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Summary of WP Student Team

Advancing the Customer Journey: Sustainable and Technological Innovations in Fashion

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Note: this template is a support document for the jury members before the defense, only.

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Advancing the Customer Journey: Sustainable and Technological Innovations in Fashion

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Abstract

This research explores scalable methods for assessing apparel carbon emissions and the effects of communication strategies on consumer decisions in sustainable fashion. It introduces a novel approach to emissions assessment and demonstrates how the presentation of carbon footprint information impacts consumer willingness to pay. Key findings include the significant role of framing in consumer perception and the competitiveness of OpenAI's GPT-4 as an easy-to-use fashion recommender system. The research provides actionable insights for the fashion industry, highlighting the necessity of both effective communication and innovative AI technologies to enhance sustainability and market competitiveness.

Carbon Footprint Assessment, Sustainable Consumerism, Eco-Friendly Fashion, AI in fashion

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1. Introduction (Group Part)

The fashion industry, a multifaceted intersection of creativity, economy, and environmental impact, produces over 100 billion garments annually (McKinsey 2016). This sector is a significant contributor to global greenhouse gas emissions, accounting for an estimated 2% of the total (Sadowski, et al. 2021, 1). To change this and make the industry more widely adopt sustainable practices, consumer pressure through more transparency is needed.

This need is underlined by research of Lestari et al., which underscores the importance of transparency in fostering consumer-driven ecological innovation (Lestari, et al. 2021, 1). In parallel, the economic aspect of making unit-level carbon emissions data accessible is notable. Findings by McKinsey suggest that younger, urban fashion consumers increasingly prefer sustainable options, indicating the significance of transparent sustainability metrics, like per unit emissions, in influencing buying choices (McKinsey 2022). This is particularly relevant for fashion retailers and e-commerce platforms, which can leverage sustainability metrics to align with growing consumer demand.

Building upon the importance of transparency highlighted in previous research and the significance of sustainability metrics like per unit emissions, this study introduces a novel methodology. Drawing from the practice of utilizing third-party audit reports to fix dire labor conditions in the clothing supply chain, we extend this approach to calculate and estimate unit emissions for a commonly consumed item: the cotton T-shirt (Handfield, Kraft and Moore 2022). This methodology enables a more comprehensive understanding of the environmental impact of fashion products, aligning with the evolving preferences of younger, urban consumers who seek sustainable options.

Once carbon dioxide data for products are calculated, the next step is to identify an effective way to communicate this information to consumers. The study investigates different methods

of showing CO2 data for sustainable T-shirts. Survey participants are asked to share the price they would be willing to pay for a T-shirt in an e-commerce environment. The displayed T-shirts are identically displayed, except for how the carbon footprint information is displayed. The objective is to investigate whether the way carbon footprint information is presented has an impact on participants' willingness to pay. This approach has been academically examined for various consumer products such as washing machines or food, but its application to fashion products remains largely uncharted (Sammer and Wüstenhagen 2006; Li and Kallas 2021).

Moreover, in a second experiment, it is investigated if the customer journey can further be improved by testing if recent advancements in Large Multimodal Models (LMMs) empower, often non-technical, small and medium-sized enterprises (SMEs) to create competitive fashion recommender systems. These LLMs possibly enable personalized recommendations, enhancing customer satisfaction and enabling SMEs to be more competitive with industry giants. Current recommender systems face challenges, notably the lack of detailed visual product information (Deldjoo, et al. 2023, 2). GPT-4V(ision) could address this issue by better understanding nuances of visual content. To assess this, a comparative experimental approach is used to evaluate the effectiveness of GPT-4V(ision), in enhancing fashion recommender systems against BEiT, a pre-trained Vision Transformer by Microsoft. The experiment has participants compare a base apparel item with alternatives generated by the models, selecting the one they find most visually similar. This aims to evaluate how various image retrieval methods used by these models influence consumer preferences.

Overall, the research provides insights into the ecological impact of cotton T-shirts to help consumers make environmentally conscious decisions. Further, it suggests ways for fashion businesses to best display sustainable products and highlights how SMEs in fashion can use GPT-4V(ision) as a fashion recommender system, leveling the market playing field.

2. Literature Review (Group Part)

2.1 Measuring Product Carbon Footprint

In addressing current gaps in the literature regarding environmental impact assessment, particularly in the apparel sector, this paper aims to integrate and expand upon existing methodologies. "The Carbon Catalogue," which assesses the carbon footprints of 866 commercial products across various sectors, lists 11 products under "Textiles, Apparel, Footwear, and Luxury Goods" (Meinrenken, et al. 2022). Notably, these apparel products are marked as ' N/a (product with insufficient stage-level data)' in their carbon emission columns. This lack of detailed information underscores the necessity for a scalable approach to calculate the carbon emissions of apparel products through their life cycle stages, a gap our research seeks to fill.

In integrating the methodologies of existing research into our approach, we first consider the European Union's Product Environmental Footprint Category Rules (PEFCR). This initiative, a significant stride in standardizing the evaluation of product environmental footprints, aligns with the EU's broader strategy for sustainable consumption and production.

Prior to the development of PEFCR, there was a diverse and often conflicting array of methods to evaluate the environmental impacts of products, which led to confusion and potentially misleading claims. The PEFCR emerged to provide a consistent framework that would ensure comparability, reliability, and verifiability of environmental footprint calculations of products and services. To enrich this framework, we adopt a methodology parallel to that used in Gronman et al.'s "Carbon Handprint – An Approach to Assess the Positive Climate Impacts of Products Demonstrated via Renewable Diesel Case" (Groenman, et al. 2019, 1059). This method, focusing on the positive environmental impacts of products, compares the carbon footprints of an improved product against a baseline. We apply this comparative emissions

analysis in our study, using data from Cotton Inc's "2016 LCA Full Report Update" for calculating baseline emissions of apparel products (thinkstep AG 2017).

Simultaneously, our approach incorporates aspects of Handfield, Kraft, and Moore's insights from their Harvard Business Review article (2022) on labor practices in the apparel industry. They propose the Ethical Apparel Index (EAI) to simplify and demystify audit data, enhancing transparency. Our methodology mirrors this by utilizing third-party reports for assessing sustainability practices in companies, similar to the EAI's approach in interpreting simplified audit outcomes for consumer information (Handfield, Kraft and Moore 2022).

By combining these diverse methodologies, our study focuses on the under-researched area of the fashion industry. We aim to provide a comprehensive and practical approach for assessing and comparing sustainability practices in this sector, contributing by creating a more scalable approach to assess the environmental impacts on a product level in the fashion industry.

Hypothesis 1: *A new, scalable methodology can be developed to assess and compare the carbon emissions of apparel products.*

2.2 Choice Theory and Value Sensitivity in Sustainable Fashion Consumption

In an era where sustainability is more than a buzzword, understanding the consumer's pathway to eco-friendly choices is critical. Diverse frameworks from psychology to economics offer insights into this complex landscape, each explaining distinct angles that influence consumer decisions.

Invariance in choice theory refers to the idea that certain properties of a decision problem should remain unchanged regardless of how the problem is presented or framed. This concept is important for ensuring that decision-making processes are consistent and reliable, regardless of how the decision problem is presented or framed (Tversky & Kahneman 1979). However, numerous investigations into decision framing have demonstrated that the presentation of a

choice or message markedly influences perception and response. For instance, research on Poland's national COVID-19 vaccination initiative highlighted framing as a critical component in devising and executing immunization strategies. An absence of strategic framing in communicating about vaccination has been associated with suboptimal results (Dobrowolski 2021, 538). The framing of a decision significantly influences people's perceptions and responses to it, as exhaustively established by the prospect theory (Kahnemann and Tversky 1986). For example, people may be more likely to take risks if a decision is framed in terms of potential gains, rather than potential losses (Shafir 2013, 386). The Value Sensitivity Theory suggests that the portrayal of a feature dictates individuals' reactions to it, and this is further expanded by the General Evaluability Theory, which examines the conditions under which people are more or less responsive to variations in attributes (Hsee and Zhang 2010, 343). In simple terms, the researchers suggest that how much we care about something depends on how easy it is to evaluate. They define this ease of evaluation as having enough relevant information to decide if the qualities we want for that object are met and then forming an opinion about it. The determinants of this evaluability and thus of value sensitivity are mode, knowledge, and nature (Hsee and Zhang 2010, 344-346). Mode signifies the manner in which the evaluation is presented, distinguishing between the single evaluation (SE) mode and the joint evaluation (JE) mode. JE is a mode of evaluation where two or more options are evaluated simultaneously. JE mode tends to yield higher evaluability and, consequently, greater sensitivity to the values being assessed compared to SE mode. Knowledge pertains to the amount of distributed information acquired through learning about the target attribute. A more comprehensive knowledge base results in increased evaluability and heightened value sensitivity. In general, it is easier for people to assess and compare values that represent categorical differences rather than incremental differences. In this context, categorical differences refer to cases where two values are distinct in terms of their direction or type, like whether a stock price goes up or

down, or whether an apartment includes a balcony or not. On the other hand, incremental differences involve situations where two values vary only in their degree, like how much the stock price increases today or the size of an apartment. Nature pertains to whether individuals possess an inherent and consistent physiological or psychological "scale" for evaluating attribute values. Attributes are considered inherently evaluable if such a scale exists, leading to higher evaluability and, in turn, heightened value sensitivity (Hsee and Zhang 2010, 345-349). The studies show why consumers are likely to be more value sensitive in a T-shirt purchase when they must choose between a below-average CO2 emitting T-shirt or an above-average CO2 emitting T-shirt, as this shows a categorical difference (below-average vs. above-average) compared to an incremental difference.

The paper „Do investors care about impact" evaluates how the willingness-to-pay (WTP) of investors for sustainable investments is influenced by the environmental impact of such investments. This research's goal is to provide impact information as easy-to-evaluate as possible for investors. The accomplishment of this goal relies on the assessment of two conditions. Under the *relative* condition, the emphasis is on the percentage of CO2 tons saved by an impact fund in contrast to an average investment fund. Meanwhile, the *contextual* condition involves situating the absolute CO2 savings in alignment with the objectives of the Paris agreement goals (Heeb et al. 2022, 1762-1769). Additionally, it is found that applying behavioral economics to climate change policies and expressing the cost of climate change in *monetary* terms can significantly influence both individual and collective behavior towards more sustainable practices (Seo 2017, 107). Further, consumers were found to react differently to *absolute* versus *relative* descriptions of quantities, and it was evidenced that they often judge the "size" of a number or price, rather than its absolute value, due to cognitive processes simplifying complex judgments (Weathers et al. 2012, 955-956). These four conditions (*absolute, relative, contextual, and monetary*) will be utilized to further explore in this study

how consumers react to different (framing)-conditions.

Research on the impact of environmental information on consumer behavior in the fashion industry revealed that disclosing a sustainability certification swayed consumers' purchasing choices toward sustainable products (Lee et al. 2020, 150). Additionally, research indicated the significant influence of sustainability information in shaping consumer decisions within the fashion industry (Niinimäki and Hassi 2011, 1882). Despite the existing body of research in this domain, the specific intersection of CO2 information presentation and willingness to pay for fashion products remains widely unexplored.

Hypothesis 2: *The presentation of CO2 emissions information, whether as categorical or incremental differences, impacts consumer value sensitivity and WTP for sustainable fashion, highlighting the role of information framing in eco-friendly purchasing decisions.*

2.3 Evolution of Fashion Recommender Systems

This section of the literature review aims to provide an overview of the evolution in fashion recommender systems to understand the selection of the benchmark models, current difficulties of recommender systems, and underlying technologies. Criteria for the inclusion of studies were those that contributed to the methodological, conceptual, or technological understanding of (fashion) recommender systems.

The progression of fashion recommender systems over the last decade can be primarily attributed to the advent of deep learning technologies and the accumulation of large-scale fashion datasets. Initial systems, such as The Complete Fashion Coordinator and Magic Closet, were foundational, but used basic machine learning techniques or manually provided user feedback (Tsujita, et al. 2010, 127; Liu, et al. 2012, 1334).

The methodological landscape started to shift, while still depended on user-provided context, the application of Content-Based Image Retrieval (CBIR) significantly improved the fashion

recommender systems by enabling more accurate and nuanced matching capabilities by analyzing the content of an image, such as color, texture, and shape, to find similar items in a database (Chaudhari and Patil 2012, 386). Unlike the early systems, content-based fashion image retrieval (CBFIR) systems can identify and retrieve fashion items or products with the same or comparable features when a consumer uploads a reference image and does not primarily use color and texture features for image analysis (Shoib, et al. 2023, 6-7).

This technology was enhanced by deep learning applications. The application of them enables more accurate and nuanced visual representations of fashion items. Convolutional Neural Networks (CNNs) are capable of automatically learning high-level features from images, which can then be used to represent and retrieve images (Deng et al. 2018, 33). However, a large amount of data for training the CNN is required, which can make the model difficult to converge (Hao, Zhike and Yichen 2020, 261). Furthermore, while CNNs can capture the visual features of fashion items, they may not necessarily capture the subtle characteristics of fashion (Kang, et al. 2017, 1).

In latest developments, hybrid models, utilizing Transformer-based models and CNNs were developed (Zhmoginov, Sandler and Valdymyrov 2022, 1). Similar models were recently benchmarked by Barkan et al. They established a benchmark for evaluating visual similarity discovery (VSD) models within the fashion domain. Barkan et al. innovated the Efficient Discovery of Similarities (EDS) procedure, gathering over 110,000 annotated image pairs through the expertise of domain-specific professionals. Their methodology hinged on multiple experts assessing each image pair, using majority voting to achieve a consensus on visual similarity. Their comprehensive evaluation favored pretrained models, with the BEiT model pre-trained on ImageNet21K, achieving a 95.4% micro ROC-AUC on closed-catalog discovery tasks. However, Barkan et al. also illuminated the discrepancy between model performance

and human perception, noting the need for further improvement in training schemes and the exploration of neural architectures tailored for VSD tasks. (Barkan, et al. 2023)

In the evolving landscape of recommender systems, the advent of GPT-4 could fill the gap of capturing the subtle characteristics of fashion and a high performing neural architecture on VSD tasks. Although GPT-4 is not tailored for VSD tasks, it provides a significant technical leap forward. While direct comparative studies between the latest text-based models, such as GPT-4, and image-based approaches like BEiT are not readily available as of now, the enhanced capabilities of GPT-4V(ision) in understanding and generating contextually rich text suggest a promising avenue for any task demanding the analysis of visual input (Zhengyuan, et al. 2023). GPT-4's sophisticated language processing abilities, especially in discerning nuanced user intents and preferences from textual data, position it as a potentially superior tool in scenarios where a deep comprehension of complex user queries and personalized recommendations is crucial. This hypothesis is grounded in the premise that the advanced AI models of today, particularly those like GPT-4 with their expansive training and nuanced language understanding, may offer a more holistic and user-centric approach to fashion recommendation. Such a proposition, while speculative, aligns with the trend of increasingly sophisticated AI capabilities.

Hypothesis 3: *Integrating advanced AI models like GPT-4 into fashion recommender systems could enhance user-centricity and personalization, outperforming current approaches.*

3. Methodology and Data (Group Part)

3.1 Scalable Calculation of Product Carbon Emissions

To improve transparency in the fashion industry's carbon emissions, a scalable method for calculating the carbon footprint of products is needed. This involves establishing a standard set of measurements and rules to determine the Global Warming Potential (GWP) of products. This standardization is important for fair comparisons between different products and companies. The aim of creating a standard method for carbon emission calculation is not only for consumer transparency, but also for companies to see in what life cycle stages they are lagging behind competitors. It's about understanding the origins of emissions and their relationship with corporate operations. With a standardized approach, everyone can have a clearer understanding of the carbon emissions of products, leading to discussions about improving the sustainability of industrial activities.

3.1.1 Methodological Framework

To determine which processes within the life cycle assessment (LCA) of a cotton T-shirt to evaluate, our methodology specifically utilizes the Product Environmental Footprint Category Rules. This approach ensures that our assessment aligns with the key stages outlined by PEFCR, including raw material acquisition, production, distribution, usage, and end-of-life management.

