Treaty of Saigon, Emperor Tự Đức and his government became puppets functioning through French endorsements which allowed French colonizers to expand their control rapidly throughout the country. “By the end of 1884... the government in Paris proclaimed the Union Indochinoise, which comprised three Vietnamese regions: Cochinchina (south), Annam (central), Tonkin (north), as well as Cambodia. Laos would be added to the Union in 1893” (Llewellyn, Southey, Thompson, p.10). Unsatisfied with their expansion in the South, French administrators expanded to the Tonkin region in the North to open trades with China and, at the same time, censor Confucian teachings and information. The following section will examine the history of the printing press, a French product, and its effect on the public sphere in regards to accessibility, social reform, and print culture.

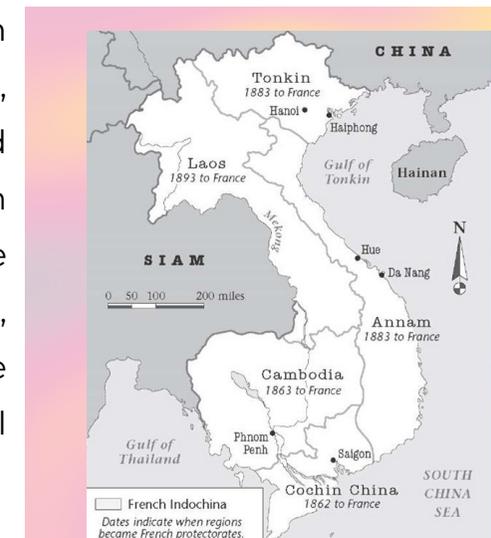


IMAGE 1.1 - REGIONAL DIVISIONS AND BORDERS FROM FRENCH ADMINISTRATION AFTER THE TREATY OF SAIGON

Woodblock vs. Lithography and Letterpress Print Process

Vietnam's print culture before French colonization consisted of engraving woodblocks to print or write on. This print process was exclusive to Buddhist temples and information was reserved for Buddhist teachings and transcripts. During this time, books from China were being reproduced at a slow rate and were only accessible for Buddhist practitioners. The woodblocks were made from bamboo and they can be directly written on or engraved. Additionally, engraved wood blocks can be covered with ink and reprinted on paper. The levels of influence exerted to the public and the information available to them can be categorized into three categories (Nguyen, Pham, Nguyen, p.52):

1. Temples that wielded a wide influence stretching over multiple provinces
2. Temples with limited influence on other temples within the province
3. Temples with no influence on other neighboring temples

The purpose of "traditional book printing is oriented towards" (Nguyen, Pham, Nguyen, p.60) and limited to:

1. Books for the education of resident novices and monks
2. Books printed for dissemination among the community and populace for the propagation of Buddhism

As early as 1862, the French administration established printing infrastructures in Cochinchina to introduce "Western typography" and officialize "Quốc Ngữ" or the Western Romanized alphabet system. It is important to note that the spread of language was the preparation for future assimilation. Their intention was to use the printing process to speed up the spread of censored information and solidify their occupation status. From existing French technology, the Vietnamese were able to adapt this process and printed their own publications to avoid French censorship. French censorship was "considered "selective", there was heavy censorship on "subversive" printed matters with little regard to what information reached the vast majority" (Mchale, p.36). In the 20th century, printing on paper such as lithography gradually became more popular and replaced oral modes of communication and old methods of writing on bamboo or wooden strips.

One of the first three printing houses to use Romanized typography and wood or metal word blocks in Vietnam was Imperial de Lang Song in 1868. Father Paul Maheu was an important figure as he brought French technicians, wide-

format lithographic presses, inks, and newspapers for Imperial de Lang Song. “According to Mémorial de Qui Nhon in 1922, 18,000 weekly newspaper issues, 1,000 books, and 32,000 other printed materials are printed annually at Imperial the Lang Song” (Nguyen, p.1), compared to the annual production rate of woodblocks which was under 100. With this huge influx of information, the general public gradually adapted “Quốc Ngữ” or Romanized alphabet and over time the level of literacy and accessibility to printing or printed materials increased. Below are two images comparing the quality and consistency of woodblock (left) and wide format lithography press (right):

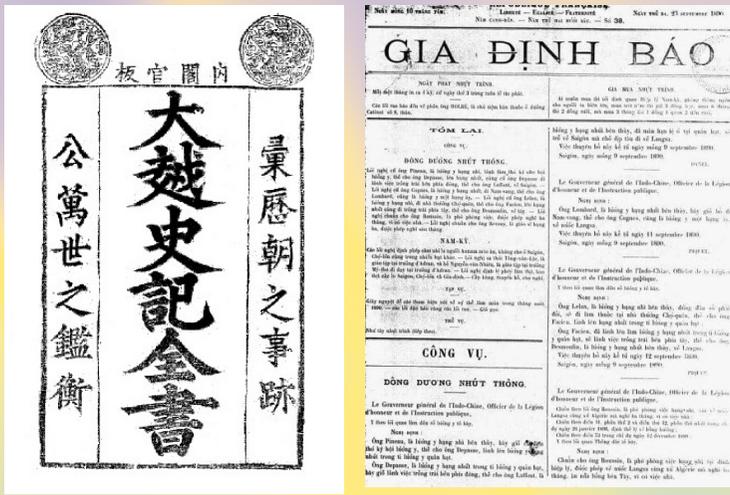


IMAGE 1.2 - WOODBLOCK PRINTING (DIGITALIZED) RETRIEVED FROM KHÊ HỒI TEMPLE (LEFT) VS GIA ĐỊNH NEWS PUBLISHED THROUGH WIDE-FORMAT LITHOGRAPHY PRESS (RIGHT)

Commercializing Printing and “The Public Sphere”

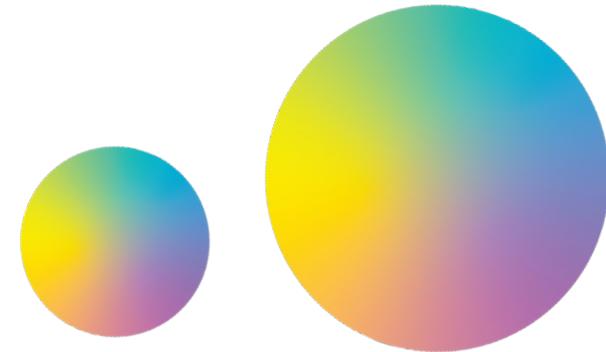
Prior to the French occupation, the print culture under the Nguyễn dynasty was pale and underdeveloped. For nearly 50 years from 1802 – 1850, the Nguyễn dynasty greatly hindered the development and spread of printing technology as they still relied on woodblock printing and word of mouth. A closed-door period began when the Nguyễn dynasty expressed their retaliation against Western countries by cutting off trade, indirectly suppressing the adaptation of the press. In addition to poor and corrupted governing bodies, the print networks were also exclusive to certain areas and Buddhist temples. “The first emperor of the Nguyen dynasty ordered the people to turn in their “hidden” books and burn information related to Sơn Tây rebel forces” (McHale, p.14). Emperor Minh Mạng, the second emperor of the Nguyễn dynasty, also ordered all woodblocks and books to be sent to Huế capital for federal control which greatly reduced the reproduction of literacy for the public.

As a result of the printing press, the concept of the public sphere was created. The public sphere was defined as the space below the state and above villages, which can be understood as referring to the average citizen with the ability and capability to learn, read, and speak Vietnamese (Mchale). Hanoi and Saigon were the largest metropolitan cities of

Vietnam in the 1920s, so the print culture was able to flourish and became more accessible. Ultimately, these two cities monopolized the production of printed matters and became the central hub for intellectual, literary, religious, and political debates. Minor cities in the Annam regions were still under the influence of the Nguyễn Dynasty and maintained their old Confucianism traditions of life, so little progress was seen until new learning reached the region.

When the French administration brought over technology and improved the quality of information, a “robust public sphere” (McHale, p.13) was created in 1865. We see the first newspaper “Gia Định Báo” or “News of Gia Dinh”. Even though it was controlled and run by the French administration, this was the public’s first exposure to modern information and the lithography press. Later in 1883, the first publication was owned by Vietnamese students “Nam Kỳ Báo” or “Southern News”. With heavy French censorship, both publications embraced the “read and enjoy” (Nguyen, Pham, Nguyen, p.55) print culture, meaning information understood by Vietnamese is limited to fictional Chinese tales and non-government related news. Despite censorship, the printing of newspapers aided the spread of information and popularized Romanized Vietnamese alphabets. During this period, the country’s print culture from Tonkin, Annam, and Cochinchina regions varied due to different levels of French and Western influence. “The transformation of Southern print culture was accompanied

by shifts in social hierarchy that came to shape the emerging public sphere” (McHale, p.13). In contrast, the Annam and Tonkin region was still under the influence of Confucianism studies, so there was initial resistance to embracing new technologies and romanized scripts. The print process in these regions included importing and translating books from China to evade French censorship. In these regions, prints from China were considered the new learning. Intellectual elites such as Huỳnh Thúc Kháng and Trần Quý Cáp encouraged all to learn both Sino-Vietnamese and Romanized Vietnamese as resistance to the French administrator. They also advocated for overseas travel to other Asian and European countries to embrace new learning for the purpose of liberation. Vietnamese intellectuals were motivated to learn the new romanized language system to better understand the mechanism of colonialism and reform their country’s education. Under the colonial climate, the Tonkin Free School was opened in 1907 and taught through printed textbooks and a romanized Vietnamese script system. The increase in general education and literacy was the direct result of the printing press.



Social Reforms, Adaptation, and Challenges to Printers

Newspapers were a significant product of Vietnam's print culture which signified a transition period to modernity. After the Treaty of Saigon and several decades of French influence, the print culture expanded to the local level where Vietnamese were allowed to own their own publication house. But at the same time, French censorship was an important factor that limited the growth and development of printing and information in general.

In addition to censorship of Vietnamese publications, "the repression of the import, publication, and circulation of printed matter went through several phases. From 1908 to 1920, the French anxiously attempted to stop Chinese-language materials from entering the country" (McHale, p.38). But from 1936–1939, publishing flourished thanks to the policies of the Popular Front from France. The local administrator loosened their censorship and control over publishers and there was more freedom to print, but this brief period ended because of the oncoming war in 1939. Due to political conflicts between French administrators and Communist Việt Minh, Vietnamese accused of being affiliated with the Communist Party were subjected to racial prejudices and unlawful arrests. "On October 12 alone, the Saigon-Cholon police carried out seventy-seven raids on suspected Communism and seized almost three

thousand tracts and brochures. In that month, the French administration shut down nineteen "communist" newspapers and raided bookstores, printing presses, and other stores to seize communist writings" (McHale, p.55). As mentioned in the previous paragraph, French censorship, although brutal, was unorganized and selective, so those who managed to evade censorship were able to create three realms of printing. This can be considered the foundation for Vietnam's print culture beyond 1945. These three realms included Confucian, Communist, and Buddhist prints, and each sector experienced different levels of French censorship. Below are images of printed matters other than newspapers, demonstrating the diversity and capabilities of Vietnamese publishers:

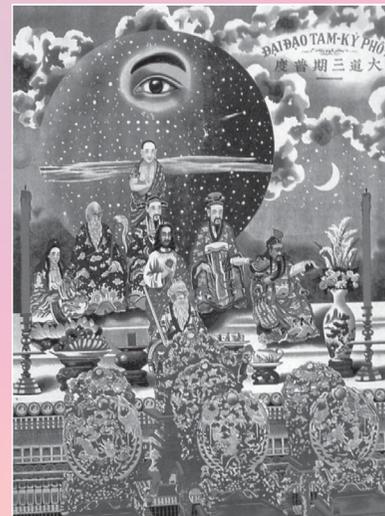


IMAGE 3.1 - POSTER PRINTS FOR RELIGIOUS GROUP, CAO ĐÀI



IMAGE 3.2 - A MONK READING TO HER NOVICE IN THE COUNTRYSIDE, INFORMATION REACHES THE "PUBLIC SPHERE"

When commercial prints were censored, Communist prints thrived and to an extent sustained the print culture through hidden small-scale publishers or Communist-affiliated publishers. “Vichy censors did not simply target political writings. As a southern police censor puts it, the problem with the Vietnamese was that they liked to read publications that “pandered to their base instincts”” (McHale, p.56). The previous statement addressed the spread of Communist prints which promoted patriotism and criticized French policies. A wide range of Communist printed materials including “... memoirs and a collection of communist and Viet Minh tracts and newspapers dating from 1929 –1931 and 1940 –1945 from central and northern Vietnam” (McHale, p.103) were most common. The spread of Communism was adopted by the public via the Romanized alphabet and created a new audience who were literate in Quốc Ngữ and possessed some level of support for the Viet Minh Communist Party. The purpose of communist prints was to simplify the Marxist-Lennist concept of Communism to the general public by using simple terminologies and real life examples. In the revolutionary lens, the Communist party struggled to reach the individual level and the concept of Communism was “alien and new” (McHale) to the public. Therefore, their print culture was somewhat ineffective over time. The problem was the ongoing status of unified languages in Vietnam where French, Classical Chinese, Sino-Vietnamese, and Quốc Ngữ

co-existed. This made the spread of information difficult as Communism concepts were not easily understood by the lower classes. The public and elites were encouraged to study Quốc Ngữ for the purpose of liberation. In 1929, Búa Liềm or Hammer and Sickle was published, and the book was organized in a roadmap structure, explaining Communist terminologies and revolutionary concepts targeted towards the colonial administrator. The success of this book led to mass production and was considered the “central organ of the Indochina Communist Party” (McHale, p.173). Below are two images which showcase the published Cứu Quốc Newspaper published by Hồ Chí Minh and Việt Minh Party. The name Cứu Quốc directly translates to Save Our Country. Vietnamese printers improved the print process with stylized titles and smaller font sizes. The newspaper contributed to the mass communication of Viet Minh soldiers and patriotic civilians through anti-France articles such as Tinh Thần Khởi Nghĩa Nam Kỳ Trỗi Dậy or The Revolutionary Spirit of Southern Provinces and Đừng Nộp Thóc Cho Giặc or Don’t Give Your Rice to The Enemy. Educating the population about the crimes of French occupants was essential to evoking regional revolution and resistance against the French administration. Below are two images depicting the adaptation of French technology for Vietnamese benefits.

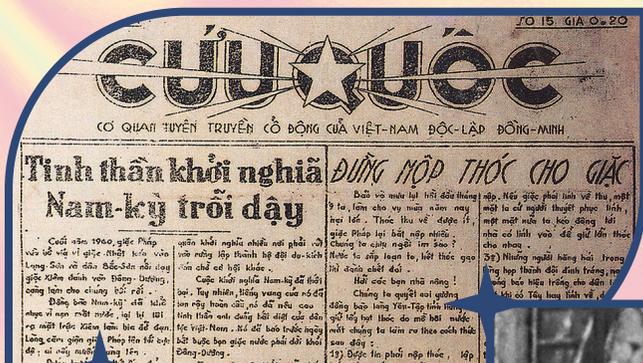


IMAGE 3.3 - Cứu Quốc PUBLICATION WRITTEN BY NGUYỄN ÁI QUỐC AND PUBLISHED FOR VIỆT MINH SUPPORTERS

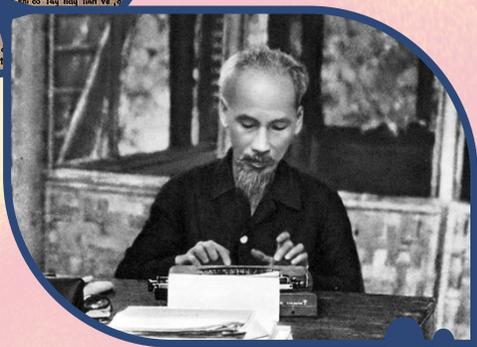


IMAGE 3.4 - NGUYỄN ÁI QUỐC USING A TYPEWRITER, ADAPTATION AND POPULARIZATION OF FRENCH TECHNOLOGY

RESEARCH METHODOLOGY



This section of the paper focuses on The History of Press Regimes in Vietnam Vol.1: Prior To August Revolution 1858 –1945 written by Journalist/Lawyer/Doctorate Phan Đăng Thanh. The following sections will provide chronological insights into and development of newspapers in Vietnam under different colonial periods, respectively. They will also speak about social impacts and the limitations of newspapers.

Newspapers are essential and original methods of mass communication produced by the printing press. With speculation on Western countries, newspapers have been in circulation as early as the 17th century. According to the World Association, it recognizes the weekly “Relation” in 1605 as the first newspaper in the world produced by The Gutenberg Press. From a comparative perspective, Vietnam was far behind the modern world by two centuries

IMAGE 4.1 - SECONDARY SOURCE FOR RESEARCH METHODOLOGY, ORIGINAL TEXT IN VIETNAMESE, QUOTATIONS AND IDEAS ARE TRANSLATED INTO ENGLISH



and did not possess any form of mass communication. In retrospect, Vietnam had only 60 years to establish and adopt a print culture suitable for Vietnamese audiences. “Prior to the newspaper, communication was done orally” (Phan, Nguyen, p.12). A messenger called “Mô Làng” was responsible for communicating information to lower illiterate social classes in designated areas. In addition to messengers, there were common areas where the Imperial family printed and hung notices or announcements for the public, but this only existed in larger cities with a higher literacy rate. The transition from primitive methods of communication to mass communication can be divided into three chronological periods, each with its own adaptations to Colony policies:

1. Introduction of Newspaper During French Occupation of Cochinchine
2. “Freedom of Press” in Cochinchina According to August 29th, 1881 Policies
3. State of Press Freedom According to December 30th, 1889 Policies

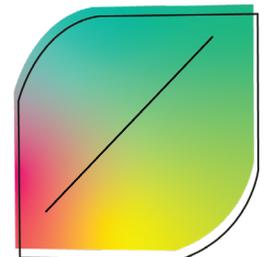
Introduction of Newspaper During French Occupation of Cochinchine

It is important to note that this was the period of full scale colonial assimilation, so every aspect of life and production was controlled by the French Administration. Due to France’s aggression and overwhelming technological advancement, the Imperial Nguyễn family was forced to sign multiple treaties in which they forfeited the majority of provinces. French censored newspapers were immediately introduced after their occupation and there were two clear purposes for their circulation:

1. “Occupy and expand the territory, restore security and order in the temporary war zone, and gradually build up a colonial government agency” (Phan, p.17)

2. “Step up psychological warfare measures to influence the fighting spirit of the expeditionary army as well as propagate French civilization to all classes of people” (Phan, p.17)

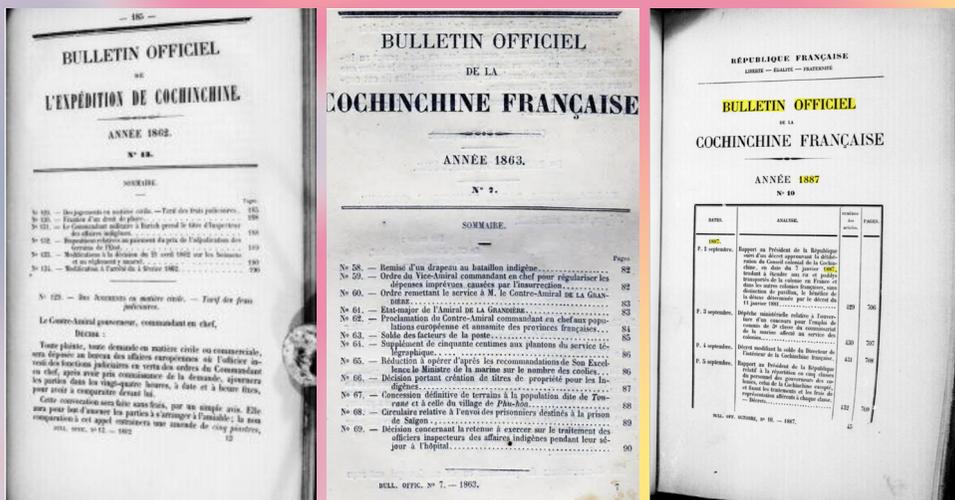
“The earliest records of the newspaper were owned by the French administration and only published in French and Classical Chinese” (Phan, p.18). These were known as “công báo” or government-oriented announcements with the intent of spreading constitutional and regulatory rights or “acte législatif” and “les règlement”. With recognition of the low literacy rate of Classical Chinese and more so French, the French Administrative introduced a romanized Vietnamese language system called “Quốc Ngữ” and published the first Vietnamese newspaper Gia Định News in 1865. In addition to Gia Định News, French publishers continued to republish “Annam - Latin Dictionary or Dictionarium Annamatico-Latinum” by J.L Taberd. During this period, newspapers were categorized in one of three languages, French, Chinese, or Vietnamese publication, each intended for a specific audience. Along with newspapers, the French aimed to educate the public about Quốc Ngữ.



Newspaper for the French Audience

1. **Bulletin Officiel de l'Expédition de la Cochinchine** - The publication published their first weekly issue in "September 29th, 1861 on 14 x 25cm newspaper" (Phan, p.20). The content included legislations and announcements for native French officers. This could be considered a form of internal communication between the French administrative authorities because only a small number of Vietnamese were able to read French at the time.

IMAGE 4.2 - BULLETIN OFFICIEL DE L'EXPÉDITION DE LA COCHINCHINE ARTICLES AND ANNOUNCEMENTS



2. **Courrier de Saigon** - "The second French publication was established in 1864 under supervision of Gaston

Amelot" (Phan, p.21). By 1894, the publication was publishing three issues a week with the "addition of international economic, social, cultural, and local news from China, Thailand, Japan..." (Phan, p.20). The purpose of French publication became clearer in 1899 when the new owner of the publication, Paul Blanchy, used this platform to promote his colonial ideology to contest the current position of Governor-General of French Indochina from Paul Doumer. According to Phan, French newspapers were "cultural weapons" that did not require violence to assimilate the population, motivating them to abandon their Vietnamese culture.



Newspaper for Vietnamese Scholars and The Public

1. **Bulletin des Communes**, written in classical Chinese - As mentioned in the previous section of the Literature Review, the remaining social classes are considered the public sphere, and circulated information also differs from French publications. The intended audience was in smaller areas and villages. The publication only existed as a compensating solution until the public was educated in "Quốc Ngữ".

2. **Gia Định News**, written in Quốc Ngữ - Although the publication was French-owned and operated, this was

Repression of Vietnamese Publications in 1898

By 1898, the French administration realized allowing freedom of the press was dangerous due to the rapid spreading of Anti-colonial and revolutionary ideology that encouraged the public to fight back forcefully. They required more control and censorship of newspapers, so a bill was passed to prevent the freedom of Vietnamese publications. In summary, any publications not written in French will be screened and the office can ban them unconditionally. The laws made Vietnamese publishers reliant on French officials to let them print. “Many publishers resorted to black-market printers to evade French censorship but this was risky and unlawful” (Phan, p.64). In an article published in 1919 by Nguyễn Ái Quốc or Hồ Chí Minh in L’Humanité and Le Populaire publication, he criticized the Laws of Press Repression and the exploitation of language to promote the French administration. One paragraph roughly translated to “The French government abused their power to only allow favorable publications which praise them”. The government also exploited Vietnamese newspapers for their benefit and promoted their Colonial government to receive grants and money from France.” (Nguyễn Ái Quốc, 1919). Nguyễn Ái Quốc also pointed out the irony of having twenty million Vietnamese but not even one Vietnamese publication, which made sense because by 1925 there were a total of

121 publications in the country. The table below shows the quantity of documented printed matters in circulation.

TABLE 3 - QUANTITY OF PRINTED NEWSPAPER BY 1925 (PHAN, P.83)

REGION	TOTAL	FRENCH PUBLICATION	VIETNAMESE PUBLICATION
COCHINCHINA	49	38	11
TONKIN	69	56	13
ANNAM	3	2	1
TOTAL	121	96	25

Vietnam’s print culture was created as a means to control the population, but it ultimately became the catalyst for patriotic movements and aided the spread of anti-French ideology. As time progressed, printing techniques improved with the introduction of graphic prints in 1949. In a sense Vietnam print culture embodied the meaning of newspapers being both informative and entertaining.



IMAGE 5.1 - Bầu Cử Hội Đồng Nhân Dân Tỉnh Print in 1949, Explain The Voting Process For Local Officials

IMAGE 5.2 - Mười Điều Kháng Chiến OR 10 REVOLUTIONARY ACTIONS



In conclusion, the original intention for introducing the print culture was for complete control and repression of the population. However, the adaptation of French technologies eventually aided the education and revolution of the Vietnamese. When physical revolutions were not possible, there was intellectual resistance to French colonial ideology instead. Perhaps the studies have shown that whilst despised, the French colonial period was essential for setting the foundation of the print culture and long-lasting patriotism in Vietnam.

RESULTS

Through the research of this paper, it is safe to conclude that the assimilation process was extremely difficult due to ongoing political conflicts, and commercializing print at the turn of the 20th century had different regional effects. The French occupation was an essential factor in setting the foundation of Vietnam's modern print culture. There were many new realms of printing created under the influence of the French administration and the Viet Minh Communist Party, respectively. The effectiveness of their print culture also heavily relied on the receiving audience, which was mostly illiterate in Quốc Ngữ. This paper offered critical views on the effectiveness of the new print culture and the printing process at the administrator and public levels. The success of Vietnam's print culture during the French colonial period was not definite because there were various levels of successes and failures at different periods in time. Despite the slow spread of information, this was an important period for Vietnam because it was a stepping stone for the rapid development of print after Independence in 1945.

The analysis of the secondary sources indicated important milestones for Vietnamese publications and newspapers. The results also reinforced the dictating role of French administration in the print culture and the print culture that existed under French control. Censorship intentions

were beyond press repression, it was also the suppression of ideology, free speech, and human rights. Kindly refer to Table 2 in the appendix for collected data on banned publications as it recorded a common ban pattern on patriotic publications. Although French censorship had near complete control of the print culture, it did not prevent Vietnamese from adopting the technology and using it for their patriotic movements. Understanding the complex relationship between print culture and politics was essential for assessing the success of a country's print culture.

DISCUSSION

My original prediction was that a seamless adaptation of the printing press and the spread of information was constant throughout the colonial period. But research has proven that printing and print culture had dependencies on government policies and political turmoils. I believe that the chronological framework effectively describes the development of Vietnam's print culture and who has access to print and information. It was clear from the results that the French administration and Viet Minh Party dictated the print culture in Vietnam. We can interpret that the print culture was built and established by French Colonialism but sustained by the Communist movement. Reproduction of this study will result in similar results, but there is more to speculate upon.

The Result of Adapting Quốc Ngữ?

From the previous sections, Quốc Ngữ was essential for the development of newspaper and mass education of a new language system. Those in favor of spreading Quốc Ngữ believed that Vietnamese should have an internationally recognized language system because language is part of national identity. From a larger scale, Quốc Ngữ simplified communication, and information became more accessible to the public. Quốc Ngữ was easier to understand and learn compared to Classical Chinese or French which increased the influence of the Communist movements amongst lower social classes. Quốc Ngữ allowed readers to convey and understand complex terminologies and ideologies, it would have been nearly impossible to explain Communism or science researches in Classical Chinese. Further research in this section should also focus on the advancements in education and schools as a result of Quốc Ngữ. Resistance to new method of education was present at the time and Quốc Ngữ education was not common amongst Vietnamese. Newspapers played a significant role in setting the foundation and promoting the love for a new language system. How did Quốc Ngữ changed its stigma of being "an evil or colonizer's language" through mass education and reform?

Post-Colonial Print Culture?

The Post-Colonial Period was an important time for the development of print and newspaper. Vietnam was occupied by America after WWI, and along with their occupation, they also introduced the American print culture. American occupation in the South was vastly different compared to French occupation, there was more freedom of press and emphasis on the quantity of printed matters. America spent resources to build the city of Saigon into an economic hub in Indochina, therefore giving the Vietnamese more freedom and human rights. Citizens of Saigon were considered American to an extent in regard to benefits. During this period, most of the country became literate in Quốc Ngữ and the entertainment aspect of newspapers developed strongly. Research in this period should focus on the development of newspapers in the South with the introduction of American newspapers and the results from the freedom of press. The American occupation brought over a new period of tactical and cultural warfare and newspapers were an effective way to divide the country's support. Citizens of Saigon were given rights similar to American citizenship similar to countries such as Korea and Taiwan which included freedom of press. Based on the differences in policies regarding freedom of speech and press from the South and North, the Southern regions of

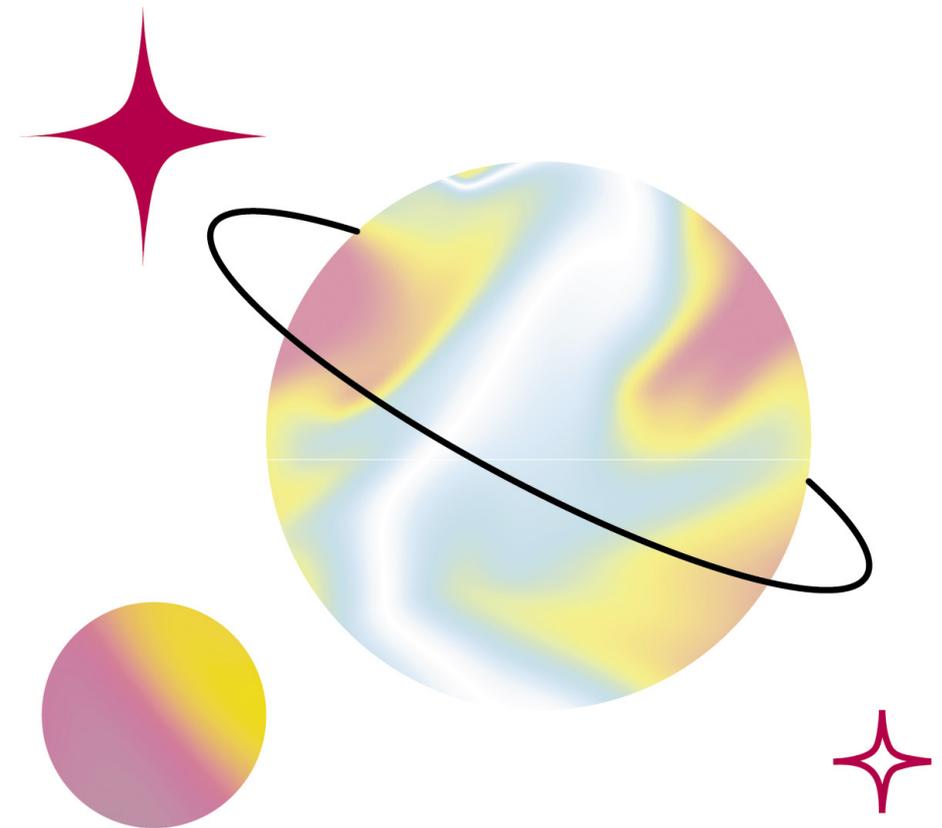
Vietnam became supportive of the American administrator and ultimately worked for them to earn benefits. Perhaps the success of the print culture in this period was dependent on how information was used to persuade the Vietnamese to join American forces and administrators. The circulation of printed information from the United States helped solidify the idea of being American and promoted them to strive for the "American dream". At one point, Saigon was named The Pearl of the Far East with more freedom and faster economic growth than other countries in the region. This was also the prime time of billboards, hand painted and printed, so more printers adapted wide-format presses to produce commercially.



