Proceedings in Technology Transfer

Djihed Berkouk
Uday Chatterjee
Tallal Abdel Karim Bouzir
Imed Ben Dhaou *Editors*

Proceedings of the 1st International Conference on Creativity, Technology, and Sustainability

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Editors

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Preface

This book addresses the challenges and opportunities arising from the dynamic interplay between technology and sustainability, emphasizing the need for research, practice, and technological advancements to align with the United Nations Sustainable Development Goals (SDGs) and the Kingdom of Saudi Arabia Vision 2030. Following a rigorous peer-review process, this volume presents a selection of exceptional contributions originally presented at the International Conference on Creativity, Technology, and Sustainability (CCTS) held at Dar Al-Hekma University in Jeddah, Saudi Arabia, in May 2024. The book's chapters include case studies, literature reviews, and scientific contributions that provide a comprehensive overview of how technology can be mobilized to meet sustainability targets. These contributions cover wide range of relevant topics, organized into five main sections:

- Technology for Innovation and Safety: This section explores how technology can drive innovation and safety across various domains. It delves into AI applications in education and missing persons searches, deep learning for sustainable agriculture, and security solutions for smart technology adoption and the Internet of Things (IoT).
- Sustainable Solutions for Technology and Infrastructure: This section focuses on sustainable approaches to technology and infrastructure development. It explores research on cybersecurity for e-health and IoT, sustainable urban design, smart waste management, and financing options for sustainable businesses.
- Transforming Education and Social Impact: This section highlights the transformative potential of technology in education and social contexts. It discusses the integration of AI in education, creativity in eLearning, and the social impact of technological innovations on business sustainability and gender equality.
- Sustainable Environment and Smart Cities: This section emphasizes sustainable practices and technologies for smart cities and the environment. It explores AI-driven tools for walkability, sustainable design with AI, optimizing building design for energy efficiency, utilizing recycled materials, and the social aspects of smart communities.

- Technologies for Health, Environment, and Sustainability: This final section showcases how technology can address health challenges and environmental concerns. It explores technology use in healthcare delivery, noise pollution analysis, renewable energy technologies, sustainable agricultural practices, and green solutions for soil remediation.

Throughout the book, we delve into how technology fosters innovation, safety, and sustainability across various fields, aligning with specific UN SDGs (examples provided for SDGs 2, 4, 9, 10, 11, 12, 13, 15, and 16). Moreover, the book presents practical applications that raise awareness about sustainability and encourage responsible behavior. It facilitates knowledge transfer, benefiting the public sector, innovative companies, academia, and research centers.

Targeting researchers, policymakers, sustainability advocates, and decision-makers committed to achieving the UN's SDGs and Saudi Vision 2030, this book identifies key areas for attention in architecture, design, social and environmental sciences, law, and business, all essential contributors to sustainable development. It also serves as a valuable guide for professionals in technology-driven sectors like AI and the Internet of Things. The content underscores technology's vital role in addressing sustainability challenges, enhancing efficiency, promoting environmentally friendly processes, and reducing costs—ultimately improving the quality of life for all.

Jeddah, Saudi Arabia — Djihed Berkouk
West Bengal, India — Uday Chatterjee
Blida, Algeria — Tallal Abdel Karim Bouzir
Jeddah, Saudi Arabia — Imed Ben Dhaou

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Dr. Tallal Abdel Karim Bouzir is an Associate Professor at the Institute of Architecture and Urbanism of the University of Blida in Algeria, and his area of expertise is the analysis of urban and architectural atmospheres. Specifically, he concentrates on examining how the sound, visual, and thermal environment interacts with human perception, comfort, and public health. His research aims to deepen our understanding of how the urban and architectural environment impacts the quality of life of individuals.

Prof. Imed Ben Dhaou is a Full Professor and Docent in Embedded Systems for IoT at the Department of Computer Science, Dar Al-Hekma University, since 2021. He has authored and coauthored over 120 journal and conference papers, and received numerous awards, including the Best Paper Award from the 1997 Finnish Symposium on Signal Processing, travel grants from the Ph.D. Forum at DAC, Los Angeles in 2000, a publication award from Qassim University, and the Dr. Hussein Mohammed Al-Sayyed award for research. Since September 2014, Dr. Ben Dhaou has served as an editor to the Microelectronics Journal, Elsevier, and was the Guest Editor for four special issues in ISI journals. He has also served as TPC chair or TPC member for several conferences in his primary fields of expertise.