Mirroring this holistic methodology, attempts to support transparency and standardization in the quantification of product carbon emissions is important. This necessity is exemplified in the initiatives aimed at improving labor conditions within the apparel industry. An interdisciplinary team at North Carolina State University initiated the EAI project. The objective of the EAI was to simplify the evaluation of social standards in the apparel industry, converting multifaceted audit outcomes into a straightforward message, thereby enhancing the

visibility of the ethical manufacturing practices in factories. (Handfield, Kraft and Moore 2022) The EAI project underscores the significant role external organizations play in fostering transparency and standardization. Similarly, the domain of calculating Global Warming Potential could benefit from leveraging insights from external reports. Adopting methodologies similar to those used by the EAI for carbon emission calculations could be beneficial. Utilizing detailed data from credible external sources could lead to the development of a standardized and adaptable calculation method. Such an approach creates a single unified source, thereby enhancing transparency for consumers and increases the reliability and impartiality of the carbon emission assessment process.

3.1.2 Research Approach

Examination of reports from Remake, Baptist World Aid, and Stand.earth is conducted to evaluate the sustainability of fashion brands throughout their life cycle stages (re/make 2022; Baptist World Aid 2022; STAND.earth 2023). These reports serve as foundational sources for this assessment and key facts about them are detailed in Table 1. Sustainability levels of these brands are quantified using a scale ranging from 1 to 5, where a score of 5 indicates that a brand ranks within the top 20% of the industry in terms of sustainability.

Central to this evaluation method is the analysis of the most emission-intensive processes at each life cycle stage and the estimated absolute global warming potential of these stages (see Appendix 1). The primary data for this analysis is sourced from Cotton Incorporated (thinkstep AG 2017). This report provides an in-depth examination of the global warming potential, measured in CO2 equivalents, associated with cotton cultivation. It presents average data on the contribution of cotton farming to global warming and outlines the variations in emissions across different stages of production.

Organization	Report Type	Focus Area	Evaluation Method	Key Aspects
Remake	Yearly Checks	Traceability, Commercia Practices, Raw Materials Environmental Justice	Annual Reviews, Assessing Commitment and Progress	Transparency in Reporting, Sustainability Initiatives, Meeting Environmental Targets
Baptist World Aid	Ethical Fashion Guide and Report	Supply Chain Traceability, Sustainable Fibre Usage, Climate Action	Detailed Surveys to Companies, Set Criteria Assessment	Eco-friendly Materials, Energy Efficiency, Carbon Footprint Reduction Initiatives
Stand.earth	Fossil Free Fashion Scorecard	Climate Commitments and Transparency, Renewable and Energy-efficient Manufacturing, Low-carbon and Longer Lasting Materials	Rating Global Brands, Assessing Commitments and Transparency	Energy Policies, Environmental Reporting Practices
Cotton Incorporated	LCA Update of Cotton Fiber and Fabric Life Cycle Inventory	Cotton Life Cycle Asesment	Lifec ycle Inventory Collection	Cradle-to-Gate Global Warming Potential of Cotton

Table 1: Third party reports. Details of the reports that were used to gather information about fashion brands and their sustainability.

Not included in the report by Cotton Inc. is the standard deviation of emissions during the fabric production & manufacturing stages of cotton. Here we made the following assumptions:

The percentage distribution of the countries of origin for cotton that are included in the report are: China 43.6%, European Union (EU) 21%, India 5.7%, and the United States 4% (WTO 2022). The corresponding percentages of renewable energy usage in these countries is: China 45.3% (IRENA 2023, 102), EU 53.8% (IRENA 2023, 104), India 33.5% (IRENA 2023, 102), and the United States 29.5% (IRENA 2023, 106).

Furthermore, the GWP of the production stage is reported as 10,169 CO2 Equivalents per 1000kg of fiber (thinkstep AG 2017, 79). This figure serves as an initial benchmark for our

analysis.

By calculating a weighted standard deviation, which considers each country's contribution to the energy mix and their renewable energy usage, we derive the missing standard deviation for the fabric production and manufacturing stage as 6.64%.

Using the mean values per stage from the cotton report, combined with the standard deviations, we then calculate the emission ranges for each of the 5 ranks (see Figure 1 and Appendix 2).

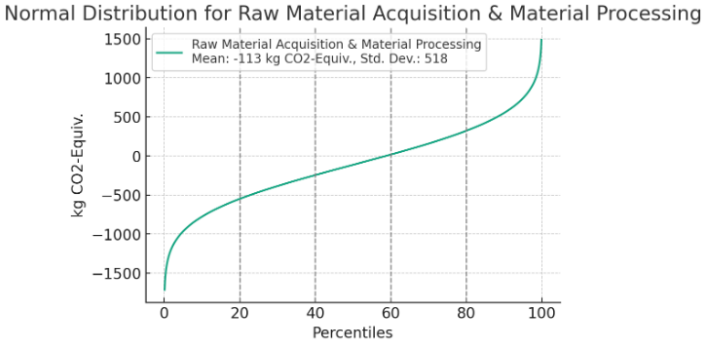

Figure 1: Carbon emission distributions per life cycle stage. The normal distribution curves for greenhouse gas emissions at different life cycle stages of a cotton T-shirt, with percentiles. Information from Cotton inc. that builds the foundation to calculate the emission ranges for each rank in Table 2.

The emission ranges per rank are as follows:

Life cycle Stage	Rank 1 Top 99%	Rank 2 Top 80%	Rank 3 Top 60%	Rank 4 Top 40%	Rank 5 Top 20%-1%
Raw Material Acquisition & Material Processing	(1092, 323)	(323, 18)	(18, -244)	(-244, -549)	(-549, -1318)
Fabric Production	(11740, 10737)	(10737, 10340)	(10340, 9998)	(9998, 9601)	(9601, 8598)
T-Shirt Manufacturing	(444, 407)	(407, 391)	(391, 379)	(379, 363)	(363, 326)
Use-Phase	(13146, 9070)	(9070, 7455)	(7455, 6065)	(6065, 4450)	(4450, 374)
End-of-Life	(2162, 1816)	(1816, 1679)	(1679, 1561)	(1561, 1424)	(1424, 1078)

Table 2: Emission Ranges per Rank. Based on a normal distribution and the mean and standard deviation seen in Figure 1, this table shows the emission ranges in kg of CO2 Equiv. per life cycle stage for each of our ranks that a fashion brand receives based on the scoped third-party reports.

3.1.3 Illustrative Application of Emission Estimation Methodology

Raw Material Acquisition and Processing: H&M is actively working to improve the environmental impact of the fibers and materials used in its products, specifically by increasing the use of recycled and sustainable materials (Baptist World Aid 2022, 36). The company has made a commitment to using organic, recycled, or better cotton, and is investing in programs to increase closed-loop apparel-to-apparel recycling for synthetics and plant-based materials, however, H&M has not fully committed to 100% organic cotton or cotton sourced from regenerative agriculture and H&M does not ensure that more than 50% of biogenic materials sources are net positive (re/make 2022, 19-20).

Fabric Production and T-Shirt Manufacturing: In the manufacturing stage, H&M discloses greenhouse gas emissions associated with its products and has implemented various initiatives to reduce these emissions. The company measures and publicly discloses CO2 emissions at the product level from the manufacturing stage and aggregate Scope 3 emissions (re/make 2022, 26). H&M also provides training and resources to its suppliers for making energy efficiency improvements (STAND.earth 2023, 90-91).

Use-Phase: In the 'Use Phase' of its products, H&M's sustainability efforts are limited. The company is transparent about the environmental impacts during use and disposal of its products and educates consumers on reducing these impacts (Baptist World Aid 2022, 38). However, H&M's products are not specifically designed for longevity or minimal environmental impact during use (re/make 2022, 35-36). This gap in product durability and eco-conscious design contributes to increased environmental strain, as it leads to a higher turnover of garments, counteracting efforts to mitigate the global warming potential during this phase.

End-of-life: H&M assesses and seeks to improve the environmental impacts and resulting waste from its products at their end of life. The company has implemented repair and take-back programs, allowing used textiles to be recycled into new materials, thus reducing landfill and

the need for virgin resources (Baptist World Aid 2022, 38). However, recent allegations suggest that H&M's recycling initiatives might not be as effective as claimed. Investigations revealed that some collected garments were shipped to the Global South and ended up in landfills, casting doubt on the actual environmental benefits of these programs (Preuss 2023).

Life Cycle Stage	H&M Emissions Estimate in kg CO2 Equiv. per 225g T-shirt	Rank	Assessment
Raw Material Acquisition & Material Processing	(-0.055, 0.004)	3	Compared to other fashion brands, H&M got an average grade in low-carbon materials. This suggests a standard emission level (STAND.earth 2023, 3)
Fabric Production	(1.935, 2.160)	5	H&M received the best grade among competitors (B-) in renewable energy. Therefore, H&M is industry benchmark and receives the top score. (STAND.earth 2023, 3)
T-Shirt Manufacturing	(0.073, 0.082)	5	See fabric production.
Use-Phase	(1.365, 1.677)	3	Limited sustainability measures in product design suggest that emissions do not significantly deviate from the industry average. (re/make 2022, 35-36)
End-of-Life	(0.351, 0.378)	3	H&M's recycling and take-back programs result in lower emissions compared to industry standards (Baptist World Aid 2022, 38). However, recent scandales question H&M's take back program, wherefore, we deduct a rank.

Table 3: Emissions of an H&M T-shirt. A sample carbon emission calculation based on the ranges provided in table 2 for a 225g cotton T-shirt from H&M. Information provided by the third-party reports is utilized.

Therefore, according to our methodology, a 225g cotton T-shirt by H&M emits between 3.669 and 4.301 kg CO2 equivalent.

Building on the findings of our methodology, as evidenced by the calculation that a 225g cotton T-shirt by H&M emits between 3.669 and 4.301 kg CO2 equivalents, this study substantiates Hypothesis 1. It demonstrates the feasibility of a scalable approach to assess and compare the carbon emissions of apparel products, thereby offering a standardized framework to evaluate the environmental impact of products across the fashion industry.

3.1.4 Limitations

In this study, we developed a methodology for calculating the carbon emissions of fashion products, focusing on the life cycle of cotton T-shirts. While our approach offers valuable insights, it is important to acknowledge several limitations that impact its robustness and applicability.

A primary limitation lies in the reliance on external data sources, such as the reports used from Remake, Baptist World Aid, and Stand.earth. These sources provide critical information for our analysis but vary in their methodologies, update frequencies, and potential biases. The inconsistency and variability inherent in these reports introduce a degree of uncertainty, which could affect the accuracy of our emission estimates. The dynamic nature of the fashion industry further compounds this challenge. Practices and regulations within the industry are constantly evolving, which could quickly render parts of our analysis outdated or less relevant. This rapid change underscores the need for continuous updating and validation of our methodology to ensure its ongoing relevance. Additionally, the use of some self-reported data from fashion brands in the reports raises concerns about objectivity, as this method may lead to a reliance on potentially biased information.

Another limitation is the set of assumptions underpinning our emission calculations. We assumed a normal distribution in calculating emission ranges for each sustainability rank, a statistical choice that may not accurately reflect the actual distribution of emissions in the industry. This assumption, while simplifying the analysis, could potentially lead to skewed results. Additionally, our methodology assumes variability in the carbon capture effect of cotton plants during the raw material acquisition stage. However, in reality, this effect might not vary significantly, which suggests that our model might overstate or understate the carbon footprint associated with this life cycle stage.

Finally, our approach to estimating emissions during the use-phase and end-of-life of fashion products requires scrutiny. We generalized that emissions are primarily influenced by product design and take back programs, thereby overlooking the significant contributions of household practices. For example, the use of washing machines and dryers, along with varied consumer behavior and appliance efficiency, plays a crucial role in determining the carbon footprint during this phase. Our methodology does not fully capture the diversity and complexity of emissions attributable to consumer use.

In conclusion, while our study makes important strides in understanding the carbon emissions of fashion products, these limitations highlight areas for future refinement. Addressing these challenges will enhance the accuracy and applicability of our findings, contributing to a more comprehensive understanding of sustainability in the fashion industry.

3.2 Evaluating Consumers' Willingness-to-Pay Based on the Way T-Shirts' Carbon Footprint Information Is Displayed (Individual Part: Karim Germershausen)

The methodology developed in this work should be scalable and, through transparency, motivate consumers to act more sustainably and thereby put pressure on companies to produce more sustainably. Now the question arises as to how this transparency, in this case carbon footprint information, can reach consumers in the most understandable way possible. As in various research, there are several options for displaying the emission information, but whether the type of presentation has any influence at all, and if so, which is most effective for a fashion product, has not yet been investigated. The effectiveness of the different conditions should be made measurable through willingness-to-pay (WTP), which is determined through an experimental approach. Therefore, the fundamental question to answer is: "*Does the way carbon footprint information is presented to consumers affect their willingness-to-pay for fashion products?"*

This research investigates how consumers react and make choices based on the carbon footprint information of the same types of T-shirts and evaluates whether presenting carbon footprint information in an easier-to-evaluate way can lead to a higher WTP for a T-shirt with below-average emissions. The WTP of consumers is evaluated for two T-shirts that differ in their carbon footprint (below-average and above-average) and in the way by which this carbon footprint is presented (absolute, relative, contextual, and monetary conditions), aiming to understand the influence of these variables on purchasing decisions. This study delves into framing effects, which involve examining how altering the way attributes are described, such as the environmental impact of a T-shirt, can influence consumers' WTP and their subsequent decision-making (Scheufele and Tewksbury 2007, 13).

For the sake of simplicity, T-shirts with lower-than-average CO2 emissions will be termed "below-average T-shirts," while those with higher-than-average emissions will be called "above-average T-shirts."

3.2.1 Experimental Method

A lab-based experimental framework refers to a research approach conducted within a controlled laboratory setting, typically involving experiments that allow for precise manipulation of variables and conditions. This study employs a lab-based experimental framework, enriched with elements of artefactual field experiments as described by Roe & Just and Harrison & List (Roe and Just, 2009; Harrison and List, 2004). Unlike conventional laboratory experiments, artefactual field experiments strive for enhanced realism by incorporating a representative sample, location, and task parameters. In this study, participants comprise fashion consumers, serving as a pertinent sample for the research objectives. These participants are exposed to an environment mimicking a digital shopping scenario, albeit without real financial consequences or rewards.

The strength of this methodological approach lies in its elevated internal validity, which offers greater confidence in isolating the causal relationship between manipulated variables and observed outcomes (Roe and Just 2009, 1267). In this specific context, uniformity is maintained in the variables like T-shirt style, size, webshop design, and material. Consequently, variations in the participants' WTP can be more conclusively attributed to changes in the presentation of the carbon footprint information and the numerical values associated with it. Publicly available datasets rarely offer such a controlled setting, primarily because few brands disclose the environmental footprint of their products in a directly comparable manner.

3.2.2 Impact Information Conditions

In the present study, the variable of 'climate impact' is operationalized using CO2 emissions as the metric. The rationale for this choice stems from both existing literature that quantifies impact through CO2 emissions and the capacity to translate these emissions into financial metrics via the EU-ETS carbon price. Within the scope of the experiment focused on framing effects, participants are exposed to one of four randomly assigned conditions that modify how climate impact information is conveyed, which are explained below:

- **Base Condition:** Climate impact is articulated in absolute terms—specifically, the tonnage of CO2 emissions saved or more emitted relative to a T-shirt with average CO2 emissions.
- **Relative Condition:** Here, climate impact is framed in relative terms as a percentage of CO2 emissions saved or more emitted when compared to an average T-shirt.
- **Contextual Condition:** This condition provides information in absolute terms, like the Base Condition, but also contextualizes the emissions savings and more emissions within the framework of the achievement of the 2030 Paris Agreement goals.
- **Monetary Condition:** In this scenario, climate impact is translated into a monetary

metric by multiplying the tonnage of CO2 emissions saved or more emitted by the EU-ETS carbon price, assumed to be €100 per ton.

All conditions are supplemented with data on the average CO2 emissions attributable to a white 100% cotton T-shirt, with information derived from Carbon Fact, utilizing the Product Environmental Footprint (PEF) methodology established by the European Union. A below-average T-shirt is assumed to emit 5 kgCO2e, while an average T-shirt emits 7 kgCO2e, and an above-average T-shirt emits 10 kgCO2e (Carbonfact 2023). The presentation of these four conditions to the experiment's participants is further detailed in Table 4.