CONCLUSION

This study aimed to provide a chronological and critical analysis of the unique case of Vietnam print culture and what is considered the foundation of modern Vietnamese newspapers. In summary, the French administrator was essential in establishing print technology and culture in Vietnam. They helped set the foundation of newspaper printing in Vietnam with the supply of technology and funds. Over time, Vietnamese had the opportunity to learn and adapt this technology to their own needs. The study also provided multiple viewpoints from different social classes and their accessibility to the print culture. Vietnam had a unique development timeline where there were constant struggles for power and who dictated the development of the print culture. The common argument was French censorship suppressed both freedom of speech and press, but studies have shown that their suppression was essential for igniting patriotic print movements. The most important party was the audience because their ability to access printed matters determined the success of their print culture. Upon establishment, the mass public was illiterate and unable to read newspapers, but within 20 years there were enough readers to help spread information. The spread of information and technology was extremely rapid, so it is safe to conclude that the print culture during the Colonial period was successful for the Vietnamese

with regard to the quality of printed matters and education of the mass public. Evaluation of selected secondary sources and framing them chronologically was a good way to understand the growth progress of the print culture. This research method effectively demonstrated the growth of newspapers and the changes in their purposes and target audiences.



REFERENCES

Primary Sources

- Baldanza, K. (2018). Publishing, book culture, and reading practices in Vietnam. *Journal of Vietnamese Studies*, 13(3), 9–28. <https://doi.org/10.1525/vs.2018.13.3.9>
- Cường, N. T., Tuấn, P. V., & Thanh, N. V. (2018). Buddhist print culture in Nineteenth-century Northern Vietnam. *Journal of Vietnamese Studies*, 13(3), 87. <https://doi.org/10.1525/vs.2018.13.3.51>
- F., P. P. M. (2012). *The birth of Vietnamese political journalism: Saigon, 1916-1930*. Columbia University Press.
- Goscha, C. (2004). 'the modern barbarian': Nguyen Van Vinh and the complexity of colonial modernity in Vietnam. *European Journal of East Asian Studies*, 3(1), 135–169. <https://doi.org/10.1163/1570061033004758>
- Marr, D. G. (1984). *Vietnamese tradition on trial, 1920-1945*. University of California Press.
- McHale, S. F. (1995). *Printing, power, and the transformation of Vietnamese culture, 1920-1945* (dissertation). Faculty of the Graduate School of Cornell University, Ithaca, New York.
- Nguyen, M. T. (2012). *The self-reliant literary group (Tu Luc van Doan): Colonial modernism in Vietnam, 1932-1941* (dissertation). University of California, Berkeley, California.

- Nguyễn Đức Hiệp. (2019). *Sài Gòn-Chợ Lớn: đời sống Xã hội Và Chính trị Qua tư Liệu báo chí*. Nhà xuất bản Tổng hợp Thành phố Hồ Chí Minh.
- Nguyễn Công Khanh. (2006). *Lịch sử Báo chí sài gòn-Tp. hồ chí Minh, 1865-1995*. Nhà xuất bản Tổng Hợp Thành phố Hồ Chí Minh.
- Phan Đăng Thanh, & Trương Thị Hòa. (2017). *Lịch sử Các Chế độ báo Chí ở Việt Nam*. Nhà xuất bản Tổng hợp Thành phố Hồ Chí Minh.
- Tạ Thị Thúy. (2017). *Lịch Sử Việt Nam Tập 9 - Từ năm 1930 đến năm 1945*. Nhà xuất bản Khoa học xã hội.
- Womack, S. W. (n.d.). *Colonialism and the collaborationist agenda: Pham Quynh, print culture, and the politics of persuasion in colonial Vietnam* (dissertation). ProQuest Dissertations Publishing, Ann Arbor, Michigan.

Secondary Sources

- Báo Điện Tử Đảng Cộng Sản Việt Nam. (2020, April 6). *Báo Chí Năm 1942 Góp Phần Hưởng Dẫn Nhân Dân, Tổ chức lực Lượng Cách Mạng*. Báo chí năm 1942 góp phần hưởng dẫn nhân dân, tổ chức lực lượng cách mạng. Retrieved April 3, 2022, from <https://dangcongsan.vn/huong-toi-ky-niem-90-nam-ngay-truyen-thong-nganh-tuyen-giao/thong-tin-tu-lieu/bao-chi-nam-1942-gop-phan-huong-dan-nhan-dan-to-chuc-luc-luong-cach-mang-552130.html>

Eliot, S., & Rose, J. (2009). *A companion to the history of The book*. Blackwell Publishing.

History of education. Education in Vietnam. (n.d.). Retrieved April 4, 2022, from <https://sites.miis.edu/educationinvietnam/historyofvietnam/history-of-education/>

<http://what-when-how.com/>. (n.d.). FRENCH INDOCHINA (Western Colonialism). Retrieved from <http://what-when-how.com/western-colonialism/french-indochina-western-colonialism/>.

Jammes, J. (2018). Printing cosmopolitanism, challenging orthodoxies: Cao đài journals in Twentieth Century Vietnam. *Vienna Journal of East Asian Studies*, 10(1), 175–209. <https://doi.org/10.2478/vjeas-2018-0007>

Khiêm, L. (2014, March 16). *Sưu tập tranh tuyên truyền, cổ động trong kháng chiến chống thực dân Pháp (1946-1954)*. Retrieved April 3, 2022, from <http://baotanglichsu.vn/vi/Articles/1002/16373/suu-tap-tranh-tuyen-truyen-co-djong-trong-khang-chien-chong-thuc-dan-phap-1946-1954.html>

Kornicki, P. F. (2018). *Languages, scripts, and Chinese texts in East Asia*. Oxford University Press.

Lee, G. (2020, January 21). Early printing in Indochina. *BiblioAsia*. Retrieved April 3, 2022, from <https://biblioasia.nlb.gov.sg/vol-15/issue-4/jan-mar-2020/printing-in-indochi/>

Llewellyn, J., Southey, J., & Thompson, S. (2018, January 6). The conquest and colonisation of Vietnam. *Vietnam War*. Retrieved April 3, 2022, from <https://alphahistory.com/vietnamwar/conquest-and-colonisation-of-vietnam/>

Milner, A. (1990). *Southeast Asia Languages and Literatures: A select guide*. Kiscadale Publications.

Nghiệp, C. T. (2021). *Gia Định Báo*. Trithuc.vn. Retrieved April 3, 2022, from <https://trithucvn.org/van-hoa/gia-dinh-bao.html>.

Pelley, P. (2018). *Vietnamese historical writing*. Oxford Scholarship Online. <https://doi.org/10.1093/oso/9780199225996.003.0028>

Quang, N. T. (2017, July 27). *Nhà in làng sông - Trung Tâm Truyền bá chữ quốc ngữ và văn học quốc ngữ*. Giáo phận Qui Nhơn. Retrieved April 3, 2022, from <http://gpquinhon.org/q/tu-lieu/nha-in-lang-song-trung-tam-truyen-ba-chu-quoc-ngu-va-van-hoc-quoc-ngu-261.html>

Quê Hương Ta Nhớ. (2020, May 24). *Gia định Báo – SỐ 4 năm Thứ Hai (Tháng tư 1866)*. *Gia Định Báo – Số 4 năm thứ hai (tháng tư 1866)*. Retrieved April 3, 2022, from <https://www.cochinchine-saigon.com/gia-dinh-bao-so-4-nam-thu-hai-thang-tu-1866/>

Quế, V. X. (2021). *Nam Kỳ – Tờ báo Quốc ngữ cuối thế kỷ 19 còn ít được biết đến*. *Nghiên Cứu Lịch Sử*. Retrieved April 3, 2022, from <https://nghiencuulichsu.com/2021/04/22/nam-ky-to-bao-quoc-ngu-CC%83-cuoi-the-ky-CC%89-19-con-it-duo-CC%A3c-biet-den/>.

APPENDIX

TABLE 2 - BANNED PUBLICATIONS ACROSS VIETNAM BY FRENCH CENSORSHIP

PUBLICATION	YEAR BANNED	WHERE BANNED
Trần Hữu Độ , Hồn độc lập (Soul of Independence) (Saigon : Xưa Nay , 1926)	1927	Tonkin
Trần Huy Liệu , Một bầu tâm sự (A heartfelt concern) (Saigon : Báo Tôn , 1927)	1927	Tonkin
Phan Bội Châu , Sách thuốc chữa dân nghèo (Medical remedies to cure the poor) (Saigon : Imp. Cô Mu [?] , n.d.)	1928	Tonkin
Nhượng Tống , Dân tộc chủ nghĩa (Nationalism)(Hanoi : Long Quan, n.d.)	1927	Tonkin
Việt Nam bực sanh báo (Vietnamese students newspaper)	1928	Indochina
La nation annamite	1928	Indochina
Phan Bội Châu , Lời hỏi (Questions) (Saigon : Xưa Nay , 1928)	1928	Tonkin
Lời kính cáo cung đong báo của Dang Viet Nam doc lap	1928	Indochina
Trần Huy Liệu and Đào Khắc Hưng , Tân quốc dân (New citizens) (Saigon : Tam Thanh , 1928)	1928	Tonkin
Nguyễn An Ninh , Hai Bà Trưng (The Trưng sisters) (Saigon : Báo Tôn , 1928)	1928	Tonkin
Rabindranath Tagore , Đông phương tây phương (East and West)	1929	Tonkin
Anh hùng yêu nước (Patriotic heroes)	1929	Tonkin
Phủ Đức (Pharmacy) , Tiểu anh hùng Võ Kiệt (The young heritag : h12)	1930	Tonkin
Trần Huy Liệu and Nguyen Thanh Lam , Hội kín (Secret societies) (Hanoi : Đông Dương , 1936)	1936	Tonkin

NOTE. THE TABLE DOES NOT EXPRESS UNCENSORED MATERIALS SO THE QUANTITY OF TOTAL PRINTED MATERIALS IS INESTIMABLE (MCHALE, P.40)

Suarez, M. F., & Woudhuysen, H. R. (2013). *The book: A global history*. Oxford University Press.

Thắng, L. M. (2020). Lưu bản Báo Cứu Quốc mô tả cuộc chiến giữa quân ta với quân Pháp ở Hải Phòng tháng 11-1946 (tư liệu). Khí phách oai hùng mang tên “Công an xung phong Hải Phòng.” An Ninh Hải Phòng. Retrieved April 3, 2022, from <http://anhp.vn/khi-phach-oai-hung-mang-ten-cong-an-xung-phong-hai-phong-d36850.html>.

VIETNAM NATIONAL MUSEUM OF HISTORY. (2014, May 16). Sưu tập tranh tuyên truyền, cổ động trong kháng chiến chống thực dân Pháp (1946-1954). Retrieved April 4, 2022, from <http://baotanglichsu.vn/vi/Articles/1002/16373/suu-tap-tranh-tuyen-truyen-co-djong-trong-khang-chien-chong-thuc-dan-phap-1946-1954.html>

Việt Nam Anh Hùng. (2020). Chiếc máy chữ và chiếc đồng hồ của Bác Hồ. Việt Nam Anh Hùng Thông Tin Truyền Thông. Retrieved April 3, 2022, from <https://vietnamanhhung.com/chiec-may-chu-va-chiec-dong-ho-cua-bac-ho.html>.

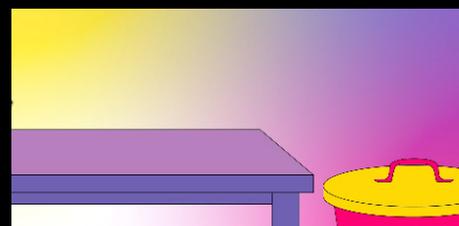


03



**THERMAL-OXIDATIVE
DEGRADATION OF
SINGLE-USE PAPER CUPS:
PHA BIOPLASTICS AS
AN ALTERNATIVE TO
TRADITIONAL POLYETHYLENE
FILM COATINGS**

by hayden Mcgreal

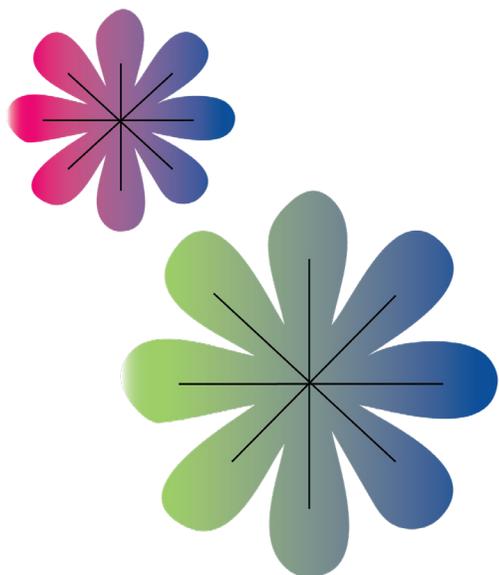


ACKNOWLEDGMENTS

I would like to thank my thesis supervisor Dr. Ehsan Bezadfar for his guidance and encouragement throughout this process. Without his support, I would not have been able to delve into such an advanced field of study.

I am grateful to the entire student base of Dr. Bezadfar's Sustainable Packaging Lab. Every individual there has contributed to my learning in some way or another. I would like to acknowledge both Sebastian Blair and Hadis Torabi for their reliability and candidness over the course of this project.

I also need to thank my close friends and family for their unconditional support and endless patience throughout.



ABSTRACT

Biopolymers, specifically Polyhydroxyalkanoates (PHAs) and PHA blend biopolymers are emerging as promising alternatives to traditional petroleum-based plastic packaging materials. Paper single-use cups present a challenge for current recycling systems; as a result, most end up in landfills. The conventional plastic films utilized by paper cups accumulate as debris and add to the global plastic waste problem. The desirable properties of PHA blend biopolymers can potentially provide practical solutions to many of the issues faced by traditional plastics. In this study, ThermoGravimetric Analysis (TGA) was performed to quantify the thermo-oxidative degradation characteristics of plastic samples currently present in the market and biopolymers suitable for their substitution. Samples were gathered from restaurants and purchased at a consumer level. PHA/Polylactic Acid (PLA) blend was found to degrade the fastest amongst pure PLA, Polypropylene (PP), and Polyethylene (PE) film found in paper cups. Ultimately, the use of PHA is a significant improvement in terms of both sustainability and degradability to existing market applications.

INTRODUCTION

The paper coffee cup has become ubiquitous in the lives of many North Americans; this simple container is touched by millions each day. Market research suggests that single-use hot beverage containers are being produced with an annual compounded growth rate of 1.27%. Currently sitting at 260 billion units per year, the market is expected to reach 280 billion units produced annually by 2027 (iMarc, 2022). Single-use beverage containers are a staple product segment of the food and beverage industry; their use is and will continue to be widespread across the globe. The sustainability of single-use beverage containers, particularly hot-beverage containers, has been a point of contention for some time. Unlike typical cold-beverage containers, the hot-beverage counterparts are challenging to recycle correctly. The standard structural design of a paper cup consists of a paperboard outer wall with a plastic-coated inner surface. The plastic barrier is typically made of petroleum-based Polyethylene (PE). The nature of this laminated construction demands special processing procedures by both the end user and recycling facilities. As a result, many single-use beverage containers go directly to landfills, where the PE coating cannot be recycled or adequately degraded.

Bioplastics – polymeric materials produced from renewable biomass sources, are emerging as a sustainable alternative

to the traditional PE coatings of single-use beverage containers. Polylactic acid (PLA) has been adopted as an alternative material, with substantial improvement in sustainable disposal, and suitable implementation of container properties like insulative capacity and structural stability. Polyhydroxyalkanoate (PHA) type bio-polymers are another alluring alternative due to their biocompatibility and superior biodegradability. However, no market options are currently available for PHA-based single-use beverage containers (Triantafillopoulos et al., 2020). There is insufficient data for the use of PHA, and PHA blend biopolymers as an effective packaging film compared to traditional plastics. Consumers often perceive paper cups as more eco-friendly than plastic-based constructions; this can be attributed to extensive marketing practices. Greenwashing is a term used to identify the deliberate approach of marketing and product positioning as environmentally positive or eco-friendly, regardless of the actual status of the product itself (de Freitas Netto et al., 2020). Greenwashing can be a deliberate act by an individual company or in the case of paper cups, a colloquial understanding established by larger marketing trends. As PHA and PHA blend bioplastics emerge in the packaging industry, do the properties of these polymers provide a significant advancement in degradability and sustainability when used in packaging applications, specifically single-use beverage containers?

Thermogravimetric Analysis (TGA) can be utilized to quantify the degradation process. TGA is a technique used to produce data on the thermal stability and presence of volatile components in a material by observing the changes in mass as the sample is exposed to controlled heat treatment (Loganathan et al., 2017). TGA is a powerful method for understanding the composition of materials for the rate at which thermal decomposition occurs. TGA alone is insufficient for determining the characterization and identity of individual components present in a material. However, the analysis can give valuable insight into a material's total overall degradation curve. This paper seeks to identify the differences in the degradation process between traditional single-use beverage packaging materials and PHA/PLA blend polymer substitutes.



LITERATURE REVIEW

The use of biopolymer substitutes for petroleum-based plastics as a packaging material is still in its infancy. Bioplastics have many attractive properties in both their material qualities and their marketing advantages. Bioplastics also have a greater perception of eco-friendliness than traditional plastics, though production can still be taxing on the environment (Álvarez-Chávez et al., 2012). The sustainability of bioplastics needs to be examined with full consideration of the material's entire lifecycle. There is little literature exploring the use of PHA bioplastics in packaging applications. Typically, research conducted on degradation in plastics involves several advanced testing procedures or those which allow for the precise identification of individual components that make up the complete chemical profile of the polymer. Insight into the overall sustainability of bioplastics, in general, is substantial. There is significant evidence pointing towards biopolymers like PLA and PHA as potentially desirable replacements for the PE coatings found in single-use beverage containers; however, focused research on PHA is still currently being established.

Research from Changwichean and Gheewala's (2019) comparative life cycle assessment for petroleum-based plastic, bioplastic, and reusable stainless steel containers was conducted. Overall it was found that reusable stainless steel containers presented the most effective option in

terms of reducing environmental impacts from single-use beverage containers. Bioplastic (PLA) cups were found to have a notably better environmental profile than traditional plastics derived from non-sustainable sources. However, significant economic and infrastructural influences currently make bioplastics undesirable from a cost perspective. The production cost of PLA cups was found to be 2-3 times higher than traditional means, making the economic decision to adopt the alternative material not clearly as advantageous. Additionally, the inappropriate processing and disposal of PLA were found to potentially release methane into the atmosphere, an environmentally hazardous consequence that contributes to climate change. Changwichan and Gheewala (2019) concluded that bioplastics are a better choice for beverage packaging than current market options. However, the implementation of said alternatives requires significant oversight regarding the proper management and disposal of the material. PLA especially can release significant levels of methane without appropriate processing. It was also noted that recycling procedures for traditional plastics, when operating as intended, can significantly reduce the pressure on the creation of new feedstock for conventional plastics. (Changwichan and Gheewala, 2019). These findings are significant as they present relative evidence of bioplastics, specifically PLA, as being of notable improvement to overall sustainability compared to petroleum-based plastics like PP or

polyethylene terephthalate (PET). This research also highlights the setbacks of bioplastic applications in today's market. The current infrastructure for recycling and waste management is curated to petroleum-based plastics. Proper processing procedures must be established if bioplastics are to produce a favorable environmental impact.

Álvarez-Chávez et al. (2012) examined the overall sustainability of bioplastics across their entire lifecycle, emphasizing the flow of materials in the production of biopolymer substitutes. Bioplastics were found to be overall more environmentally friendly than their petroleum-based counterparts; however, when examined across their entire lifecycle, none of the contemporary bioplastics were found to be fully sustainable. The production processes of biopolymers were commonly found to either produce toxic chemical byproducts or utilize them throughout their production. Many biopolymers also integrated non-renewable co-polymers in their manufacturing process, further limiting sustainability. It should be noted that a consensus definition for fully sustainable bio-based plastics does not exist. Instead, collective notions of sustainability are agreed upon among stakeholders. Typically, removing all non-renewable and environmentally degrading processes and inputs from the manufacture of bio-based plastic will qualify it as sustainable. Álvarez-Chávez et al. (2012) ultimately finds that there are several barriers to the sustainability of bioplastics as they currently exist. The unsustainable and environmentally

taxing means of producing feedstock for plastic production, the use of hazardous chemicals and additives throughout the manufacturing process, and the general lack of infrastructure for the industrial compost or disposal of biopolymers, are all key concerns. The use of hazardous chemicals in PLA production is of note; those used to refine or regulate the production processes of PLA can affect the environmental impact of the end product. Though the resulting material is more environmentally friendly than petroleum-based plastics, parts of the production process can still be optimized. The novelty of PLA/PHA blend substitutes lies in the composition of the material as a fully bio-composed polymer. Rather than a partial mixture of PLA and some other petroleum-based polymer, PLA/PHA is fully biodegradable and composed solely of biomaterial. Its resulting sustainability profile differs from those studied in Álvarez-Chávez et al. (2012).

Choi et al. (2018) investigated the carbon footprint of PLA and PLA blend biopolymers, with particular attention to the resulting Greenhouse Gas (GHG) emissions and Global Warming Potential (GWP) when compared to traditional petroleum-based plastics. The research found that PLA blend plastics have a high index of GWP when disposed of via incineration. PLA films sent to landfills were favorable over incineration, though inadequacies in local waste management streams make the improper disposal of PLA and PLA-blend packaging likely. PLA was shown to have a comparable GWP

to some traditional plastics in waste management processes, but the composition of the polymer blend greatly affected the resulting index. Choi et al. (2018) focused their research on three waste management streams: landfill, Incineration, and recycling; with the PLA and PLA blend packaging unable to be recycled, they are considered for incineration and landfill only. As seen in Changwichan and Gheewala (2019) and Álvarez-Chávez et al. (2012), it seems that bioplastics may be favorable in terms of their overall environmental impact when special care is taken to adapt existing waste management streams. However, existing processes render some potential environmental gains mute, with the improper handling and disposal of biopolymer and biopolymer blend plastics. Choi et al. (2018) ultimately find that in some cases biopolymer blends can be more inimical to the environment in terms of emissions. These findings are notable, with the distinction that different polymer combinations have vastly different resulting environmental profiles. PLA/PHA is a full bioplastic blend with no traditional filler; this composition would likely deviate from the results of Choi et al. (2018).

In research by Lomonaco et al. (2020), the release of Volatile Organic Compounds (VOCs) from discarded plastic debris is examined, specifically via the photodegradation process. This study only examines the characterization of VOCs emitted from traditional petroleum-based plastics, which make up most waste debris today. It is found that plastic

debris releases harmful VOCs as it degrades, varying across different polymer classifications and blends. PE and PP were both found to release toxic VOCs, confirming that the large masses of plastic debris accumulating constitutes a valid air quality concern apart from the more obvious concern of litter. This issue is prominent for traditional plastics across their respective lifecycles; however, substantial research remains to be conducted as to the degree to which these findings apply to bioplastics. In a review by Cabanes et al. (2020) the different VOC profiles of various plastics were examined. It was found that post-consumer recycled and discarded plastics often contain a large amount of absorbed VOCs as opposed to virgin samples of the same polymer. The focus of this review and many other studies on VOC emission from plastic waste is concerning the stripping of these supplemental VOCs in the recycling process. Insight such as that from Lomonaco et al. (2020) is scarce in literature for traditional plastics and even more scarce for alternatives. Pollutants emitted from landfill waste is a crucial point of interest when examining bioplastics which are more than likely to end up in landfills. Understanding the comprehensive environmental impact of these emerging bio-based alternatives can determine the most appropriate focus allocation for the market and municipal waste management systems. Contingent on the overall implications of bioplastic replacements, efforts to improve recycling systems for existing plastic debris may prove more fruitful in terms of overall environmental impact.

There is a gap in the literature regarding the degree to which biopolymers, specifically PHA-type polymers, improve upon traditional PE coatings in terms of degradability and overall sustainable impact. PLA and PLA/Petro-based blend substitutes have made it to market, though the lack of catered infrastructure presents challenges to the actual sustainability of the products. PE and PP plastics have been observed to negatively impact VOC emissions, though the same can be said of some PLA blend plastics. The current PE films used in single-use beverage containers cannot be recycled correctly in many waste management systems; the focus of bioplastic alternatives is to reduce debris left as the paperboard exterior degrades. A comprehensive understanding of the total impact of bioplastics will either make their use in containers more desirable or, conversely, the focus on enhanced recycling systems more advantageous; the research remains to be seen. Concerning the comparison of existing single-use beverage containers and potential bioplastic alternatives, this paper seeks to determine the degree to which emerging PHA alternatives may improve these materials' sustainability.



METHODOLOGY & MATERIALS

Tested Materials

The bioplastic samples selected for this experiment are derived from 3D-printing filament; each is available on the North-American market and is commonly used in additive manufacturing. Two types of bioplastic have been selected. The first was a pure PLA sample manually cut from a spool of 3D-printing filament. The sample was suitable for extrusion and intended for use in additive manufacturing applications. Relevant technical data was listed as (Melt Temperature - $>157^{\circ}\text{C}$, Density - 1.24 g/cm^3). The second was a PHA/PLA blend sample, which was also manually cut from a spool of 3D-printing filament. The applications of this sample are similar to those of the pure PLA; relevant technical data was listed as (Melt Temperature - $>155^{\circ}\text{C}$, Density - 1.24 g/cm^3). The precise chemical composition of each of the bioplastic samples is unknown, though they are both assumed to represent typical formulations. See Table 1 for sample tabulations.

The samples of single-use beverage containers for this experiment are assumed to be representative of market standards. The first sample consisted of one unused hot-beverage paperboard cup obtained from a Tim Hortons

restaurant in March of 2022. "Tim Hortons" is Tim Hortons Inc., the Canadian multinational food chain. The second sample was a solid PP cold-beverage container obtained from a Tim Hortons restaurant in March of 2022. The plastic lining of the hot beverage sample was assumed to be PE, with the outer layer being made up of paperboard. According to industry standards, the plastic barrier was typically made of petroleum-based Polyethylene (PE). The paperboard component of the cup was typically of high basis weight, usually $150 - 350\text{ g/m}^2$, while the PE film typically measured at $8 - 20\text{ g/m}^2$ with a thickness of approximately $50\mu\text{m}$ (Triantafillopoulos et al., 2020). These assumptions are visually consistent with the sample. See Figure 1; Table 1

FIGURE 1. - PHOTOGRAPHS OF SAMPLE MATERIALS SUBMITTED FOR THERMOGRAVIMETRIC ANALYSIS.

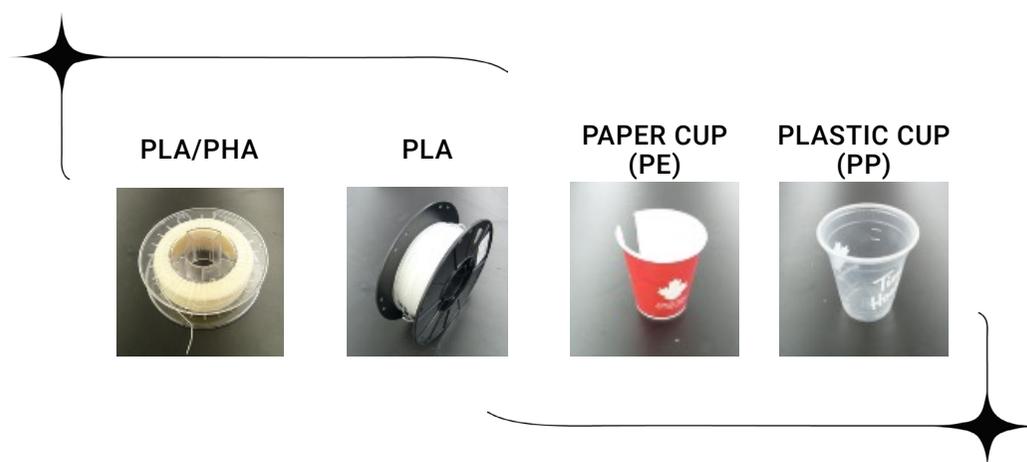


TABLE 1. - SAMPLE DIMENSIONS.

SAMPLE	THICKNESS (MM)	UNIT WEIGHT (MG)
PLA	1.75	10.469092
PLA/PHA	1.75	8.330923
PAPER CUP	0.45	5.532684
PLASTIC CUP	0.3	6.327195

Experimental Set-Up

The experimentation was carried out with quantitative analysis as the objective. Small sample units were extracted from the initial sample materials, weighing ~>10 mg and measured approximately 1 cm in length. Each sample was tested individually through TGA, and the resulting data was analyzed to determine the % weight thermal-oxidative degradation curve. The samples were then compared against each other to determine an index for the thermal-oxidative degradation characteristics amongst the selected bioplastics and gathered petroleum-based plastics that are currently in use across

the market. Since TGA is a destructive analysis method, the samples have no physical condition after testing. Inputs for the experiment are the plastic and bioplastic samples, and the outputs are the TGA data. All testing was carried out in the Sustainable Packaging Research lab at Ryerson University.

Key assumptions in this experiment are listed as follows.

- The PLA and PLA/PHA samples are representative of formulations suitable for film applications and, by extension, the current market applications.
- The gathered packaging samples are representative of packaging constructions in the larger market as a whole.
- The measured thermal-oxidative curve is assumed to be replicable and consistent with established findings.

The main limitation of this experiment was the scope of TGA. With TGA as the sole testing procedure carried out, it was only possible to determine the % weight thermal-oxidative degradation curve of a sample; there was no way to independently verify any potential filler materials or the chemical characteristics of the sample. This limitation made substantive analysis difficult as the degree to which each sample’s fillers and unique chemical formulations impact the degradation curve was unknown.