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Whiffs of Waste: Product Application Preferences Among Saudis and Malaysians for Material from Coffee Ground Waste

Zati Hazira Ismail, Fadzli Irwan Bahrudin, Nuraini Daud, Yong Kian Liew, and Basyarah Hamat

Abstract In industrial design, sustainably focused materials, such as recyclable and renewable materials, are rapidly emerging. Product materials are linked to their origins when narrating their claims in sustainable marketing. Coffee ground waste is now used in non-food items like cups and eyewear. Online users connect material information to their knowledge of its origin, influenced by product types and cultural backgrounds. The Implicit Association Test (IAT) tested positive and negative associations of coffee ground waste materials with various products among respondents from Saudi Arabia and Malaysia. Malaysian respondents associated the material with food-related products and "indulgent", while Saudi respondents linked it to memorabilia and "sentimental". This study's findings provided valuable insights for designers, enabling them to strategically apply materials made from Coffee Ground Waste to ensure a positive reception in the market.

Keywords Industrial design · Sustainable material · Implicit association test · Cross-cultural study · Material perception · Product application

1 Emerging Sustainable Materials for Products

Designers understand traditional materials like plastic and metal, which users widely accept. In the quest for sustainability, new materials like plant-based, waste, renewable, and recyclable emerge, shaping industrial design [1]. Sustainable materials

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include those from waste, virgin resources, living organisms, or natural sources [2]. Many researchers and product developers are researching and applying these materials as one of the initiatives for sustainability [3, 4]. Methodologies and frameworks have been introduced to support designers in their material application design process for these new materials [5, 6]. However, studies on users' experiences with these new materials and their product applications are still being conducted. Besides the materials' surface qualities or aesthetics, the smell properties also affect the material acceptances and likability appraisals [7]. Studies indicate that consumer interaction with the product material is composed of seeing it, feeling the texture, hearing its sound by tapping it and inhaling its smell [8, 9]. Material perception is often influenced by the participant's sensory experiences, expectations, and previous knowledge of the subject [10].

Online shopping and digital product promotion are commonplace, often featuring sustainable materials through photos or videos. Consumers heavily rely on visual presentation and text descriptions to shape their product perception [11]. Online product viewing poses challenges in assessing new materials, especially those with non-visual factors like food waste. Introducing novel materials with unique smells requires considering the interplay between material perception and appraisal, which are closely linked [12].

2 Emerging Materials with Associated Smell

New materials with distinct smells are being developed for product applications. For example, coffee ground waste was repurposed by Kaffeeform for coffee cups in 2015 and Japanese Designer Ryohei Yoshiyuki for an ashtray design. When the smell aligns with product use, it positively impacts market perception, but negative smells can affect market appearance [13]. Kaffeeform's success in commercialising coffee ground waste has spurred many material developers to use it for various products. Now, the material is utilised in packaging, food trays, lampshades, shoe soles, and eyewear. Malaysian brand Duck incorporated coffee waste fabrics from Scafefabrics into their sportswear lines [2].

The smell associated with materials impacts market value. Products should be carefully designed for public acceptance. Cultural backgrounds influence smell-material associations, affecting online perception and product reception [14]. Sustainable product developers seek innovative solutions using emerging sustainable materials, requiring designers to strategise material applications to ensure positive market reception [12]. Product developers should consider users' smell associations with material descriptions, as users attribute meaning from waste material's past to new product applications. For example, a jacket made from a hot air balloon evokes a sense of freedom [15]. The natural smell can be removed from materials like coffee through industrial processes. Despite this, the material's name, indicating its origin, remains associated with its resource origins in product descriptions [16].

Material smell is also essential in food-related products, where the smell of materials is associated with users' expectations of the foods' edibility and taste. For instance, the material used for eating utensils can either repulse the eating experience or enhance the dining experience [17]. Materials for food packaging should be safe for consumption and congruent with the expected taste of the food or drink [18]. Smell-associated materials influence four product categories: Food-Related Products such as packaging and cookware; Memorabilia and Specialized Items including furniture and tableware, Sports and Travel; and Wearables and Accessories such as scarves and face masks [19].

Krishna et al. [20] highlighted that the imagined smell happens when the mind has the object of reference. Smell presence is linked to users' familiarity with its origins. The associated smell of material differs depending on users' backgrounds and familiarity with its origin. Cultural variations influence smell perception, as users perceive smells differently based on substance function. Familiarity with the origin affects its perceived values and affection [14]. Designing non-food products from recycled coffee grounds is seen as innovative. Consumers value the creativity in repurposing waste into valuable items, fostering positive perceptions. If these products offer unique benefits like skincare advantages or household utility, consumers perceive them as value-added [21]. This perception can enhance their appeal and influence purchasing decisions [22]. However, symbolism, historical significance, traditional associations, cultural rituals, aesthetic preferences, substance functionality, and prestige contribute to the meanings assigned to substances [6].