	T-Shirt A (below average)	**T-Shirt B (above average)**
Product	White T-shirt	White T-shirt
Material	100% cotton	100% cotton
Estimated carbon footprint *(Base condition)*	This 100% cotton T-shirt saves 2kg CO2 emission relative to an average T-shirt. (Question 1)	This 100% cotton T-shirt emits 3kg more CO2 than an average T-shirt. (Question 2)
Estimated carbon footprint *(Relative condition)*	This 100% cotton T-shirt saves 29% of CO2 emissions relative to an average T-shirt. (Question 3)	This 100% cotton T-shirt emits 43% more CO2 than an average T-shirt. (Question 4)
Estimated carbon footprint *(Contextual condition)*	This 100% cotton T-shirt saves 2kg CO2 emission relative to an average T-shirt. This emission reduction is enough to achieve 2030 Paris agreement goals. (Question 5)	This 100% cotton T-shirt emits 3kg more than an average T-shirt. This emission reduction is not enough to achieve 2030 Paris agreement goals. (Question 6)
Estimated carbon footprint *(Monetary condition)*	At the EU-ETS carbon price of €100 per ton, this T-shirt saves the equivalent of €0.2 of CO2 emissions relative to an average T-shirt. (Question 7)	At the EU-ETS carbon price of €100 per ton, this T-shirt cost the equivalent of €0.3 of CO2 emissions more relative to an average T-shirt. (Question 8)

Table 4: Purchasing opportunities. Survey participants are shown one of estimated carbon footprint information in the survey in addition to the same white cotton T-shirt and then must give an amount in EUR that they are willing to pay for the shirt.

3.2.3 Post-Experiment Survey

While the previous chapter explains the four different conditions, this section now shifts its focus to the control variables employed in the survey. After the quantification of participants' WTP, a series of control variables are evaluated. Control variables that exhibit no discernible

differential effect between treatment groups as determined by a Mann-Whitney U Test (p-value > 0.70) in multiple experiments, according to existing literature of Heeb et al., have been excluded for simplicity (Heeb et al. 2022, 1746) The selected control variables encompass factors such as the significance of income level, climate change problem recognition, income, as well as demographic variables like age and gender. The considerations behind the control variables were as follows:

1. **Income Level**: This can be a significant factor in determining WTP. Higher income levels may correlate with a higher WTP for sustainable or ethical products.
2. **Gender**: Gender can influence purchasing decisions and WTP. Some studies like "Effect of the Ethical Consumption Tendency of Millennials and Members of Generation Z on the Purchase Intention of Social Enterprise Fashion Products." suggest that women are more likely to purchase sustainable products than men (Lee, Chung, and Cho 2022, 443).
3. **Age**: Different age groups may have varying levels of WTP for sustainable or ethical products, influenced by generational attitudes, financial stability, etc.
4. **Educational Level**: This control variable could offer insights into whether educational attainment influences the willingness to pay for sustainable or ethical products. Higher levels of education might correlate with greater awareness of sustainability issues, which could, in turn, affect purchasing decisions.
5. **Climate Change Problem Recognition**: This could gauge the respondent's general attitude toward environmental issues, which might not necessarily translate into sustainable shopping habits but could still influence WTP for a product that is marketed as having a lower carbon footprint.

For a detailed measurement procedure for each control variable, see Appendix 3.

3.2.4 Experimental Design

The online experiment involves several key stages: a random assignment to various experimental conditions, the presentation of two T-shirts under distinct climate impact information conditions, the assessment of participants' WTP for both below-average (T-shirt A) and above-average (T-shirt B) purchase options, and a concluding post-experiment survey aimed to measure pertinent control variables.

To elucidate the experimental procedure, participants are initially provided with information concerning an identical white T-shirt crafted entirely from 100% cotton, which bears an average carbon footprint and is priced at 15€. Provided with this information, participants are subsequently prompted to insert the amount they would be willing to pay for the same T-shirt but with a distinct carbon footprint. This inquiry is conducted twice, once when presenting a T-shirt with a below-average carbon footprint and again when introducing a T-shirt with an above-average carbon footprint. This experimental design is illustrated in Figure 2.

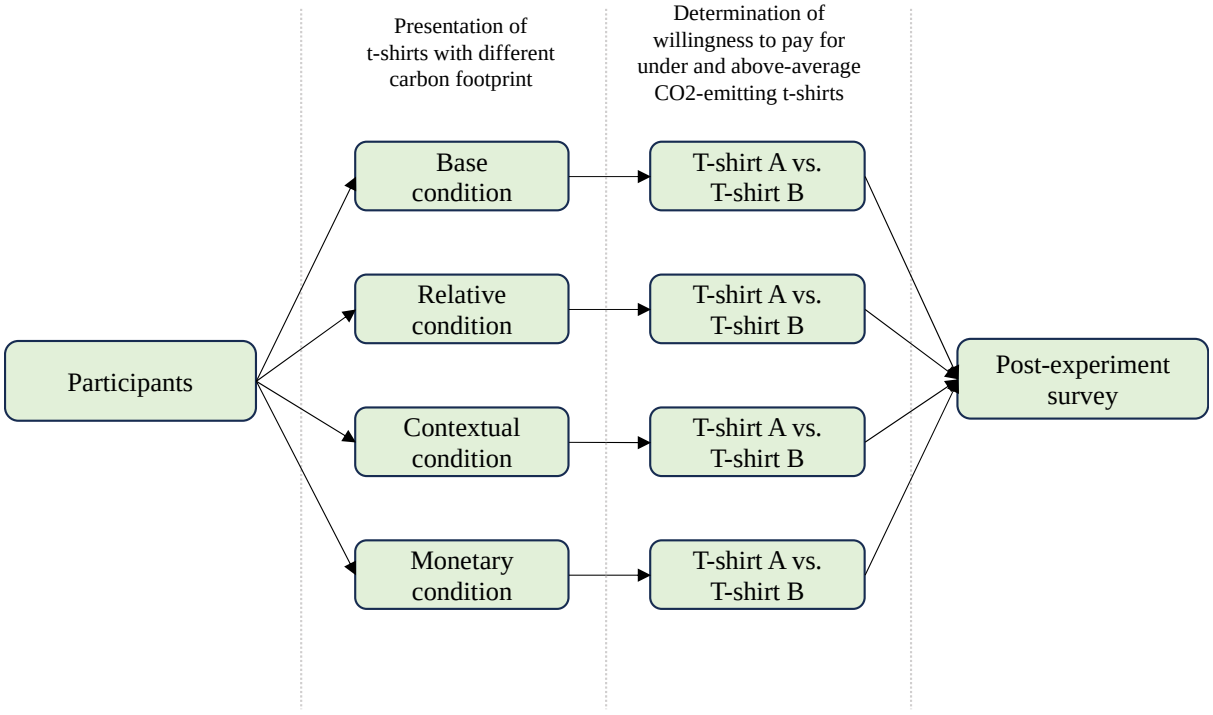

Figure 2: Experimental Design of WTP Experiment (Framing Effects). The participants are randomly allocated to questions showing different conditions and end the survey by conducting the post-experiment survey.

To replicate an online T-shirt purchase experience as authentically as possible, an experimental web page was developed using WIX.com (see Appendix 4).

3.2.5 Data and Statistical Analysis

Data is gathered through an online survey conducted on the Qualtrics platform. Qualtrics is utilized for its capability to allocate participants randomly to different sets of questions in an evenly distributed manner. This randomization is employed to present subsets of participants with one of the four carbon footprint information framing conditions in the study. The target group consists of all potential consumers of fashion products. This group is reached mainly through social media platforms like Instagram, WhatsApp, and LinkedIn.

Figure 3, displayed below, illustrates the methodology employed for gathering responses. The outputs are labeled as "Q" for question in the survey. Q1, Q3, Q5, and Q7 are the below-average T-shirts within the four framing conditions and Q2, Q4, Q6, and Q8 are above-average T-shirts.

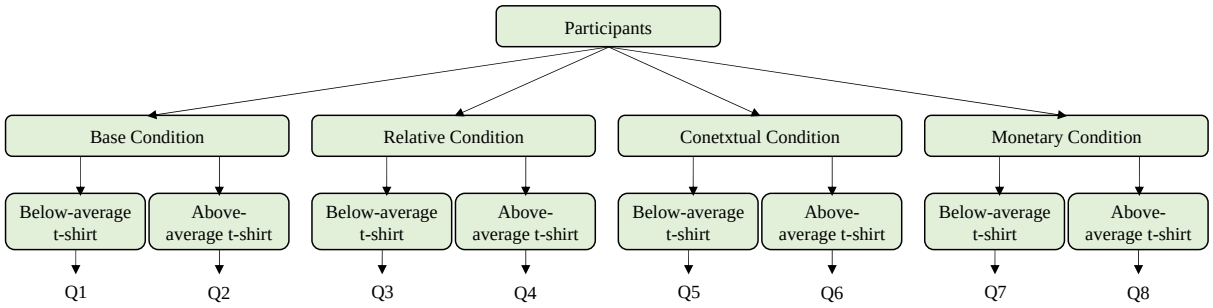

Figure 3: Survey outcome design. The survey is evaluated on eight questions that give insights about each of four conditions for two types of product emission data shown.

To analyze the collected data, a series of statistical tests are conducted using Python.

Initially, for the preliminary data assessment, essential descriptive statistics were utilized. This approach unveiled valuable initial insights pertaining to each condition, utilizing key metrics such as Mean WTP, Median WTP, Standard Deviation, and Minimum and Maximum WTP values. The Shapiro-Wilk test results indicate a significant deviation from normality in the data, justifying the use of non-parametric tests to analyze the WTP across different conditions. To evaluate the median differences across multiple groups like framing conditions in this case,

especially when dealing with ordinal or continuous data like WTP in euros, a non-parametric counterpart to the one-way repeated measures ANOVA, the Friedman Test will be employed. Once the Friedman test reveals significant differences, it becomes necessary to perform post-hoc tests for pinpointing specific groups that vary from each other. To compare the below-average T-shirts and above-average T-shirts within the different framing conditions, the Wilcoxon Signed-Rank Test, a non-parametric method, will be employed. This test is suitable for comparing two related samples, specifically the set of participant responses for T-shirts with below-average CO2 emissions and those with above-average CO2 emissions, provided by the same participants under each framing condition. The test's applicability arises from its ability to handle non-normally distributed differences and its appropriateness for the continuous nature of the survey responses, allowing for an assessment of median differences in valuation between the T-shirts. To determine whether there is a statistically significant difference in participants' WTP for T-shirts with below-average and above-average carbon footprints based on the framing conditions they are exposed to, the Wilcoxon Signed-Rank Test is employed again. To test whether the effects of the experimental conditions on participants' WTP for the T-shirts still hold after accounting for the measured control variables a regression analysis will be conducted.

3.2.6 Summary Statistics

Table 5 below provides the mean, standard deviation, median, and other basic descriptive statistics for the dependent variable collected in the survey. The mean shows, that the participants are willing to pay the most under the contextual condition Q5 and the least under the contextual condition Q6. The least variability is observed in Q2, under the base condition, and the highest variability is observed in Q8, under the monetary condition. This may indicate that participants' WTP is less consistent when the carbon footprint is presented in monetary

terms. The distribution range, characterized by the maximum and minimum values of WTP, unveils distinct patterns across different framing conditions. A wider range in WTP is evident under the contextual condition, suggesting that this form of framing elicits a more diverse set of responses from participants. On the other hand, the narrowest range of responses is seen under the base condition, which may imply that this type of framing is less polarizing among participants.

	Base condition		**Relative condition**		**Contextual condition**		**Monetary condition**	
Measure	**Q1 (€)**	**Q2 (€)**	**Q3 (€)**	**Q4 (€)**	**Q5 (€)**	**Q6 (€)**	**Q7 (€)**	**Q8 (€)**
Mean	16.02	14.67	17.93	12.74	18.68	11.24	17.05	13.02
Std Dev	0.18	0.15	0.19	0.18	0.47	0.44	0.45	0.48
Min	15.50	13.50	17.50	11.50	18.00	10.00	16.00	12.00
25th %ile	16.00	14.00	18.00	12.00	19.00	11.00	17.00	13.00
Median	16.00	14.00	18.00	12.00	19.00	11.00	17.00	13.00
75th %ile	16.00	14.00	18.00	12.00	19.00	11.00	17.00	13.00
Max	16.50	14.50	18.50	12.50	20.00	12.00	18.00	14.00

Table 5: Summary Statistics of Dependent Variable. The conducted survey showed that participants have the most extreme willingness to pay for a T-shirt where contextual information about the product carbon emissions were shown.

3.2.7 Empirical Tests

To test if the differences in the median WTP across the different framing conditions are significant the Friedman Test is conducted. First, the following hypotheses are stated.

- Null Hypothesis **(H_0):** There are no significant differences in the median WTP across the different framing conditions.
- Alternative Hypothesis **(H_1):** There are significant differences in the median WTP across the different framing conditions.

The Friedman Test yields a very high Friedman statistic with 108.45 and a p-value that is

essentially zero. This indicates statistical significance, suggesting that there are indeed differences in the medians WTP across the different framing conditions. Given the p-value of essentially zero, we reject the null hypothesis $\mathbf{H_0}$ in favor of the alternative hypothesis.

Following the Friedman test two of Wilcoxon signed-rank tests are conducted for post-hoc analysis.

The Wilcoxon matched-pairs signed-rank test serves two distinct purposes in the analysis: Firstly, to evaluate whether, within each specific framing condition (intra-condition), participants' WTP for a below-average T-shirt differs from their WTP for an above-average T-shirt; and secondly, to conduct pairwise comparisons aimed at identifying which specific conditions differ from each other (inter-condition), meaning that for instance the WTP for the below-average T-shirt in the relative condition will be compared to the WTP for the below-average T-shirt in the monetary condition.

Table 6 shows the test statistic and p-value for the comparison of the WTP for below-average versus above-average CO2 emission T-shirts under all four different conditions.

Condition	Comparison	Test Statistic	p-value
Base	Below-average T-shirt vs. Above-average T-shirt	0.0	1.58×10^{-9}
Relative		0.0	1.38×10^{-8}
Contextual		0.0	1.67×10^{-7}
Monetary		0.0	2.09×10^{7}

Table 6: Wilcoxon matched-pairs statistics (intra-condition). A consistent, significant difference in the WTP for T-shirts across all conditions was found in the Wilcoxon tests.

In all conditions, the test statistics are 0.0, which indicates that all the differences are in the same direction, and the p-values are extremely small. This suggests that there is a significant difference in the WTP for T-shirts based on their CO2 emissions across all conditions tested.

Proceeding with the inter-condition Wilcoxon matched-pairs signed-rank test the table 7 shows the test statistic and p-value for the comparison of the below-average T-shirt across the conditions. The comparison of the above-average T-shirts can be found in the appendix (see

Appendix 5).

Condition	Wilcoxon Statistic	p-values
Base vs. Relative	1.5	3.16×10^{-40}
Base vs. Contextual	0.0	9.34×10^{-39}
Base vs. Monetary	16.5	6.48×10^{-37}
Relative vs. Contextual	29	1.04×10^{-35}
Relative vs. Monetary	100.5	3.56×10^{-36}
Contextual vs. Monetary	12.5	1.73×10^{-38}

Table 7: Wilcoxon matched pairs statistics for below-average T-shirts (inter-condition). All conditions show significant differences between all conditions.

All p-values are significant, indicating that each pair of conditions showed a significant difference in WTP. The differences in test statistics among the pairs are influenced by the consistency and direction of the differences in WTP, with lower test statistics pointing to more pronounced differences between the conditions being compared. In this case, the most pronounced difference can be seen in the pairwise comparison of Base vs. Contextual.

To further understand the magnitude of these differences, the median differences between each pair were utilized from the descriptive statistics and ranked in table 8.

Rank	Condition	Median Difference
1	Base vs. Contextual	-3.0
2	Base vs. Relative	-2.0
3	Contextual vs. Monetary	2.0
4	Base vs. Monetary	-1.0
5	Relative vs. Contextual	-1.0
6	Relative vs. Monetary	1.0

Table 8: Ranked median differences. Contextually showing the product carbon emission leads to the highest extremes in WTP.

The ranking of the median differences suggests that the most pronounced difference in WTP is

between the Base and Contextual conditions, followed by Base vs. Relative supporting the previous test results. The negative values indicate that the second condition within the pair has a higher median WTP.

To determine whether the observed significant differences in willingness to pay are truly attributable to the different conditions or if they might be influenced by other control variables, a regression analysis is conducted. The regression results indicate that most of the measured control variables are not statistically significant at a 95% confidence level, except for the "Climate Change Problem Recognition" variable. This variable has a positive coefficient of 0.1218, which is significant at a 99% confidence level. This means that participants with higher climate change recognition are willing to pay a premium that corresponds to this coefficient for T-shirts perceived to be sustainably produced or beneficial in the context of climate change. However, other control variables like age, gender, and income did not yield statistically significant results, suggesting that these factors do not significantly influence WTP under the given framing conditions. This could point to a complex, possibly counterintuitive, relationship between consumers' perceptions of sustainability and their actual willingness to pay a premium for sustainable products.