Thermogravimetric Analysis

TGA was conducted using a Perkin Elmer TGA 4000 apparatus under an air atmosphere. Measurements were performed by increasing the temperature from 30°C up to 600°C at 20°C/min. Graphing and calculations were conducted knowing the weight (W) of the material before (W₀), and after degradation (W); with constant data of weight against temperature, it was possible to obtain the weight loss (WL(%)).

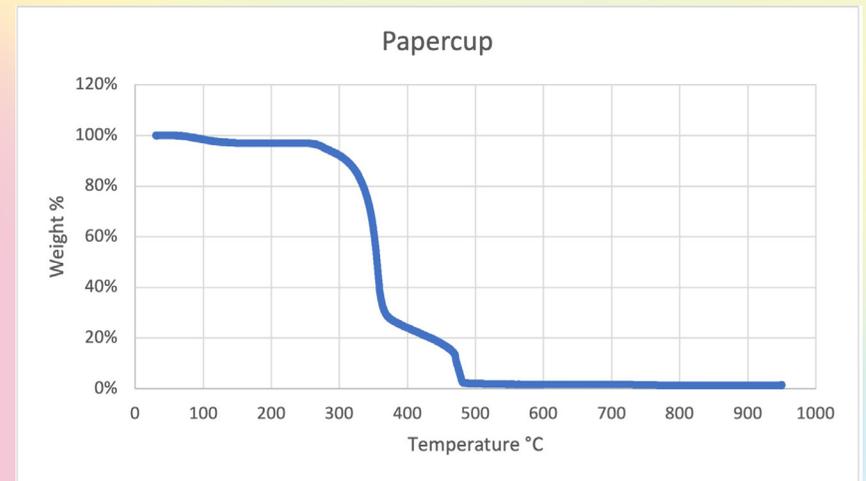
$$WL(\%) = [(W)/(W_0) \times 100]$$

The TGA provided weight data for graphing, which was later examined. An understanding of the sample material's overall degradation time could be extrapolated from the curve. With this analysis, an understanding of the degradability and, therefore, suitability as landfill waste was determined. Due to the precision and stability of TGA, multiple samples need not be submitted to achieve replicable results. One single sample unit was submitted for each sample material for this experiment.

RESULTS

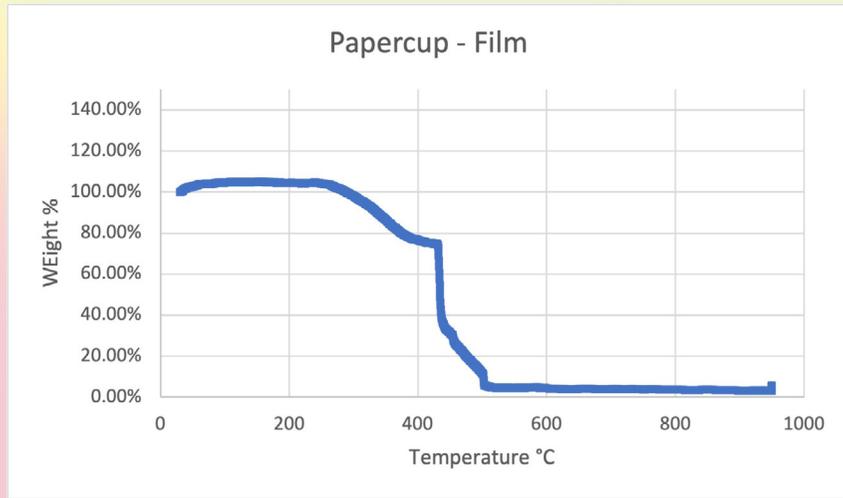
Thermogravimetric Analysis provided a weight percentage thermal-oxidative degradation curve for each sample material; Figures 2-6.

FIGURE 2. - THERMAL-OXIDATIVE DEGRADATION FOR PAPER CUP SAMPLES UNDER AIR ATMOSPHERE. (20°C / MIN)



The paper cup was first tested as a cut sample comprising the paperboard and PE layers. The data contains a steep initial drop in weight % starting around 250°C and plateauing around 380°C. The initial drop was presumed to be the incineration of the paper board layer, with subsequent drops making up the degradation of the PE film and any additives. The sample fully degraded at approximately 500°C.

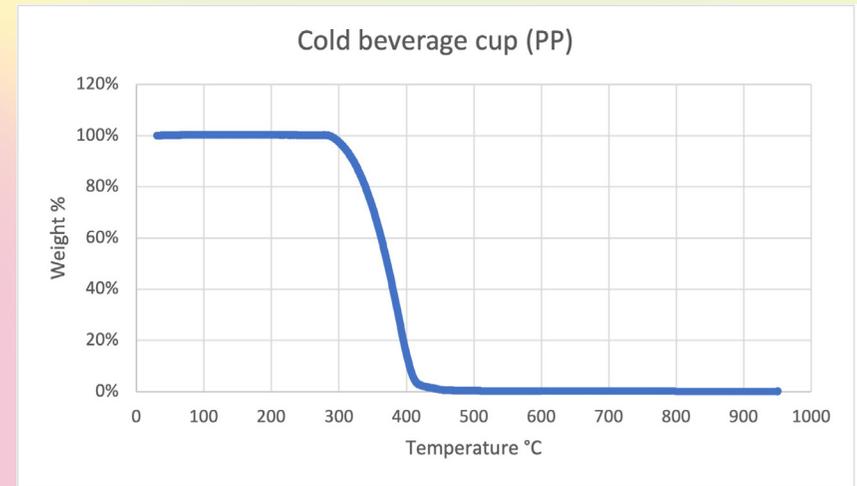
FIGURE 3.



- THE CURVE OF THERMAL-OXIDATIVE DEGRADATION FOR FILM SAMPLES UNDER AIR ATMOSPHERE. (20°C / MIN)

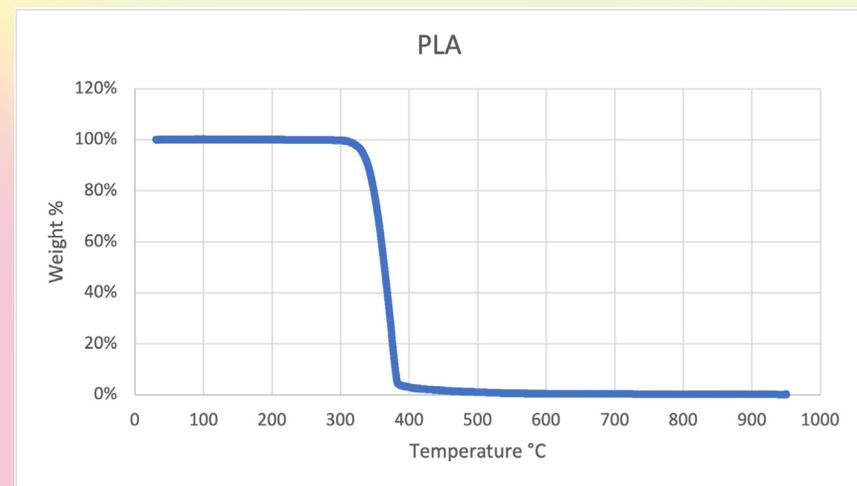
The paper cup was tested again, with the paperboard portion of the sample removed. The resulting graph comprises the degradation curve of the isolated PE film. With the absence of the paperboard, the graphs of the isolated and non-isolated curves gave a clear distinction of the degradation curve for the PE film alone. This second test confirmed the preliminary analysis of the first test, with the second portion of the curve replicated. The isolated sample curve and the previous unisolated sample were conclusive with other TGA tests conducted on paper hot-beverage containers (Biswal et al., 2013).

FIGURE 4. - THERMAL-OXIDATIVE DEGRADATION FOR COLD-BEVERAGE CUP SAMPLES UNDER AIR ATMOSPHERE. (20°C / MIN)



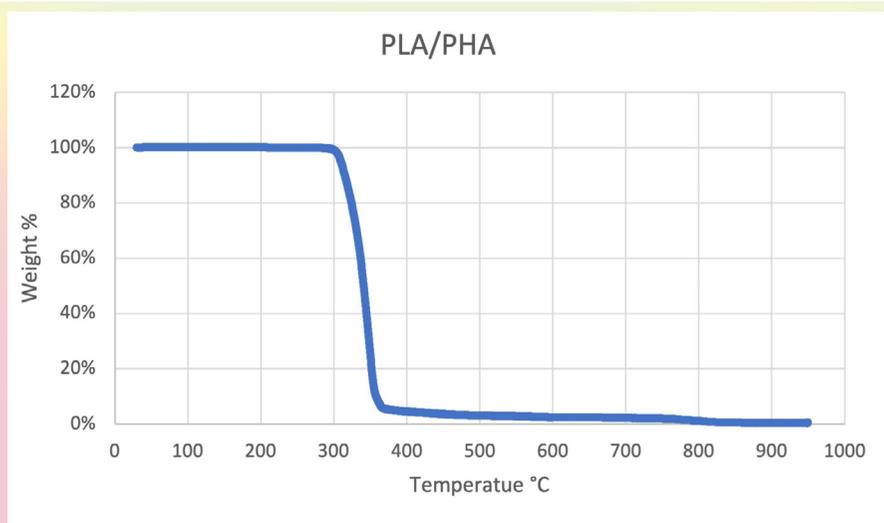
The cold-beverage plastic cup was tested. The graphed data contained a straightforward curve, which fell at approximately 280°C and completely degraded at approximately 400°C. This was consistent with a formulation that has very few fillers or additives.

FIGURE 5. - THERMAL-OXIDATIVE DEGRADATION FOR PLA SAMPLE UNDER AIR ATMOSPHERE. (20°C / MIN)



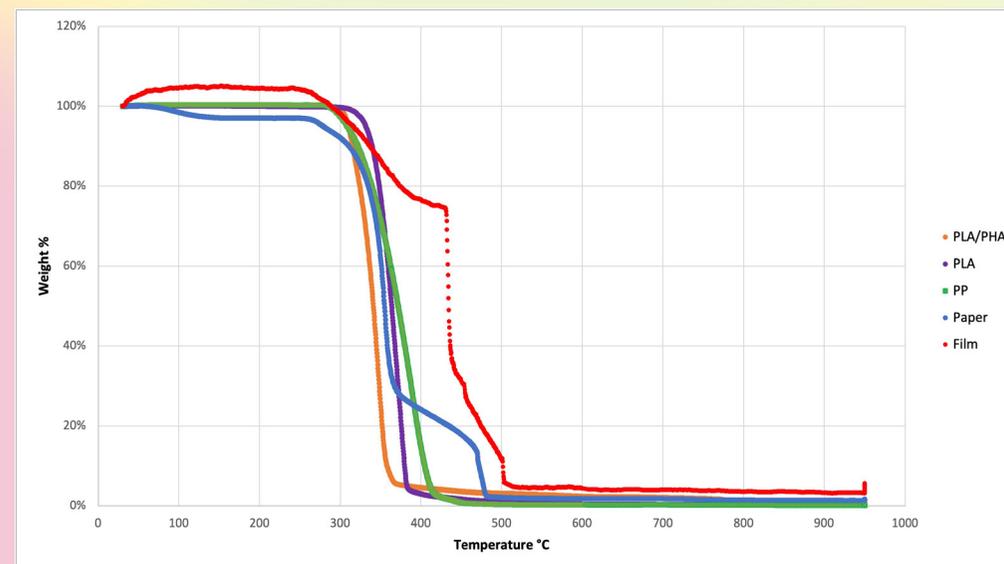
The PLA sample was tested. The graphed data was similar to that of a PP-type plastic, whose curve fell at approximately 300°C and bottomed out at approximately 360°C. This tendency towards lower temperature was indicative of a faster degradation time under environmental conditions.

FIGURE 6. - THERMAL OXIDATIVE DEGRADATION FOR PLA/PHA SAMPLE UNDER AIR ATMOSPHERE. (20°C / MIN)



The PLA/PHA blend sample was tested. The results were very similar to those of the pure PLA and the PP samples. There was a slight improvement upon pure PLA, with the curve falling at approximately 300°C and bottoming out at approximately 330°C.

FIGURE 7. - OVERLAY PLOT OF THERMAL-OXIDATIVE DEGRADATION FOR ALL SAMPLES UNDER AIR ATMOSPHERE. (20°C / MIN)



With all of the curves overlaid, it was possible to observe an index for degradation temperature. PLA/PHA degraded under the lowest temperature, followed by pure PLA, PP, and finally, the PE samples.

DISCUSSION

The results of the TGA testing present evidence that the existing PE polymer films currently being used in single-use hot-beverage containers require a considerably longer time to degrade fully than both the two biopolymer samples and the PP cold-beverage container's sample.

According to the time-temperature superposition principle of polymer physics, the degradation curve of a polymeric material can be observed as identical at a higher temperature for a shorter period of time as at a low temperature for a longer period of time. Using this principle, the resulting TGA data can represent the duration of the various material's degradation processes. The PLA/PHA material performed the best of all the tested samples. These findings are consistent with existing literature, as the general biodegradable properties of bioplastics have been well established. It should be noted that the PLA/PHA blend performed better than all of the tested samples by a noticeable margin. This finding conclusively answers the research question of this experiment; in terms of degradation, PHA polymer substitutes provide an exceedingly large improvement over existing applications. In addition to degrading faster, PHA is also biocompatible, making it a favourable substitute from a food safety perspective. An interesting aspect of these results is the vast discrepancy between the PE film and the other samples. The PE film

was found to degrade approximately 100°C hotter than the average of the other plastics. This difference is assumed to be due to fillers and additives present in the PE formulation. Per the time-temperature superposition principle, this ~100°C difference establishes the material as essentially inert within the environment for an immensely long period of time compared to all the other plastic samples tested. This finding is particularly troubling as landfill is the most widely accepted disposal stream for paper cups (Changwichan and Gheewala, 2019). Following the findings of this experiment, paper cups currently in landfills would likely have their plastic component remain intact for many years longer than even the PP cold beverage cups. The impact made by a bioplastic substitute for existing polymer coatings would be substantial. Previous studies such as Lomonaco et al. (2020), have focused their examination on photo-degradation which is most prominent when the debris is in the open air; the structure of this experiment examines thermal degradation, the process by which materials degrade at a relatively stable temperature range for a prolonged period of time. In photodegradation, PE plastics were shown to emit harmful VOCs into the atmosphere (Lomonaco et al., 2020), establishing long-lingering PE films as being more than just a concern of debris. As these plastic films remain in the environment, they pose a considerable health threat to both humans and surrounding biota. These paper cups,

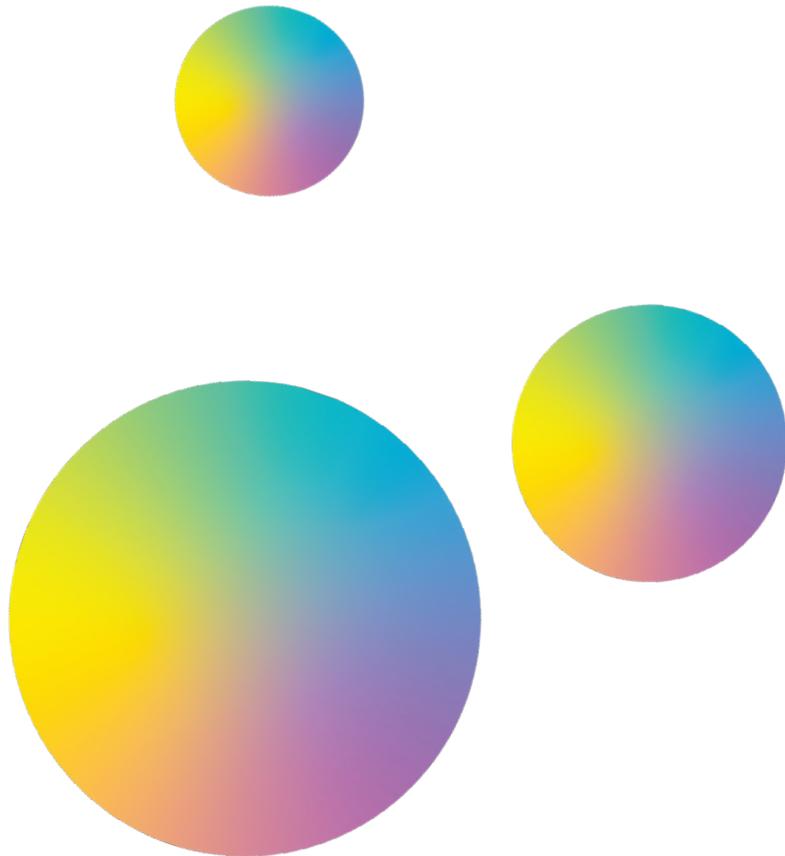
while seemingly less caustic than plastic waste, can account for far more devastating effects in the long term. PHA, and other biopolymer alternatives to PE, constitute a clear and present solution to an environmentally critical issue.

This experiment is relevant to this issue as the critical examination of emerging alternatives like PHA is currently limited. The data derived from TGA is robust enough to conclude concrete answers for the initial research question. However, this experiment is limited to the very broad understanding of thermal-oxidative degradation duration for each sample. Ideally, a detailed analysis of the individual chemical compositions of each submitted sample would be conducted. The sample collection could be expanded to incorporate several different paper cups currently available in restaurants. An understanding of the degree to which the findings of this experiment vary across similar products would be valuable. Additionally, an array of different PHA formulations could be tested further to narrow down an optimal substitute for PE film. More broadly, this experiment could be expanded upon to produce actionable results for use in packaging design. Overall the data collected is replicable and valuable, even if only by the instrumentation alone.

CONCLUSION

The current standard established for single-use hot-beverage containers leaves much to be desired in terms of environmental consciousness. Compared to bioplastic alternatives, specifically PHA-type biopolymers, the shortcomings are evident. PHA blend biopolymers provide a significant advancement in terms of degradability and sustainability when considered for use in packaging applications, especially hot-beverage containers. Thermogravimetric analysis (TGA) was effective in establishing an index for the thermal-oxidative degradation of PLA, PLA/PHA, PP, and PE plastics; the resulting data established PLA/PHA as the most suitable candidate for prompt degradation in landfill conditions. PE film was found to be excessively resistant to thermal-oxidative degradation. This understanding produces concerning questions about the state of plastic waste from paper cups. Much of the plastic waste produced by this type of packaging has and will continue to exist as debris for a significant period of time. The implications of this notion will continue to be relevant as global environmental concerns grow larger. PHA and other biopolymers present a viable solution to traditional petroleum-based plastics; the benefits are numerous, though significant infrastructural

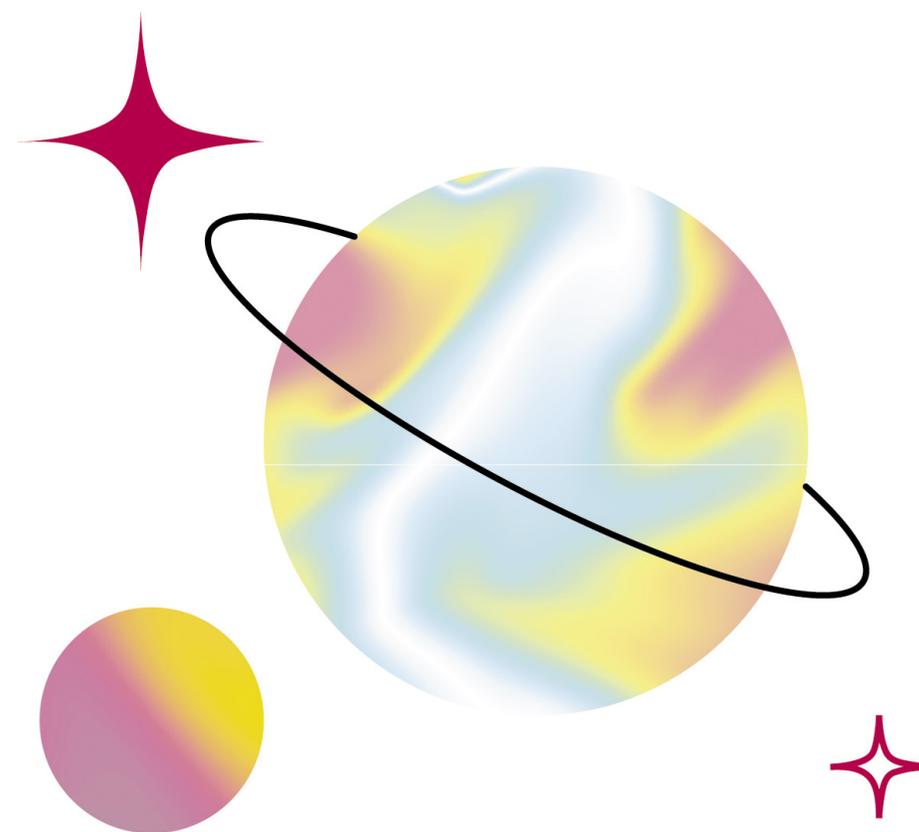
accommodation is necessary. Comprehensive research into biopolymers, specifically PHA, is still developing, and more robust characterization and application-based approaches are needed. Much can be remedied with a better understanding of biopolymers' qualities and characteristics.



REFERENCES

- Álvarez-Chávez, C. R., Edwards, S., Moure-Eraso, R., & Geiser, K. (2012). Sustainability of bio-based plastics: general comparative analysis and recommendations for improvement. *Journal of Cleaner Production*, 23(1), 47–56. <https://doi.org/10.1016/j.jclepro.2011.10.003>
- Biswal, B., Kumar, S., & Singh, R. K. (2013). Production of Hydrocarbon Liquid by Thermal Pyrolysis of Paper Cup Waste. *Journal of Waste Management*, 2013, 1–7. <https://doi.org/10.1155/2013/731858>
- Cabanes, A., & Fullana, A. (2021). New methods to remove volatile organic compounds from post-consumer plastic waste. *Science of The Total Environment*, 758, 144066. <https://doi.org/10.1016/j.scitotenv.2020.144066>
- Cabanes, A., Valdés, F., & Fullana, A. (2020). A review on VOCs from recycled plastics. *Sustainable Materials and Technologies*, 25, e00179. <https://doi.org/10.1016/j.susmat.2020.e00179>
- Changwichan, K., & Gheewala, S. H. (2020). Choice of materials for takeaway beverage cups towards a circular economy. *Sustainable Production and Consumption*, 22, 34–44. <https://doi.org/10.1016/j.spc.2020.02.004>
- Choi, B., Yoo, S., & Park, S. I. (2018). Carbon Footprint of Packaging Films Made from LDPE, PLA, and PLA/PBAT Blends in South

- Korea. Sustainability, 10(7), 2369. <https://doi.org/10.3390/su10072369>
- de Freitas Netto, S. V., Sobral, M. F. F., Ribeiro, A. R. B., & Soares, G. R. D. L. (2020). Concepts and forms of greenwashing: a systematic review. *Environmental Sciences Europe*, 32(1). <https://doi.org/10.1186/s12302-020-0300-3>
- iMarc. (2022). Paper Cups Market Size, Share, Trends and Forecast 2022–2027. IMARC Group. Retrieved April 6, 2022, from <https://www.imarcgroup.com/paper-cups-manufacturing-plant>
- Loganathan, S., Valapa, R. B., Mishra, R. K., Pugazhenth, G., & Thomas, S. (2017). Thermogravimetric Analysis for Characterization of Nanomaterials. *Thermal and Rheological Measurement Techniques for Nanomaterials Characterization*, 67–108. <https://doi.org/10.1016/b978-0-323-46139-9.00004-9>
- Lomonaco, T., Manco, E., Corti, A., La Nasa, J., Ghimenti, S., Biagini, D., di Francesco, F., Modugno, F., Ceccarini, A., Fuoco, R., & Castelvetro, V. (2020). Release of harmful volatile organic compounds (VOCs) from photo-degraded plastic debris: A neglected source of environmental pollution. *Journal of Hazardous Materials*, 394, 122596. <https://doi.org/10.1016/j.jhazmat.2020.122596>
- Triantafillopoulos, N., & Koukoulas, A. A. (2020). The future of single-use paper coffee cups: Current progress and outlook. *BioResources*, 15(3), 7260-7287. https://ojs.cnr.ncsu.edu/index.php/BioRes/article/view/BioRes_15_3_Review_Triantafillopoulos_Single_Use_Paper_Cups

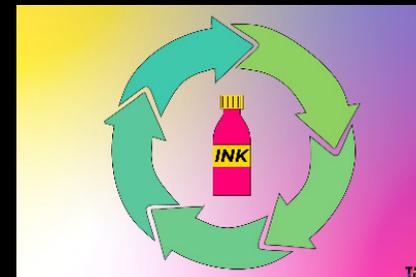


04



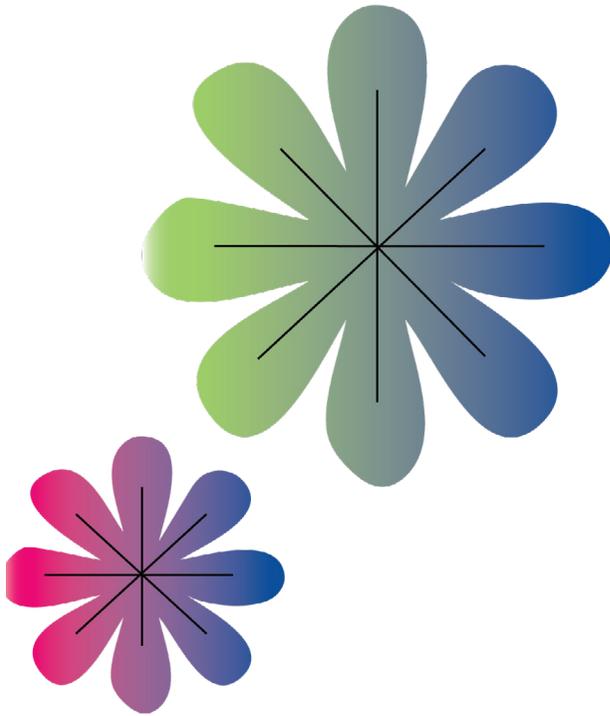
**GATE-TO-GATE LIFE CYCLE
ANALYSIS OF WIDE-FORMAT
FLATBED INKJET PRINTING**

by Zuha Waqar



RESEARCH QUESTION

What are the life cycle analysis contributions of the Ricoh Pro TF6250 Ultra-violet (UV) Light-emitting Diode (LED) Wide Format Flatbed printing system under the comparative analysis of the UV bottle inks (g), expendable consumables used for set-up and cleaning processes (g), and electricity consumption of the printing press and assistive printing device inventories (kWH) to output 10,000 plastic point-of-purchase (POP) products?



ACKNOWLEDGMENTS

Thank you to all the individuals who supported and guided this thesis project. Navigating an experimental thesis project for the first time was a jarring experience, but several people, to whom I will always be grateful, have made this process a memorable learning experience.

I would like to acknowledge Dr. Jonghun Park for acting as this project's thesis advisor and for his guidance in the preparation of this paper. Thank you for spending the time to mentor me and teach me the fundamentals of life cycle analysis research. Also, thank you for your patience as I learned how to navigate the LCA software as it was a lengthy process for us both.

I would also like to acknowledge the assistance of the Design + Technology Lab at Toronto Metropolitan University, specifically Orit Zewge-Abubaker and Alda Escareno, for their assistance throughout this project. This thesis would not have been possible without the cooperation of the lab, especially without their best efforts to guide my exploration of the printing system and provide essential information about the equipment and other processes along the way.

This research was further supported by Ricoh Canada and Begum Walji. I would like to thank Walji for taking the time to learn about my thesis project and to provide me with useful data about the UV bottle inks. Her knowledge allowed me to

further improve my methods to reflect possible limitations in my study and to understand the mechanics of this wonderful yet greatly intricate inkjet printing system.

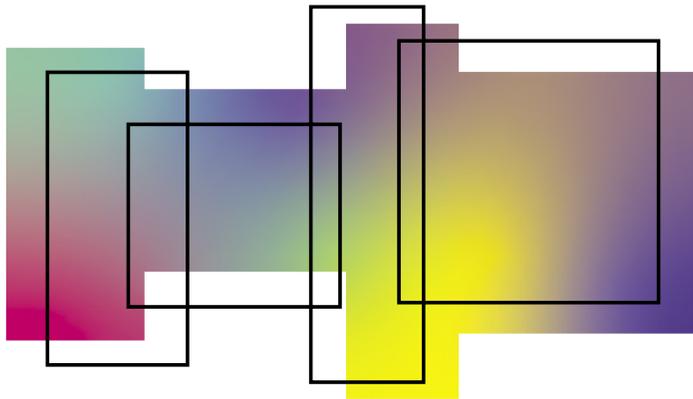
I would like to thank Professor Ian Baitz for his support as the course instructor and for working with the class to provide an array of helpful resources, answer questions, and provide excellent feedback. Remote learning is a great challenge and I greatly value the time he spent to address my concerns and questions as it all greatly added value to the development of my project.



ABSTRACT

Life cycle analysis (LCA) studies of ultra-violet (UV) inks, used for inkjet printing systems, are an emerging field of research within the print and packaging industries. This study conducts a life cycle inventory analysis on four process UV light-emitting diode (LED) inks throughout the production of a plastic point-of-purchase (POP) display. Furthermore, this study considered the inventories of UV bottle inks, expendable consumable materials used for the set-up and cleaning processes of a wide-format flatbed inkjet printer, and its total electricity consumption. The study found that electricity consumption from the wide format printing press (E1) contributed the most to human health, ecosystems, and resources endpoint indicators. Conversely, the UV bottle inks' environmental contributions and expendable consumables (M1) amounted to <0.1, with most of the environmental impact stemming from the production of the polypropylene (PP) body of the lint-free microfiber cleaning swabs. In addition, the process contribution analysis per impact category indicated that the most significant environmental impacts contributed to (1) human health, and global warming, (2) fine particulate formation, (3) human carcinogens, and (4) human non-carcinogens impact categories. The limitations of the study included a lack of a controlled printing environment which affected ink consumption values. Likewise, this study only

considered the environmental impact of the inkjet printer following the production of a plastic POP display. Hence, the results are specific to the final product. This study also substituted ink ingredients based on relevant literature due to a lack of available inventories on SimaPro v9.0. Future studies are recommended to explore additional methods to model UV ink inventories, calculate ink consumption, and measure emissions of UV LED inks for multiple print applications. The study's results further indicated that future research is needed to optimize the electrical consumption of inkjet printing systems to decrease environmental contributions.



INTRODUCTION

The graphic communications industry widely accepts ultra-violet (UV) curable ink technology as an environmentally sustainable alternative to traditional inks for many print and packaging applications. For example, a number of flatbed printers broadly use UV ink technology in print production processes (Hudd, 2010). Moreover, the substance stability of UV inks enables them to be affordable and energy-efficient (Hudd, 2010). A novel research area of UV-curable inks within the print industry includes the formulation of light-emitting diode (LED) ink technology with extensive use in inkjet printing (Ren et al., 2009; Hudd, 2010).