Arab countries' coffee culture has influenced global perceptions. Coffee symbolises Arab identity, deeply rooted in traditions, customs, and values, fostering cultural pride and belonging [23]. It is sometimes consumed as part of spiritual rituals or gatherings, symbolising spiritual awakening and communion [24]. Overall, coffee is highly respected in Arab culture, embodying values of hospitality, tradition, identity, and connection. On the flip side, coffee is considered one of the many culinary delights in Malaysian cuisine. Malaysians have developed unique coffee recipes and methods, incorporating local flavours and ingredients [25]. Besides traditional coffee preparations, Malaysians have also embraced the modern coffee culture, including speciality coffee shops and trendy cafes [26]. This blend of traditional and contemporary coffee culture reflects the dynamic nature of Malaysian society.

Integrating effective communication, transparent practices, and product excellence are crucial factors in shaping consumer perceptions of products that utilise materials from coffee ground waste. Therefore, the main goal of this research is to explore the cultural associated preferences with coffee materials when they are incorporated into non-food products using implicit association tests.

3 Investigation

3.1 Data Collection

The method used for this study is an Implicit Association Test (IAT). The Implicit Association Test (IAT) measures the strength of an associative link between two concepts, one of the most widely used and validated methods for measuring implicit attitudes. Greenwald [27] stated that the faster and more consistently an individual pairs two concepts together, the stronger the implicit attitude towards it. Research on consumers' associations and behaviours has increasingly used the IAT. Techniques such as the association test have been adapted in multiple smell association studies in the design field, such as product design, packaging design and textile design [28].

This study develops a specific IAT web application designed for this research purpose. The study measures users' implicit associations for material from coffee ground waste with four product categories. The test is conducted with respondents from two different countries, Malaysia and Saudi Arabia. The chosen countries are based on their similarity in the coffee association factors. Four product function categories are used in the association test, namely (1) Food-Related Products, (2) Wearables & Accessories, (3) Memorabilia & Specialized Items and (4) Sports, Travel and Self-care.

Four hundred thirty-five implicit association samples were collected from 145 participants in Malaysia and Saudi Arabia using the Heroku App, a cloud platform supporting various programming languages. Heroku was selected for its polyglot features, allowing developers to build, run, and scale applications uniformly across languages. The IAT program's programming languages are accessible online. The researcher designed the web interfaces, layout, and contents for user-friendly research. Participants accessed the final design via a direct link and used devices with keyboards to reduce outcome variations.

The test is arranged in six sections. Participants must choose one of two items from two product categories for each section. Each product category consists of six items. The items consist of four icons representing four product functions under each product category and two words representing the described experience about the product category as per findings from objective three. The test arrangement is shown in Table 1.

The six trials are for two product categories per section. Section 1 is for product categories A and B. Section 2 is for product categories A and C. Section 3 is for product categories A and D. Section 4 is for product categories B and C. Section 5 is for product categories B and D. Lastly, Section 6 is for product categories C and D. Category A is for products that serve its functions in the Sports, Travel and Self Care. Category B is for Food-Related Products. Category C is for Wearables Products and Accessories. Lastly, Category D is for products highly associated with common materials embodiment for the products and named under Memorabilia and Specialized Items. The icons are chosen instead of actual images of the product because the study needs to limit the association to only the function without having

Table 1 Test arrangement

Content	Section	Product category	Page(s)
Entry page	Introduction	NA	1
Brief on research	Introduction	NA	2
Consent	Introduction	NA	3
Test guide	Introduction	NA	4
Test placebo	Section X	NA	5–12
Material description	*Coffee ground waste*	NA	13
Trial 1	Section 1	A × B	14–21
Trial 2	Section 2	A × C	22–29
Trial 3	Section 3	A × D	30–37
Trial 4	Section 4	B × C	38–45
Trial 5	Section 5	B × D	46–53
Trial 6	Section 6	C × D	54–61

association with other elements such as colour, texture or associated brand. The icons used are generic from Microsoft Office Software to avoid any associated style. The icons and words used to represent each item under each category are depicted in Fig. 1.

Section X, the placebo, initiates the test and sets the control variable for comparing durations across sections. Its necessity was determined post-pilot test. Starting page 5, Section X familiarises participants with the experiment's concept through straightforward questions. Each section's start and stop buttons activate and halt the timer, with the spacebar used for starting. The "W" and "O" keys correspond to left and right items, encouraging hand dexterity. Participants respond to the middle item accordingly by selecting "W" or "O" before advancing to the next page.