3.2.8 Robustness Check

To ensure the robustness of the significant results obtained from the Friedman test, a data-splitting approach was employed. The dataset was divided into two equal halves, each representing a random subset of participants. The Friedman test applied independently to these halves produced Friedman statistics of 96.65 and 91.81 with p-values of essentially zero too. The consistency in statistical significance between the subsets confirms that the influence of the different framing conditions on willingness to pay is not an artifact of sample variation. This robustness check substantiates the initial findings, illustrating the method's reliability in

assessing the impact of carbon footprint information presentation on consumer behavior.

In the robustness check for the Wilcoxon Signed-Rank Test conducted on the survey data, a bootstrapping methodology is employed, resampling the dataset 1000 times with replacement. Each of these bootstrap samples undergoes the Wilcoxon test to assess the consistency of the original findings. The key metrics analyzed in this robustness check are the distribution of test statistics and p-values across these samples. The average test statistic from these bootstrapped samples consistently remains at 0.0, reflecting the uniformity observed in the original analysis where differences in WTP are consistently in one direction across all pairs. The average p-value derived from the bootstrap samples is approximately 1.98×10^{-6}, only slightly higher than the original results, yet still indicating strong statistical significance far below the conventional threshold of 0.05. The variance observed in the test statistics is negligible, and in the p-values, it is very low, approximately 6.47×10^{-11}. These findings from the robustness check reinforce the conclusions of the initial analysis, suggesting that the significant differences observed in participants' willingness to pay for T-shirts based on their CO2 emissions are robust and not merely an artifact of the specific sample.

3.2.9 Discussion

This research demonstrates, as examined in Hypothesis 2, that framing effects play a significant role in influencing consumers' willingness to pay for sustainable fashion, particularly in the context of CO2 emissions information presentation. The study finds that the presentation of carbon footprint information, whether in categorical or incremental differences, impacts consumer value sensitivity and their WTP for sustainable fashion products. When carbon footprint information is framed in a way that leverages consumers' prior knowledge, such as providing relevant benchmarks or reference points, as seen in the contextual and relative conditions, consumers exhibit a statistically significant additional willingness to pay for a

below-average emitting CO2 T-shirt compared to an average one.

These findings carry implications for the approach to measuring and presenting CO2 emissions information to exert consumer pressure on companies to adopt more eco-friendly practices. The research underscores that the precision of CO2 estimations may not be as critical as providing consumers with an approximate value that is contextualized and easy to evaluate. In contrast, precise measurements, as demonstrated in the base condition, can be challenging for consumers to comprehend, leading to less polarized reactions. Therefore, the framing of carbon footprint information is a potent tool in influencing eco-friendly purchasing decisions and encouraging sustainability in the fashion industry.

3.2.10 Limitations

While the methodology effectively serves its purpose of addressing whether the presentation of carbon footprint information impacts consumers' WTP, its external validity is limited to some extent. This becomes visible in the purchase scenario. In real-world sustainable purchase choices, consumers weigh multiple variables, which might not be considered in the study's scope. Additionally, since the shopping scenario does not involve actual financial transactions or tangible rewards, the psychological factors influencing participants' decisions may differ from a true buying scenario.

Moreover, consumption choices might be impacted by social desirability bias. As participants are aware that this is a research study on sustainable fashion, they may be biased to give a higher willingness-to-pay for the below-average T-shirts. This social desirability bias may be further enhanced by the fact that there are no real consequences to participants' stated willingness-to-pay, so they can simply provide answers that they think will be seen favorably by the researchers.

Another limitation is observed in the method of measuring carbon footprint information for the

below-average T-shirt in this study. The CO2 savings of the below-average T-shirt were assessed by comparing it with the CO2 emissions from an average T-shirt. It must be acknowledged that purchasing a T-shirt with lower carbon emissions does not necessarily equate to a further reduction in emissions. It is therefore important to note that while buying a sustainable t-shirt helps to achieve the overall aim of carbon reduction, the notion of 'saves' may not accurately represent the situation, as every purchase of a fashion product, regardless of sustainability claims, contributes to CO2 emissions. A different wording like 'emits less compared to an average t-shirt' could mitigate this limitation.

Finally, the diversity of the samples is limited as it is more a reflection of our social environment. Most of our survey participants are under 30 and come from Germany and Portugal, which is not optimal to get the best possible representation. If the sample lacks diversity, it can raise questions about the validity of the survey results. External validity, in particular, which pertains to the extent findings can be generalized to other settings, populations, or time periods, might be compromised (Babbie and Earl 2020, 62).

3.2.11 Future Research

The results of the evaluation of consumers' WTP are a clear testament to how displaying carbon footprint information shapes consumers' WTP. The most striking finding is the specific contextual condition under which consumers were most inclined to pay a premium. This aspect offers a fertile ground for future research endeavors. In this context, achieving the Paris 2030 climate targets was used as a case study, but further research should investigate various contexts to identify the most influence on consumer WTP. Potential translations of CO2 savings could include equivalent trees planted, avoided flight kilometers, smartphone charging times, and daily emissions of an average person in the EU.

In addition, this study does not explore various factors that could shape the WTP of consumers

in the realm of purchasing decisions. This omission includes the differentiation in how this study's findings apply to diverse fashion products, such as sweaters, jackets, or trousers, and various impact measurement types, like biodiversity impact or water conservation, where established benchmarks are less prevalent.

Finally, this research revealed a direct correlation between the sustainability of a T-shirt, as measured by its CO2 emissions, and the price consumers are willing to pay: the lower the emissions, the higher the willingness to pay. This finding leads to an intriguing consideration for businesses. Specifically, it would be valuable to determine at what point consumers' willingness to pay more for increasingly sustainable T-shirts begins to plateau. Is there a threshold beyond which reductions in CO2 emissions – for example, from 1.5kg to 1kg – no longer significantly impact the consumer's valuation of the product? Understanding this stagnation point could be crucial for companies in strategizing their sustainability efforts and pricing models.

3.3 Visual Similarity Discovery with GPT-4, A Comparative Study in Fashion Product Recommendations (Individual Part: Pascal Strewe)

In the world of e-commerce, the ability to accurately recommend products to customers is crucial. However, implementing advanced recommender systems typically requires substantial technical expertise, either for developing neural networks for product labeling or for the labor-intensive process of manual data labeling. This research focuses on addressing this challenge by exploring a non-technical, comprehensive pipeline for fashion recommender systems, utilizing the capabilities of GPT-4V(ision). The entire process consists of generating product descriptions and utilizing them for fashion recommender systems to find the best fitting alternative product.

GPT-4, known for its advanced language and vision processing abilities, offers a promising

solution for automating and simplifying the process of creating accurate descriptions through its vision model (Zhengyuan, et al. 2023, 156). However, the focus of this research extends beyond just the generation of descriptions. It includes the integration of these descriptions into a user-friendly pipeline that can recommend fashion products based on textual similarity. The study evaluates how GPT-4 can facilitate the entire pipeline – from processing product images and generating descriptions to providing fitting recommendations to customers.

If GPT-4 proves effective in this role, it lowers the barrier for small and medium-sized fashion retailers in adopting advanced recommender systems. The implementation of a non-technical, GPT-4 based pipeline allows a broader range of retailers to offer personalized shopping experiences to their customers. This could lead to enhanced customer satisfaction and potentially increased sales.

3.3.1 Experimental Method

The study unfolds within a comparative framework, aimed at measuring the efficacy of various approaches in pinpointing visually similar apparel items. In the experiment an original apparel image is showcased alongside five alternative images obtained by distinct models. Participants are then assigned with the task of selecting the alternative they perceive as most visually identical with the original.

By creating a controlled environment, where variables such as apparel type, size, and brand are sustained constant, the experiment aspires to attribute any fluctuations in consumer preferences to the efficacy of the respective image retrieval methodologies.

Nonetheless, this methodology might harbor limitations regarding external validity. Resonating with the first experiment, the controlled scenario may fall short of encapsulating all variables impacting consumer choices in real-world shopping efforts. This methodology employs elements of human perception, utilizing human judges to score the similarity between

images. Human perception and judgement, however, can be influenced by a multitude of factors such as personal biases, cultural backdrop, and antecedent experiences. The analysis then transitions into a phase where a quantitative analysis is employed to rank the models based on their scores. Although aligning well with real-world shopping scenarios by leveraging comparative analysis and visual similarity assessment to measure model efficacy in generating similar apparel items, this methodology does not provide granular insights into which attributes are most influential in impelling perceived visual similarity and purchase intent.

3.3.2 Experimental Design

The experiment is designed to compare the efficacy of GPT-4V(ision) in generating labels and descriptions for images against keyword labels. Results of both approaches are compared against the pre-trained model BEiT. Further, eight surveys were conducted including three to five questions that are to be answered. Each question includes an original T-shirt image and the output of the five models, resulting in two to five answer options, depending on if multiple models had the same T-shirt as an output (duplicates were not shown). The participants then completed the surveys in a random order.

The dataset selected for this study comprises a collection of images generated by DALLE-3, (see Appendix 6). This dataset consists of 50 images, each accompanied by labels and descriptions. These annotations were acquired by submitting the images to GPT4-V(ision), coupled with the associated prompt (see Appendix 7). The collection of these 50 images formed the basis for our models to identify the closest matching T-shirt, serving as a reference dataset for comparative analysis.

The first model in the experiment is GPT-4 with normal descriptions. It utilizes GPT-4(V)ision to generate descriptions of T-shirt images, which are then input into GPT-4 for similarity comparison against a database of 50 other T-shirt descriptions that were retrieved the same way

(see Appendix 8). This model tests the effectiveness of contextual descriptions in visual similarity discovery, exploring how depth in description influences retrieval accuracy and combining it with the power of contextual nuances that are captured by GPT-4 in the comparison process.

The second model is GPT-4 with keyword descriptions. The model is like Model 1, but it uses concise, keyword-based descriptions for the image comparison process (see Appendix 9). The inclusion of this model aims to assess whether concise, keyword-focused descriptions are sufficient for accurate visual similarity retrieval, providing a contrast to the detailed description approach of Model 1.

The third model utilizes the keyword descriptions as well and performs term frequency-inverse document frequency (TF-IDF) on the descriptions. After TF-IDF transformation is applied to the keyword descriptions for vectorized comparison, cosine similarity is used to find the most similar T-shirt. This model investigates the efficiency of keyword-based descriptions without preprocessing in image retrieval, testing the impact of minimalistic textual data on retrieval outcomes, and giving a baseline to assess the second model and how important the comparison within GPT is or if the description generation via GPT is the more important part.

The fourth model is BEiT. It employs Microsoft's state-of-the-art BEiT model for image-to-feature conversion, using these features to identify the most similar T-shirt image via cosine similarity. BEiT was initially pretrained on a large collection of images from the ImageNet-21k dataset (Bao, et al. 2022). Following the pre-training, BEiT was fine-tuned in a supervised fashion on the ImageNet dataset (also referred to as ILSVRC2012), which comprises 1 million images spread across 1,000 classes (Russakovsky et al. 2015). The BEiT model is chosen as a benchmark model after Barkan et al. found the model to be superior to others on visual similarity tasks in the context of finding best fitting alternatives for fashion products in a

closed-shop scenario (Barkan, et al. 2023, 8).

The last model utilizes TF-IDF on the normal descriptions generated by GPT-4Vision followed by cosine similarity for image retrieval. This model is designed to test the effectiveness of preprocessing and detailed textual data in improving the accuracy of image retrieval, offering a comparison with the keyword-based approach of Model 3 and the capabilities of GPT-4 in finding the most similar T-shirt of Model 1.

Model	Input	Conversion Method	Comparison Method	Description Generation	Rationale
Model 1: GPT with Normal Descriptions	Generated images of a T-shirt	Image to normal descriptions using GPT-4Vision	GPT-4 with normal description database	Detailed, contextual	Evaluating depth of description in similarity discovery
Model 2: GPT with Keyword Descriptions	Generated images of a T-shirt	Image to keyword descriptions using GPT-4Vision	GPT-4 with keyword description database	Concise, keyword-focused	Assessing efficiency of concise descriptions
Model 3: TF-IDF with Keyword Descriptions	Generated images of a T-shirt	Image to keyword descriptions using GPT-4Vision	TF-IDF and cosine similarity with keyword database	Concise, keyword-focused	Testing minimalistic textual data impact
Model 4: BEiT	Generated image of a T-shirt	Image-to-feature conversion using BEiT	Cosine similarity with image database	Feature-based visual analysis	Benchmarking transformer-based image analysis
Model 5: TF-IDF with Normal Descriptions	Generated images of a T-shirt	Image to normal descriptions using GPT-4Vision	Preprocessing, TF-IDF, and cosine similarity with normal database	Detailed, contextual	Examining preprocessing effect on detailed data

Table 9: Models in comparative approach. Within the comparative study of different pipelines to show visual similarity discovery, the five models in the table were compared.

The evaluation was conducted by human evaluators who compared image outputs of the five models against the original image. The 28 human judges had then to rank each of the up to five generated output images based on the perceived similarity to the original image.

3.3.3 Data and Statistical Analysis

First, the analysis of participant responses was investigated to determine the extent of

subjectivity influencing their preferences. Through an analysis of the mean rank and standard deviation for each option across diverse questions, the objective is to identify patterns that reveal either subjective perceptions or collective consensus by participants (see Appendix 10). In the statistical evaluation of the models' performance, the descriptive statistics revealed a consensus among participants with a consistent standard deviation around 1 and notable distinctions in the mean rank of models. Model 1 emerged as the most preferred, with participants consistently ranking it as offering the closest visual similarity to the original images, as evidenced by the lowest mean rank of 1.880. This preference, however, is closely contested by Model 2, which, with a mean rank of 1.992, is only marginally less preferred. Notably, the consistency of perception towards Model 2 is the highest among all, indicated by the lowest standard deviation of 1.022, suggesting that participants' opinions were most aligned regarding this model's performance. Model 3, while not the least preferred, exhibited the greatest variability in participant rankings (with the highest standard deviation of 1.066) and a higher mean rank of 2.482, reflecting a broader divergence in opinions and potentially a less consistent retrieval performance. Model 4, despite being the least preferred option as indicated by the highest mean rank of 2.641, revealed a paradoxically high level of agreement on its rankings among participants (a low standard deviation of 1.019), hinting at a unanimous acknowledgment of its suboptimal performance. Model 5 represented an intermediate position with a mean rank of 2.123 and a standard deviation of 1.049, signifying a middling preference and average agreement among participants.

Model	Average Std. Dev.	Mean Rank
1	1.033	1.880
2	1.022	1.992
3	1.066	2.482
4	1.019	2.641
5	1.049	2.123

Table 10: Descriptive statistics. GPT-4 based Model 1 outputs the most similar T-shirts recommendations according to rank averages.

Next, a Rank Frequency Analysis is employed as a complementary method to further interpret the comparative performance of the different models. The Rank Frequency Analysis examines the frequency distribution of each model's ranks across all responses. This approach is particularly insightful in scenarios where not only the top-ranked alternative is of interest, but also lower-ranked alternatives that might still be viable and fitting. For instance, an image ranked second or third could be almost as suitable of an alternative as the top-ranked image.

The Rank Frequency Analysis reveals insightful patterns in how each option was ranked across survey responses. Once again, Option 1 emerged as the most frequent top-ranked choice, with a total count of 433 first-place rankings. This indicates a strong preference among participants for this model. Furthermore, with a substantial number of second and third-place rankings (247 and 156, respectively), Option 1 demonstrates consistent performance across different scenarios.

Option 2, with 374 first and 289 second-place rankings, also shows considerable effectiveness. While slightly less dominant than Option 1 in securing the top spot, it maintains a robust presence in the upper ranks, indicating its reliability as a viable alternative.

Option 3 presents a more varied performance. Although it ranks lower in the first and second positions (214 and 260, respectively), it shows a notable increase in third-place rankings (264), suggesting that while it might not always be the top choice, it frequently serves as a close alternative.

Option 4, gained the fewest first and second-place rankings (217 and 199, respectively). This underlines the participants perception of BEiT as providing the least similar alternatives.

Option 5 demonstrates a balanced distribution in the middle ranks but less frequency in the top and bottom ranks. This could imply that while it is not frequently the best or the least suitable choice, it often falls within the moderately suitable range.

	Model 1	Model 2	Model 3	Model 4	Model 5
Rank 1	433	374	214	217	362
Rank 2	247	289	260	199	214
Rank 3	156	146	264	232	213
Rank 4	60	88	132	222	108
Rank 5	16	15	42	42	15

Table 11: Rank frequency analysis results. Model 1 received the highest amount of first Ranks and was ranked least in the last two ranks.