A variety of studies have been conducted on the environmental impact of UV ink-based printing, including a comparison of solvent-based, water-based, UV-curable, and soy-based inks used in flexographic printing (Piluso et al., 2009). In addition, a comprehensive review of typical formulations of UV printing inks is described in *The Chemistry of Inkjet Inks* (Magdassi, 2009), which stated that inkjet printing must consider the system components, namely hardware, ink components, and power to evaluate the ink performance (Hudd, 2010). However, few life cycle assessments (LCA) have been conducted on the full printing ink system to include intermediate processes (e.g., the electricity consumption

of the printing press and assistive devices, makeready consumables, and maintenance procedures), and the extraction and processing of raw materials. Subsequently, this study conducted an environmental contribution assessment of a wide-format flatbed UV LED inkjet printing system under the aforementioned system components.

Although there are few LCA studies that focused on UV LED ink-based inkjet printing systems, Piluso et al. (2009) conducted an environmental and economic evaluation of flexographic printing comparing UV-curable ink with solvent-based and water-based inks. Moreover, LCA studies regarding printing inks have disproportionately focused on solvent-based inks, and printing systems that use ink cartridges and toner-based inks (Bousquin et al., 2011). Hence, there was a lack of LCA knowledge about inkjet printers using UV LED ink technology. For this reason, this project aimed to obtain a detailed life cycle inventory analysis and impact assessment of a UV LED flatbed inkjet printing system. Furthermore, this study used a functional unit of UV ink (g), electricity (KWh), and other consumables (g) consumed for the digital printing of 10,000 plastic point-of-purchase (POP) products.

LITERATURE REVIEW

This study conducted a life cycle assessment (LCA) of a UV LED inkjet printing system used to produce one point-of-purchase (POP) display for consumer-packaged goods (CPG). The subsequent sections provide general overviews of prior literature that studied sustainability within the print and packaging industries, life cycle assessments in the printing industry, overview of UV inks, and life cycle assessment studies of UV-curable inks.

Sustainability in the Print and Packaging Industry

The role of sustainability has become a priority for many consumers regarding the production of consumer-packaged goods (CPG) (Jerzyk, 2015) and is a widely discussed function of packaging (Nordin, & Selke, 2010). In 2020, the global inkjet print industry was worth \$80.4 billion (Smithers, 2020). Likewise, the global UV print machine market was valued at \$278 million in 2017 and is expected to increase to \$555 million in 2024 (McKeegan, 2021). However, an increase in the UV LED machine market directly resulted in an increase of print component consumption, thereby leading to the newfound growth of emissions to air, water, and land.

Life Cycle Assessments in Printing

Life cycle assessment (LCA) measures the environmental contributions through input and output products, such as the extraction of raw materials, intermediate processes, transportation, use, and disposal (ISO, 2006). LCA studies were first popularized by Coca-Cola in the 1970s (Bousquin et al., 2011), and have continued to be a significant determinant of environmental contributions within the print and packaging industry. The guidelines for LCA studies have been developed in part by the International Organization for Standardization (ISO) (ISO, 2006). For example, ISO standards 14040 and 14044 defined the goal and scope, the functional unit, system boundaries, the life cycle inventory analysis (LCI), and the life cycle impact assessment (LCIA) sections necessary to conduct a life cycle analysis (LCA) (ISO, 2006). In like manner, the requirements of an LCI analysis also included the quantification of input and output values as noted in the above section (ISO, 2006).

Bousquin et al. (2011) conducted an extensive literature review of existing LCA studies within the print industry. Their review found that the industry's sales revenue largely concentrated on personal and office printers and photocopiers, and their solid ink or cartridge contributions. Comparatively, Robert

(2015) stated no overview of renewable-based printing inks had been made at the time of writing. Instead, many available LCA studies focused on LaserJet printing applications (Robert, 2015). This literature review similarly found numerous LCA studies regarding the environmental implications of ink cartridges and toner-based ink (Pollock & Coulon, 1996; Kara, 2010; Krystofik & Gaustad, 2014), and solvent-based inks (Egawa & Kozake, 2019), but only found a few recently published studies that expressly analyzed the environmental impact of organic-based inks, such as water-based solvents (Robert, 2015; Kawaguchi et al., 2020), soy-based solvents (Tolle et al., 2000), and UV ink technology (Piluso, 2009; Liao et al., 2012; Seipel et al., 2018). As a result, there is a lack of LCA knowledge about inkjet printing systems that use UV LED ink technology. For the purposes of this research, the subsequent subsections solely examine works of literature that provide analytical information about UV inks.



Overview of UV Inks

The use of ultra-violet (UV) curing technology has dramatically increased in print and packaging applications within recent years such that “the volumes consumed have doubled every five years” (Hutchinson, 2009, 178). For this reason, there are few publications that have analyzed UV-cured printing systems. For example, Hutchinson (2009) analyzed the performance trends and properties of ink ingredients predominantly used in the formulation of UV-curable inks for inkjet printing applications. In particular, the material examinations discussed the advantages and disadvantages of its formulation, as well as its general properties and functions (Hutchinson, 2009). Hence, their research and discussion enabled the optimization of existing UV ink formulations to improve performance standards. This study will later detail the material composition of UV inks and existing literature that analyzed its environmental impact through quantitative methodologies, including life cycle assessments.



UV Ink Components

Most UV inkjet formulations are mixtures of several different acrylates, namely monomer and oligomer acrylates, and several photoinitiators that provide a unique set of ink properties useful for their end-use (Hutchinson, 2009).

First, monomers used in UV inkjet applications include epoxy acrylates, polyester acrylates, and urethane acrylates (Hutchinson, 2009). Acrylates vary in terms of their functionality and reactivity. For example, acrylate monomers can be divided into monoacrylates, diacrylates, and triacrylates (Hutchinson, 2009). Other factors further differentiating monomer performance include their classification as either linear or cyclic; with cyclic monomers further categorized as either aromatic or aliphatic (Hutchinson, 2009). Yun et al. (2013) investigated the impact of monomers on the dispersion characteristics of UV-LED inkjet inks. The study analyzed seven monomers to compare “viscosity, surface tension, curing rate of the ink and flexibility and adhesion” characteristics to obtain the best performance and specifically concluded that monomers significantly influenced the curing rate of UV ink (Yun et al., 2013).

Second, oligomers are categorized as epoxy acrylates, urethane acrylates and polyester acrylates (Hutchinson, 2009). However, acrylate oligomers are less prominent in the overall composition of UV inkjet inks due to their highly viscous properties (Hutchinson, 2009).

Third, UV-curable inkjet inks use a combination of multiple photoinitiators to optimize curing properties. The photoinitiators absorb UV light at such a speed that allows for optimum surface curability of the ink film. Photoinitiators can be categorized as Type I, such as acetophenone (Dietlin et al.,

2020), or Type II, such as benzophenone (Allushi et al., 2017). Type I photoinitiators are advantageous in their formulation compared to the conventional Type II photoinitiator (Randolph et al., 2016).

Fourth, other ink components included phenolic sensors, additives that improved wettability characteristics as well as pigments (Hutchinson, 2009; Robert, 2015).

Conclusions

Although the studies focused on the material composition and environmental impact of UV inks, a gap remained within literature regarding the analysis of the environmental burdens of UV ink systems and life cycle inventories. Moreover, present studies that directly analyzed the life cycle assessment of UV inks were limited to a flexographic printing press (Piluso et al., 2009) instead of inkjet applications and did not consider the life cycle phases. Furthermore, the studies did not consider the holistic printing system as described by Hudd (2010). For this reason, this study aimed to understand the role of inkjet printers that drive the environmental impact of UV inks. In particular, it investigated the impact of a wide-format flatbed UV LED inkjet printer and its consumption of ink, energy, and other consumables used for cleaning and set-up procedures.

METHODOLOGY

This study conducted a life cycle assessment (LCA) of a wide-format flatbed UV LED inkjet printing system in collaboration with an imaging and electronics company, and a Toronto Metropolitan University-based creative technologies lab. This study complied with ISO 14040-14044 (ISO, 2006) and used SimaPro v9.0.

Goal and Scope

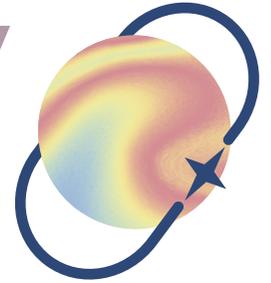
The goals of this LCA were to build a life cycle inventory for UV LED inks and to analyze the environmental impacts of the intermediate processes involved in the inkjet printing of a plastic consumer packaged goods (CPG) point-of-purchase (POP) display (18-inch by 30-inch) using UV LED inks. The intermediate processes included raw material extraction and production of the UV inks, expendable consumables, and electricity consumption. First, the LCA constructed a life cycle inventory for four UV bottle inks (CMYK) comprised of oligomers, monomers, photoinitiators, phenolic sensors, and additives based on primary data sourced from the ink manufacturer, as well as secondary sources (Hutchinson, 2009). Second, the LCA analyzed the environmental contribution of the ink, electricity, and expendable consumables using a gate-to-gate system boundary (See Figure 1). Transportation

and disposal were not considered in this study. Likewise, the use and processing of raw materials for electrical energy production and consumption of the print system were not considered. The functional unit used for this study was the printing of 10,000 products.

TABLE 1. - DESCRIPTION OF INVENTORIES ANALYZED IN THE CASE STUDY

	DESCRIPTION
PRODUCT TYPE	Plastic POP Display - Dimensions (in.): 18 x 30 - 4C; Ink coverage (%): 55.2 - Ink Used (ml): 2.36 - Cost (\$): 0.47
UV INK TYPE	UV Ink Bottle (g): Black (0.62), Cyan (0.32), Magenta (0.57) and Yellow (0.85) - Total Volume (mL): 2.36
EXPENDABLE CONSUMABLE	Cleaning Liquid - Weight (mL): 0.05 g (per twenty print runs)
	Expendable lint-free cleaners made of high-density polyethylene and polystyrene - Weight (g): 0.34 g (per twenty print runs)
	Expendable gloves made of low-density polyethylene - Weight (g): 1.52 (per twenty print runs)
	Expendable bags made of low-density polyethylene - Weight (g): 24.80 (per twenty print runs)
	Mixed Pulp Paper - Weight: 12.87g
	- Expendable tape made of kraft paper and synthetic rubber - Weight: 8.09 g
DEVICES	UV LED flatbed printer - Voltage: 6500W
	Dual 17" LCD Monitors - Voltage: 150W

Life Cycle Inventory Analysis



CMYK UV Inks

The inventory analysis for the UV bottle inks considered the materials and intermediate processes used for their creation. The ink components consisted of oligomers, monomers, photoinitiators, and additives, as noted from primary and secondary sources. The goal of this inventory was to estimate the total amount of UV ink components, from a gate-to-gate perspective, for 10,000 products. This study used primary data to gather information about the POP product characteristics (e.g., substrate type, dimensions, ink percentage breakdown, ink coverage percentage) as noted in Table 1. The specific ink ingredients and percentage of ingredients for each UV bottle ink inventory used the information listed on the corresponding SDS and was calculated using the formula below [1]. Thus, this study used primary and secondary resources to create the material flows. For the inventory, the following percentages are applied to construct UV ink inventories:

1. Main proportions of UV inks are additives, oligomers, monomers, Type I and II photoinitiators, and phenolic sensors.
2. Proportions of oligomers are: (8%) from bisphenol A epoxy-based resin ester.

3. Proportions of monomers are: (15% – 30%) from methyl methacrylate, (30% – 49%) from Ethoxylated (4) phenol acrylate, and (2% – 21%) from 2-ethylhexyl acrylate and (4% – 8%) dioxane glycol diacrylate.
4. Proportions of Type I photoinitiators are: (5% – 10%) from acetophenone emission to air, and Type II photoinitiators are: (1% – 2%) from benzophenone emission to air.
5. Proportions of phenolic sensors are: (0.02%) from 4-nitrophenol.
6. Proportions of other additives are: (5% – 13%) from pigments, unspecified.

$$\text{Process Ink Consumption (g)} = \text{Process Ink Weight} \times \text{Material \%}$$

[1]

This study acknowledged several limitations due to a variance in media profiles, substrates, print location, and a lack of a controlled environment. The limitation of different media profiles and print substrates are especially important factors that affect ink consumption. Furthermore, the project was

executed in a non-controlled environment with variable levels of humidity (See Figure 1, Appendix for the profile used in this study). Sharma (2018) stated that the humidity and temperature of the room and media greatly impact the functioning of digital presses. As a result, the ink consumption value provided by the ONYX RIP (See Figure 4, Appendix) may have included the residual quantity of other inks, such as UV bottle ink (White) (Personal correspondence, March 11, 2022). Therefore, the ink consumption calculations will greatly vary depending on the variables and the provided measurement may not be accurate.

Tables 2 – 5 document the ingredient component, material, function, substituted material and its function, overall properties of the ink component, and material percentage. The materials and material % columns were extracted from the SDS, but most materials were unavailable in the SimaPro v9.0 inventories. For this reason, the materials were substituted with similar materials from the same ink component, as seen in the tables below (Hutchinson, 2009). The function columns following the material column and the material (substituted) column offer clarity about the comparison between the original and substituted ink ingredient. Likewise, the properties column provides an overall description of the ink component qualities (Hutchinson, 2009).

TABLE 2. - MATERIALS RETRIEVED FROM SDS SHEETS FROM INK MANUFACTURER (UV INK BOTTLE BLACK)

INK COMPONENT	MATERIAL	FUNCTION	MATERIAL (SUBSTITUTED)	FUNCTION	PROPERTIES	MATERIAL %
A ^a	Additives, unspecified	Pigment	Pigment, unspecified	Ink Dye	Unspecified	12.8
M ^b	2-phenoxyethyl acrylate	Aromatic Monofunctional Monomer	Ethoxylated (4) phenol acrylate	Aromatic Monofunctional Monomer	Viscosity, adhesion	30
	Isobornyl acrylate	Cyclic Monofunctional Monomer	2-Ethylhexyl Acrylate	Linear Monofunctional Monomer		8
	(5-Ethyl-1-1, 3-dioxan-5-) methyl acrylate	Monofunctional Acrylic Monomer	Methyl methacrylic	Monofunctional Acrylic Monomer	Cure speed	30
	Tricyclo decane dimethyl diacrylate	Difunctional Acrylic Monomer	Dioxane Glycol Diacrylate	Difunctional Acrylic Monomer	Cure speed, adhesion	8
P ^c	Diphenyl(2,4,6-trimethylbenzoyl) phosphine oxide	Type I Photoinitiator	Acetophenone	Type I Photoinitiator	Enable UV Curing	10
	Phenyl bis(2,4,6-trimethylbenzoyl)-phosphine oxide	Type I Photoinitiator	N/A	N/A		1
PS ^d	4-Methoxyphenol	Phenolic Sensor	P- Nitrophenol	P-nitrophenol (GLO) market for Cut-off, U	Deaeration, Surface wetting	0.2

A= ADDITIVES, B = OLIGOMERS, C = MONOMERS, D = PHOTOINITIATORS, E = PHENOLIC SENSOR

TABLE 3. - MATERIALS RETRIEVED FROM SDS SHEETS FROM INK MANUFACTURER (UV INK BOTTLE CYAN)

INK COMPONENT	MATERIAL	FUNCTION	MATERIAL (SUBSTITUTED)	FUNCTION	PROPERTIES	MATERIAL %
A ^a	Additives, unspecified	Pigment	Pigment, unspecified	Ink Dye	Unspecified	11.8
O ^b	4-(1-oxo-2-propenyl)-morpholine	Epoxy Acrylates	Bisphenol A epoxy based vinyl ester resin	Epoxy Acrylates	Cure film resistance, flexibility	8
M ^c	2-phenoxyethyl acrylate	Aromatic Monofunctional Monomer	Ethoxylated (4) phenol acrylate	Aromatic Monofunctional Monomer	Viscosity, adhesion	49
	Isobornyl acrylate	Cyclic Monofunctional Monomer	2-Ethylhexyl Acrylate	Linear Monofunctional Monomer		21
	Tricyclo decane dimethyl diacrylate	Difunctional Acrylic Monomer	Dioxane Glycol Diacrylate	Difunctional Acrylic Monomer	Cure speed, adhesion	8
P ^d	Diphenyl(2,4,6-trimethylbenzoyl) phosphine oxide	Type I Photoinitiator	Acetophenone	Type I Photoinitiator	Enable UV Curing	5
	Phenyl bis(2,4,6-trimethylbenzoyl)-phosphine oxide	Type I Photoinitiator	N/A	N/A		1
PS ^e	4-Methoxyphenol	Phenolic Sensor	P- Nitrophenol	P-nitrophenol (GLO) market for Cut-off, U	Deaeration, Surface wetting	0.2

A= ADDITIVES, B = OLIGOMERS, C = MONOMERS, D = PHOTOINITIATORS, E = PHENOLIC SENSOR

TABLE 4. - MATERIALS RETRIEVED FROM SDS SHEETS FROM INK MANUFACTURER (UV INK BOTTLE MAGENTA)

INK COMPONENT	MATERIAL	FUNCTION	MATERIAL (SUBSTITUTED)	FUNCTION	PROPERTIES	MATERIAL %
A ^a	Additives, unspecified	Pigment	Pigment, unspecified	Ink Dye	Unspecified	6.8
O ^b	4-(1-oxo-2-propenyl)-morpholine	Epoxy Acrylates	Bisphenol A epoxy based vinyl ester resin	Epoxy Acrylates	Cure film resistance, flexibility	8
M ^c	2-phenoxyethyl acrylate	Aromatic Monofunctional Monomer	Ethoxylated (4) phenol acrylate	Aromatic Monofunctional Monomer	Viscosity, adhesion	51
	Isobornyl acrylate	Cyclic Monofunctional Monomer	2-Ethylhexyl Acrylate	Linear Monofunctional Monomer		2
	(5-Ethyl-1,1,3-dioxan-5-) methyl acrylate	Monofunctional Acrylic Monomer	Methyl methacrylic	Monofunctional Acrylic Monomer	Cure speed	18
	Tricyclo decane dimethyl diacrylate	Difunctional Acrylic Monomer	Dioxane Glycol Diacrylate	Difunctional Acrylic Monomer	Cure speed, adhesion	6
PI ^d	Diphenyl(2,4,6-trimethylbenzoyl) phosphine oxide	Type I Photoinitiator	Acetophenone	Type I Photoinitiator	Enable UV Curing	5
	2-Phenoxyethanol	Type I Photoinitiator	Benzophenone	Type II Photoinitiator		2
	Phenyl bis(2,4,6-trimethylbenzoyl)-phosphine oxide	Type I Photoinitiator	N/A	N/A		1
PS ^e	4-Methoxyphenol	Phenolic Sensor	P- Nitrophenol	P-nitrophenol {GLO} market for Cut-off, U	Deaeration, Surface wetting	0.2

A= ADDITIVES, B = OLIGOMERS, C = MONOMERS, D = PHOTOINITIATORS, E = PHENOLIC SENSOR

TABLE 5. - MATERIALS RETRIEVED FROM SDS SHEETS FROM INK MANUFACTURER (UV INK BOTTLE YELLOW)

INK COMPONENT	MATERIAL	FUNCTION	MATERIAL (SUBSTITUTED)	FUNCTION	PROPERTIES	MATERIAL %
A ^a	Additives, unspecified	Pigment	Pigment, unspecified	Ink Dye	Unspecified	5.8
O ^b	4-(1-oxo-2-propenyl)-morpholine	Epoxy Acrylates	Bisphenol A epoxy based vinyl ester resin	Epoxy Acrylates	Cure film resistance, flexibility	8
M ^c	2-phenoxyethyl acrylate	Aromatic Monofunctional Monomer	Ethoxylated (4) phenol acrylate	Aromatic Monofunctional Monomer	Viscosity, adhesion	49
	Isobornyl acrylate	Cyclic Monofunctional Monomer	2-Ethylhexyl Acrylate ₁	Linear Monofunctional Monomer		6
	(5-Ethyl-1,1,3-dioxan-5-) methyl acrylate	Monofunctional Acrylic Monomer	Methyl methacrylic	Monofunctional Acrylic Monomer	Cure speed	15
	Tricyclo decane dimethyl diacrylate	Difunctional Acrylic Monomer	Dioxane Glycol Diacrylate	Difunctional Acrylic Monomer	Cure speed, adhesion	5
PI ^d	Diphenyl(2,4,6-trimethylbenzoyl) phosphine oxide	Type I Photoinitiator	Acetophenone	Type I Photoinitiator	Enable UV Curing	8
	2-Phenoxyethanol	Type I Photoinitiator	Benzophenone	Type II Photoinitiator		2
	Phenyl bis(2,4,6-trimethylbenzoyl)-phosphine oxide	Type I Photoinitiator	N/A	N/A		1
PS ^e	4-Methoxyphenol	Phenolic Sensor	P- Nitrophenol	P-nitrophenol (GLO) market for Cut-off, U	Deaeration, Surface wetting	0.2

A= ADDITIVES, B = OLIGOMERS, C = MONOMERS, D = PHOTOINITIATORS, E = PHENOLIC SENSOR

Table 6 contains the complete life cycle inventory analysis for all ink components and materials, including the life cycle inventory name (as it appeared in SimaPro v9.0), and the LCI type. In all ink inventories, the photoinitiator, phenyl bis (2,4,6-trimethylbenzoyl) phosphine oxide, was excluded due to unavailability within SimaPro and the lack of an appropriate substitute that was also available in the LCA software database.

Table 7 presents the complete life cycle inventory analysis for the inkjet printing system components, namely the four UV bottle inks, the electricity usage of the printer and the print

devices, and the consumables used throughout the set-up and cleaning procedures. Moreover, Table 7 provides the material composition of the aforementioned print components and their complete life cycle inventory name and corresponding database as seen in SimaPro v9.0.

TABLE 6. - LIFE CYCLE INVENTORY ANALYSIS OF THE UV LED BOTTLE INKS

INK COMPONENT	MATERIAL	MATERIAL (SUBSTITUTED)	LCI	LCI TYPE	PEDIGREE SCORE
A ^a	Additives, unspecified	Additives	Pigment, paper production, unspecified, at plant/US-US-EI U	US LCI	(1,3,1,1,2,3)
O ^b	4-(1-oxo-2-propenyl)-morpholine	Bisphenol A	Bisphenol A epoxy-based vinyl ester resin, {GLO} market for APOS, S	US LCI	(1,3,1,1,2,3)
M ^c	2-phenoxyethyl acrylate	Ethoxylated (4) phenol acrylate	Ethoxylated alcohols, unspecified, at plant/US-US-EI U	US LCI	(1,3,1,1,2,3)
	Isobornyl acrylate	2-Ethylhexyl Acrylate	2-Ethylhexyl Acrylate/EU-2	Inventory Data 2.0	(1,3,1,1,2,3)
	(5-Ethyl-1-1,3-dioxan-5-) methyl acrylate	Methacrylic Acid	Methyl Methacrylate/ EU-27	Inventory Data 2.0	(1,3,1,1,2,3)
	Tricyclo decane dimethyl diacrylate	Dioxane Glycol	Dioxane glycol, at plant/US-US-EI U	US LCI	(1,3,1,1,2,3)
PI ^d	Diphenyl(2,4,6-trimethyl benzoyl)phosphine oxideves, unspecified	Acetophenone	Acetophenone Airborne emission	SimaPro v9.0	(1,3,1,1,2,3)
	2-Phenoxyethanol	Benzophenone	2-Phenoxyethanol	SimaPro v9.0	(1,3,1,1,2,3)
	Phenyl bis (2,4,6-trimethylbenzoyl) -phosphine oxide	N/A			
PS ^e	4-Methoxyphenol	P- Nitrophenol	P-nitrophenol {GLO} market for APOS, S	Ecoinvent 3.0	(1,3,1,1,2,3)

A= ADDITIVES, B = OLIGOMERS, C = MONOMERS, D = PHOTOINITIATORS, E = PHENOLIC SENSOR

FIGURE 1 - SYSTEMS BOUNDARY FOR RICOH PRO TF6250 UV LED PRINTER (GATE-TO-GATE)

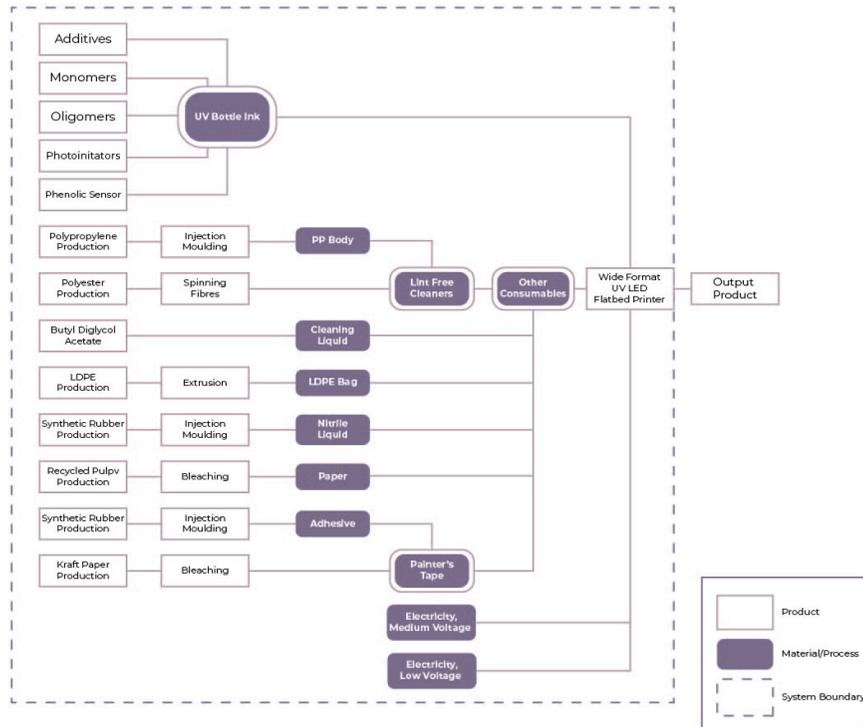
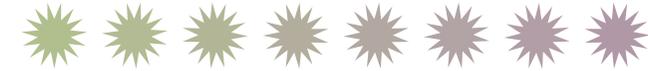


Figure 1 depicts the gate-to-gate systems boundary of the wide format flatbed UV LED inkjet printing system, including the UV bottle inks, electricity consumption, and expendable consumables used for set-up and cleaning procedures.

Expendable Consumables Used for Set-up and Cleaning

The second inventory considered the raw materials and intermediate processes used to produce the expendable consumables. The goal of this was to estimate the consumption of the expendable consumables used for cleaning and maintenance, such as cleaning liquid, lint-free microfiber cleaning swabs, expendable plastic bags, and expendable

nitrile gloves. Likewise, this inventory also considered the consumables used in makeready processes, including painter's tape and recycled pulp paper, as observed from the Toronto Metropolitan University-based lab visitations. The cleaning materials were used once every 20 print runs, assuming the print runs are of average print size and ink consumption, whereas each print run used makeready materials.



Electricity Consumption

The third inventory focused on the electricity consumption generated by the UV LED flatbed inkjet printer (see Table 1). The Toronto-based lab estimated an approximate time spent for set-up and printing of 12.50 minutes and 2 minutes, respectively. This study also calculated inventories for the computer monitors. The average computer monitor's energy consumption for a typical 17-inch (431.8 mm) LCD monitor was 35 W, and the average computer energy consumption for a desktop computer was between 60 – 250 W (Northwestern University, n.d.). The study used the following formula to calculate the total energy consumption of the flatbed printer and the LCD monitor for 10,000 products:

$$\text{Total Energy Consumption (KWh)} = \frac{\text{Watts (W)}}{1,000} \times \left(\frac{\text{Set-up Time (min)}}{60} + \frac{\text{Total Print Time (min)}}{60} \right) \times 10,000$$

TABLE 7. - LIFE CYCLE INVENTORY ANALYSIS OF THE UV LED FLATBED PRINTING SYSTEM FOR 10,000 PRODUCTS

INVENTORIES	COMPONENTS	MATERIAL	INVENTORY NAME	VALUES/ FUNCTIONAL UNIT	INVENTORY TYPE	PEDIGREE SCORE
UV Bottle Inks ^a	UV Ink Bottle Magenta UV Ink Bottle Cyan UV Ink Bottle Yellow UV Ink Bottle Black	See Tables 2 - 5		2.36 kg	See Tables 2 - 5	
Electricity ^b	Printer	Electricity	Electricity, medium voltage, at grid/Ontario CA US-EI U	15,600 kWh	US-EI 2.2	(1,2,1,2,2,5)
	17" Dual LCD Monitors	Electricity	Electricity, low voltage, at grid/Ontario CA US-EI U	400 kWh	US-EI 2.2	(1,3,1,3,2,5)
Expendable Consumables ^c	Cleaning Liquid	Butyl diglycol acetate	Butyldiglycol acetate {GLO} butyldiglycol acetate production APOS, S	10 g	Ecoinvent 3.0 allocation at point of substitution - system	(1,2,1,2,2,5)
	Lint-free Microfiber Cleaning Swabs	PP Process Polyester Process	Polypropylene, granulate, at plant/US-US-EI U Injection moulding, at plant/US- US-EI U Unsaturated polyester, resin, at plant/US- US-EI U Injection moulding, at plant/US- US-EI U	163.8 g	US-EI 2.2	(1,2,1,2,2,5)
	Painter's Tape	Kraft Paper Synthetic Rubber	Kraft paper, bleached, at plant/US US-EI U Synthetic rubber, at plant/US US-EI U	114.2 kg	US LCI US-EI 2.2	(1,3,1,2,2,3) (2,3,1,3,2,5)
	Expendable LDPE Bags	LDPE Process	Low density polyethylene granulate, at plant/US- US-EI U Extrusion, plastic film, at plant/US US-EI U	97.2 g	US LCI US-EI 2.2	(1,3,1,2,2,3) (2,3,1,3,2,5)
	Expendable Nitrile Gloves	Synthetic Rubber Process	Synthetic rubber, at plant/US- US-EI U Extrusion, plastic film, at plant/US US-EI U	53.4 g	US LCI US-EI 2.2	(1,3,1,2,2,3) (2,3,1,3,2,5)
	Paper	Recycled Pulp	Graphic paper, 100% recycled {RoW} production Conseq, U	219 kg	Ecoinvent 3.0 allocation at point of substitution - system	(1,3,1,3,2,5)

A = ULTRA-VIOLET INK PRODUCTION AND CONSUMPTION, B = ELECTRICITY CONSUMPTION OF PRINTER AND DESKTOP, C = EXPENDABLE CONSUMABLES USED FOR MAKEREADY AND CLEANING

Life Cycle Impact Assessment

The life cycle impact assessment used an endpoint-oriented life cycle impact assessment methodology called ReCIPE 2016 (H). The ReCIPE model was selected for this study and used a normalization weight level to interpret the results. The model analyzed three endpoint impact categories: human health, ecosystems, and resources.