To evaluate the robustness of the rank frequency analysis of our data, we employed bootstrap resampling, a non-parametric approach that allows us to assess the stability and reliability of our statistical estimates. This method involves repeatedly sampling with replacement from the original dataset to create numerous pseudo-samples, known as bootstrap samples. Each of these samples is then used to compute the rank frequencies anew. This process enables us to observe the variation in our results due to the inherent sampling variability and to estimate the confidence intervals for our rank frequencies.

The bootstrap resampling is conducted with the following specifications:

1. **Number of Bootstrap Samples**: 1000
2. **Resampling Technique:** Sampling with replacement
3. **Data Points per Sample:** Equal to the number of original data points
4. **Computation:** Rank frequencies for each option were recalculated across all bootstrap samples.

The bootstrap resampling yields a diverse set of rank frequency distributions, one for each pseudo-sample. The aggregate result of this process, representing the mean rank frequencies across all bootstrap samples, is as follows:

	Model 1	Model 2	Model 3	Model 4	Model 5
Rank 1	547	382	247	187	364
Rank 2	198	307	273	220	224
Rank 3	112	123	256	261	208
Rank 4	47	75	110	175	90
Rank 5	8	25	26	69	26

Table 12: Rank frequency analysis robustness check. Model 1 performs best after bootstrap sampling was conducted, confirming the original results.

The results demonstrate a consistency in the distribution of ranks across the options, with Option 1 frequently achieving the top rank and Option 4 frequently appearing in the lower ranks. The stability in these rank frequencies across the bootstrap samples suggests robustness in the rank ordering of the options. Minor variations across the samples provide insights into the sensitivity of our rank frequencies to sampling variability, indicating a generally reliable rank frequency analysis.

After uncovering a mix of clear preferences and individual subjectivity in the initial survey analysis, the next step is to conduct a Friedman test. This test is chosen for its suitability in handling rank-based data and its ability to statistically discern whether the observed preferences and patterns hold consistently across different participant groups. By applying the Friedman test, we aim to validate the initial trends and understand the extent of subjectivity in the responses, ensuring a more robust and objective evaluation of the survey data.

Before conducting the Friedman test, the responses were averaged out, so that a single score per group (models) per subject (participant) was found. Additionally, to address models receiving the same rank in a question, the experiment incorporated a method to manage tied ranks. In cases of ties, each tied value was assigned the average of the ranks that would have been given without ties. This approach was important to maintain the integrity and accuracy of

the ranking data, allowing for a more detailed analysis that accurately reflects participants' evaluations of the model outputs' similarity to the original T-shirt.

In the experiment, the primary focus was on the dependent variable, which involved the ordinal measurement of participants' rankings of outputs from five different models. These rankings, assigned based on the similarity of the T-shirt identified by each model to an original image, varied from Rank 1 to Rank 5. This ranking system inherently provided ordinal data, aligning with the requirement for the dependent variable to be ordinal or continuous in nature.

Concerning the independent variable, the study centered on the model used to find the most similar T-shirt. With the assessment encompassing five unique models, the study effectively satisfied the criterion of having an independent variable with at least two levels, thereby enabling a comprehensive comparative analysis.

A key aspect of the study's design was the use of related or matched groups. This was evident as the same participants evaluated the outputs from all five models. By adopting these repeated measures approach, where each subject contributes across all conditions (all model outputs), the study adhered to the necessary condition of involving related groups.

The study also presumed a random order of completion. This aspect of randomization is integral to experimental design, as it helps to minimize potential biases and ensure the generalizability of the results. The survey was designed that the task was split in eight surveys that were randomly completed where the models were randomly assigned to answer options.

This resulted in a structured dataset where each row corresponded to a participant and each column to a model, with values representing the average ranking across the same task, where the hypothesis are:

- Null Hypothesis **(H_0):** There is no significant difference in the rankings of the five machine learning models
- Alternative Hypothesis **(H_1):** There are significant differences in the median

ranking of the five machine learning models.

Upon applying the Friedman test to the data, a significant test statistic of 81.0917 with 4 degrees of freedom is obtained, with a p-value less than .00001. This p-value, significantly lower than the conventional alpha level of 0.05, leads to the rejection of the null hypothesis. This implies statistically significant differences in how participants ranked the machine learning models.

Then, robustness checks were performed to validate the consistency and reliability of the statistical analysis conducted on the dataset.

The dataset is split into two equal halves based on participants, with each half independently analyzed using the Friedman test. Results from both halves demonstrated statistically significant differences in model rankings:

- **First Half**: Friedman Statistic ≈ 42.36, P-Value ≈ 1.40×10^{-8}
- **Second Half**: Friedman Statistic ≈ 39.21, P-Value ≈ 6.29×10^{-8}

These consistent findings across different participant subsets confirm the reliability of the initial results.

After rejecting the null hypothesis of the Friedman test, which indicated statistically significant differences, the Nemenyi test becomes a subsequent step. This post-hoc test is specifically designed to perform pairwise comparisons between the groups (in this case, models) to identify which specific pairs have significant differences in their rankings. The necessity of conducting the Nemenyi test arises from the limitation of the Friedman test: while the Friedman test confirms that at least one model differs significantly from the others, it does not specify which models are significantly different from each other. The Nemenyi test fills this gap by providing a detailed comparative analysis, enabling us to discern the relative effectiveness of each model in a pairwise manner. This level of granularity is vital for understanding the specific strengths and weaknesses of each model, thereby informing more nuanced conclusions and guiding

future model development and selection strategies.

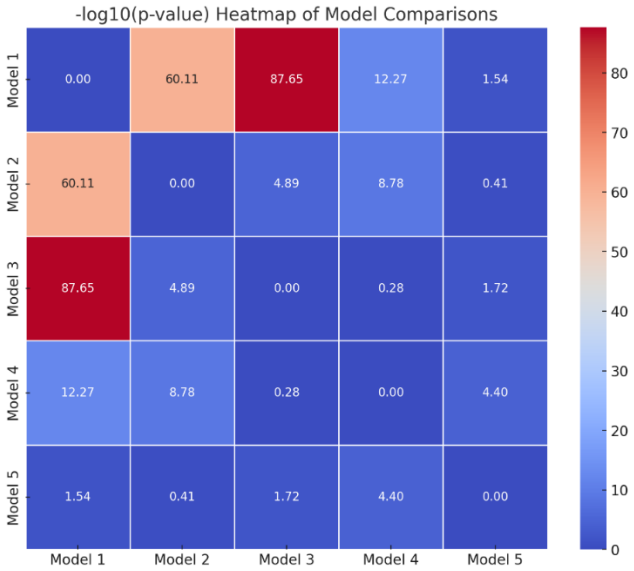

Figure 4: Nemenyi test results. The Nemenyi test shows that, except of models 2 & 5 and models 3 & 4, results between the five models are statistically different using a common p-value of 0.05. In combination with the results of the descriptive analytics and rank frequency analysis, it solidifies the superiority of Model 1.

3.3.4 Discussion

This study, focusing on T-shirt image retrieval, revealed that machine learning models, especially GPT-4 for textual descriptions stood out in visual similarity challenges, affirming our Hypothesis 3 about the benefits of integrating such AI in fashion recommender systems for improved personalization and user-centricity.

GPT-4 with Normal and Keyword Descriptions (Models 1 and 2): Both models demonstrated high effectiveness in image retrieval tasks. Model 1, using detailed descriptions, and Model 2, focusing on keyword-based descriptions, outperformed more complex models in terms of preference and consistency. This indicates that GPT-4V(ision)'s ability to generate labels plays a significant role in improving retrieval accuracy. Especially the performance of Model 1, suggests that detailed textual descriptions can capture details in images that are essential for accurate retrieval, a task where traditional methods might fall short.

Comparison with BEiT (Model 4): BEiT, representing a more complex, feature-based image analysis approach, did not perform as well as the GPT-4 models. This comparison underscores

the potential limitations of image-to-feature-based methods in certain applications, particularly in the apparel domain where nuanced understanding is crucial. The relatively straightforward implementation and effectiveness of GPT-4 models make them a more accessible and equally, if not more, effective than technically more complex models like BEiT.

The GPT-4 models demonstrate that advanced, accurate image retrieval can be achieved without very limited technical knowledge. This is particularly beneficial for non-technical teams or smaller organizations that may not have the resources or capability to implement more complex models like BEiT. The GPT-4 approach offers a user-friendly, efficient solution that can be easily integrated into various systems, democratizing access to the benefits of LMM's.

In conclusion, the performance of GPT-4-based models in this context not only challenges the reliance on complex methods but also opens up new avenues for simpler, more accessible solutions. The ability of GPT-4 to provide detailed, nuanced descriptions makes it an attractive option for a wide range of applications, offering a balance of simplicity, accessibility, and effectiveness.

3.3.5 Limitations

The experiment only includes a small dataset of 50 images, which may affect the generalizability of results. The reliance on the BEiT model, with its specific pre-training and fine-tuning, could also skew the findings compared to other models or a different set-up of the BEiT model. Another significant limitation is that while the participants did rank the images simultaneously, they refrained from providing feedback on whether any of the pictures were viable options; instead, they ranked them without additional commentary. This could limit applicability to real-world scenarios where multiple options of similar products are shown to the customer. Further, a bias of large language models is in the experiment. LLM's like GPT-4 struggle with tasks involving middle segments of a large context, which might have

influenced the frequency of selecting images from the middle of our database by Models 1 and 2. This bias questions the uniformity and representativeness of the evaluation across the dataset. Moreover, a critical aspect to also consider is the varying degrees of complexity and computational cost of the models compared. For instance, using the BEiT model is free of charge, offering a cost-effective solution, whereas employing GPT-4V(ision) incurs API costs or requires a premium subscription to OpenAI. This variation in cost and resource requirement is not captured, yet it bears significant relevance to the practical application and scalability of these models. Decisions in real-world applications often hinge not only on performance metrics but also on cost-efficiency and computational feasibility.

3.3.6 Future Research

As for future research, the next step is to assess the scalability and robustness of the GPT-4 approach in image retrieval. A critical aspect of this future work will involve testing the models on larger, more diverse datasets, such as ImageNet. This will provide insights into how the model performs at scale, especially in terms of accuracy, consistency, and computational efficiency.

Further, evaluating GPT-4V(ision) on a dataset like ImageNet, known for its size and diversity, will help in understanding the models' performance across a wide range of image types and categories. This is crucial for establishing the generalizability of the findings from this study and for assessing the practical applicability of the GPT-4 approach in various real-world scenarios.

4. Conclusion (Group Part)

4.1 Conclusion

In the realm of sustainable fashion, this thesis has charted new territories, unraveling the intricate dynamics between transparency, consumer behavior, and the burgeoning role of artificial intelligence. At its core, the study confronts the need for a paradigm shift in the fashion industry, propelled by ethical imperatives and technological advancements.

The EAI project stands as a testament to the transformative power of external organizations in fostering transparency and standardization. By dissecting third-party reports of Remake, Baptist World Aid, and Stand.earth, this research has developed an innovative system for estimating carbon emissions of cotton T-shirts. This system, ranking brands on their sustainability practices, marks a leap towards less complex and scalable emissions calculations.

Moreover, the study sheds light on the potent influence of framing in shaping consumer preferences. The revelation that the presentation of carbon footprint data significantly alters consumer willingness to pay for a T-shirt underscores a crucial aspect of consumer psychology. Contextualizing emissions data, making it relatable and understandable, evidently resonates more with consumers, influencing their WTP. This insight highlights the need for strategic communication of sustainability efforts, transcending beyond mere accuracy to the realm of impactful presentation.

Lastly, GPT-4V(ision) outperforming feature-based system BEiT underscores the potential of language-based AI. This insight is particularly beneficial for SMEs, offering them an accessible yet powerful tool to enhance customer experience and compete in a market dominated by larger entities. The democratization of such advanced technology leads to innovation not being the exclusive domain of the few but a resource available to many.

4.2 Practical Implications

The implications of these findings are manifold. For one, the fashion industry must recognize the growing demand for transparent and effectively communicated emissions data. By aligning their marketing strategies with this demand, brands can foster a deeper connection with an increasingly environmentally conscious consumer base. Moreover, the emphasis on the framing of emissions data opens new avenues for creative and impactful marketing strategies, which could be pivotal in guiding consumer choices towards more sustainable options.

For fashion retailers and e-commerce platforms, the integration of sustainability metrics into their offerings is not just a moral decision but a strategic one. By harnessing the insights from this research, they can distinguish themselves in a competitive market, appealing to a demographic that values sustainability.

In addition, the accessibility of GPT-4V(ision) provides SMEs with a unique opportunity to revolutionize their customer engagement strategies. By adopting these advanced AI tools, they can offer personalized and sophisticated shopping experiences, leveling the playing field with larger corporations.

As we consider the broader implications of this research, it becomes evident that the journey towards sustainable fashion is not a solitary endeavor. It requires a collective effort – a synergy between consumers, corporations, and policymakers. Consumers must educate themselves and demand transparency, while fashion enterprises must embrace and communicate their sustainability initiatives effectively while policymakers need to enforce standardized guidelines.

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Appendix

Appendix 1: Cotton GWP per stage and process

Stage	Processes	Description	Sources of Emissions	Emission Breakdown	Global Mean
Raw Material Acquisition	Cotton Cultivation	Growing of cotton plants, involving land use, water consumption, use of fertilizers and pesticides.	Irrigation	• Emissions occur primarily from the energy used to operate irrigation systems, which are often powered by fossil fuels. • Water pumping, distribution, and application systems all require energy, contributing to GHG emissions.	163 kg CO2 Equiv. per 1,000 kg of fiber
			Fertilizer	• Energy consumption in manufacturing fertilizers. • Emissions released during the application of fertilizers in the field. (Subsequent chemical reactions in the soil can lead to emissions.) • Nitrous oxide emissions due to runoff and leaching (Fertilizers that are not absorbed by plants can be washed away by rainfall (runoff) or can infiltrate through the soil to groundwater (leaching).	390 kg CO2 Equiv. per 1,000 kg of fiber
			Cotton Fiber Production	• On-farm production captures more greenhouse gases (GHGs) than it emits, leading to a net negative carbon impact.	-1,057.5 kg CO2 Equiv. per 1,000 kg of fiber

				• 113 kilograms of CO2 equivalent captured per 1,000 kilograms of cotton.	
	Cotton Harvesting	Mechanical or manual harvesting of cotton.	Machine operation	• Fuel for the machinery	109 kg CO2 Equiv. per 1,000 kg of fiber
Material Processing	Ginning	Separating cotton fibers from seeds.	Ginning machines	• Energy used to operate the ginning machines	200 kg CO2 Equiv. per 1,000 kg of fiber
	Spinning	Turning raw cotton fibers into yarn.	Spinning machines	• Running the spinning machines	
Fabric Production	Weaving/Knitting	Converting yarn into fabric through weaving or knitting processes.	Looms and knitting machines, ancillary equipment, heat generation	• Weaving and knitting involve the use of looms and knitting machines, which require electricity to operate • Air conditioning and humidity control systems are vital for creating optimal conditions for weaving/knitting operations and can be significant energy users, thus contributing to emissions. • Some knitting processes require heat, which, if generated from combustion of fossil fuels, leads to CO2 emissions.	5,350 kg CO2 Equiv. per 1,000 kg of fiber
	Dyeing and Finishing	Application of color and finishing	Heat energy, drying of the fabric,	• The dyeing process often requires water to be heated to high	4,819 kg CO2 Equiv. per