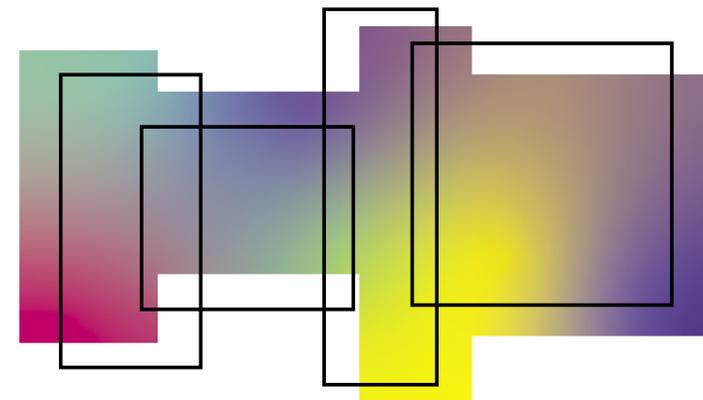
Limitations and assumptions

The assumptions and limitations that could affect the results in this study are as follows:

- The transportation of raw materials for ink, electricity, and consumables from their manufacturing sites to the Toronto-based lab was excluded from the scope of this study.
- The disposal of waste products for ink, electricity, and consumables was excluded from the scope of this study.
- This study was not conducted in a controlled print environment. Hence, there were variances in humidity and temperature that affected the amount of ink consumed. Other factors affecting ink consumption

include profiles (See Figure 1 – 3, Appendix), substrate type, and print location (See section 3.2).

- Some material components of the UV ink provided by the ink manufacturer were not available on SimaPro v9.0. Therefore, all material components for the UV ink components were substituted based on equivalents referred to in literature (Hutchinson, 2009)
- Phenyl bis(2,4,6,-trimethylbenzoyl)-phosphine oxide was excluded from the ink inventories due to a lack of a suitable substitute sourced from literature.
- It was assumed that the 17" LCD dual monitors generated electricity of 185 W (Northwestern University, n.d.).



RESULTS

Life cycle inventory results

Tables 2 – 5 presents the life cycle inventory for UV LED bottle inks. The material column lists the ingredients extracted from the SDS supplied by the ink manufacturer. However, many ink ingredients were unavailable on SimaPro v9.0. Hence, some materials were substituted based on secondary sources (Hutchinson, 2009). Furthermore, the ink and expendable consumables inventories (sections 3.1.1 - 3.1.2) were combined to form one overall inventory (M1), whereas the second and third inventories consisted of the electrical consumption of the printing press (E1) and desktop devices (E2), respectively.

Results of Contribution Analysis

A contribution analysis was conducted at the level of normalization to interpret the LCA results, specifically to determine how much environmental impact was generated from each inventory of the case study. The impact assessment analyzed three endpoint indicators, such as human health, ecosystems, and resources (see Figure 2). In Figure 2, the

electricity, medium voltage, at grid/Ontario CA (E1) had the greatest environmental impact in all three endpoint indicators. Out of all three endpoint indicators, the digital printer greatly contributed to the human health endpoint indicator, whereas the contribution to the ecosystem and resources endpoints are nearly negligible (<0.1).

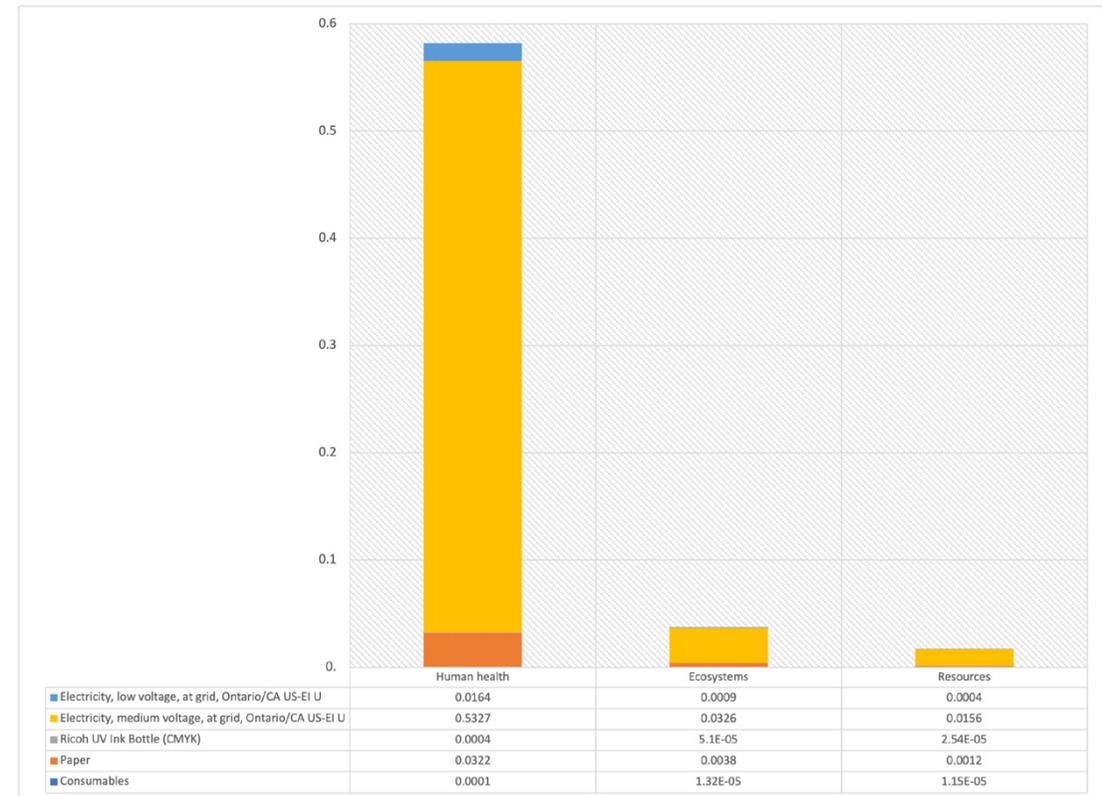


FIGURE 2 - RESULTS OF CONTRIBUTION ANALYSIS OF THE UV LED FLATBED PRINTING (NORMALIZED VALUES)

The results indicated that the electricity consumption of the printing process had the greatest environmental impact in all three endpoint environmental impact categories including human health (91.6% of the total impact), ecosystems

(87.2% of the total impact), and resources (90.1% of the total impact). Specifically, diesel burned in the power plant contributed the most to human health and ecosystems, while natural gas burned in the power plant had the most contribution to resources.

Paper production generated the second largest environmental burden for all environmental impact categories (5~10% of the total impact). In particular, the electricity used for the recycling process to manufacture recycled paper had the greatest contribution to human health. The natural gas consumed during the pulping process contributed most to ecosystems and resources. The electricity consumption of the computer monitor had the third largest environmental impact for all environmental impact categories. It accounted for approximately 2% of the total environmental burden for those impact categories.

The environmental impact of the ink was nearly negligible as it only accounted for 0.07%, 0.14%, and 0.15% of the total environmental impact for human health, ecosystems, and resources, respectively. The consumables used for the printing process including cleaning liquid, lint-free microfibre cleaning swabs, LDPE bags, gloves, and painter's tape contributed the least to all environmental impact categories (less than 0.1).

The greatest environmental impact was generated by printer hardware similar to the findings from relevant literature, which concluded that inkjet printer systems were energy-intensive

machinery. For example, Viluksela et al. (2010) stated that digital printing methods consumed greater amounts of energy and ink consumption when compared to other methods. For the UV bottle inks and consumables inventories, it was expected that the environmental impact generated would be negligible in comparison to the electrical consumption of the print system. Similarly, the subsequent results indicated some impact on the degradation of human health, such as in the categories of human carcinogens and non-carcinogens, although the specific amounts were approximately 0.1.

DISCUSSION



The comparative analysis results showed that for electricity, medium voltage generated the highest environmental burden for all the endpoint categories. The main reason for this finding was the different amounts of energy consumed during the life cycle of each packaging system. The electricity, medium voltage (E1), was the largest contributor to the human health, ecosystems, and resources impact indicators. Specifically, the diesel used to build the machine and supply energy was the most significant contributor to the electricity, medium voltage (E1) and the electricity, low voltage (E2). The inventory consisted of processes such as building machines for infrastructure, lubricating oil and fuel consumption, and some measured air

emissions, as output. The main reason for this finding was the different amounts of energy consumed during the life cycle of each packaging system. The large amount of electricity consumed, and their intermediate processes (i.e., diesel used for building machines, and processing of natural gas) were the primary contributors to the environmental impact for all the impact categories (See Figure 2). For the UV bottle inks and consumables (M1), the processing of natural gas to produce the recycled paper and lint-free microfiber cleaning swabs were the largest environmental contributors. The inventory consisted of processes such as fuel input from high pressure networks, infrastructure (boiler), emissions to air, and electricity needed for operations.

The greatest environmental impact was generated by printer hardware, similar to the findings of relevant literature that concluded inkjet printer systems were energy-intensive machinery. For example, Viluksela et al. (2010) stated that digital printing methods consumed greater amounts of energy and ink when compared to other methods. For the UV bottle inks and consumables inventories (M1), it was expected that the environmental impact generated would be negligible in comparison to the electrical consumption of the print system. Similarly, the results indicated some impact on the degradation of human health, such as in the categories of human carcinogens and non-carcinogens, but the specific amounts were <0.1 (see Figure 2). The reason for

this environmental contribution is due to the processing of polypropylene to produce the body of the lint-free cleaners and the processing of recycled pulp to form the paper used in set-up procedures. Therefore, the environmental contributions of the UV bottle ink and expendable consumables were negligible in the identification of the main environmental contributors of the wide-format flatbed UV LED inkjet printing system.

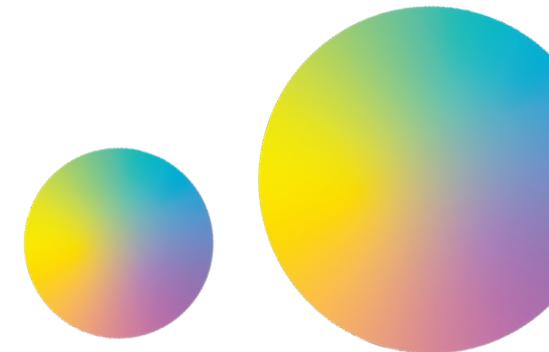


CONCLUSION

The environmental contributions of the overall inkjet printing system largely stemmed from the electrical consumption of the printing press (medium voltage), as opposed to the desktop monitors that also consumed electricity (low voltage). Hence, the inkjet printing system was energy intensive. Despite the lack of LCA studies on the environmental impacts of UV LED inkjet presses, there is a general understanding that digital methods consume greater energy than traditional printing presses (Viluksela et al., 2010). However, the degree to which the energy consumption offsets the environmental contributions of other printing systems is underexplored. Future studies are recommended to compare multiple printing systems, including UV inkjet printers, to gain a thorough understanding of printing ink sustainability implications.

This study analyzed the environmental impact of a UV LED flatbed inkjet printing system with a focus on the materials and intermediate processes inventories based on a case study. First, the study found the electricity generated from the UV flatbed inkjet printer (medium voltage) contributed the most to all impact categories in comparison to all three material inventories. The difference between E1 and the other two inventories was significant, whereas the difference between E2 and M1 were relatively close to each other. Second, the production of the polypropylene body of the lint-free

microfiber cleaners contributed the most to the human health and ecosystem categories, whereas the production of recycled pulp contributed the most environmental impact to the resources category when analyzing the UV bottle ink and consumables inventory. Third, the study found that the ink ingredients did not contribute to the overall environmental impact in either of the three impact categories. However, the UV LED ink inventories were difficult to assess due to the lack of available inventories. More research is needed to obtain a better and more reliable understanding of the UV LED inks. These include input and output figures like materials consumption, emissions, and waste output. The suitable functional units are the mass and the surface area of ink coverage, i.e., one square meter of ink coverage. Future studies are encouraged to examine the environmental impact of digital printing systems by optimizing electricity consumption processes. Likewise, the results of this study are only applicable to the production of the product under study. For this reason, it is encouraged to conduct similar studies of different print products.



REFERENCES

- Hudd, A. (2010). Inkjet printing technologies (pp. 3-18). World Scientific Publishing, Hackensack, NJ, USA.
- Allushi, A., Kutahya, C., Aydogan, C., Kreutzer, J., Yilmaz, G., & Yagci, Y. (2017). Conventional Type II photoinitiators as activators for photoinduced metal-free atom transfer radical polymerization. *Polymer Chemistry*, 8(12), 1972-1977.
- Bousquin, J., Esterman, M., & Rothenberg, S. (2011). Life cycle analysis in the printing industry: A review. In *NIP & Digital Fabrication Conference (Vol. 2011, No. 2, pp. 709-715)*. Society for Imaging Science and Technology.
- Dietlin, C., Trinh, T. T., Schweizer, S., Graff, B., Morlet-Savary, F., Noirot, P. A., & Lalevée, J. (2020). New phosphine oxides as high performance near-UV type I photoinitiators of radical polymerization. *Molecules*, 25(7), 1671.
- Egawa, T., & Kozake, K. (2019). Development of Eco-Friendly Water-Based Inkjet Ink for Flexible Packaging Film. *Soft Drink Gijyutsusiryō*, 188, 111-118.
- Hutchinson, I. (2009). Raw materials for UV curable inks. *The Chemistry of Inkjet Inks*.
- ISO. (2006). ISO 14044:2006 - Environmental management — Life cycle assessment — Requirements and guidelines. Retrieved April 1, 2022, from <https://www.iso.org/standard/38498.html>

- Jerzyk, E. (2015). Sustainable packaging as a determinant of the process of making purchase decisions from the perspective of Polish and French young consumers. *Journal of Agribusiness and Rural Development*, 37(3), 437-445.
- Kara, H. (2010). Comparative Carbon Footprint Analysis of New and Remanufactured Inkjet Cartridges. Center for Remanufacturing and Reuse.
- Kawaguchi, F., Egawa, T., Kunii, S., Kozake, K., Okada, T., Shibata, M., Itsubo, N. (2020). Environment assessment of water-based inkjet printing for flexible package. In *Proceedings of the 15th Meeting of the Institute of Life Cycle Assessment, Tokyo, Japan, 10-12; pp. 160-161*.
- Kozake, K., Egawa, T., Kunii, S., Kawaguchi, H., Okada, T., Sakata, Y., Shibata, M., Itsubo, N. (2021). Environmental Impact Assessment of Flexible Package Printing with the "LUNAJET " Aqueous Inkjet Ink Using Nanodispersion Technology. *Sustainability*, 13, 9851. <https://doi.org/10.3390/su13179851>.
- Krystofik, M., Babbitt, C. W., & Gaustad, G. (2014). When consumer behavior dictates life cycle performance beyond the use phase: case study of inkjet cartridge end-of-life management. *The International Journal of Life Cycle Assessment*, 19(5), 1129-1145.
- Liao, S., Tai, M. T., Lin, S. C., & Lin, C. K. (2012). A Study of Print Quality of UV Ink-Jet Printing on Glass. In *Applied Mechanics and Materials (Vol. 262, pp. 287-290)*. Trans Tech Publications, Ltd. <https://doi.org/10.4028/www.scientific.net/amm.262.287>

- Magdassi, S. (Ed.). (2009). *The chemistry of inkjet inks*. World scientific.
- McKeegan, D. (2021). UV print innovations drive new market growth and creative applications for the décor industry. FESPA. Retrieved April 2, 2022, from, <https://www.fespa.com/en/news-media/features/uv-print-innovations-drive-new-market-growth-and-creative-applications-for-the-decor-industry>
- Nordin, N., & Selke, S. (2010). Social aspect of sustainable packaging. *Packaging Technology and Science*, 23(6), 317-326.
- Northwestern University. (n.d.). Computer Energy Consumption (Average User). Retrieved March 29, 2022, from, <https://www.it.northwestern.edu/hardware/eco/stats.html>.
- Piluso, C., Serafano, J., Kloock, L. M., Grandke, R., & Bradlee, C. A. (2009). Eco-efficiency analysis demonstrates the environmental and economic benefits of flexographic printing inks in film applications. *Ink World*, 15(6), 66.
- Pollock, D., & Coulon, R. (1996). Life cycle assessment: of an inkjet print cartridge. In *Proceedings of the 1996 IEEE International Symposium on Electronics and the Environment. ISEE-1996* (pp. 154-160). IEEE.
- Randolph, L. D., Steinhaus, J., Möglinger, B., Gallez, B., Stansbury, J., Palin, W. M., ... & Leprince, J. G. (2016). Photopolymerization of highly filled dimethacrylate-based composites using Type I or Type II photoinitiators and varying co-monomer ratios. *Dental materials*, 32(2), 136-148.

- Ren, X., Liu, W., Yao, Q., Wang, S., Liu, W., Gu, H., ... & Peng, X. (2022). A UV-LED excited photoinitiator with low toxicity and low migration for photocurable inks. *Dyes and Pigments*, 200, 110133.
- Robert, T. (2015). "Green ink in all colors"—Printing ink from renewable resources. *Progress in Organic Coatings*, 78, 287-292.
- Rothenberg, S., & Zyglidopoulos, S. C. (2007). Determinants of environmental innovation adoption in the printing industry: the importance of task environment. *Business Strategy and the Environment*, 16(1), 39-49.
- Seipel, S., Yu, J., Periyasamy, A. P., Viková, M., Vik, M., & Nierstrasz, V. A. (2018). Inkjet printing and UV-LED curing of photochromic dyes for functional and smart textile applications. *RSC advances*, 8(50), 28395-28404.
- Sharma, A. (2018). *Understanding color management* (Second ed.). John Wiley & Son Ltd.
- Shimizu, H., & Nagata, K. (2010). Integrated life cycle assessment (LCA) approach for printing service by using environmental load point (ELP) method. *Journal of Printing Science and Technology*, 47(3), 177-185.
- Smithers. (3 March, 2020). *The Future of Inkjet Printing to 2025*. [PDF]. Retrieved March 20, 2022, from [https://www.smithers.com/resources/2020/june/inkjet-print-market-in-2020-is-worth-\\$80-4-billion](https://www.smithers.com/resources/2020/june/inkjet-print-market-in-2020-is-worth-$80-4-billion)

Tolle, D.A., Evers, D.P., Vigon, B.W. et al. Streamlined LCA of soy-based ink printing. *Int. J. LCA* 5, 374 (2000). <https://doi.org/10.1007/BF02978677>

Viluksela, P., Kariniemi, M., & Nors, M. (2010). Environmental performance of digital printing. *VTT Research Notes*, 2538.

Yi, Q., Wei, X. F., Huang, B. Q., & Wang, Q. (2014). Effect of monomer on performance of UV-LED inkjet ink. In *Applied Mechanics and Materials* (Vol. 469, pp. 68-73). Trans Tech Publications Ltd.

Zhai, D., Zhang, T., Guo, J., Fang, X., & Wei, J. (2013). Water-based ultraviolet curable conductive inkjet ink containing silver nano-colloids for flexible electronics. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 424, 1-9.

APPENDIX

FIGURE 3 - SCREENSHOT OF ONYX MEDIA PROFILE (PLASTIC) FOR INK LIMIT TABLE

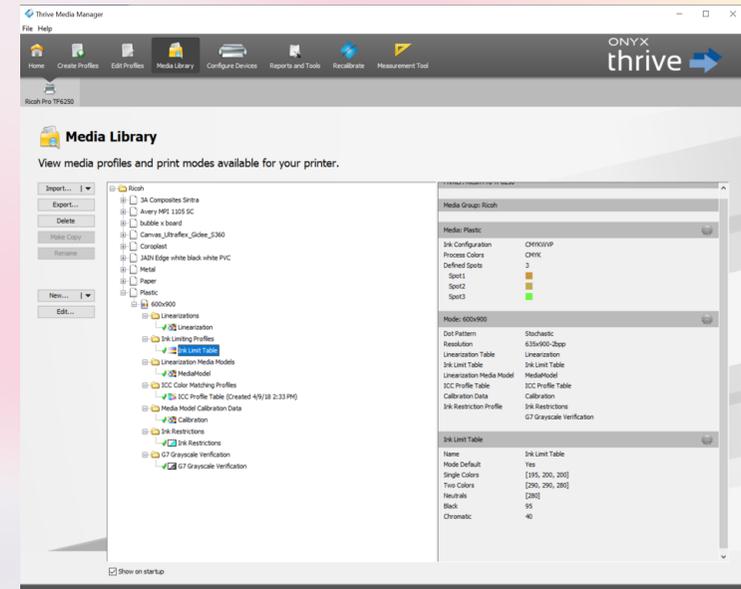
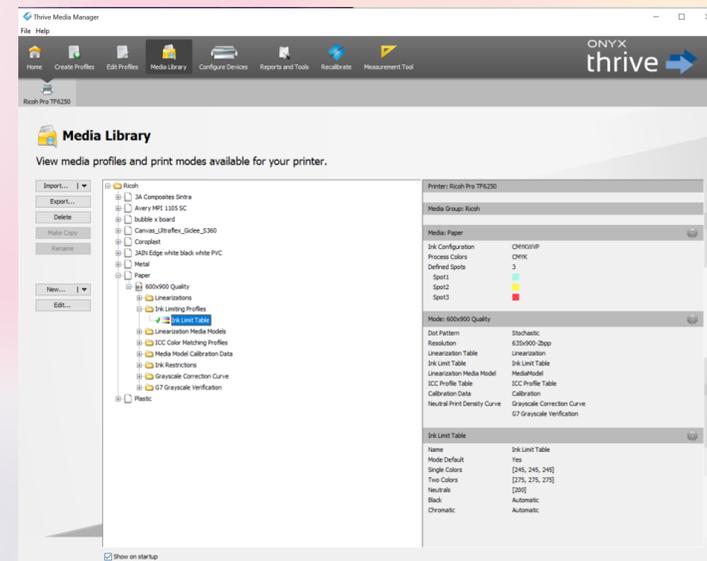


FIGURE 3 - SCREENSHOT OF ONYX MEDIA PROFILE (PAPER) FOR INK LIMIT TABLE



APPENDIX

FIGURE 3 - SCREENSHOT OF ONYX MEDIA PROFILE (PLASTIC) FOR INK LIMIT TABLE

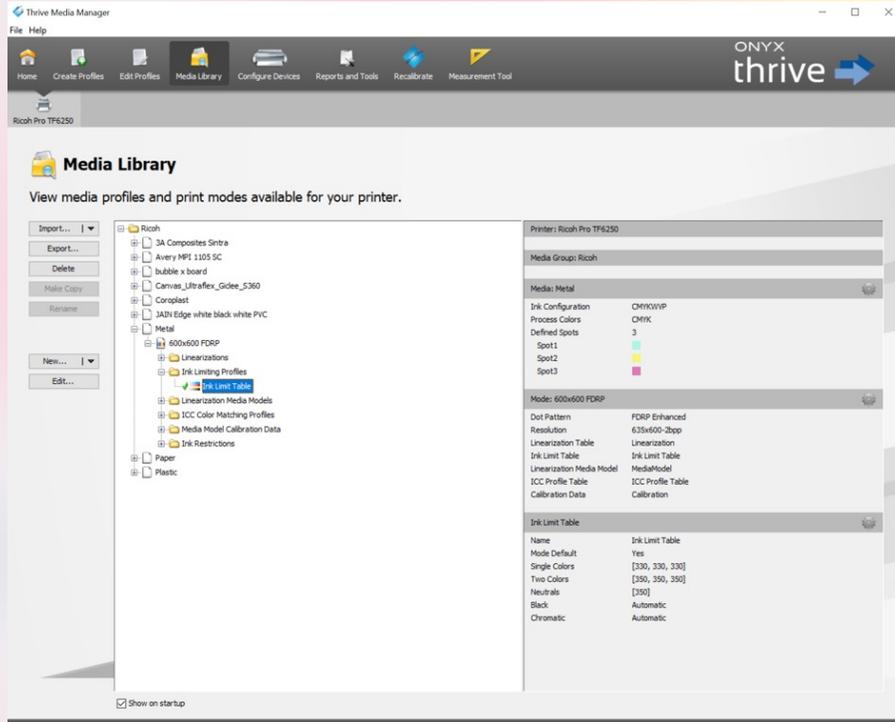
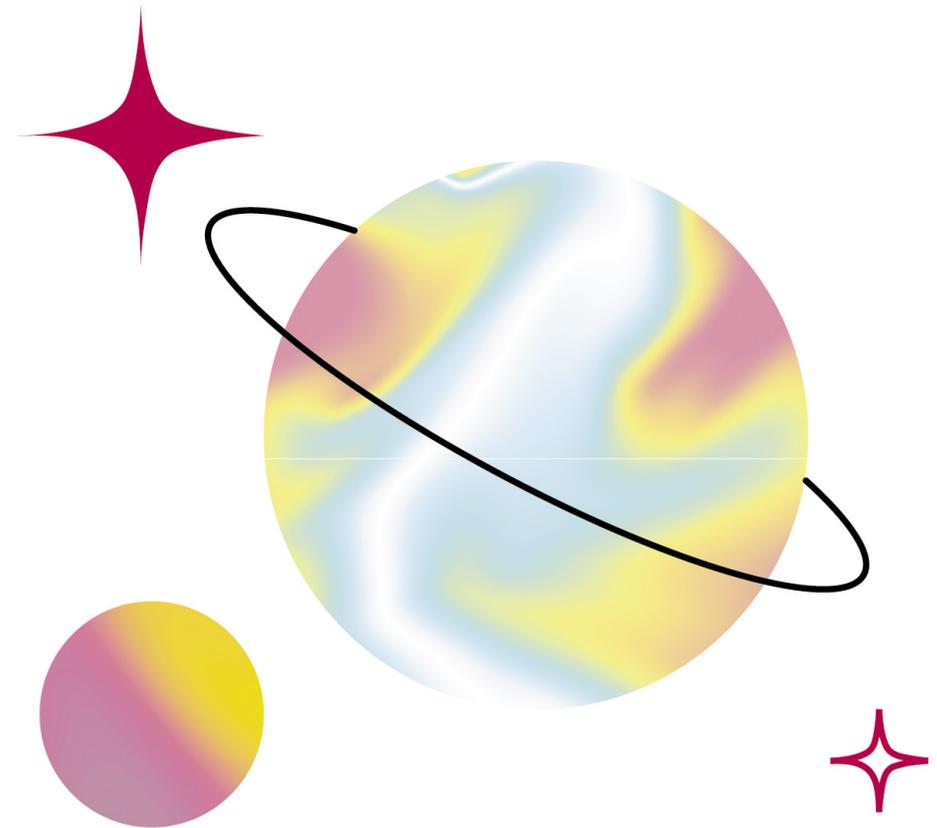


FIGURE 4 - SCREENSHOT OF THE PRINT JOB STATISTICS

Y: 0.85 M: 0.57 C: 0.32 K: 0.62 \$0.47 55.20%
 W: 0.00 V: 0.00 P: 0.00



05



**VISUAL CUES AND
SUSTAINABILITY: AN
ANALYSIS ON CONSUMER
PERCEPTION OF POTATO
CHIP PACKAGING
ARTWORK IN CANADA**

by Anastasia Partserniak



ACKNOWLEDGEMENTS

Throughout this writing process, there are several important contributors that deserve recognition and gratitude.

First and foremost, I wish to thank Professor Jay Park for acting as my thesis supervisor and academic mentor throughout my years of undergraduate studies. Your expertise in literature review structure, survey design, and interpretation of results has greatly helped me evolve my critical thinking and vastly improved my formal writing.

I would also like to acknowledge several student peers who helped advance my thought process for the literature review by identifying a major research gap. You provided me with a new perspective on how to approach this thesis and directed my analysis in the right direction.

Finally, I would like to thank Samantha Jakubcak for diligently reviewing and editing my thesis by presenting helpful comments to grammatically enhance my quality of work.



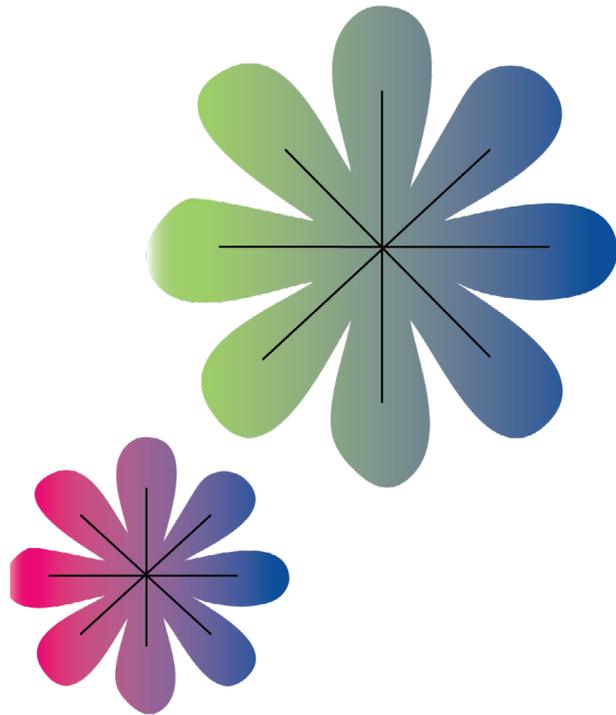
ABSTRACT

Young adult Canadian potato chip consumers prioritize different visual and sustainability cues when facing an in-store purchasing decision. Studies show that users aged 18-24 are visual shoppers and open-minded to modifications to packaging artwork. This thesis aims to identify the most important visual cues to these consumers and their degree of willingness to purchase sustainable packaging alternatives. Moreover, it explores how consumers react to a change in packaging artwork and how adding eco-labels impacts their purchasing decision on potato chip products.

To test the hypothesis that consumers respond negatively to artwork changes and positively to sustainability claims, a survey was circulated to undergraduate students within Toronto Metropolitan (formerly Ryerson) University's Graphic Communications Management Thesis capstone course (GCM490). Respondents were asked to rate their preferences in visual and sustainability cues using Likert scales, followed by a real-life case study that included open-ended questions. Data was quantitatively and qualitatively analyzed using various tools such as two-sample t-tests and analysis of variance (ANOVA). The results established that young adult consumers consider imagery and pictures as their most relied visual cue when searching for potato chip products in-store. Additionally, although many respondents deprioritized eco-

labels initially, almost all respondents judged the case study's sustainable packaging sample to be the most impactful and attractive product.

These results point to the importance of maintaining brand integrity as consumers heavily rely on visual cues, specifically imagery and pictures, when making purchasing decisions. Likewise, these results showcase that environmental consciousness is growing in importance amongst a new generation of consumers who rely increasingly on the presence of eco-labels to make purchasing decisions.



INTRODUCTION

The last several decades have welcomed innovative and pivotal packaging improvements into the Canadian food industry. Effective marketing tactics support the visual artwork on food packaging and heavily assist in generating sales. By integrating artistic eye-catching elements that remain consistent with brand guidelines on packaging artwork, consumers can more easily identify their favourite products on retail store shelves and remain loyal to their brands of choice. However, with growing concerns about environmental deterioration, marketers and product developers seek to find a more sustainable packaging solution. In doing so, many consumers are becoming more aware of today's environmental challenges, and consciously base their purchasing decision on alternative eco-friendly packaging. Although it is one of the most profitable food sectors, snack foods continue to be victims of historical packaging practices. This food industry leader estimates an increase in revenue at an annualized rate of 1.2% to \$3.9 billion over the next five years in Canada, according to Buchko (2021), an author of IBISWorld database firm. Despite their optimistic forecasts, consumers are progressively gravitating towards health-conscious food products with sustainable packaging which may, in turn, contribute to long-term economic decline for this industry.

The snack food industry is segmented into four categories.

In Canada, Buchko (2021) portions them as potato chips (31.3%), tortilla and corn chips (25.1%), other snacks (27.6%), and nuts and seeds (16.0%). With potato chips accounting for the largest segment share, it is evident that this segment is not short of vibrant artwork through which consumers can easily recognize their preferred potato chip product. However, its packaging practices are the most outdated in terms of modern sustainability efforts. Presently, most potato chip packaging is composed of multi-laminate polymer films. The fusion of different laminates serves as a critical barrier to effectively preserve the product from exposure to oxygen, vapours, external odours, and various compounds (Siracusa, 2012). Synthesizing these substrates, though, categorize potato chip packaging as non-recyclable. This introduces a challenge for consumers as they are unable to sustainably dispose of their products' packaging and thus they add to waste landfills.

The emergence of a new generation of consumers requires a modified list of purchasing criteria, one which may not coincide with the current potato chip packaging practices. Known for "preferring a healthier environment and often choosing companies implementing sustainability principles" (Dabija et al., 2020; Jain et al., 2014), young consumers aged 18-24 triumph as an appropriate target segment for this research. Literature shows that these consumers are overarchingly more open-minded to changes and creatively focused on brand engagement (Mitchell, 2019). Building on these

observations, these users define new shopping patterns as they are often described as "digital natives" and frequently utilize digital retail channels such as e-commerce. However, it is unclear to what extent this target demographic directly engages with conventional retail markets. To fully understand their relationship with brick-and-mortar stores, this thesis solely focuses on traditional retail markets and does not discuss other channels.

Young adult consumers require their own unique purchasing criteria. With the aforementioned personality traits in mind, it is important to understand the targeted demographics' visual needs when identifying a potato chip product on the shelf and recognizing how sustainability plays a role in the packaging artwork. Therefore publications that characterize consumer purchasing decisions from a psychological lens are pivotal. Critical studies by Olsen & Jacoby (1972) and Reber et al. (2004) define how consumers visually process a product through the use of visual cues and processing fluency. While these important theories are extensively endorsed and frequently discussed in modern literature, most findings are either limited by several cues or broadly categorized with no quantitative basis. Hence, the following research question emerges: within the potato chip industry, how do young consumers perceive a change in brand artwork design and a change to eco-labels on the packaging in traditional retail channels in Canada?

Beyond analyzing published literature, this thesis incorporates

a hybrid approach of qualitative and quantitative research methodology. In addition, it narrows down the existing cues young consumers use to evaluate potato chip packaging and offers the opportunity to derive a more precise result. From the four main cue categories (structural, sensory, visual, and environmental impact), only visual cues were examined and distinguished by brand indicators, colour schemes, imagery and pictures, and eco-labels. A questionnaire was then designed and distributed as a survey to internal candidates in the Thesis capstone course. In the process, two vital research objectives were established:

1. Identify which visual cue is most influential to young consumers when scanning snack food retail shelves, and
2. Generate insight on how young consumers react to potato chip packaging artwork changes in a real-life scenario.

Following the outlined methodology, acquired data was reported in the following section titled “Results” and supported with visual charts. The paper is anteceded by a discussion section where the results are further synthesized and evaluated. The remainder of the thesis presents the implications, limitations, and recommendations. Afterwards, the conclusion responds to the research question and reveals the most important visual cues to young potato chip consumers and the role of sustainability in their purchasing decision.

LITERATURE REVIEW

This thesis paper aims to understand consumer perceptions of potato chip packaging and examine the most important visual features during a purchasing decision while in-store shopping. This further segues into noticeable packaging artwork modifications and how those visual changes may affect customer loyalty as well as purchasing decisions towards a given potato chip brand. The following journals referenced within this literature review are recently dated with modern thematic references to sustainability and brand consistency as well as epistemic theories surrounding consumer perception. Using cue utilization theory (CUT) (Olsen & Jacoby, 1972) and processing fluency theory (PFT) (Reber et al., 2004), we can generate a better understanding of the consumers’ visual needs for potato chip packaging.



Cue Utilization Theory

Holistically, packaging design is an important tool to inform consumers about a given product. As purchase selection can be a complex decision-making process, consumers look for easy ways to assess a package. This methodology is frequently leveraged by cue utilization theory (Olsen & Jacoby, 1972). The CUT model fixates on intrinsic and extrinsic cues to evaluate packaging quality. The model is subcategorized further into four branches: structural cues, sensory cues, visual cues, and information on environmental impact, with each containing unique criteria as shown in Figure 1. Within the food and beverage industry, extrinsic attributes—such as visual cues—highly influence and potentially overpower intrinsic attributes like materiality (White et al., 2016). This, in turn, affects the purchasing decision as changing a recognizable brand mascot, for example, would be more visually striking compared to a modification to a less glossy substrate coating.

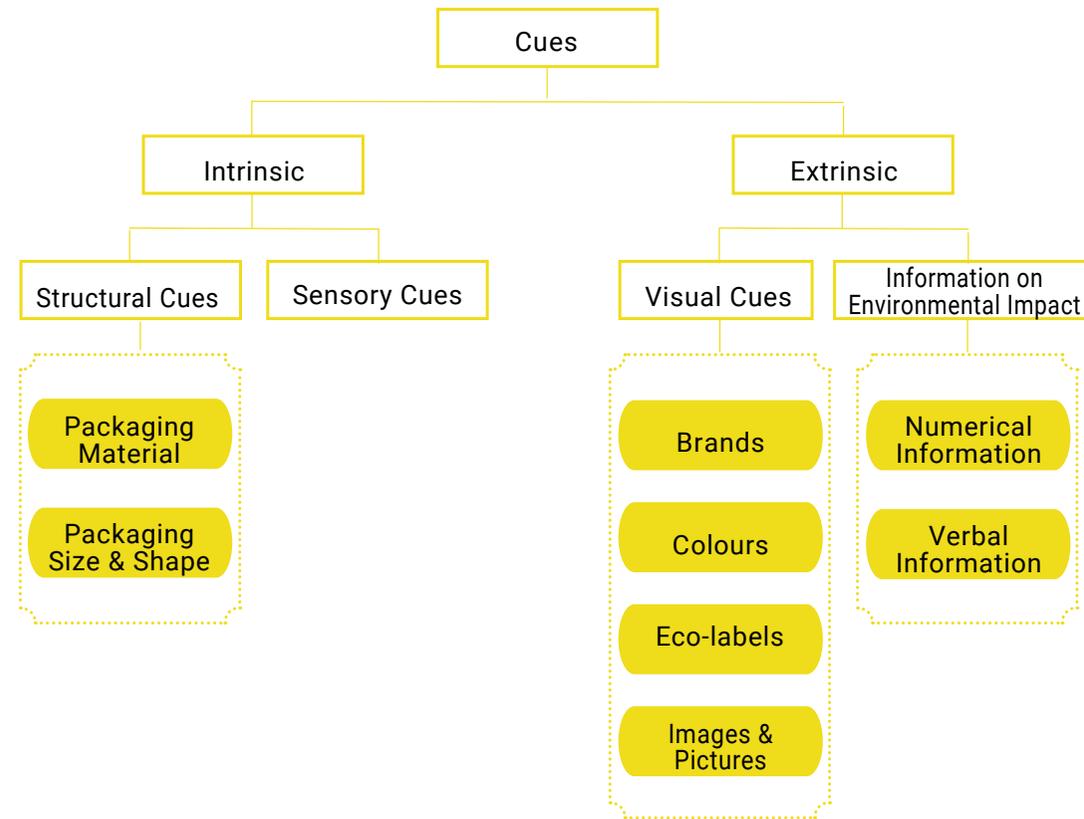


FIGURE 1. - HIERARCHICAL DISPLAY OF CUES DEPICTED WITHIN CUE UTILIZATION THEORY.

While Jacoby (1971) expresses how the effect of extrinsic cues on perceived quality may be evidenced primarily through interactions with intrinsic cues, contemporary literature fixates on a particular characteristic: sustainability. Part of product assessment at retail shelves is the examination of sustainable judgements. To the human eye, sustainability in food packaging is most prevalent through intrinsic attributes. Whether it be an eco-label showcasing the recycling iconography or an ethically sourced ingredient on the nutrition label, numerous studies indicate that “consumers will favour the sustainable cue related to the intrinsic attribute when assessing product

quality” (Magnier et al., 2016). Another study by Herbes et al. (2020) further explored which specific sustainable attribute affected consumer perception the most and concluded that eco-labels have the greatest impact on products and packaging amongst CUT’s visual cues.

Although recurring themes of sustainability are widespread in today’s literature, there is some debate about the origin of CUT. In a previous work, Jacoby et al. (1971) indicated that extrinsic cues must work cohesively parallelly to intrinsic cues to impact perceived [brand] quality. However, Olson & Jacoby (1972) later determined that “intrinsic...cues were generally perceived to be the most accurate indicators of brand quality.” This leads to the question of whether a relationship between intrinsic and extrinsic cues still exists or if there is a discourse in both historic and modern consumer perception of perceived quality. This evaluation considers whether intrinsic and extrinsic cues are assessed in a disjointed manner where, for example, visual cues triumph over sensory cues. Nonetheless, this unresolved question yields ongoing research and still dawns on today’s literature. In a more recent journal, Magnier et al. (2016) argued that the “sustainable intrinsic attribute is directly related to the perceived quality,” whereas Herbes et al. (2020) stated that “eco-labels, [an extrinsic attribute,] have been identified in many studies to impact consumers’ perception.” While there has been much research on sustainable attributes in CUT, few researchers have taken the hierarchical importance of

sustainability into consideration. In other words, research needs to be conducted on which sustainable attribute—whether internal or external—prevails in perceived packaging quality.



Processing Fluency Theory

As products are assessed on retail shelves, consumers visually inspect and gravitate toward recognizable cues. The long-term repetition of a packaging shape or brand colour scheme generates product familiarity and reliability. This phenomenon lies at the heart of processing fluency theory (PFT) (Reber et al., 2004). Originating in the early 2000s with theoretical roots stemming from several decades prior, PFT describes how easily information is processed in the human mind concerning aesthetics. In the case of potato chip packaging, PFT is directly applicable to brand artwork and how consumers favor a recognizable brand over its competitors.

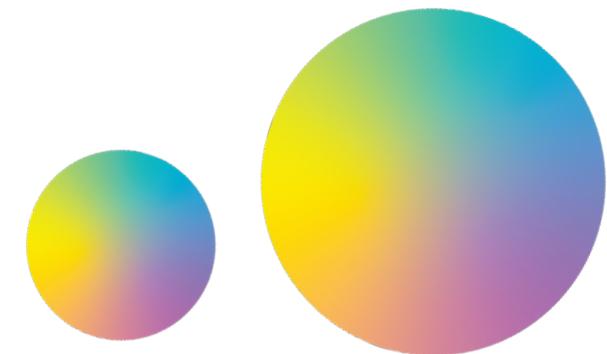
This modern theory has been heavily analyzed in recent literature. Having recurring keywords of consistency and fluency, PFT is an expanding concept that breaches the borders of advertising and has been applied to other realms such as linguistics and stock market statistics (Dragojevic &

Giles, 2016; Alter & Oppenheimer, 2006). From an advertising lens, recurring themes revolve around brand representation and consistency in relation to PFT. Authors Janiszewski & Meyvis (2001) made an initial claim that “repeated exposure to an advertisement can influence liking for an advertisement and for the brand names and product packages included in the advertisement.” As consumers continually witness the repeatability of a given product, the human eye observes consistency which enhances the ease of processing a brand, resulting in favourable brand evaluations (Lee & Labroo, 2004). Beyond frequent repetition tactics, it is vital that products can be easily assessed. Concepts like CUT work cohesively with PFT to not only distinguish product familiarity, but also product readability. If a product is from a world-renowned brand but is visually challenging to interpret, it may hinder consumer perception and dissuade its purchase overall. In Reber et al.’s (2004) original theory, “the more fluently perceivers can process an object, the more positive their aesthetic response.”

Sustainability as an overarching theme in recent packaging relies on PFT. Throughout the years, marketers have recognized characteristics such as colour impact and influence consumer perception of the brand’s environmental consciousness (Seo & Scammon, 2017). Earth-toned shades like green, blue, brown, and white help brands represent themselves as more eco-conscious (Scott & Vigar-Ellis, 2014). In addition, the study noted that colour coordination inherently affects processing

fluency. With sustainability in mind, selecting a “colour that matches the content of a message makes the information easier to process, thereby increasing the appeal of the message” (Sea & Scammon, 2014). For instance, choosing a bright red background for a packaging product with eco-labels and sustainability callouts will likely be misinterpreted by consumers and discourage its purchase. Rather than invoking eco-consciousness, consumers are driven to confusion by visual misguidance. Even though much literature discusses sustainability in relation to PFT, more research is required to assess what specific aspects of sustainability would deem a packaged product more fluent in its advertising.

Pivotal publications such as Olson & Jacoby’s (1971) cue utilization theory and Reber et al.’s (2004) processing fluency theory are frequently cited by modern literature. As shown, consumers rely on simple ways to assess a product through intrinsic and extrinsic cues, along with how fluently the artwork packaging can be interpreted. Thus, this thesis aims to offer a deeper understanding of the qualitative and quantitative aspects that affect consumer perception of potato chip packaging.



RESEARCH METHODOLOGY



The goal of this research study was to explore the following research question: how do consumers interpret a change in artwork design and change to eco-label callouts on potato chip packaging in traditional retail channels in Canada? To better evaluate the research question and integrate it into the methodology, two research objectives were established:

1. Identify which CUT visual cue is most influential to consumers when scanning the snack food retail shelves, and
2. Generate insight on how consumers react to potato chip packaging artwork changes in a real-life scenario.

Data acquired from the first research objective had leeway to be expressed both quantitatively and qualitatively. However, to derive a more accurate result, a numerical expression was deemed more appropriate. The second research objective was solely based on qualitative data and analyzed through an open-ended question. To collect primary data, a survey of 30 questions was designed and then issued to select undergraduate students. Survey participants were acquired through a student mailing list that was internally part of the GCM490 Thesis capstone course. The targeted demographic of survey respondents were aged 18-24 with no restriction to

gender, race, religion, ethnicity, family background, and dietary preferences. The only restrictions were that the subjects currently live in Canada and fall in the age group of 18-24. Before starting the survey, respondents were asked for consent in regard to using the acquired data for an undergraduate thesis. The survey was shared with the aforementioned group using a direct URL link and a summary of the study's purpose was provided.

The survey questions were stored as a Google Forms document and included a variety of multiple-choice questions, Likert scales ranging from 1-5 (for example, very unlikely to very likely), and open-ended questions. The survey was conducted during a two-week period in March 2022. The estimated amount of time needed to complete the survey was cumulatively 10-15 minutes and respondents had the option to exit the survey and complete it at their convenience. Additionally, participants had the right to retract their answers for 72 hours after completing the survey. The aggregated results were stored as a .csv file under the university's Google Drive for optimizing data security.

The survey was categorized into five main sections: (1) general information and background, (2) food packaging cues, (3) food packaging and visual cues, (4) food packaging and sustainability, and (5) a case study questionnaire about Pringles® artwork packaging. The full list of survey questions can be found in Appendix 1.

General Information and Background

In the first section, survey participants were asked to verify whether their age was between 18-24. Should their age not fall under that category, the participants were still invited to fill out the survey, however, their responses were omitted when studying the data. The following few questions were about personal food preferences such as the frequency of purchasing and the frequency of consuming potato chips.

Food Packaging Cues

The next section of the questionnaire was based on cue utilization theory's structure. These featured intrinsic and extrinsic qualities and asked participants about their evaluation of structural, visual, environmental, and sensory cues in relation to food packaging. Responses were presented through a Likert scale with five categories ranging from "Not Important" to "Very Important" shown in Figure 2. Acquired data would be analyzed through Google Sheets and would incorporate basic chart tools such as pie charts.

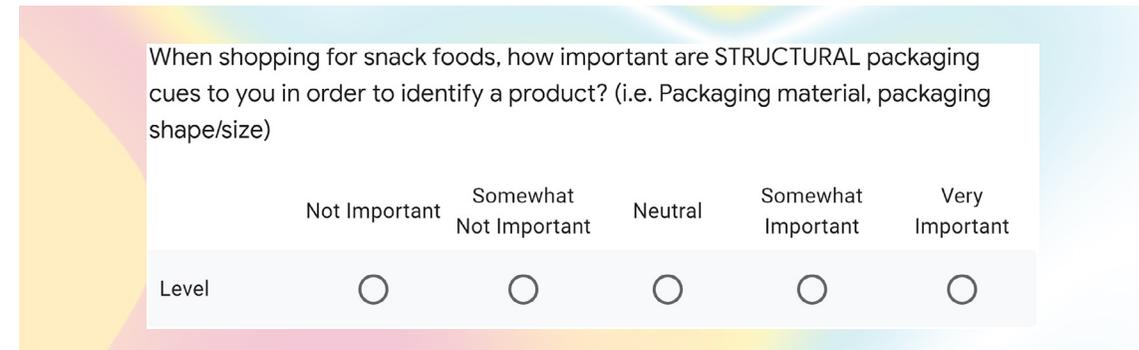


FIGURE 2. - AN EXAMPLE OF A QUESTION FROM THE GOOGLE FORMS SURVEY USING CUE UTILIZATION THEORY.

Food Packaging and Visual Cues

Diving further into CUT, the following set of questions were specific to the visual cues within food packaging. This covered brand indicators, colour schemes, imagery and iconography, and eco-labels. Similarly to the previous section, a Likert scale was implemented with a range of not important to very important. Several examples of each visual attribute were included to improve clarity for the survey taker. A sample question is provided below in Figure 3.

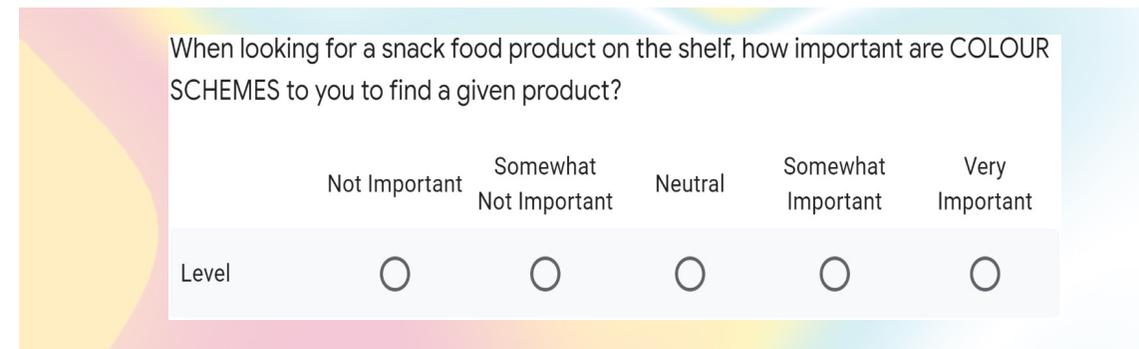


FIGURE 3. - AN EXAMPLE OF A VISUAL CUE PROMPT TAKEN FROM THE GOOGLE FORMS SURVEY.

The evaluation of data was conducted in Google Sheets and integrated stacked bar charts as well as a single factor analysis of variance (ANOVA) tool. The unit of measure for variance was the mean value's square of the units (σ^2). The stacked bar chart was based on the five-point Likert Scale. The ranges of not important to very important illustrated which visual cue was most prominent on retail shelves in percentages. ANOVA defined the disparity in the data and required establishing independent variables, categories, and hypotheses. The independent variables were brand indicators, colour schemes, imagery and pictures, and eco-labels. Each independent variable was assigned five categories: not important, somewhat not important, neutral, somewhat important, and very important. The null hypothesis (H0) assumed that each category yielded the same result. The alternate hypothesis (Ha) assumed that there would be drastic variance between each visual attribute.

Food Packaging and Sustainability



Four questions about packaging sustainability within the food industry were asked. With two questions referring to CUT's environmental impact attribute, Likert scales were also used with the same model of not important to very important. The third question was multiple-choice and asked about

personal preference in regard to deeming a piece of packaging sustainable. Finally, a Likert scale ranging from very unlikely to very likely asked for the respondent's opinion regarding purchasing behaviour. An example of a sustainability-based question is displayed in Figure 4.

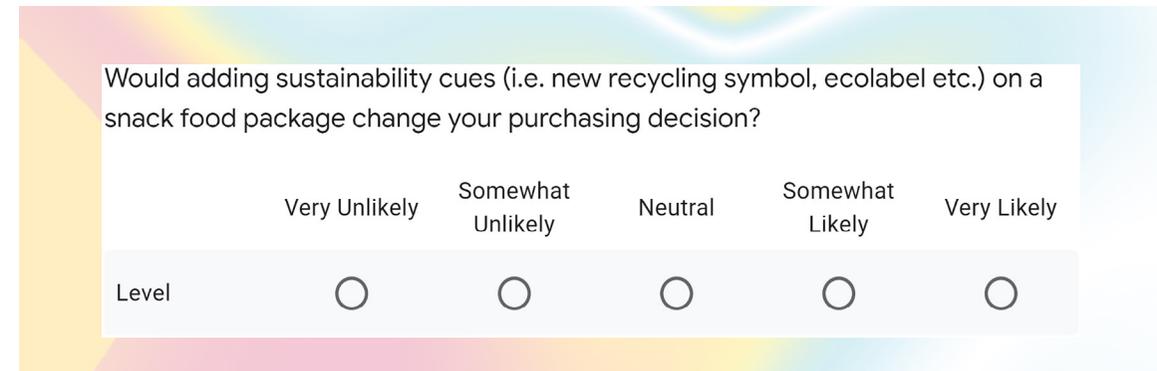


FIGURE 4. - AN EXAMPLE OF A SUSTAINABILITY-BASED QUESTION WITHIN THE SURVEY.

Within Google Sheets, a column chart was modeled to show the results of Figure 4. The following questions on the survey asked: how important is numerical information containing sustainability claims to you; and how important is verbal information containing sustainability claims to you. To compare the results, analytical tools such as standard deviation and t-tests were performed. Standard deviation was used to identify the amount of variability within each question. The two questions were formatted using a Likert scale with five groups (dependent variables) ranging from not important to very important, thus identifying their variances was critical. The independent variables were defined as numerical and verbal information. A t-test was used to numerically describe

whether potato chip consumers prioritize numerical or verbal sustainability attributes. Since the attributes originated from two different populations (i.e. numerical versus verbal), a two-sample t-test was selected. The direction of difference was irrelevant, therefore, a two-tailed t-test sufficiently confirmed whether there was a difference at all. Similarly to the previous section, two hypotheses were established where a null hypothesis (H0) assumed that there was no difference between the two independent variables and the alternate hypothesis (Ha) assumed there was a difference between data. Lastly, for the question “In your opinion, how do you determine if a package is sustainable?”, a simple pie chart was created in Google Sheets.

Case Study: Pringles® Packaging

In order to further generate a response, a real-life packaging scenario was applied. Respondents were asked to evaluate the packaging of a Pringles® potato chip can based on three different designs: one that was prevalent in the market from 2001-2021, one that was introduced in 2021 and continues to be present in today’s market, and one that was initiated as a six-week trial and promoted sustainable packaging. The questionnaire introduced the first image followed by a set of questions, the second image accompanied by the same

questions, and the third image also paired with the same questions. Respondents were asked about noticeability on the shelf, consumer perception of different visual packaging attributes (for example, colour scheme), and the likeliness of purchasing that product solely based on its physical appearance. Likert scales ranging from one to five were used to evaluate the survey taker’s decision. The final two questions were open-ended and showcased the three iterations of the Pringles® packaging together (Figure 5). The questions were perception-based and inquired about visual attributes and the probability of purchasing the product.

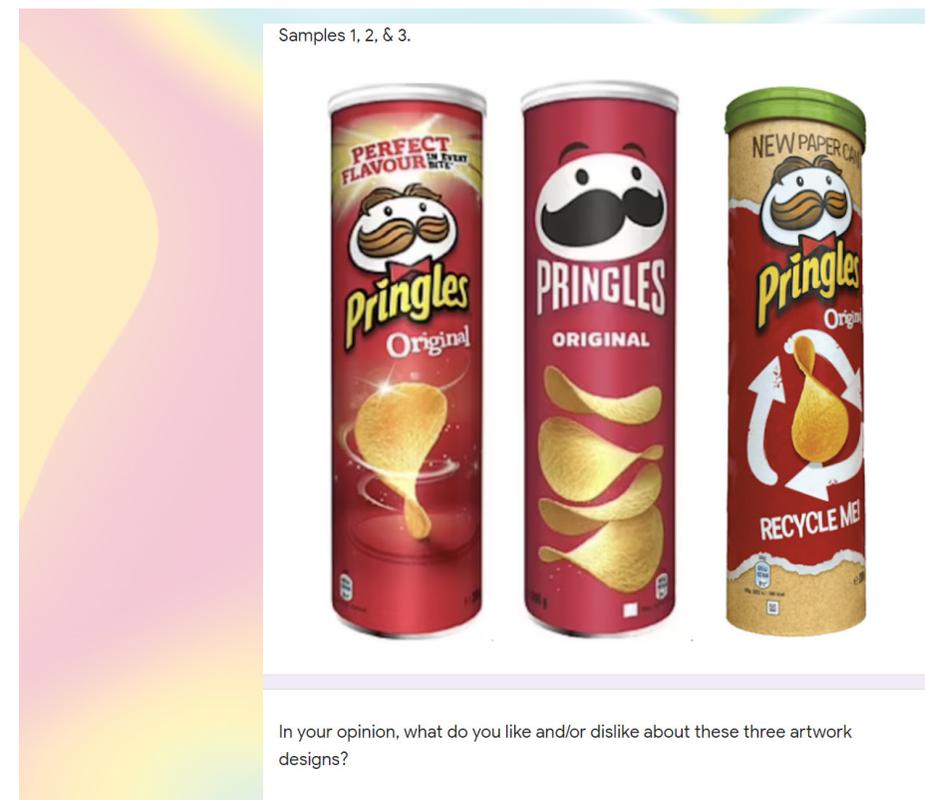
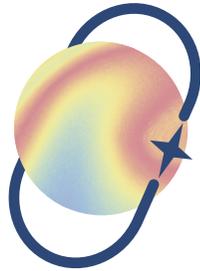


FIGURE 5. - AN EXAMPLE OF AN OPEN-ENDED QUESTION AS PART OF THE PRINGLES® PACKAGING CASE STUDY.

Data was aggregated using Google Sheets, where clustered column charts and variance calculations were output. The unit of measure for variance was denoted as σ^2 . The second research objective was achieved by posing an open-ended question to account for qualitative research data.

RESULTS



Two research objectives guided the questionnaire: define the most important visual features consumers use to evaluate a potato chip product; and gain insight into consumer perceptions of artwork changes on potato chip packaging, which included the addition of eco-label attributes. The main demographic variable (age) was used to narrow down the completed results. The survey consisted of N=27 respondents aged between 18-24 and N=2 respondents aged older. Since this thesis primarily focuses on the consumer perception of 18–24 year-olds, any results from an outlier category were omitted. Several results required to be further narrowed down by only utilizing the last two groups of Likert scale questions (i.e. somewhat important and very important). In this paper, this is referred to as affirmative responses. The questionnaire leveraged cue utilization theory and was applied to a self-conducted case study at the end of the survey.

Food Packaging Cues

Utilizing CUT to gauge generalized consumer perception, the results yielded that a drastic 40% (Figure 6) of respondents prioritize visual cues to assess potato chip products at the retail store shelf. The next most important consideration was structural cues (25%), including packaging shape and size. The less significant cues were deemed to be environmental and sensory, broken down in Figure 6 as 19% and 16%, respectively.

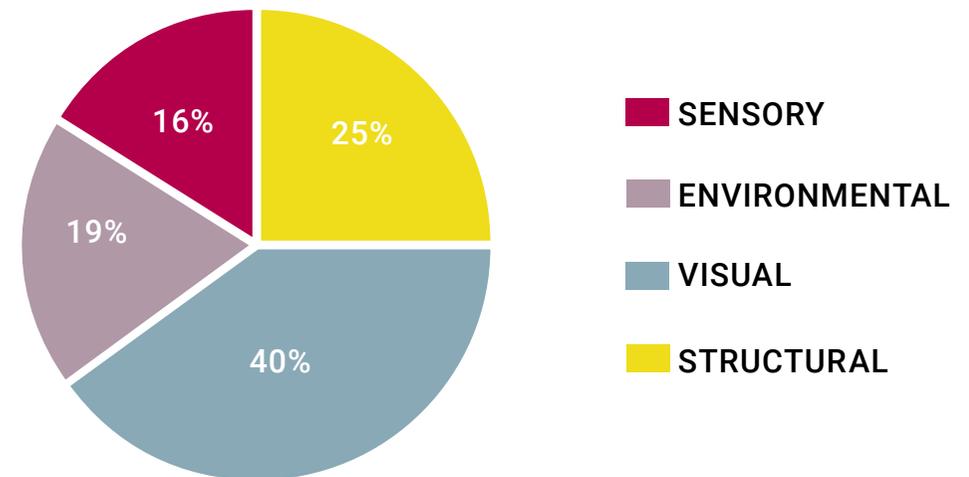


FIGURE 6. - A PIE CHART BREAKDOWN OF OLSON & JACOBY'S (1972) CUT AND RESPONSES TO THE MOST IMPORTANT PACKAGING CUES TO IDENTIFY A POTATO CHIP PRODUCT AT THE BRICK-AND-MORTAR SHELF.