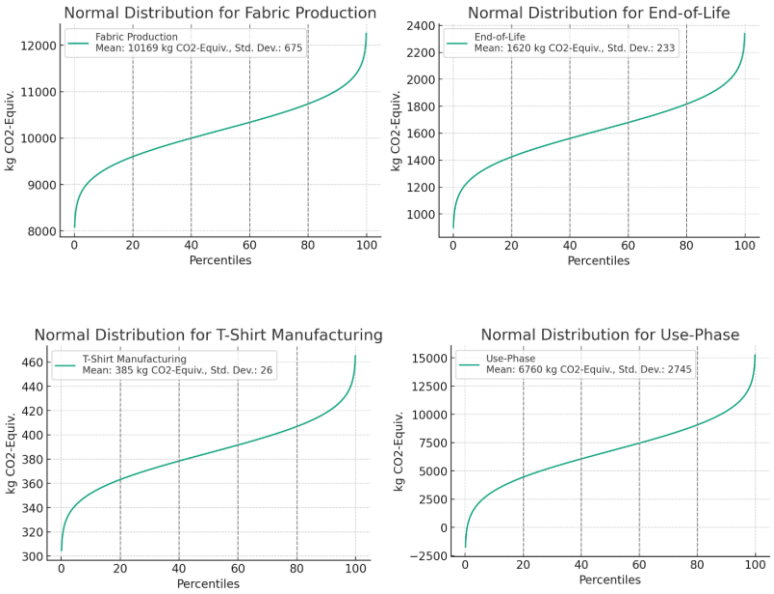
		treatments to enhance fabric properties.	chemical production, machine operation	temperatures, which is energy-intensive. • After dyeing, fabrics often need to be dried, which can involve the use of gas-fired dryers or other drying methods that consume large amounts of energy. • The production of dyes and finishing chemicals can be energy-intensive and may involve emissions of GHGs during their manufacture. • The operation of machinery for applying dyes and finishes can consume electricity.	1,000 kg of fiber
T-Shirt Manufacturing	Cutting & Sewing	Cutting the fabric into T-shirt shapes.	Machine operation	• Automated cutting machines, which are used to cut fabric into T-shirt shapes, consume electricity.	385 kg CO2 Equiv. per 1,000 kg of fiber
		Assembling the T-shirt pieces using sewing techniques.	Machine operation, conveyors	• Sewing machines, especially industrial ones, consume electricity. • Conveyors and other material handling systems used in large sewing operations consume electricity	
	Quality Control	Inspecting for defects and quality assurance.	-	• -	-
Packaging & Distribution	Packaging	Use of packaging materials (e.g.,	Material production,	• The production of packaging materials like plastic and cardboard involves emissions. This	26.6 kg CO2 Equiv. per

		plastic, cardboard).	packaging operations	includes e. g. extracting raw materials and manufacturing processes • Machinery used for packaging, such as wrapping, sealing, and labeling machines, consumes electricity.	1,000 kg of fiber
	Transportation	Transport of materials and finished product through various stages, including to retail outlets.		• The largest source of emissions in transportation is the combustion of fuel by trucks, ships, trains, or airplanes used to move materials and finished products. This includes transport from the manufacturing site to warehouses, distribution centers, and retail outlets.	17.1 kg CO2 Equiv. per 1,000 kg of fiber (fiber only)
Use-Phase	Washing, Drying & Ironing	Consumer use phase involving regular washing.	Washing machines, water heating	• The primary source of emissions in the washing process comes from the electricity used to operate washing machines. • If hot water is used, the energy required to heat the water contributes significantly to emissions.	6,760 kg CO2 Equiv. per 1,000 kg of fiber
		Use of tumble dryers or natural drying methods.	Dryers	• Tumble dryers are energy-intensive and contribute to high emissions	
		Regular ironing by the consumer.	Irons	• Ironing involves the use of electric irons, which consume electricity.	

End-of-life	Reuse/Recycling & Disposal	Potential for the T-shirt to be reused or recycled.	Recycling process, collecting, and sorting	• Recycling fabric, especially cotton, can be energy intensive. It involves breaking down the material into reusable fibers, which requires mechanical and chemical processing, leading to emissions depending on the energy sources used. • The process of collecting and sorting used T-shirts for recycling or reuse requires energy, typically from transportation and sorting facilities.	1,620 kg CO2 Equiv. per 1,000 kg of fiber
		Involves landfilling or incineration if not recycled.	Landfilling, Incineration	• When T-shirts are disposed of in landfills, they contribute to greenhouse gas emissions, especially methane, as they decompose over time in anaerobic conditions. • Incinerating old T-shirts for waste-to-energy purposes can generate emissions, although it can also produce energy. • The carbon captured by the plant is released again	1,057.5 kg CO2 Equiv. per 1000 kg of fiber

Source: thinkstep 2017, 68-79, 94, 102-104

Appendix 2: Carbon emission distributions per life cycle stage



Appendix 3: Measurement of control variables

Variable	**Measurement**
Educational Level	On a scale of 1 to 5, what is your highest level of Education? Possible answers: • 1: Less than a high school diploma • 2: High school graduate or equivalent • 3: Some college or Associate's degree • 4: Bachelor's degree • 5: Postgraduate degree
Income Level	On a scale of 1 to 5, what is your approximate annual income? Possible answers: • 1: Under $25,000 • 2: $25,000 - $49,999

	• 3: $50,000 - $74,999 • 4: $75,000 - $99,999 • 5: $100,000 or more
Climate Change Problem Recognition	On a scale of 1 to 5, how seriously do you take the issue of climate change? Possible answers: • 1: Not Seriously At All • 2: Slightly Seriously • 3: Neutral • 4: Seriously • 5: Extremely Seriously
Gender	What gender do you identify as? Possible answers: • 1: Male • 2: Female • 3: Non-Binary/Third Gender • 4: Prefer not to say
Age	• Answer to the question “How old are you?”

Appendix 4: Webpage for the survey on the WTP for T-shirts (framing condition: relative)

Appendix 5: Wilcoxon matched-pairs statistics for above-average T-shirts (inter-condition).

Condition	Wilcoxon Statistic	p-values
Base vs. Relative	12.5	2.73×10^{-28}
Base vs. Contextual	0.0	4.21×10^{-25}
Base vs. Monetary	99.5	1.86×10^{-27}
Relative vs. Contextual	29	1.12×10^{-27}
Relative vs. Monetary	10.5	2.26×10^{-26}
Contextual vs. Monetary	132.5	7.13×10^{-21}

Appendix 6: ChatGPT prompt to create the T-shirt images

Please create a batch of pictures from T-shirts. It should look like a picture that can be seen in an online shop, showing the front of the T-shirt. All generated pictures should have the same plain and basic background.

The T-shirts generated should all look similar, yet not the same. Feel free to be creative and give them different prints, the same print in a different style, slight color differences in parts of the T-shirt and so on. Be creative with it.

After you gave out 4 pictures, ask me if I am satisfied with the batch of T-shirts or if I'd like to change something. If I want to change something, redo the T-shirt batch with the changes. If not, continue making the next set of 4 T-shirt images following the same pattern. Do it until I say stop.

Appendix 7: ChatGPT prompt to create the T-shirt descriptions

Initial prompt

Please describe this picture. The description should be fitted to perform TF-IDF on later. So already account for that and don't use stopwords and other best practices to be best able to compare the text to others and find the most similar one. But be as accurate as possible and give as many as necessary to accurately describe it. The description should involve the color, shape, drawings, pictures, detailed descriptions of visuals and everything else necessary to get a good understanding of the picture.

Also provide a normal description without tailoring it for tf-idf. It should cover the same level of detail.

Consecutive prompts

Do the same for this one.

Example:

TF-IDF Optimized Description:

T-shirt, cream base. Dominant feature: overlapping geometric figures. Color palette: gold, deep blue, cream. Shapes: rectangles, triangles, linear grooves. Design philosophy: abstract, maze-like patterns. Juxtaposition: blue-gold symmetrical interaction. Texture: raised, tactile design. Finish: sophisticated, urban chic.

Normal Description:

This cream-based T-shirt showcases a captivating composition of overlapping geometric shapes in shades of gold and deep blue. The design features a mix of rectangles and triangles, accentuated with linear grooves, creating an abstract, maze-like pattern. The color palette is chosen with precision, allowing the deep blue and gold to interact symmetrically, highlighting the intricate details. The raised texture of the design gives it a tactile feel, adding an extra layer of sophistication. With its urban chic finish, this T-shirt exudes a contemporary elegance.

Appendix 8: Example ChatGPT prompts to find the most similar T-shirt based on normal descriptions

This T-shirt, with its soft cream hue, becomes a canvas for a mesmerizing mandala design at its center. The artwork captures a blend of Bohemian and tribal inspirations, showcasing meticulous patterns formed with circles, arches, and petal-like shapes. The monochromatic color scheme, ranging from cream to black with varying shades of brown, magnifies the intricacy and depth of the design. Achieving perfect radial balance, the symmetry of the mandala captivates the eye, while the smooth texture ensures comfort. A piece that intertwines art and fashion, this T-shirt embodies a deep-rooted cultural elegance.

Find the best alternative to the provided tshirt out of all of these ones. The above one is too expensive so I want the singular most similar one with the same style.

This light gray T-shirt serves as a canvas for an eye-catching geometric pattern that bursts with energy. Dominated by triangles and quadrilaterals, the design employs a lively palette of cyan, orange, red, blue, aqua, and white, creating a dynamic visual interplay. While each color stands boldly on its own, their combination creates a harmonious and modern look, making the T-shirt a statement piece. The overall design leans towards contemporary, ensuring that the wearer stands out with a flair of modern sophistication.

This T-shirt, set on a creamy canvas, offers a tranquil portrayal of nature through its central emblem. Featuring a layered landscape of trees and foliage, the design captures the essence of serenity using a soft green and off-white color scheme. The smooth graphic imprint stands out against the neutral background, offering a glimpse of a forest silhouette. The T-shirt's modern silhouette is complemented by the contrasting green trim on the collar, creating a balanced and minimalistic aesthetic.

This beige T-shirt presents a distinctive design inspired by architectural elements. At its forefront is a structured pattern of black lines, both vertical and horizontal, that intersect at strategic points, creating abstract sections. Some lines gently curve, adding a touch of fluidity to the otherwise rigid geometry. The minimalist and precise design approach results in an artful play of forms, reminiscent of modern architectural blueprints. The shirt, with its smooth texture and flat design, is a testament to contemporary fashion, merging simplicity with intricate detailing.

This powder blue T-shirt is adorned with an inviting depiction of wavy, abstract patterns that seem to be inspired by the gentle flow of water. An artful blend of pastel peach with varying shades of blue - from a deep marine to a soft sky blue - creates a mesmerizing gradient effect. The organic shapes and undulating waves manifest a serene and tranquil ambiance, exuding a calming effect on the observer.

The smooth texture and flat design, combined with the harmonious color palette, culminate in a T-shirt that embodies a modern aesthetic while evoking feelings of peace and fluidity.

Exuding a sense of nostalgia, this pastel pink T-shirt is adorned with a pixelated camera illustration, reminiscent of early digital art. The color palette, primarily composed of pastel pink, contrasts the black and white camera graphics, punctuated with fuchsia accents that bring vibrancy to the design. Characterized by its squares and rectangles, the pixel art aesthetic gives the piece a playful yet contemporary flair. The soft, smooth texture of the T-shirt combined with its intriguing graphic design results in a garment that is both visually engaging and touchably soft. This T-shirt encapsulates a blend of modern design with a nod to retro digital culture.

This T-shirt, gracefully transitioning from a patterned top to a solid cream bottom, captures attention with its intricate tribal-inspired geometric designs. Showcasing a monochrome palette, the upper half boasts diamonds, triangles, and rhythmic linear motifs, exuding a sense of cultural resonance. The intentional juxtaposition between the detail-rich top and the minimalistic bottom lends the garment a unique, contemporary appeal. The rich detailing, while visually intricate, remains confined to a monochromatic scheme, ensuring versatility and a sense of modern elegance.

This deep purple T-shirt prominently features a striking retro synthwave graphic, immediately evoking the unmistakable 80s aesthetic. Central to the design is a radiant circular sunset set against a starry, cosmic backdrop, with alternating horizontal lines in neon blue and hot pink hues. Below the sunset, the bold typographic element "880s" stands out with its shadow effects and neon outlines, all set upon a geometric blue grid reminiscent of vintage arcade games. The combination of vivid colors and space-themed elements culminates in a design that exudes both nostalgia and vibrant pop culture energy.

This light grey T-shirt features a striking silhouette of a city skyline, highlighted by the iconic central tower that stands out prominently. The design beautifully captures the essence of urban landscapes, showcasing skyscrapers in varying shades of grey, transitioning smoothly into a deep black at the base. The minimalist approach, combined with the sharp contrast of the skyline against a plain backdrop, brings a modern and metropolitan feel to the garment, perfect for those who resonate with city vibes.

This light gray T-shirt elegantly features an expansive and voluminous swirl that covers a significant portion of its front. Utilizing a monochrome color palette, the shades of gray bring out the intricacies of the fluid, coiled curves, creating a mesmerizing, almost hypnotic, spiral pattern. The design's brilliance lies in its ability to capture a 3D illusion, giving the swirl a multi-dimensional appearance that seems to leap off the fabric. This visual play on depth and perspective lends the T-shirt a layered texture, enhancing its tactile allure. The overall finish is sleek and avant-garde, making this T-shirt a statement piece for those with a penchant for modern aesthetics.

This light gray T-shirt serves as a canvas to an intricately designed black mandala, commanding attention and exuding an ethereal charm. The design intricacies lie in its layered circular patterns and petal-like formations, which radiate outwards in a symmetrical fashion. Every detail of the mandala, from the smallest dot to the finely drawn lines, is accentuated against the muted gray, creating a stark yet harmonious contrast. The smooth printed texture ensures that the beauty of the design is uninterrupted. The T-shirt, with its center-focused design, provides a spiritual vibe, making it not just a piece of clothing but an expression of art and serenity.

This light gray T-shirt proudly presents a bold typographic design in the center. Dominated by the message 'YOU TOUR HERE' in strong block letters, it captures attention immediately. Just beneath, a cleverly phrased subtitle 'Y'UT TO THIS HERE' adds a layer of intrigue. Set against a monochromatic color palette, the black typography stands out prominently against the soft gray background. The entire design is encapsulated in a rectangular box, reinforcing its central importance. With a modern and minimalist approach, this T-shirt brings a message-driven design that embodies a contemporary streetwear aesthetic.

This T-shirt, set against a soft cream backdrop, showcases a delightful cartoonish cloud exuding joy through its smile and playful hand gesture. The design, defined by its bold black outlines, features radiant lines emanating from the cloud, emphasizing its jovial presence. With a minimalist approach, the playful cloud becomes the focal point, making the tee perfect for those looking to wear something fun and light-hearted. Its smooth texture and printed design merge well with the shirt's casual and youthful vibe.

This light-gray T-shirt features an exquisite and intricate floral motif that spreads symmetrically from the edges towards the center. Drawing from a monochromatic gray color palette, the botanical designs are brought to life with detailed blossoms and leaves, creating an organic pattern with a sense of depth. The artistic gradient between darker and lighter shades adds to the shirt's visual interest. With its elegant and classic finish, this T-shirt is a refined choice for those appreciating detailed artistry.

This light grey T-shirt displays an elegantly crafted wave design in a contrasting dark grey shade. The design captures the essence of a swirling ocean wave, with its flowing and rhythmic line patterns evoking a sense of serenity and connection to nature. The printed motif on the smooth fabric embodies

a minimalist approach, making it a versatile piece for various occasions. With its oceanic ambiance, this T-shirt offers both style and tranquility to the wearer.

This light grey T-shirt stands out with its timeless design featuring uniformly spaced black polka dots. The monochrome pattern, consisting of perfect circles, offers a minimalist and clean look. The contrast between the black dots and the light grey base brings a refreshing balance to the garment. Designed with a smooth texture and detailed print, this T-shirt carries a casual yet chic vibe that's perfect for everyday wear.

This light gray T-shirt is adorned with intricately designed floral motifs that radiate symmetrically from the hem and sleeves towards the center. The delicate blossoms, leaves, and petals are rendered in a monochrome palette, enhanced with gradient shading to add depth and dimension. The design captures the essence of nature's beauty in a harmonious arrangement, making this T-shirt an elegant choice for those who appreciate fine details and a nature-inspired aesthetic.

Sporting a cream base, this T-shirt captivates with its meticulous maze pattern, rendered in a bold black hue. The design is characterized by interlocking linear pathways, showcasing geometric intricacy. The stark contrast between black and cream amplifies the visual appeal, making the pattern pop out strikingly. Void of any tactile dimension, the design's strength lies in its visual complexity. With its modern finish and avant-garde style, this T-shirt stands as a testament to contemporary fashion sensibilities.

This T-shirt, with a soft pale base, prominently showcases an intricately designed wave motif in a striking dark blue hue. The fluid, curvilinear patterns of the waves evoke a sense of calm and natural elegance, reminiscent of the ocean's timeless beauty. The contrast between the neutral base and the bold wave design adds depth and visual interest. Crafted with a smooth texture and a printed design, this T-shirt embodies a relaxed, nautical aesthetic, making it a perfect choice for those who appreciate the beauty of the sea.

This T-shirt, set on a neutral light gray base, boasts a classic polka dot pattern. The evenly spaced dark dots present a striking contrast against the lighter background, producing a minimalist yet captivating design. The monochrome color scheme, combined with the regularity of the dots, offers a timeless appeal that is both casual and versatile, perfect for a myriad of occasions.