Food Packaging and Visual Cues

In the following section of the questionnaire, respondents were surveyed on specific visual cues based on CUT. A stacked bar chart (Figure 7) was used to illustrate the different percentages across each visual category. According to the results, brand indicators, colour schemes, and imagery and pictures were almost of equal importance when identifying a potato chip product on the shelf. Results were narrowed down by only assessing the affirmative groups. Respondents identified imagery and pictures as the most important visual cue (50%), followed by brand indicators (47%), and colour schemes (46%). Eco-labels showed more evenly distributed results for each percentage group compared to the previous three visual cues.

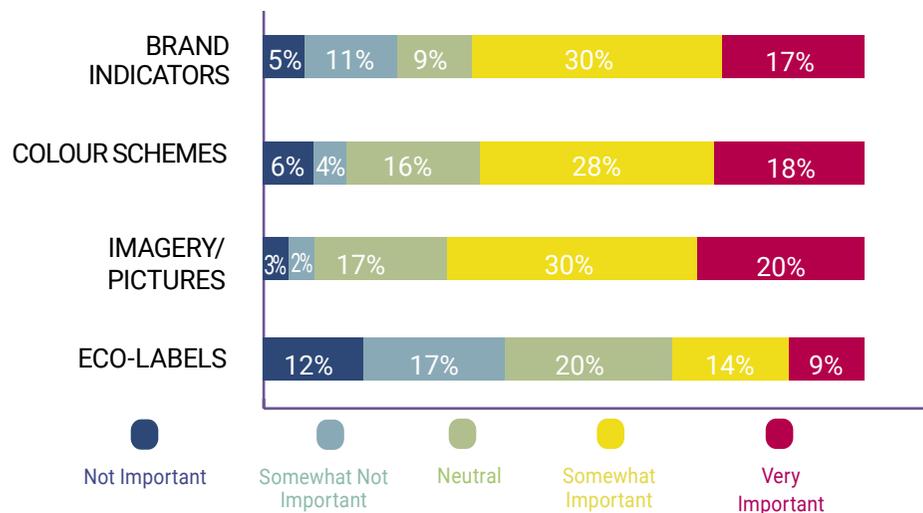


FIGURE 7. - A BAR CHART WITH PERCENTAGES SHOWING THE LIKELIHOOD OF PURCHASING A SUSTAINABLY PACKAGED POTATO CHIP PRODUCT.

A single-factor ANOVA statistical tool was used to further explore the relationship between visual cues on potato chip packaging and consumer responses to each visual cue’s importance. Based on the results, the degree of spread in data—known as variance—was most drastic for imagery and pictures at 141.3σ². This was a substantially larger outcome than for other attributes such as brand indicators and colour schemes, each sharing a variance of 94.8σ². The attribute with the lowest variance (18.3σ²) was eco-labels. The higher variances indicate that users are more decisive about which visual attribute stands out to them on the retail shelf. The lower variances, on the other hand, show that users deprioritize a given attribute. For reference, a more detailed summary of the ANOVA can be found in Appendix 2, Table 1. The variety of values discovered within the results confirm the validity of the alternate hypothesis (H_a): each visual attribute is evaluated differently by young consumers.

Food Packaging and Sustainability

In both aforementioned results, environmental cues and attributes were not prominent elements when scanning retail shelves. The proceeding section of the survey focused on sustainability for potato chip packaging. When respondents were asked “Would adding sustainability cues (i.e. new recycling

symbol, eco-label, etc.) on a potato chip package change your purchasing decision?”, the majority of respondents stated that they would be more inclined to purchase a snack food product containing eco-labels (Figure 8). Over 51% of participants suggested they would be somewhat likely to alter their purchasing decision and, furthermore, approximately 8% of participants would be very inclined to do so.

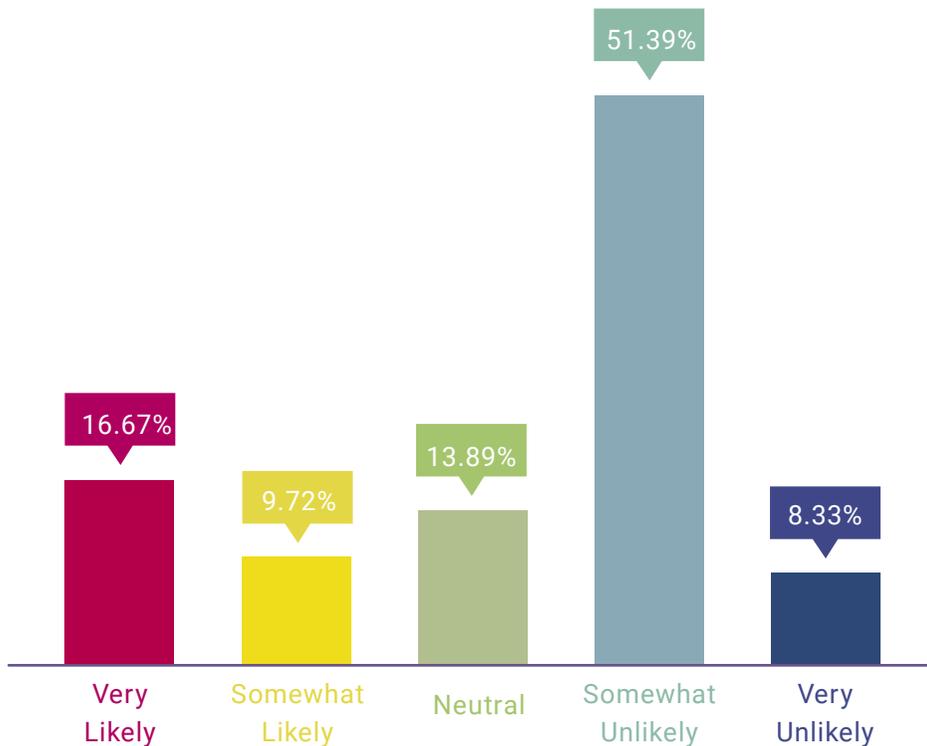


FIGURE 8. - A BAR CHART WITH PERCENTAGES SHOWING THE LIKELIHOOD OF PURCHASING A SUSTAINABLY PACKAGED POTATO CHIP PRODUCT.

To compare the results of the following questions: “How important is numerical information containing sustainability claims to you?” and “How important is verbal information containing sustainability claims to you?”, the standard deviation for each question was calculated (Appendix 2, Table 2). The results for numerical information deviated by 5.36 from the mean, whereas verbal information deviated by 6.95. These low standard deviations mean the acquired “values are clustered close to the mean” (Bhandari, 2021) and respondents felt similarly about the importance of numerical and verbal sustainability claims. Next, to answer which of the two sustainability claims was more important to young consumers and whether the results differ from one another, a two-sample t-test was conducted. The difference in affirmative responses between numerical information (Mean = 14.4; SD = 5.36) and verbal information (Mean = 14.4; SD = 6.95) was minimal ($t(8) = 0; p < 0.92$). The probability value (p-value) measured proportion; to the effect that if the value was less than 0.05, “that [meant] that 5% of the time you would see a test statistic at least as extreme as the one you found if the null hypothesis was true” (Bevans, 2021). As the p-value was larger than 0.05, the alternate hypothesis (H_a) was rejected and a conclusion was drawn that consumers see minimal difference between the numerical and verbal sustainability attributes.

When survey takers were asked “In your opinion, how do

you determine if a package is sustainable?”, the multiple-choice answers generated the pie chart below (Figure 9). The list of qualitative responses was inspired by Herbes et. al’s (2020) article on green packaging and included six valuations from their study. Almost half of the respondents (44%) determined that eco-labeling was the most obvious indicator, anteceded by personal product evaluation (26%) and online research (15%). These outcomes demonstrated that consumers were more likely to assess a packaged product themselves rather than relying on other communication channels such as word of mouth.

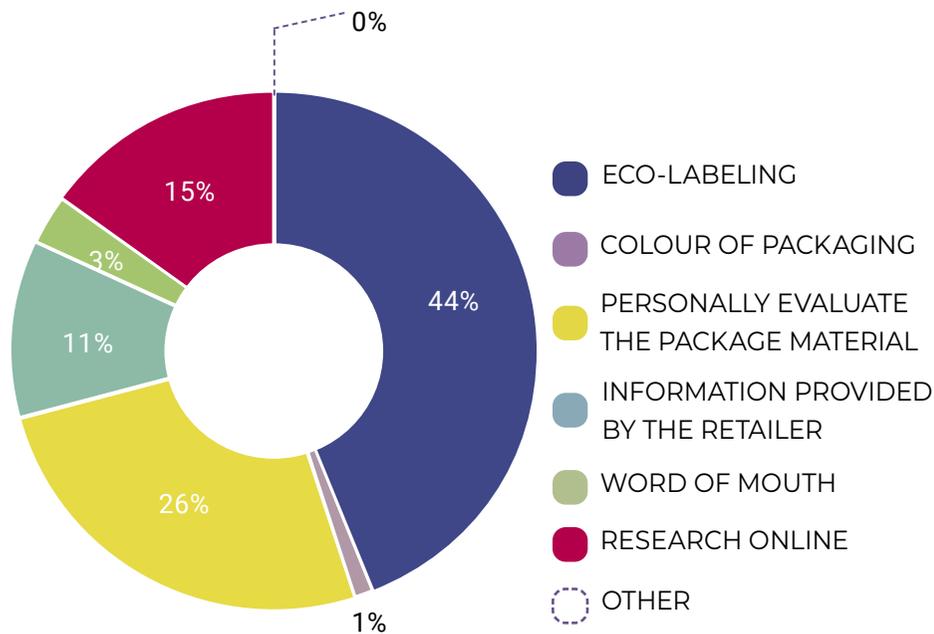


FIGURE 9. - PIE CHART BREAKDOWN ILLUSTRATING WHICH SUSTAINABLE ATTRIBUTE CONSUMERS FIRST NOTICE.

Case Study: Pringles® Packaging

The final portion of the survey presented three artwork variations of the Pringles® chip can. Results in Figure 10 show that respondents were consistently most familiar with the mascot logo—part of brand indicators—across all three samples. The colour schemes attribute showed the least amount of variance calculated at 30.3σ2. As there were minimal graphics on all three package samples beyond product photography, imagery and pictures were less observed by respondents. Eco-labeling proved to have the largest variance at 768σ2 and was only noticed by consumers on the sustainable package sample.

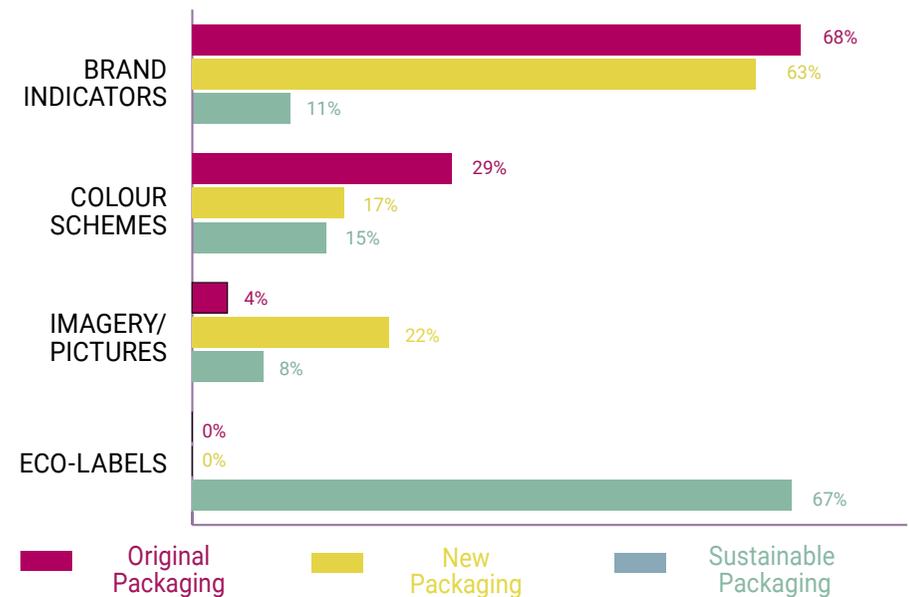


FIGURE 10. - A CLUSTERED BAR CHART COMPARING THE NOTICEABILITY OF VISUAL CUES FOR THE PRINGLES® ORIGINAL PACKAGING (SAMPLE 1), NEW, PACKAGING (SAMPLE 2), AND SUSTAINABLE PACKAGING (SAMPLE 3).

To answer the survey question “Based on the visual artwork, how likely is it that you would purchase this product?”, another clustered column chart was generated (Figure 11). Affirmative responses (very likely and somewhat likely) confirmed that 71% of survey takers would purchase the original Pringles® product based on its familiar artwork design. 38% of respondents would remain loyal to the brand and purchase the revised package (Sample 2). Of the three samples, consumers would be most inclined to purchase the sustainably packaged product (73%).

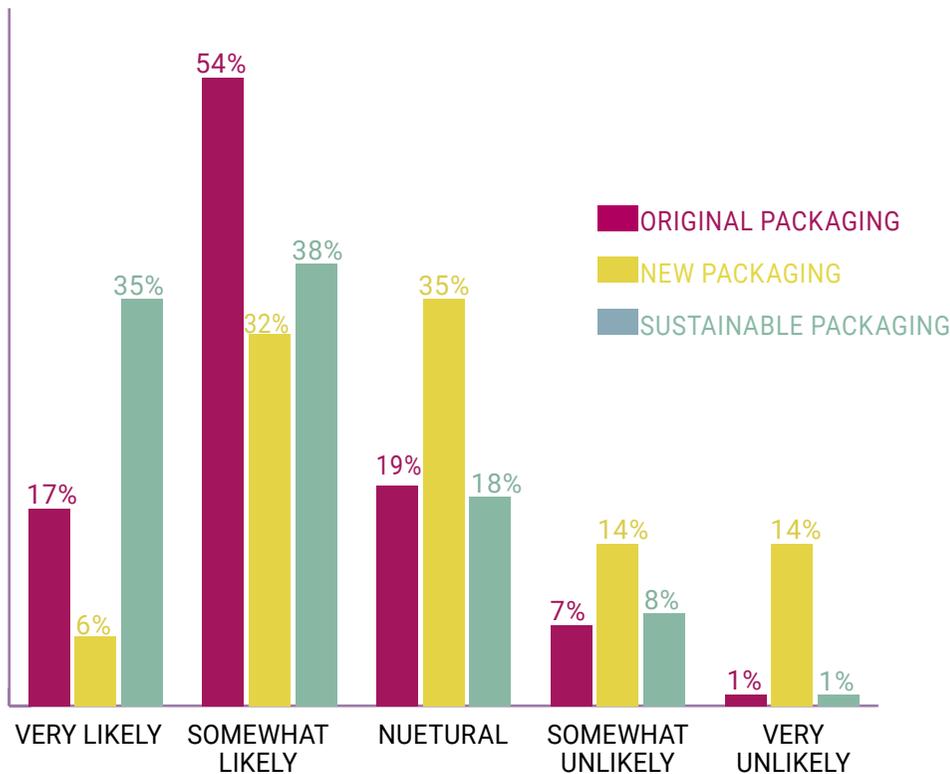
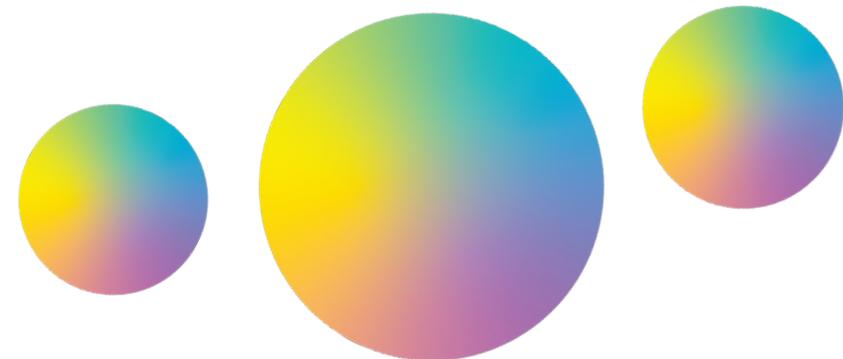


FIGURE 11. - CLUSTERED BAR CHART COMPARING THE LIKELIHOOD OF PURCHASING PRINGLES® ORIGINAL PACKAGING (SAMPLE 1), NEW, PACKAGING (SAMPLE 2), AND SUSTAINABLE PACKAGING (SAMPLE 3) BASED ON THEIR ARTWORK.

With regard to the second research objective, respondents were asked the following open-ended question: “From the three samples, which potato chip can are you most likely to purchase? Please explain why.”

The majority of survey takers (N=20) selected the sustainable Pringles® package (Sample 3) as their choice of purchase. One respondent stated that modifying artwork design to visually include sustainable attributes “would help contribute to practicing sustainability”. Another respondent suggested that cost is an overlooked factor in relation to sustainability and if there is a low willingness to buy, several consumers would be more inclined to “just buy the cheaper can.” Other respondents gravitated towards the original package (N=5) (Sample 1) and frequently used words like “classic,” “recognizable,” and “familiar” to describe their reasoning. Only two respondents (N=2) preferred the modified package (Sample 2) identifying it as the most eye-catching and “uniform”.



DISCUSSION

By circulating a survey to consumers aged 18-24, the results confirmed the most important visual cues and general perceptions of potato chip packaging. Aligning with the hypothesis, young adult consumers scan for familiar imagery attributes, such as product photography, and tend to deprioritize eco-labels when searching for a potato chip product. However, the importance of visual transparency in promoting environmental sustainability on packaging artwork is not undermined. This trend directly reflects the Pringles® case study in which both imagery and sustainable elements like eco-labels are the prominent visual cues, thereby supporting the research hypothesis.

Food Packaging Cues

Unsurprisingly, respondents identified visual cues to be the leading factor in identifying a potato chip product. This conclusion is consistent with the framework of the original cue utilization theory (CUT) which was derived by Olsen & Jacoby (1972) where visual cues triumph in influencing a purchasing decision. When searching for a potato chip product at the store, consumers usually visualize a product by mentally recalling attributes such as colour or graphics. What catches the eye is only the most obvious elements of the packaging design;

all subordinate cues, including sensory and structural cues, are initially dismissed. As a result, when searching for a new product, consumers will first and foremost identify the visual cues on the package and sort them by importance before starting the evaluation process.

These results build on existing evidence of processing fluency theory (PFT) where repeatability expressed through visual means positively affects the consumer's purchasing decision. In line with Janiszewski & Meyvis' (2001) discussion on PFT, remaining consistent with visual solutions better assists consumers in making reasonable brand evaluations. This directly correlates to the repetitive visual cues on potato chip packaging. Brand loyalty is partially driven by visual consistency. If a package frequently modifies artwork, consumers may associate visual inconsistency directly with the product quality or may not even be able to identify the product on the shelf. This statement is supported further in Section 5.4.

The largest limitation of the acquired results is generalizability. Under the discretion of the university's ethics board, the scope of the demographic surveyed was limited to internal undergraduate students' part of the thesis capstone course. This poses a bias within the data as participants have a thorough background understanding of graphics arts, sustainability, and packaging. Had the survey been distributed to a larger collective, the questionnaire would yield different results. Further research is needed to establish the variability

between different demographics. Although this paper solely focuses on the age group of 18-24 within the capstone course, acquiring data from external candidates aged 18-24 would modify the outcome. Likewise, releasing the survey to a variety of age groups (i.e. ages 57-75) may identify notable trends and preferences.

Food Packaging and Visual Cues

As visual cues prove to be the most distinguished identification for potato chip packaging, the more specific results were unexpected. Half of the survey takers scan the store shelves by referring to imagery and pictures when identifying a product. Further analysis generates a variance of 141.302 as scattered data is present for this visual attribute. Plainly, these targeted consumers are more decisive and use imagery and pictures as vital tools to find their product. However, these results contradict the claims of Magnier et. al (2016) where the nomination of eco-labels is deemed the most important attribute. Based on the data found in this thesis, a small variance (18.02) is associated with eco-labels. This means that consumers share different views on sustainability as the data is more evenly distributed across all categories.

The data contributes a clearer understanding of how consumers observe and interact with a potato chip product.

While more recent research has focused on sustainability attributes, these results demonstrate that other attributes are prioritized. As the null hypothesis (H0) was rejected, data shows that consumers almost equally rely on brand indicators, colour schemes, and imagery and pictures to locate their in-store products.

Similarly to Section 5.1., the reliability of this data is affected by the lack of diversity in the surveyed group's demographics. Expanding the demographic to not only include a variety of age groups, but also those with visual impairments (for example, colour vision deficiency), could alter the outcome of the data. The broader sample of the survey would be preceded by a comparative study with the explicit objective of concluding the effect of vision deficiency on brand recognizability.

Food Packaging and Sustainability

The data in the survey's sustainability section proves that young consumers are eager to alter their purchasing decision when confronted with sustainability attributes on potato chip packaging. With over half of the respondents supporting the likelihood of purchasing an eco-friendly chip package, this data compliments the observations of Magnier et al. (2016). These observations lie at the centre of perceived quality and environmental consciousness, instilling a direct correlation.

As Magnier et al. state, “redesigning the [sustainability] attributes of packaged food products into more sustainable alternatives can thus increase consumers’ perception of quality” (2016). This shows that by adding a simple eco-label to the packaging artwork, young consumers are inclined to make a purchasing commitment.

Furthermore, these results support the claims of Herber et al. (2020). The results to the question “In your opinion, how do you determine if a package is sustainable?” runs parallel to the compared study. As 44% of respondents in this paper prioritize eco-labeling, consumers in Herber et. al. “identified labelling as their first cue to the environmental merit of packaging” (2020). Modifications to include prominent eco-labels would more likely alter the consumers’ purchasing decisions.

The experiment provides new insight into the relationship between consumers and various sustainability attributes. Upon consideration of the results, identifying whether consumers value the difference between numerical and verbal sustainability information led to the rejection of the alternate hypothesis (Ha). The results dictate that consumers do not value one attribute over the other and view sustainable callouts equally as important. Nevertheless, with Magnier et al.’s (2016) theories, overpopulating packaging artwork with sustainability cues dictates a negative response. If consumers are overwhelmed by the packaging artwork, then “the accumulation of cues does not appear to represent an

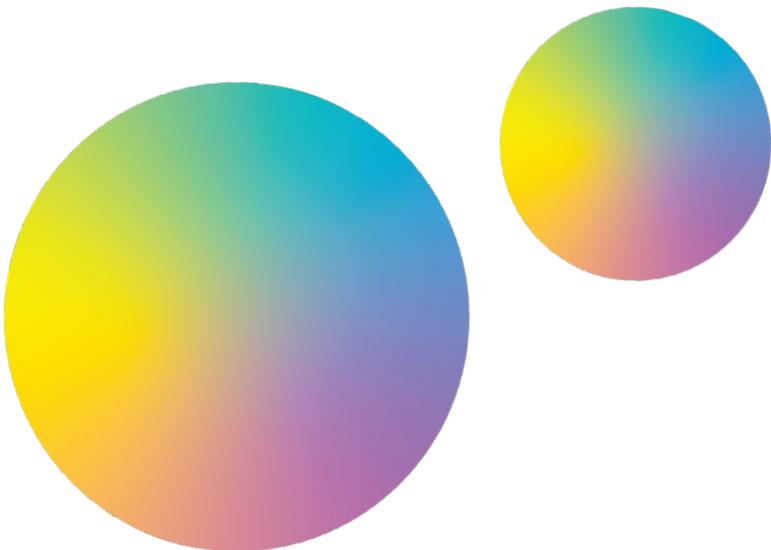
efficient strategy” (Magnier et al., 2016).

The shortcomings of this section included solely assessing the quality of potato chip packaging. By establishing a relationship between packaging quality and product quality, more accurate results could be drawn about consumer perception. In most instances, perceived product quality is associated with packaging quality as Magnier et al. imply that “individuals make inferences about the quality of food products when assessing a noticeably sustainable packaging” (2016). Future scientific studies could examine the effect of different sustainable material substrates rather than on only packaging artwork and derive a pragmatic conclusion. Moreover, future research could compare ethically sourced potato chips, thereby recognizing relationships between sustainable packaging materiality versus its conventional counterparts.

These results build on existing evidence of processing fluency theory (PFT) where repeatability expressed through visual means positively affects the consumer’s purchasing decision. In line with Janiszewski & Meyvis’ (2001) discussion on PFT, remaining consistent with visual solutions better assists consumers in making reasonable brand evaluations. This directly correlates to the repetitive visual cues on potato chip packaging. Brand loyalty is partially driven by visual consistency. If a package frequently modifies artwork, consumers may associate visual inconsistency directly with the product quality or may not even be able to identify the product on the shelf.

This statement is supported further in Section 5.4.

The largest limitation of the acquired results is generalizability. Under the discretion of the university's ethics board, the scope of the demographic surveyed was limited to internal undergraduate students' part of the thesis capstone course. This poses a bias within the data as participants have a thorough background understanding of graphics arts, sustainability, and packaging. Had the survey been distributed to a larger collective, the questionnaire would yield different results. Further research is needed to establish the variability between different demographics. Although this paper solely focuses on the age group of 18-24 within the capstone course, acquiring data from external candidates aged 18-24 would modify the outcome. Likewise, releasing the survey to a variety of age groups (i.e. ages 57-75) may identify notable trends and preferences.



Case Study: Pringles® Packaging

The derived case study identified several unique discoveries and trends. Contrary to previous findings that recognized imagery and pictures as the most important visual cue, the case study revealed that brand indicators are in fact more influential across all three Pringles® packaging samples for consumers aged 18-24. These results greatly differ from observations found in contemporary studies that substantiate eco-labeling as the primordial visual cue (Herbes et al., 2020; Magnier et al., 2016). It is important to note that while respondents claimed not to care about sustainable packaging in Samples 1 and 2, 67% of respondents prioritized eco-labeling in Sample 3. This shows that the noticeability of eco-labels, while initially perceived as insignificant, is in reality an important factor to consider for young consumers.

These results support the literature describing processing fluency theory (PFT). Results show that young consumers easily process recognizable visual cues and their purchasing decisions are highly influenced by familiarity. Furthermore, the Pringles® case study demonstrates the importance of maintaining brand recognition, as most respondents are reluctant to accept modifications to the traditional packaging artwork. For example, an analysis of Samples 1 and 2 confirms that altering the design even slightly—in this case with a

minimalist approach to the brand mascot, colour saturation, and new product photography—evoked a negative response from participants. Reber et al. further explore the concept of familiarity: “high fluency may elicit positive [effects] because it is associated with progress toward successful recognition of the stimulus” (2004). For this reason, the original Pringles® canister is the most desirable option for all consumers, concluding that even the young demographic targeted in the case study gravitates towards familiarity. Despite the popularity of the original packaging (Sample 1), the new design of the eco-conscious packaging (Sample 3) was surprisingly more attractive to potential consumers, indicating that sustainable attributes were embraced rather than rejected by respondents. These findings should be taken into account when considering how to continue developing brand strategies for potato chip packaging artwork.

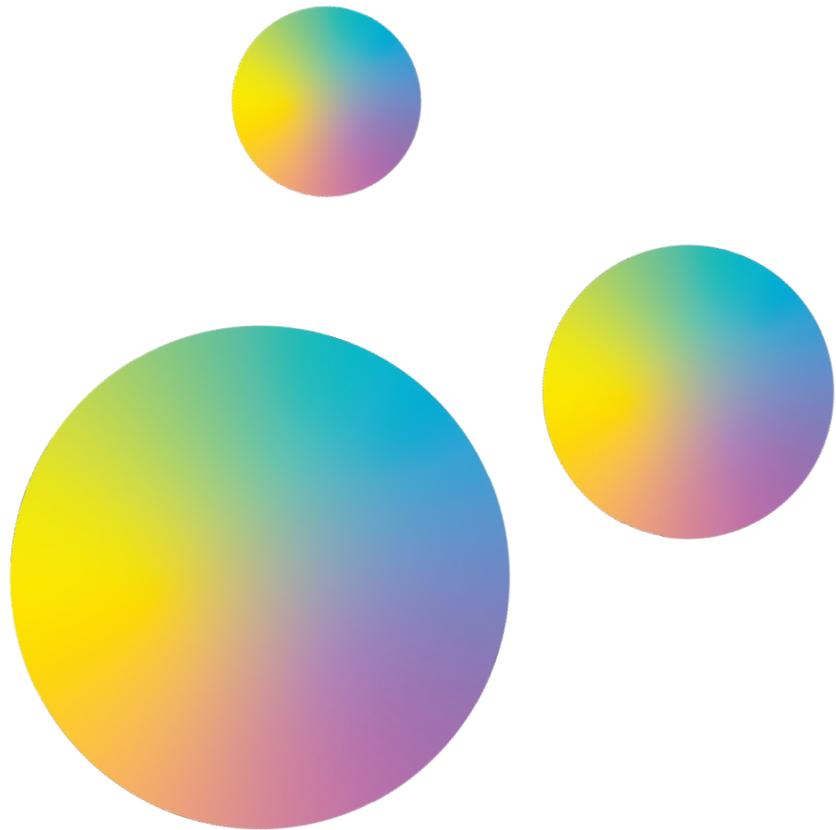
In Appendix 1 (Section 5, Question 12), in the response to the survey question “From the three samples, which potato chip can are you most likely to purchase? Please explain why.”, most respondents selected the sustainable option (Sample 3). The open-ended question qualitatively derived valuable inputs, affirming cue utilization theory (CUT) that sustainability callouts are of the greatest visual impact (Herbes et al., 2020; Magnier et al., 2016). The majority of the young consumers were not dissuaded from the eco-label in Sample 3 and even preferred it to the original (Sample 1). It is important to note

that while Sample 2 was a radical change from Sample 1, the eco-friendly Sample 3 remained loyal in style and expression to the original packaging. This is perhaps why the participants responded so positively to the eco-label modifications (Sample 3) and so negatively to the minimalistic Pringles® canister design (Sample 2).

For the purpose of this case study, the differences in cost of sustainable packaging were not taken into account. In general, sustainable products and packaging are of higher cost. Although not mentioned in the literature review, authors Manning (2021) and Stanfield (2021) support this claim. By revising packaging to be more environmentally conscious, “materials can cost... 25% more compared to traditional packaging” (Manning, 2021). Should the sustainable Pringles® product generate higher costs because of its substitution for eco-conscious materials, several consumers within the survey would be more inclined to “just buy the cheaper can.” Although it is beyond the scope of this study to observe price, Stanfield (2021) states that “the cost largely depends on the size of the product, what it is made of, and how much it costs to produce it in the first place.” Therefore, integrating questions about product price across the three presented samples could affect the conclusion of the survey.

A qualitative and quantitative analysis of consumer perception was gauged in the conducted case study. Even though there are several overlooked elements, such as cost, future studies

could consider greenwashing packaging to assess the ability of consumers to differentiate between genuine sustainable practices and the appearance of it. This could tie into both CUT and PFT by analyzing consumer fluency, primary visual cues, and the reaction of consumers to greenwashing tactics. Additionally, incorporating a survey section on Pringles® packaging end-use and disposal could help future studies to ascertain the recycling practices of young consumers and their willingness to respond to environmental challenges.



CONCLUSION

Numerous studies on consumer perception of food packaging fixate on the psychological interpretations of consumers rather than their hierarchy of visual assessment on a given package that contains both artwork and environmental claims. By analyzing the most effective visual factors and sustainability callouts on potato chip packaging for adult consumers (aged 18-24) in Canada, this thesis has identified that most users positively respond to adding eco-labels to their favoured potato chip products whilst heavily relying on most visual cues to identify changes in packaging artwork design and spot their product on the shelf.

In answering the posed research question—within the potato chip industry, how do consumers perceive a change in brand artwork design and change to eco-labels on the packaging in traditional retail channels in Canada—several studies followed by a circulated survey aided in drawing conclusions. Overall, consumers are most receptive to imagery and pictures to locate their products on the shelf. Should a familiar product modify its packaging artwork, some users struggle to identify the product and, moreover, may revoke their purchasing decision. Based on qualitative and quantitative analysis of sustainability elements on potato chip packaging, many consumers deprioritize eco-callouts through a theoretical lens but value sustainable packaging through a practical lens. When

asked about how important sustainability attributes (i.e. eco-labels) are in comparison to other visual cues, most consumers rated the element as least important. Notwithstanding, when a practical situation was applied through the Pringles® case study, consumers contradicted their previous response and preferred eco-labels over other CUT visual cues.

Future research is required to identify new variables and fill in the gaps in sustainable potato chip packaging. By expanding the demographic to a variety of age groups and visual abilities, more diverse data for this food category can be acquired. Purchasing behaviours and hierarchy of visual perception can be, then, segmented by age range. Introducing new variables such as cost can better identify willingness to purchase a potato chip product. Modified packaging artwork or substrates at the expense of increased cost can drastically alter purchasing decisions. This, again, can be distributed to numerous age groups to observe demographic trends. Future practitioners should also consider greenwashing tactics and draw a relationship to consumers' education on false advertising. Identifying a greenwashed product could be segmented by age range, knowledge of sustainability, and the visual cues users rely on to notice a given snack food product. Packaging disposal is another insightful opportunity for future research. Given the current circumstances of most potato chip packaging disposal (currently not recyclable), recording how different users discard their packages

could showcase unique findings. This could also relate to sustainability by inquiring whether consumers would respond differently if the package were fully recyclable. Additionally, uncovering how users differentiate between ethically sourced packaging substrates versus food product ingredients should be investigated to better understand purchasing behaviour in relation to sustainability. Although not addressed earlier, evaluating different purchasing avenues through traditional brick-and-mortar versus e-commerce retail channels could affect how consumers view a product and better identify any visual discrepancies within their purchasing journey.

Assessing the most important visual and sustainable cues on potato chip packaging determined how consumers perceive packaging artwork and how it influences their purchasing decision. Results derived from the survey point to the importance of preserving image integrity and remaining consistent with brand guidelines. Additionally, this research notes the sustainable efforts (via eco-labels) on packaging artwork and connects it to consumer perception. While this has been discussed in the literature review, this thesis confirmed that cue utilization theory's (CUT's) intrinsic sustainable attributes (i.e. eco-labels, recycling symbols) are directly associated with perceived packaging quality. In short, these findings uncover the diversity of how young adult consumers evaluate a potato chip product and what factors contribute to a positive purchasing experience at the retail store shelf.

REFERENCES

- Alter, A. L., & Oppenheimer, D. M. (2006). Predicting short-term stock fluctuations by using processing fluency. *Proceedings of the National Academy of Sciences*, 103(24), 9369-9372.
- Bevans, R. (2021, January 7). The p-value explained. Scribbr. Retrieved March 24, 2022, from <https://www.scribbr.com/statistics/p-value/>
- Bhandari, P. (2021, December 9). Understanding and calculating standard deviation. Scribbr. Retrieved April 1, 2022, from <https://www.scribbr.com/statistics/standard-deviation/>
- Buchko, M. (2021). (rep.). *Snack Food Production in Canada* (pp. 1–40). Los Angeles, CA: IBISWorld Inc. Retrieved February 3, 2022, from <https://my-ibisworld-com.ezproxy.lib.ryerson.ca/ca/en/industry/31191ca/about>.
- Dabija, D., Brandusa, B., & Pușcaș, C. (2020). A Qualitative Approach to the Sustainable Orientation of Generation Z in Retail: The Case of Romania. *Journal of Risk and Financial Management*, 13(7), 152. <https://doi.org/10.3390/jrfm13070152>
- Dragojevic, M., & Giles, H. (2016). I don't like you because you're hard to understand: The role of processing fluency in the language attitudes process. *Human Communication Research*, 42(3), 396-420.
- Herbes, C., Beuthner, C., & Ramme, I. (2020). How green is your

- packaging—a comparative international study of cues consumers use to recognize environmentally friendly packaging. *International Journal of Consumer Studies*, 44(3), 258–271. <https://doi.org/10.1111/ijcs.12560>
- Hyslop, G. (2020). Pringles Cannister 2020. Bakery and Snacks. William Reed Ltd. Retrieved April 2, 2022, from <https://www.bakeryandsnacks.com/Article/2020/09/10/Pringles-iconic-tube-pilots-an-eco-makeover-in-UK>.
- Jacoby, J., Olson, J. C., & Haddock, R. A. Price, brand name, and product composition characteristics as determinants of perceived quality. *Journal of Applied Psychology*, 1971, 55, 570-579.
- Jain, V., Vatsa, R., and Khyati, J. (2014). Exploring generation z's purchase behavior towards luxury apparel: A conceptual framework. *Romanian Journal of Marketing*, 2, 18–29.
- Janiszewski, C., & Meyvis, T. (2001). Effects of brand logo complexity, repetition, and spacing on processing fluency and judgment. *Journal of Consumer Research*, 28(1), 18–32. <https://doi.org/10.1086/321945>
- Kellogg Europe Trading Limited. (n.d.). Pringles Cannister 2021. Pringles. Retrieved April 2, 2022, from <https://www.pringles.com/uk/products.html>.
- Lee, A. Y., & Labroo, A. A. (2004). The effect of conceptual and perceptual fluency on brand evaluation. *Journal of Marketing*

- Research, XLI (May), 151–165.
- Magnier, L., Schoormans, J., & Mugge, R. (2016). Judging a product by its cover: Packaging sustainability and perceptions of quality in food products. *Food Quality and Preference*, 53, 132–142. <https://doi.org/10.1016/j.foodqual.2016.06.006>
- Manning, L. (2021, April 27). Consumer demand for sustainable packaging holds despite pandemic. *Food Dive*. Retrieved March 27, 2022, from <https://www.fooddive.com/news/consumer-demand-for-sustainable-packaging-holds-despite-pandemic/599013/>
- Mitchell, B. (2019). *Generation Z & Consumer Trends In Environmental Packaging*.
- Olson, J. C., & Jacoby, J. (1972). Cue utilization in the quality perception process. In 3rd annual conference of the Association of Consumer Research (pp. 167–179).
- Pearson-Jones, B. (2021). Pringles Cannister 2001. *Daily Mail*. Associated Newspapers Ltd. Retrieved April 2, 2022, from <https://www.dailymail.co.uk/femail/food/article-10027685/Pringles-rebrand-slammed-bad-hurtful.html>.
- Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: Is Beauty in the perceiver's processing experience? *Personality and Social Psychology Review*, 8(4), 364–382. https://doi.org/10.1207/s15327957pspr0804_3
- Scott, L., & Vigar-Ellis, D. (2014). Consumer understanding, perceptions and behaviours with regard to environmentally

- friendly packaging in a developing nation. *International Journal of Consumer Studies*, 38, 642–649. <https://doi.org/10.1111/ijcs.12136>
- Seo, J.Y., & Scammon, D.L. (2017). Do green packages lead to misperceptions? The influence of package colors on consumers' perceptions of brands with environmental claims. *Mark Lett*, 28, 357–369. <https://doi.org/10.1007/s11002-017-9420-y>
- Siracusa, V. (2012). *Food Packaging Permeability Behaviour: A Report*. *International Journal of Polymer Science*, 2012. <https://doi.org/10.1155/2012/302029>
- Stanfield, S. (2021, September 30). Is recyclable packaging more expensive? (with cost comparison). *Citizen Sustainable*. Retrieved March 27, 2022, from <https://citizensustainable.com/recyclable-packaging-expensive/>
- White, K., Lin, L., Dahl, D., & Ritchie, R. (2016). When do consumers avoid imperfections? Superficial packaging damage as a contamination cue. *Journal of Marketing Research*, 53, 110–123. <https://doi.org/10.1509/jmr.12.0388>

APPENDIX

Appendix 1. Survey Questionnaire

About the Survey: This was a survey conducted by Anastasia Partserniak (apartserniak@ryerson.ca) and was solely used for incorporating survey results into her undergraduate thesis project.

This survey was comprised of five categories and asked about the survey taker's perception concerning snack food and potato chip packaging's visual elements. Participants may have chosen not to complete the survey and could exit it at any time.

If one volunteered to participate in this study, one would be asked to do the following things:

- Complete the survey in a remote location, preferably in a private and/or quiet area (i.e. at home).
- Dedicate anywhere from 10 minutes to 15 minutes to complete the survey. This survey only needs to be completed once.
- Reflect on one's personal experience by answering the survey questions which may be comprised of:
 - A Likert scale(s) ranging from 1 to 5 (i.e. Never to Always, Not Important to Very Important, Very Unlikely to Very Likely etc.)
- Open-ended questions that inquire for your personal and/or honest response.

- Demographic data required to be collected from subjects include:
 - Age range

This survey was anonymous. One would not be identifying oneself on the survey.

Section 1: General Information and Background

1. Do you consent for your responses to be used as part of an undergraduate thesis? Please note, this is an anonymous survey. You will not be identifying yourself on the survey.
 - a. Yes
 - b. No
2. Are you between the ages of 18-24?
 - a. Yes
 - b. No
3. Do you like to eat snack foods? (i.e. popcorn, potato chips, nuts etc.)
 - a. Once a day
 - b. Once week
 - c. Once a month
 - d. Once every 3-6 months
 - e. Once a year
 - f. Never

- 4.** Do you like to eat potato chips? If so, how often do you eat potato chips?
- Once a day
 - Once week
 - Once a month
 - Once every 3-6 months
 - Once a year
 - Never
- 5.** How often do you shop for potato chips?
- Once a day
 - Once week
 - Once a month
 - Once every 3-6 months
 - Once a year
 - Never

Section 2: Food Packaging Cues

- 1.** When shopping for potato chips, how important are STRUCTURAL packaging cues to you in order to identify a product? (i.e. Packaging material, packaging shape/size)
- Not important
 - Somewhat not important
 - Neutral
 - Somewhat important
 - Very important

- 2.** When shopping for potato chips, how important are VISUAL packaging cues to you in order to identify a product? (i.e. brand indicators, colour schemes, imagery/pictures, eco-labels)
- Not important
 - Somewhat not important
 - Neutral
 - Somewhat important
 - Very important
- 3.** When shopping for potato chips, how important are information on ENVIRONMENTAL IMPACT cues to you in order to identify a product? (i.e. verbal claims, FSC certification)
- Not important
 - Somewhat not important
 - Neutral
 - Somewhat important
 - Very important
- 4.** When shopping for potato chips, how important are SENSORY packaging cues for you to identify a product? (i.e. smells, feeling the package material, hearing the sound the packaging makes)
- Not important
 - Somewhat not important
 - Neutral
 - Somewhat important
 - Very important

Section 3: Food Packaging Cues and Visual Cues

1. When looking for a potato chip product on the shelf, how important are BRAND INDICATORS to you to find a given product? (i.e. brand mascots, logos)
 - a. Not important
 - b. Somewhat not important
 - c. Neutral
 - d. Somewhat important
 - e. Very important
2. When looking for a potato chip product on the shelf, how important are COLOUR SCHEMES to you to find a given product?
 - a. Not important
 - b. Somewhat not important
 - c. Neutral
 - d. Somewhat important
 - e. Very important
3. When looking for a potato chip product on the shelf, how important are IMAGERY/PICTURES to you to find a given product? (i.e. product photography, graphic icons)
 - a. Not important
 - b. Somewhat not important
 - c. Neutral
 - d. Somewhat important
 - e. Very important

4. When looking for a potato chip product on the shelf, how important are ECO-LABELS to you to find a given product? (i.e. recycling symbols, FSC certifications)
 - a. Not important
 - b. Somewhat not important
 - c. Neutral
 - d. Somewhat important
 - e. Very important

Section 4: Food Packaging and Sustainability

1. When looking for a potato chip product on the shelf, how important are BRAND INDICATORS to you to find a given product? (i.e. brand mascots, logos)
 - a. Not important
 - b. Somewhat not important
 - c. Neutral
 - d. Somewhat important
 - e. Very important
2. When looking for a potato chip product on the shelf, how important are COLOUR SCHEMES to you to find a given product?
 - a. Not important
 - b. Somewhat not important
 - c. Neutral
 - d. Somewhat important
 - e. Very important

3. When looking for a potato chip product on the shelf, how important are IMAGERY/PICTURES to you to find a given product? (i.e. product photography, graphic icons)

- a. Eco-labeling
- b. Colour of packaging
- c. Personally evaluate the packaging material
- d. Information provided by the retailer
- e. Word of mouth
- f. Research online
- g. Others

4. When looking for a potato chip product on the shelf, how important are ECO-LABELS to you to find a given product? (i.e. recycling symbols, FSC certifications)

- a. Not important
- b. Somewhat not important
- c. Neutral
- d. Somewhat important
- e. Very important

Section 5: Case Study: Pringles® Packaging



SAMPLE 1.

1. What visual cue do you first notice?

- a. Brand indicators (i.e. logos, mascots etc.)
- b. Colour scheme
- c. Imagery/pictures
- d. Eco-labels

2. In your opinion, how noticeable is this packaging on the shelf?

- a. Not noticeable
- b. Somewhat not noticeable
- c. Neutral
- d. Somewhat noticeable
- e. Very noticeable

3. Based on the visual artwork, how likely is it that you would purchase this product?

- a. Very unlikely
- b. Somewhat unlikely
- c. Neutral
- d. Somewhat likely
- e. Very likely



SAMPLE 2.

4. What visual cue do you first notice?

- a. Brand indicators (i.e. logos, mascots etc.)
- b. Colour scheme
- c. Imagery/pictures
- d. Eco-labels

5. In your opinion, how noticeable is this packaging on the shelf?

- a. Not noticeable
- b. Somewhat not noticeable
- c. Neutral
- d. Somewhat noticeable
- e. Very noticeable

6. Based on the visual artwork, how likely is it that you would purchase this product?

- a. Very unlikely
- b. Somewhat unlikely
- c. Neutral
- d. Somewhat likely
- e. Very likely



SAMPLE 3.

- 7.** What visual cue do you first notice?
- Brand indicators (i.e. logos, mascots etc.)
 - Colour scheme
 - Imagery/pictures
 - Eco-labels
- 8.** In your opinion, how noticeable is this packaging on the shelf?
- Not noticeable
 - Somewhat not noticeable
 - Neutral
 - Somewhat noticeable
 - Very noticeable
- 9.** Based on the visual artwork, how likely is it that you would purchase this product?
- Very unlikely
 - Somewhat unlikely
 - Neutral
 - Somewhat likely
 - Very likely



SAMPLE 1, 2 AND 3.

- 10.** Seeing as the artwork has been modified, how likely are you to purchase this product BECAUSE of its sustainability claims?
- Very unlikely
 - Somewhat unlikely
 - Neutral
 - Somewhat likely
 - Very likely
- 11.** In your opinion, what do you like and/or dislike about these three artwork designs?
- 12.** From the three samples, which potato chip can are you most likely to purchase? Please explain why.

Appendix 2. Raw Data Analysis in Google Sheets

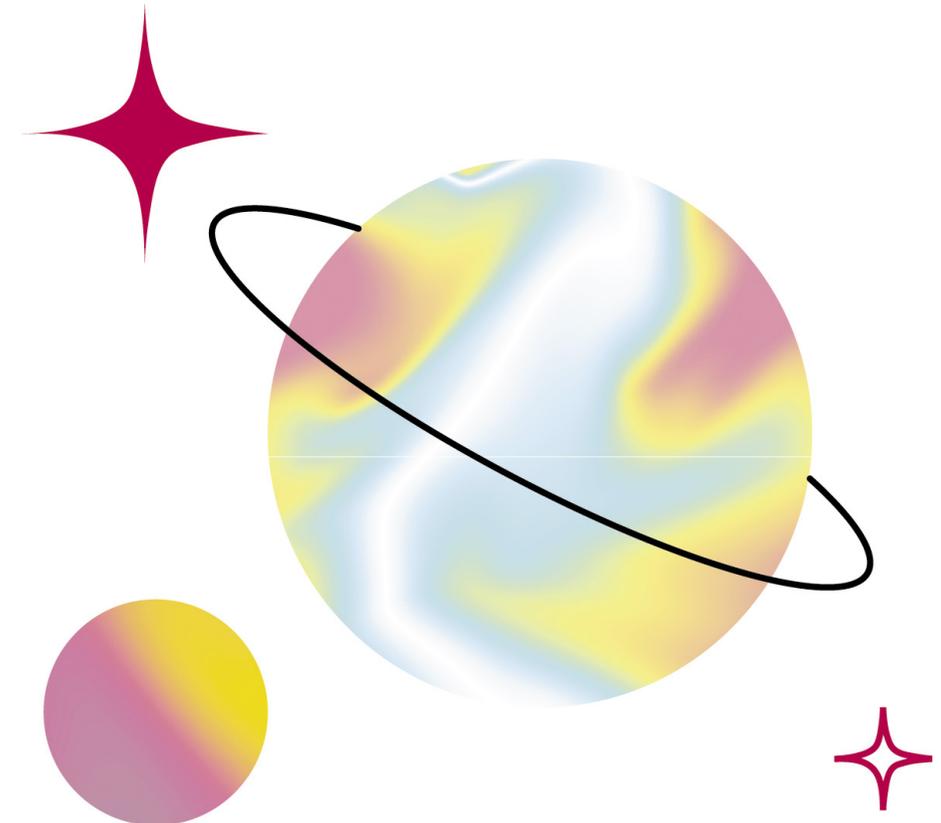
TABLE 1. - SINGLE-FACTOR ANALYSIS OF VARIANCE (ANOVA) USED TO DETERMINE THE DEGREE OF SPREAD IN VARIANCE ACROSS EACH VISUAL CUE (BRAND INDICATORS, COLOUR SCHEMES, IMAGERY/PICTURES, AND ECO-LABELS)

SUMMARY

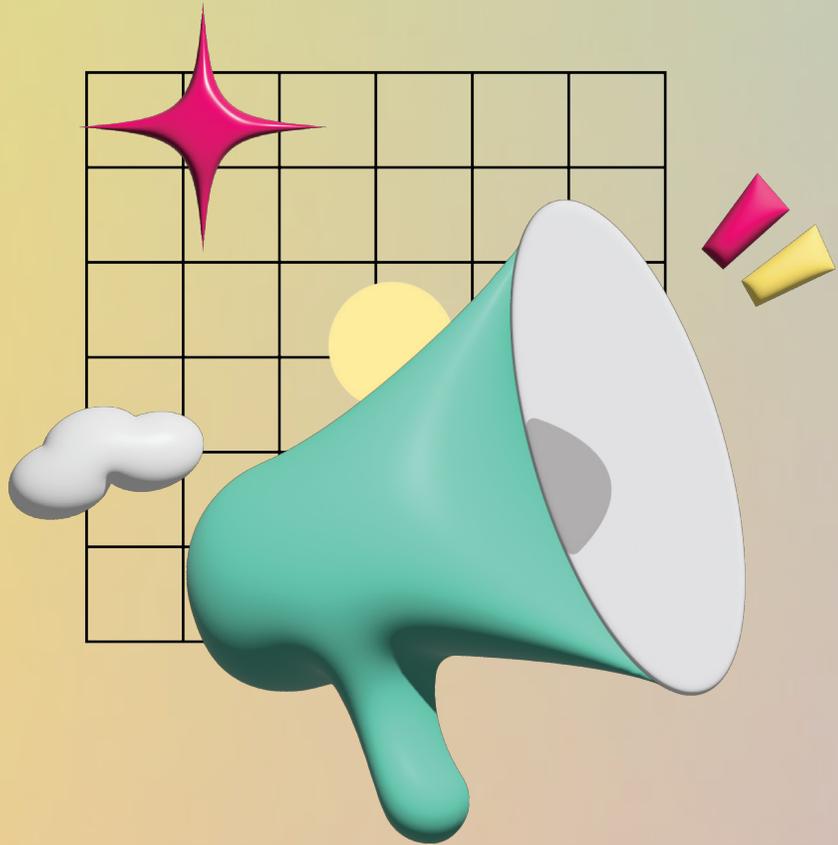
GROUPS	COUNT	SUM	AVERAGE	VARIANCE
Brand Indicators	5	27	14.4	94.8
Colour Schemes	5	27	14.4	94.8
Imagery/Pictures	5	27	14.4	141.3
Eco-Labels	5	27	14.4	18.3

TABLE 2. - T-TEST: PAIRED TWO SAMPLE FOR MEANS USED TO IDENTIFY WHICH OF THE TWO SUSTAINABILITY CLAIMS (VERBAL VERSUS NUMERICAL) ARE MORE IMPORTANT TO YOUNG CONSUMERS AND WHETHER THE RESULTS DIFFER FROM ONE ANOTHER.

	NUMERICAL	VERBAL
Mean	14.4	14.4
Variance	28.8	48.3
Observations	5	5
Pearson Correlation	0.919654	
Hypothesized Mean Difference	0	
df	4	
t Star	0.0000	
P(T<=t) one-tail	0.5	
t Critical one-tail	2.131847	
P(T<=t) two-tail	1.00	
t Critical two-tail	2.776445	



CREDITS



MEET OUR TEAM



PRESIDENT



SAMIR MACKLAI
(he/him)

I am incredibly grateful to be leading the 2022/2023 TMUTAGA team as the President for this year's student chapter. Being a part of the chapter's development for over 2 years gave me the opportunity and insight to learn about the new technical advancements in the graphic arts. Connecting both scientific research and technological innovation in this diverse field, I am excited to see how this year's journal will incorporate newfound developments, locally and internationally. This year TMUTAGA's publication will be printed, and the conference will be taking place in person. I am very excited to see the many new theoretical and practical information displayed at the TAGA conference. I am honoured to be included in analyzing new technologies in the graphic communications industry and producing our annual journal! Further, this team has been working very hard and look forward to seeing it all come together in our first year back fully in-person!

CREATIVE DIRECTOR



AISHARJA CHOWDHURY (she/her)

It has been an honor to be the Creative Director for the 2022/2023 TMUTAGA Team! As this was my first year in TMUTAGA, I was thrilled for this opportunity to not only show my creative outlet and passion for designing but to also learn new concepts/terminologies from my peers. Creating this journal has been an amazing opportunity from planning/researching the theme to actually designing it and finally having the physical copy in my hands. I was very grateful to be working with such an amazing team and my wonderful creative associates to produce an impactful journal!

CO-PRODUCTION DIRECTOR



I am very excited to be a part of TMUTAGA this year as a Production Director. I love production and the creative process behind every printed masterpiece. I'm very excited to be a part of a great team that puts together an amazing journal.

CO-PRODUCTION DIRECTOR



I'm pleased to join TMUTAGA as a Production Director this year. Working with my co-director and the rest of the team is a wonderful experience, and I'm excited to bring the journal concept to print. All the lessons I've had on book publishing will culminate to make this year's journal the best it can be. Look out TAGA conference: prepare to be wowed.

EDITORIAL DIRECTOR



I am thrilled to be the Editorial Director for the 2022/2023 TMUTAGA team. I first joined TMUTAGA last year as a Creative Associate, where I had the amazing opportunity to tap into my visual art and design skills. In this role, I look forward to expanding my knowledge on the technical and research side of the graphic communications industry and showcasing some amazing student papers at the TAGA conference. With such an incredible team of executives and associates, I am confident that we will be producing another fantastic journal to share with everyone!

MARKETING & EVENTS DIRECTOR



I am so excited to be joining TMUTAGA this year as the Marketing Director. While I've had experience working in other student groups, this is my first year with TMUTAGA. It's been an amazing experience getting to know everyone on the team, and seeing how passionate and driven they are to make this year's journal the best one yet. It's been great collaborating with the team, especially the Multimedia Director, to build out content that is both engaging and exciting for everyone to see! I'm very thankful to be working with such a hardworking team and I can't wait to share what we have in store for you this year! So keep an eye out for what's to come!

MULTI-MEDIA DIRECTOR



I'm stoked to be part of TMUTAGA as this years Multimedia Director! This is the first student group im joining at TMU and I couldn't have asked for a better team to work with. I'm someone who loves to consume and create content through different mediums and I'm looking forward to showcasing some of my ideas and skills through creating all kinds of content for the digital portion of this years journal and for our social media community. We have some pretty cool things coming this year so keep your eye on TAGA so you dont miss any of it!

TREASURY & ADMINDIRECTOR



I'm honoured to be part of the TMUTAGA team this year as the Treasury and Admin director! Since this is my first year joining TMUTAGA, I'm looking forward to learning more about the publishing process and gaining knowledge as we develop ideas to create an award winning journal. It's been a great opportunity to work with the team so far and we can't wait to show everyone the final product!

ASSOCIATES

CREATIVE

Timothy Aranas
Miguel Castro
Yubing Liu

MULTIMEDIA

Isabel (Isa) Morales Leon
Sanjana Srivastava

EDITORIAL

Jaclyn Marco
Jennifer Li
Lia Torre
Jasdeep Gaidu

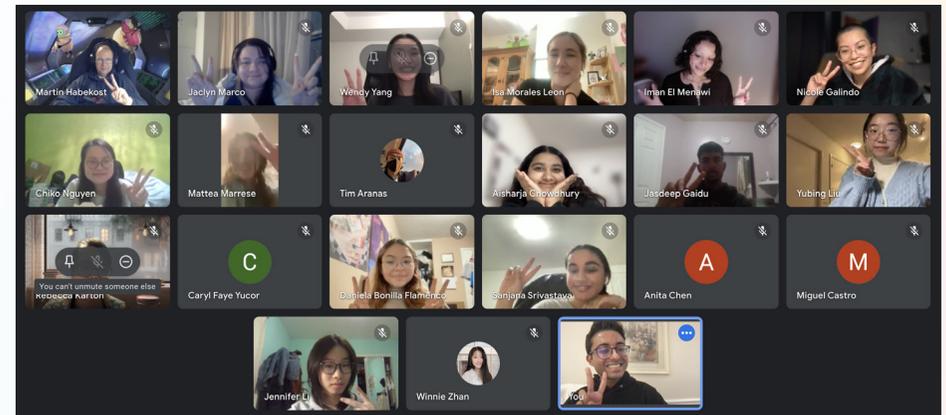
PRODUCTION

Anita Chen
Jessica Flamenco
Mattea Marrese
Minh Ngoc Nguyen

MARKETING & EVENTS

Mishel Haimov
Fleur Torres

Thank you to our associates who provided support to our executives in the completion of this years journal. We truly appreciate your hard work and dedication throughout the process. This journal would not have been possible without your help. Thank you!



COLOPHON

Software

Adobe InDesign CC
 Adobe Illustrator CC
 Adobe Photoshop CC
 Adobe Acrobat CC
 KODAK Preps
 Fiery Command Workstation

Stocks

Tango C2S 12 pt Cover
 Cougar Digital Text

Typefaces

Montserrat
 Roboto
 Futura

Equipment

Ricoh Pro C7210X
 Xerox iGen5 150
 Scodix Ultra Pro
 Heidelberg Stahlfolder
 Müller Martini Amigo Plus
 Polar 78 Paper Cutter

PRODUCTION NOTES

This year, students could return in person for the full use of the resources provided by the School of Graphic Communications Management (GCM). Martin Habekost, TMUTAGA staff advisor, guided us towards making a journal.

Scott Millward, a GCM contract lecturer, and Darsan Sivanantharajah, GCM's Client Support Technician, assisted with prepress. This included a preflight in Adobe Acrobat, imposing the journal in Fiery Command Workstation, and creating a proof.

A thicker coat than possible on a Ricoh Pro C7210X was desired for the cover to brighten the holographic design. The cover stock was sent to CJ Graphics to be printed on their Xerox iGen5 150 and enhanced by their Scodix Ultra Pro.

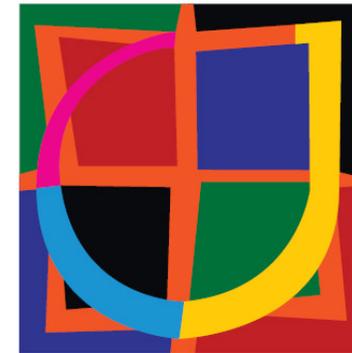
The production team then printed the journal in-house with the Ricoh Pro C7210X. Students used the 5th colour station, emphasizing key components of the journal in clear toner.

The two-page signatures printed 4-out were separated by a Polar 78 Paper Cutter. These were bound to the cover using GCM's Müller Martini Amigo Plus. The journal was trimmed with the Polar 78. Help was provided by Andrew Nigro, a contract lecturer.

MEET OUR SPONSORS



On behalf of the 2022-2023 TMUTAGA team, we would like to express our gratitude to our sponsors for their generous contributions and support in creating this year's journal.



CJ GRAPHICS INC.
COMMUNICATION SOLUTIONS

www.CJGraphics.com www.CJGroupofCompanies.com

BINDING SERVICES PROVIDED BY:

**ANDREW
NIGRO**





The Creative School

Graphic Communications Management

at The Creative School

NOTES



A grid of 20 rows and 20 columns of small, light gray dots, intended for writing notes.