Set against a muted gray base, this T-shirt proudly displays a stunning array of vibrant red blooms. Each flower, meticulously designed, features full blossoms with delicate petals, supported by dark green leaves. Drawing inspiration from traditional floral patterns, the design's attention to detail is evident. The choice of a striking red against the gray backdrop creates a stark yet harmonious contrast, making the floral elements pop. While the design is visually textured, it remains a 2D embellishment on the T-shirt's surface. Marrying classic elegance with a touch of modernity, this T-shirt embodies a timeless appeal.

This silver-gray T-shirt serves as a canvas to an enchanting display of fluid patterns. Reminiscent of flowing water or paint, the swirling design features a harmonious blend of deep blue and light blue tones, creating an illusion of depth and movement. The organic shapes and contours are inspired by fluid dynamics, seamlessly transitioning from one shade to another. This gradient and flowing

aesthetic imparts a sense of motion to the design. The smooth texture of the print, combined with its avant-garde style, positions this T-shirt as a piece of contemporary fluid art, offering both elegance and intrigue to the wearer.

This silver-grey T-shirt is adorned with a striking interconnected linear maze in a rich bronze hue. The labyrinthine design, characterized by elongated rectangles and interlocking paths, brings a sense of depth and complexity to the garment. The careful choice of a bronze on silver-grey palette not only adds a touch of elegance but also ensures a stark contrast, making the design pop. The smooth texture and uniform surface of the shirt further enhance its appeal. With its avant-garde finish, this T-shirt is a perfect blend of intricate design and modern aesthetics.

This light gray T-shirt is adorned with a captivating round emblem that celebrates the beauty of nature. The emblem features a serene forest silhouette in shades of forest green, complemented by a detailed pattern of leaves encircling its base. This nature-inspired design captures the tranquility of a dense woodland, with pine trees reaching upwards and a rich foliage pattern providing visual depth. The chosen color palette of forest green on a light gray base gives the T-shirt a refreshing and eco-friendly aesthetic. Ideal for nature enthusiasts, this T-shirt seamlessly blends casual wear with an ode to the great outdoors.

Positioned on a light gray backdrop, this T-shirt presents an intriguing design of fluid wave patterns that dance across the fabric. These undulating curves, painted in a vibrant shade of bright orange that gradually transitions into deep black, evoke a sense of movement and depth. A singular, bold orange circle adds a point of visual interest, harmoniously integrating with the wavy lines. The chosen color palette showcases a high contrast between the orange and black, making the design pop and capturing

the viewer's attention. Smooth to the touch, the printed design is a testament to modern graphic art, infusing the apparel with an energetic and contemporary flair.

This light gray T-shirt serves as a canvas for an exquisite Baroque-inspired design that dominates the center. Lavender filigree patterns are adorned with gold accents, forming an intricate and ornate motif. The swirling forms and symmetrical diamonds demonstrate meticulous detailing, with the contrasting lavender and gold elements drawing the eye. The design, while appearing embossed, remains smooth to the touch, marrying visual appeal with tactile comfort. With its regal finish, this T-shirt is a testament to intricate opulence, blending history and modern fashion seamlessly.

This gray-based T-shirt is graced with a meticulously crafted, baroque-inspired 3D relief pattern. Distinguished ornate swirls and formations are symmetrically placed, creating a harmonious visual appeal. The design features a mesmerizing color gradient, transitioning from a silver-gray to a soft pink, adding depth and dimension. The tactile texture of the raised design is not just visible but also tangible, offering a unique sensory experience. With its vintage charm and intricate detailing, this T-shirt stands as a testament to timeless elegance and artistry.

This T-shirt boasts a metallic silver base that acts as a canvas for its vibrant and flowing design. Evoking thoughts of fluid dynamics, the design showcases contoured shapes that effortlessly flow into one another, blending shades of lime green, turquoise, and deep blue. The fluid shapes resemble organic blobs, merging and separating in a dance-like motion. A careful gradient between the metallic base and the vibrant hues gives the design an almost aquatic feel. With its smooth and reflective sheen, combined with the fluidity of the shapes, this T-shirt exudes a modern, futuristic charm with an aquatic twist.

This teal-colored T-shirt boasts an entrancing design of golden swirls and waves, reminiscent of both wind and water. These swirling patterns, coupled with several concentric circles, evoke a sense of fluidity and organic movement. The stark contrast between the gold and teal creates a dynamic visual play, drawing the eye and holding its attention. This design appears to be slightly embossed, lending a three-dimensional effect to the shirt and enhancing its tactile quality. With its elegant and captivating design, this T-shirt stands as a testament to the fusion of art and fashion.

The T-shirt showcases a detailed baroque-inspired flourish in a palette that transitions from pink to grayscale. A grand and ornate centerpiece is symmetrically framed by intricate swirls and patterns. The design exhibits a mirrored composition along its vertical center, giving it a harmonized appearance. There's a gentle gradient shading that lends sophistication to the overall look. Enhancing the primary motif, curving lines and smaller embellishments dot the landscape of the shirt. The mood conveyed is both regal and meticulously crafted.

This T-shirt displays a striking geometric pattern that plays with bold angular shapes, reminiscent of a maze. Employing a red-lavender color scheme, the design strategically alternates between the two hues in a segmented fashion. The repetitive interlocking of these shapes creates a sense of movement across the fabric, evoking a visual rhythm of zigs and zags. This meticulous arrangement exudes a contemporary and bold aesthetic that's sure to catch the eye.

This T-shirt spotlights an intricate geometric design in a gradient of pink and grayscale tones. At the heart of the shirt is a boldly defined shape symmetrically anchored, further highlighted by sharp

angular patterns. The design benefits from a mirrored composition along its horizontal axis, establishing a sense of balance. A smooth gradient effect infuses the motif with a touch of elegance, while linear details and smaller accents further enrich the visual narrative. Overall, the design exudes a modern and meticulously curated feel.

This T-shirt displays an enchanting dance of fluidic wave patterns in a harmonious blend of pink and grayscale. The interconnected liquid-like designs create a sense of movement and continuity across the fabric. The entire layout has a seamless flow, with each pattern dynamically playing off the other, creating a vivid tapestry of swirls and ripples. A gentle gradient effect further accentuates the depth and dimension of the design. The mesmerizing ambiance of the T-shirt is reminiscent of flowing water, capturing the essence of fluid dynamics in art.

This cream-based T-shirt showcases a captivating composition of overlapping geometric shapes in shades of gold and deep blue. The design features a mix of rectangles and triangles, accentuated with linear grooves, creating an abstract, maze-like pattern. The color palette is chosen with precision, allowing the deep blue and gold to interact symmetrically, highlighting the intricate details. The raised texture of the design gives it a tactile feel, adding an extra layer of sophistication. With its urban chic finish, this T-shirt exudes a contemporary elegance.

This beige-based T-shirt is adorned with bold, vibrant floral patterns that take center stage. The motifs, possibly inspired by daisies or sunflowers, showcase large petals with intricate centers. The color palette is thoughtfully curated, featuring the flowers in gold/yellow and black, creating a striking contrast against the muted beige background. The design philosophy leans toward nature-inspired

motifs, giving it a fresh, botanical elegance. While the texture appears smooth, the print itself stands out, offering a visual treat. With its sophisticated finish, this T-shirt epitomizes botanical elegance.

This deep blue T-shirt is an ode to the mesmerizing depths of the ocean with its swirling organic motifs. The silver, almost metallic, swirls flow seamlessly, creating patterns reminiscent of waves, whirlpools, and other marine phenomena. These fluid, crescent forms stand in sharp contrast against the rich blue canvas, giving it a dynamic and animated feel. The raised, possibly embossed, design enhances the tactile experience of the garment. With its marine-inspired patterns and contemporary finish, this T-shirt captures the beauty and mystery of the deep sea.

This T-shirt, rooted in a terracotta base, is a beautiful embodiment of modern minimalism. The design cleverly uses bold color blocks of terracotta, white, and a rich purple to achieve a striking visual impact. Its abstract yet flowing curves offer a sense of organic fluidity, breaking the geometric constraints typical of color-blocking. The intersections of the colors are seamless, lending the garment an air of effortless sophistication. The contrasting hues are well balanced, ensuring that neither overpowers the other. Overall, the T-shirt showcases a sleek, contemporary finish that resonates with today's fashion-forward audience.

This T-shirt boasts a rich cream foundation that elegantly contrasts with its bold floral design. Large flowers, colored in a striking mustard yellow, bloom across the fabric, accompanied by jet black leaves and details. Each flower's meticulous design showcases petals radiating outwards and intricate round centers. The chosen color palette resonates vibrancy and warmth, with the yellow and black interacting harmoniously. The smooth texture of the printed design ensures comfort while maintaining its aesthetic

appeal. Drawing inspiration from nature and modern design philosophies, this T-shirt beautifully captures the essence of contemporary floral fashion.

This T-shirt, with a crisp white backdrop, is adorned with a meticulously constructed geometric pattern. The design, prominently featuring rhombuses and parallelograms, is distinguished by its sharp edges, resulting in an optical illusion of depth. A gradient transition from rose to crimson and further to charcoal creates a layered and multifaceted visual effect. This angular and mirrored symmetry is emblematic of modern geometric artistry. The stark contrast between the crimson and charcoal, complemented by softer shades of rose, offers an edgy yet harmonious appeal. This T-shirt, in essence, bridges the gap between contemporary fashion and geometric art.

This light-gray based T-shirt displays an elegant depiction of cascading waves in varying shades of teal and turquoise. The wavy lines, accompanied by crescent formations, paint an abstract representation of oceanic tides. The color gradient is thoughtfully chosen, transitioning smoothly from one shade of blue to another, creating a unified flow. The intricate detailing within each wave segment offers depth and dimension. Exuding a modern appeal, this T-shirt captures the serene ambiance of the ocean.

This T-shirt, with its pristine white base, commands attention with a bold, uppercase typographical print that reads "EMPOWER". The choice of a stark black on white palette exemplifies the simplicity of the design, while conveying a powerful message of empowerment and confidence. The sans-serif typography adds a modern touch, ensuring the shirt remains a versatile piece in any wardrobe. With its minimalistic design philosophy, this T-shirt stands as a statement of self-assurance and contemporary elegance.

This pristine white T-shirt elegantly displays a motivational phrase "Love More" in a metallic gold cursive script, capturing the essence of its message with an effortless grace. The minimalist design philosophy is complemented by the T-shirt's smooth, satiny texture. A subtle brand mark near the neckline adds a touch of authenticity. The choice of the gold-on-white color palette gives it a refined and uplifting appearance, making it a statement piece that goes beyond fashion, resonating with a universal message of love and positivity.

This white-based T-shirt features a breathtaking representation of a serene mountainous landscape. Dominant in the design are jagged peaks, descending into misty layers of blue, seamlessly transitioning into a dense purple coniferous forest silhouette at the base. The color palette, composed mainly of various shades of blue with a hint of purple, paints a tranquil scene reminiscent of a peaceful dawn in nature. This digital print design, with its gradient layers, perfectly captures the essence and beauty of a mountainous terrain, making it a must-have for nature enthusiasts and fashion-forward individuals alike.

This white-based T-shirt is adorned with a meticulous and dense pattern of green fern fronds, symmetrically arranged to radiate from the neckline. The forest green ferns against the pristine white backdrop create a striking contrast, symbolizing the refreshing and lush tropical forests. The detailed texture of each fern frond is meticulously captured, giving a tactile and authentic feel to the design. This T-shirt, with its nature-inspired aesthetic, is perfect for those who appreciate the serenity and beauty of the tropics, exuding a sense of calm and connection to nature.

This T-shirt, with its pristine white base, beautifully accentuates a cascading display of fern leaves that symmetrically radiate from the neckline. The varied shades of green used for the fern motifs complement the pure white backdrop, evoking a sense of serene natural beauty. The intricate detailing on each fern frond showcases a meticulous design philosophy that draws inspiration from the wonders of nature. The harmonious interaction between the green motifs and the white fabric lends a sense of tranquility and earthy elegance, making it a perfect choice for nature enthusiasts.

This white-based T-shirt exudes a tranquil ambiance with its beautifully crafted botanical design. The centerpiece is a cascading illustration of wisteria droplets in soft lavender shades, complemented by muted green leaves. The floral clusters and the elegant leaf structures bring a sense of serene elegance to the piece. The chosen color palette, a harmonious blend of lavender and green on a pristine white backdrop, evokes the feeling of a peaceful garden. The design's smooth texture and print emphasize its garden-inspired chic finish, making the T-shirt a reflection of nature's quiet beauty.

Set against a soft cream backdrop, this T-shirt boasts a stunning floral design in shades of fiery red and earthy brown. The centerpiece of the design is a trio of vibrant red blooms, surrounded by intricately detailed leaves and delicate tendrils. The natural botanical theme is evident, with each element meticulously rendered to capture the essence of the flowers and foliage. The contrast between the fiery red blooms and the understated cream base creates a harmonious interplay of colors, making the design pop. This T-shirt is more than just an article of clothing—it's a piece of wearable botanical artistry, designed to captivate and impress.

This T-shirt, with its pristine white base, showcases an awe-inspiring depiction of the vast expanse of the universe. A swirling galactic nebula, rendered in mesmerizing shades of blue, white, and a hint of

purple, takes center stage, suggesting the mysterious beauty of deep space. Accompanying the nebula are scattered stars and distant planets, further enhancing the cosmic theme. The design's swirling patterns and gradient transitions evoke a sense of movement and depth, while the speckled stars offer a touch of sparkle. All these elements come together to offer a finish that can only be described as ethereally elegant and decidedly otherworldly.

This white-based T-shirt is emblazoned with a meticulously detailed design of a roaring tiger, capturing its fierce essence and predatory prowess. The vibrant orange of the tiger's fur contrasts starkly against the black and white shades, emphasizing the intricacy of the patterns. The lifelike depiction, from the intense gaze of its eyes to the detailed fur, makes the design both captivating and intimidating. With its bold and fierce aesthetic, this T-shirt is a statement piece that exudes a powerful presence.

This white-based T-shirt proudly displays an artistic color burst at its center, reminiscent of a watercolor splash. The mesmerizing interplay of red, green, and purple hues seamlessly transition from one to another, creating a gradient effect. The splatter shape adds depth and texture to the design, making it a focal point. Contrasting colors dance harmoniously across the fabric, capturing the viewer's attention. The smooth texture of the shirt, combined with the paint splatter effect, exudes a contemporary flair, making it a statement piece for those looking to showcase their artistic side.

This white-based T-shirt is adorned with an attention-grabbing design inspired by the complexities of a labyrinth. Displaying a rich palette of gold and teal, the maze pattern offers a delightful visual play of interconnected paths and sharp, angular turns. The intentional choice of colors allows for a striking contrast between the gold and teal, emphasizing the shirt's symmetrical geometrical design. The

pattern, being a print design, has a smooth texture which complements the shirt's modern and abstract art finish. It's a piece that effortlessly combines traditional maze aesthetics with contemporary fashion, making it a unique addition to any wardrobe.

This white-based T-shirt prominently features a meticulously detailed, front-facing elephant in a grayscale color palette. Captured in a hyper-realistic style, the majestic creature stands against a serene backdrop of the African savannah, with acacia trees dotting the horizon. The high contrast between the elephant and the background lends a sense of depth and dimensionality to the design. Every wrinkle on the elephant's skin is intricately depicted, highlighting the texture and natural beauty of this magnificent animal. The overall design resonates with wildlife enthusiasts and those appreciative of fine, detailed artistry.

Appendix 9: Example ChatGPT prompts to find the most similar T-shirt based on keyword descriptions

T-shirt, cream hue. Dominant feature: centralized mandala. Color palette: cream, black, shades of brown. Shapes: circles, arches, petals. Design philosophy: Bohemian, tribal patterns. Symmetry: radial balance. Texture: smooth, printed design. Finish: intricate, cultural elegance.

Find the best alternative to the provided tshirt out of all of these ones. The above one is too expensive so I want the singular most similar one with the same style.

T-shirt, light gray base. Dominant feature: vibrant geometric abstraction. Color palette: cyan, orange, red, blue, aqua, and white. Shapes: triangles, quadrilaterals. Design philosophy: contemporary, energetic patterns. Juxtaposition: multi-colored asymmetrical interplay. Texture: smooth, flat design. Finish: bold, modern aesthetic.

T-shirt, cream canvas. Dominant feature: central circular emblem. Color palette: soft green, off-white, forest silhouette. Shapes: trees, leaves, layered landscape. Design philosophy: nature-inspired, tranquil portrayal. Juxtaposition: serene palette on neutral background. Texture: smooth, graphic imprint. Finish: modern, minimalistic flair, contrast green trimming.

T-shirt, beige base. Dominant feature: structured linear pattern. Color palette: beige, black. Shapes: vertical and horizontal lines, curved intersections. Design philosophy: minimalist, geometric precision. Juxtaposition: intersecting lines forming abstract sections. Texture: smooth, flat design. Finish: modern, architectural inspiration.

T-shirt, powder blue base. Dominant feature: wavy abstract patterns. Color palette: powder blue, peach, marine blue, sky blue. Shapes: organic, undulating waves. Design philosophy: serene, flowing water-inspired. Juxtaposition: peach-blue gradient interaction. Texture: smooth, flat design. Finish: tranquil, modern aesthetic.

T-shirt, pastel pink base. Dominant feature: pixelated camera illustration. Color palette: pastel pink, black, white, fuchsia accents. Shapes: squares, rectangles. Design philosophy: digital retro, pixel art aesthetic. Juxtaposition: soft base with digital graphic. Texture: smooth, visually engaging. Finish: modern, casual sophistication.

T-shirt, cream gradation. Dominant feature: tribal-inspired geometric patterns. Color palette: monochrome, black on cream. Shapes: diamonds, triangles, linear motifs. Design philosophy: tribal, rhythmic repetition. Juxtaposition: patterned top, solid bottom. Texture: visually intricate, monochromatic detail. Finish: culturally resonant, contemporary appeal.

T-shirt, deep purple base. Dominant feature: retro synthwave graphics. Color palette: deep purple, neon blue, hot pink, black, white. Shapes: circular sunset, horizontal lines, geometric grids. Design philosophy: 80s aesthetic, retrowave. Typography: bold "880s" with shadow effects. Atmosphere: space-themed, starry backdrop. Finish: nostalgic, vibrant pop.

T-shirt, light grey base. Dominant feature: city skyline silhouette. Color palette: gradient grey, black. Shapes: iconic tower, skyscrapers. Design philosophy: urban representation, minimalist. Juxtaposition: skyline against plain backdrop. Texture: smooth, printed design. Finish: modern, metropolitan flair.

T-shirt, light gray base. Dominant feature: voluminous swirl. Color palette: shades of gray. Shapes: coiled, fluid curves. Design philosophy: 3D illusion, hypnotic spiral. Texture: multi-dimensional, layered appearance. Finish: sleek, avant-garde.

T-shirt, light gray base. Dominant feature: detailed mandala. Color palette: black, light gray. Patterns: layered circles, petal-like formations. Design philosophy: intricate, symmetrical details. Juxtaposition: dense-black against muted-gray canvas. Texture: printed, smooth surface. Finish: spiritual, ethereal vibe.

T-shirt, light gray hue. Dominant feature: typographic arrangement. Typography: bold, block letters. Central design: 'YOU TOUR HERE'. Subtitle: 'Y'UT TO THIS HERE'. Color palette: monochromatic, black on light gray. Positioning: center-aligned, box encapsulation. Design philosophy: modern, minimalist, message-driven. Finish: contemporary, streetwear edge.

T-shirt, cream base. Dominant feature: cute cartoon cloud. Color palette: cream, black. Shapes: cloud, hand gesture, radiant lines. Design philosophy: playful, minimalist cartoonish. Expression: smiling cloud with hand gesture. Juxtaposition: cloud and radiating lines interaction. Texture: smooth, printed design. Finish: casual, playful elegance.

T-shirt, light-gray base. Dominant feature: intricate floral motif. Color palette: monochromatic grays. Shapes: blossoms, leaves, organic patterns. Design philosophy: botanical, symmetric composition. Juxtaposition: dark-light floral gradient. Texture: smooth with visual depth. Finish: refined, classic elegance.

T-shirt, light grey base. Dominant feature: swirling wave motif. Color palette: light grey, dark grey. Lines: flowing, rhythmic patterns. Design philosophy: nature-inspired, serenity. Texture: printed, smooth. Finish: minimalist, oceanic ambiance.

T-shirt, light grey base. Dominant feature: uniformly spaced dots. Color palette: black, light grey. Shapes: perfect circles. Design philosophy: monochrome, minimalist patterns. Juxtaposition: black-grey contrasting design. Texture: smooth, print detail. Finish: casual, timeless appeal.

T-shirt, light gray base. Dominant feature: floral motif clusters. Color palette: monochrome, gradient shading. Shapes: blossoms, leaves, petals. Design philosophy: symmetrical, radiating arrangements. Texture: smooth, printed imagery. Finish: delicate, nature-inspired.

T-shirt, cream base. Dominant feature: intricate maze pattern. Color palette: black, cream. Shapes: interlocking linear pathways. Design philosophy: structured, geometric intricacy. Juxtaposition: black-cream contrast. Texture: flat, visual design. Finish: modern, avant-garde.

T-shirt, pale base. Dominant feature: oceanic wave motif. Color palette: neutral, dark blue. Shapes: fluid, curvilinear patterns. Design philosophy: natural, oceanic elegance. Juxtaposition: contrast between neutral base and dark wave design. Texture: smooth, printed design. Finish: relaxed, nautical aesthetic.

T-shirt, neutral base. Dominant feature: polka dots. Color palette: monochrome, light gray, dark dots. Pattern: regular, evenly spaced. Design philosophy: minimalist, classic style. Juxtaposition: light-dark contrast. Texture: smooth, printed design. Finish: casual, timeless appeal.

T-shirt, gray base. Dominant feature: vibrant floral bloom. Color palette: striking red, muted gray, dark green leaves. Shapes: full blossoms, delicate petals, intricate leaves. Design philosophy: traditional floral, attention to detail. Juxtaposition: red-gray contrast, bold vs. subtle. Texture: visually textured, 2D floral embellishment. Finish: classic elegance, touch of modernity.

T-shirt, silver-gray base. Dominant feature: swirling aqueous formation. Color palette: deep blue, light blue, silver-gray. Shapes: fluid, wave-like contours. Design philosophy: organic, fluid dynamics-inspired. Movement: gradient, flowing transitions. Texture: smooth, visual depth illusion. Finish: avant-garde, contemporary fluidity.

T-shirt, silver-grey base. Dominant feature: interconnected linear maze. Color palette: bronze, silver-grey. Shapes: elongated rectangles, interlocking paths. Design philosophy: labyrinthine, symmetric complexity. Juxtaposition: bronze-silver contrast. Texture: smooth, uniform surface. Finish: intricate, avant-garde.

T-shirt, light gray base. Dominant feature: round emblem. Color palette: forest green, light gray. Shapes: pine trees, leaves. Design philosophy: nature-inspired, serene forest. Juxtaposition: forest silhouette over foliage. Texture: smooth, visual depth. Finish: casual, eco-friendly aesthetic.

T-shirt, light gray base. Dominant feature: fluid wave patterns. Color palette: bright orange, deep black, gray. Shapes: undulating curves, central circle. Design philosophy: abstract, gradient transition. Juxtaposition: orange-black high contrast. Texture: smooth, printed design. Finish: modern, energetic vibe.

T-shirt, light gray base. Dominant feature: central ornate motif. Color palette: lavender, gold, light gray. Shapes: filigree patterns, swirling forms, symmetrical diamonds. Design philosophy: Baroque-inspired, meticulous detailing. Juxtaposition: lavender-gold contrasting elements. Texture: smooth, with visually embossed design. Finish: regal, intricate opulence.

T-shirt, gray base. Dominant feature: baroque-inspired 3D relief. Color palette: pink, silver, gray. Shapes: ornate swirls, symmetrical formations. Design philosophy: baroque revival, sculpted pattern. Gradient: silver-gray to pink transition. Texture: tactile, raised design. Finish: elegant, vintage charm.

T-shirt, metallic silver base. Dominant feature: contoured fluid shapes. Color palette: lime green, turquoise, deep blue, metallic silver. Shapes: flowing curves, organic blobs. Design philosophy: modern, fluid dynamics. Juxtaposition: metallic-lime-turquoise gradient. Texture: smooth, reflective sheen. Finish: futuristic, aquatic allure.

T-shirt, teal base. Dominant feature: swirling patterns. Color palette: gold, teal. Shapes: waves, concentric circles. Design philosophy: fluidity, organic movement. Juxtaposition: gold-teal contrasting play. Texture: embossed, 3D effect. Finish: elegant, mesmerizing.

T-shirt, pink and grayscale color palette. Predominant motif: baroque-inspired flourish. Central feature: ornate, large, symmetrically framed. Design: mirrored along vertical center, intricate swirls. Gradient shading: subtle, adds sophistication. Ancillary graphics: curving lines, smaller embellishments. Mood: regal, detailed.

T-shirt, red-lavender color scheme. Predominant motif: abstract geometric. Shape features: angular, interlocked, maze-like. Design: repetitive, creates movement. Color distribution: segmented, alternating. Visual rhythm: zigs and zags, provides dynamism. Mood: contemporary, bold.

T-shirt, pink and grayscale hues. Predominant motif: complex geometric shapes. Central feature: prominent, bold, symmetrically anchored. Design: reflected along horizontal axis, sharp angles. Gradient effect: smooth, amplifying elegance. Additional graphics: linear details, minor accents. Ambiance: modern, precise.

T-shirt, pink and grayscale spectrum. Predominant motif: fluidic wave patterns. Central feature: interconnected liquid-like designs. Design: seamless flow, dynamic interplay. Gradient effect: gentle, enhancing visual depth. Additional graphics: swirling eddies, rippling effects. Ambiance: mesmerizing, flowing.

T-shirt, cream base. Dominant feature: overlapping geometric figures. Color palette: gold, deep blue, cream. Shapes: rectangles, triangles, linear grooves. Design philosophy: abstract, maze-like patterns. Juxtaposition: blue-gold symmetrical interaction. Texture: raised, tactile design. Finish: sophisticated, urban chic.

T-shirt, beige base. Dominant feature: bold floral patterns. Color palette: beige, black, gold/yellow. Shapes: large petals, detailed centers. Design philosophy: vibrant, nature-inspired motifs. Juxtaposition: gold/black contrast on beige. Texture: smooth, printed design. Finish: sophisticated, botanical elegance.

T-shirt, deep blue base. Dominant feature: swirling organic motifs. Color palette: deep blue, metallic silver. Shapes: swirls, waves, crescent forms. Design philosophy: fluid, ocean-inspired patterns. Juxtaposition: silver swirls on blue canvas. Texture: raised, embossed design. Finish: contemporary, marine elegance.

T-shirt, terracotta base. Dominant feature: bold color blocks. Color palette: terracotta, white, purple. Shapes: abstract, flowing curves. Design philosophy: modern minimalism. Juxtaposition: contrasting hues, organic intersections. Finish: sleek, contemporary.

T-shirt, cream base. Dominant feature: large floral motifs. Color palette: mustard yellow, jet black, cream. Shapes: flower petals, round centers, serrated leaves. Design philosophy: bold, contemporary

floral. Juxtaposition: yellow-black harmonious interaction. Texture: smooth, printed design. Finish: vibrant, nature-inspired chic.

T-shirt, white base. Dominant feature: angular layered patterns. Color palette: rose, crimson, charcoal, white. Shapes: rhombuses, parallelograms, sharp edges. Design philosophy: geometric, mirrored symmetry. Juxtaposition: crimson-charcoal gradient. Texture: flat, two-dimensional print. Finish: modern, geometric artistry.

T-shirt, light-gray base. Dominant feature: flowing wavy patterns. Color palette: teal, turquoise, light gray. Shapes: wavy lines, crescent formations. Design philosophy: abstract, oceanic waves. Juxtaposition: gradient of blue hues, unified flow. Texture: smooth with intricate patterns. Finish: modern, serene oceanic ambiance.

T-shirt, white base. Dominant feature: bold typographical print. Color palette: black, white. Typography: uppercase, sans-serif. Design philosophy: minimalistic, statement piece. Message: empowerment, confidence. Finish: clean, modern appeal.

T-shirt, white base. Dominant feature: cursive typography. Color palette: metallic gold, soft white. Typography: "Love More", elegant script. Design philosophy: minimalist, motivational message. Texture: smooth, satiny finish. Detail: subtle brand mark near neckline. Finish: refined, uplifting.

T-shirt, white base. Dominant feature: mountain and forest landscape. Color palette: white, blues, purple. Shapes: jagged peaks, coniferous tree silhouettes. Design philosophy: nature-inspired, gradient layers. Juxtaposition: misty mountains against dense forest. Texture: smooth, digital print. Finish: serene, tranquil ambiance.

T-shirt, white base. Dominant feature: dense green ferns. Color palette: forest green, white. Shapes: fern fronds, symmetrical pattern. Design philosophy: tropical, nature-inspired. Juxtaposition: green-white contrast. Texture: detailed fern textures. Finish: summer, nature lover's appeal.

T-shirt, pristine white base. Dominant feature: cascading fern leaves. Color palette: varied shades of green, pure white. Shapes: elongated fern fronds, natural formations. Design philosophy: nature-inspired, organic patterns. Juxtaposition: green-white harmonious interaction. Texture: visually soft, detailed imprints. Finish: tranquil, earthy elegance.

T-shirt, white base. Dominant feature: cascading botanical illustration. Color palette: soft lavender, muted green, white. Shapes: leaf structures, floral clusters, wisteria droplets. Design philosophy: nature-inspired, serene elegance. Juxtaposition: lavender-green symmetrical harmony. Texture: printed, smooth design. Finish: tranquil, garden-inspired chic.

T-shirt, cream base. Dominant feature: lavish floral arrangement. Color palette: fiery red, earthy brown, soft cream. Shapes: blooms, leaves, delicate tendrils. Design philosophy: natural, botanical showcase. Juxtaposition: red-cream harmonious interplay. Texture: smooth, detailed print. Finish: elegant, botanical artistry.

T-shirt, white base. Dominant feature: swirling galactic nebula. Color palette: shades of blue, white, purple. Shapes: swirling spirals, scattered stars, spherical planets. Design philosophy: cosmic grandeur, expansive universe. Juxtaposition: deep-space nebula against star-studded backdrop. Texture: gradient transitions, starry speckles. Finish: ethereal, otherworldly elegance.

T-shirt, white base. Dominant feature: roaring tiger face. Color palette: orange, black, white. Shapes: intricate fur patterns, fierce eyes. Design philosophy: realism, predatory prowess. Texture: flat, detailed design. Finish: bold, fierce aesthetic.

T-shirt, white base. Dominant feature: color burst effect. Color palette: red, green, purple, white. Shapes: splatter, gradient spread. Design philosophy: watercolor splash, central focal point. Juxtaposition: contrasting hues, gradient transition. Texture: smooth, paint splatter. Finish: artistic, contemporary flair.

T-shirt, white base. Dominant feature: intricate maze patterns. Color palette: gold, teal, white. Shapes: interconnected paths, angular turns. Design philosophy: labyrinth-inspired, symmetrical complexity. Juxtaposition: gold-teal geometrical contrast. Texture: flat, print design. Finish: modern, abstract artistry.

T-shirt, white base. Dominant feature: front-facing elephant. Color palette: grayscale. Scene: African savannah. Style: hyper-realistic. Contrast: elephant-savannah dimensionality. Texture: detailed skin wrinkles. Finish: natural, wildlife inspired.

ChatGPT

Attribute Description

Domain > Expert Design > Fashion & Apparel Design

Keywords T-shirt design, bohemian style, tribal patterns, radial balance, color palette, textile texture

Goal Identify the most similar alternative to the provided T-shirt design with consideration to style, color, and design elements at a lower price point, Verbose=3

Assumptions The user prefers a T-shirt that closely mirrors the style, color scheme, and design philosophy of the original expensive T-shirt described.

Methodology Analyze the given descriptions of alternative T-shirts, focusing on matching the bohemian, tribal style, color palette, and radial symmetry of the original design.

Based on the detailed description of the original T-shirt and the desired bohemian, tribal patterns, and radial balance, the T-shirt among the provided alternatives that most closely aligns with this style is:

T-shirt with a cream gradation base featuring tribal-inspired geometric patterns. The color palette of monochrome, black on cream, with shapes like diamonds, triangles, and linear motifs mirrors the original's tribal design philosophy and radial balance. The texture and finish described as visually intricate and culturally resonant also resonate with the original's intricate, cultural elegance.

This T-shirt maintains the bohemian tribal aesthetics, similar color palette, and design philosophy while also portraying a sense of cultural elegance and rhythm in its patterns, akin to the mandala feature in the original design. The monochromatic palette keeps the aesthetic clean, and the geometric tribal patterns provide a similar visual appeal as the centralized mandala.

Appendix 10: Mean and standard deviation of each model for each question