The experiment starts in section one. Section one includes an item from Group A and Group B. Like Section X, every section is designed to start with the green "start" button to activate the timer and the "stop" button to end the session and turn off the timer. For example, in section one for the first material test, the material name is in the middle to be associated either with the item on the left (Group A) or the item on the right (Group B). An example of a one-section design is shown in Fig. 2.

3.2 Data Analysis and Results

Test data was analysed using the Mann–Whitney U-Test, suitable for non-normally distributed samples. It compared associations between Saudi and Malaysian participants toward coffee ground waste materials. Malaysian data comprised 83 participants (249 samples), while Saudi data included 62 participants (186 samples), all

Fig. 1 Six items of icons and words were used for each four-category

aged 18 to 30 with industrial design backgrounds. The mean duration for all associations was 139.01 ms, median 125 ms, and mode 100 ms. Significant differences were found, detailed in Table 2.

From the analysis, a Mann–Whitney test indicated that the Food-Related Product category distribution of frequencies associated with coffee ground waste was more significant for participants from Malaysia (Mean Rank = 80.57) than for participants from Saudi (Mean Rank = 62.87), U = 1945, P = 0.011. Another product category is the Memorabilia and Specialized Products, where the distribution of frequencies associated with the material is more significant for Saudi (Mean Rank = 77.44) than for Malaysian (Mean Rank = 61.34), U = 2566.5, P = 0.037.

The lunchbox item distribution of frequencies associated with coffee ground waste was more significant for participants from Malaysia (Mean Rank = 78.8) than for participants from Saudi (Mean Rank = 65.24), U = 2092, P = 0.034. The cutlery item distribution of frequencies associated with coffee ground waste was more significant for participants from Malaysia (Mean Rank = 81.19) than for participants from Saudi (Mean Rank = 62.03), U = 1893, P = 0.004.

The indulgent word item distribution of frequencies associated with coffee ground waste was more significant for participants from Malaysia (Mean Rank = 79.98) than for participants from Saudi (Mean Rank = 63.66), U = 1994, P = 0.015. The sentimental word item distribution of frequencies associated with coffee ground

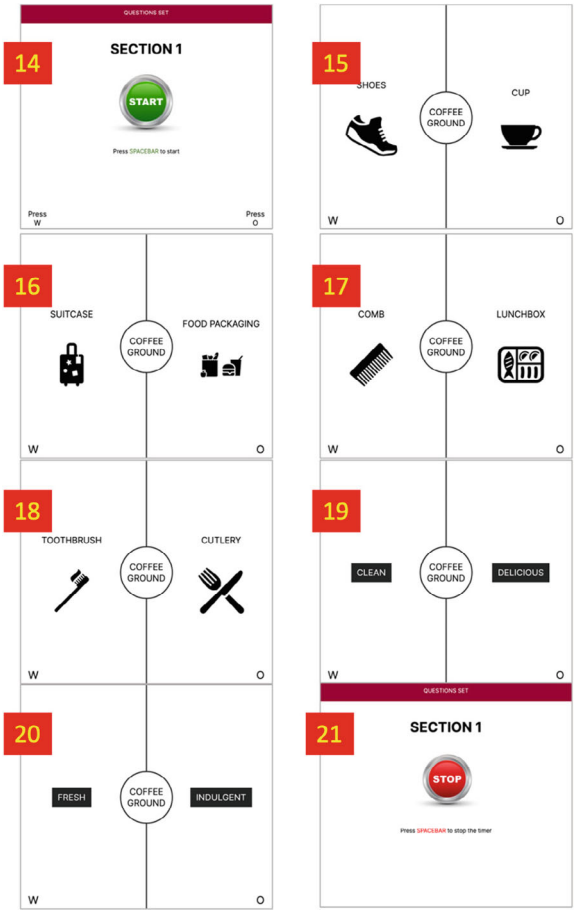

Fig. 2 Interface for one test section

Table 2 Test results summary

Results	Saudi (mean rank)	Malaysia (mean rank)	Z	U	P
Food-related product category	62.87	80.57	−2.544	1945	0.011
Memorabilia product category	77.44	61.34	2.087	2566.5	0.037
Lunchbox	65.24	78.8	−2.116	2092	0.034
Cutlery	62.03	81.19	−2.866	1893	0.004
Indulgent	63.66	79.98	−2.431	1994	0.015
Sentimental	81.08	66.96	2.086	3074	0.037

waste was more significant for participants from Saudi (Mean Rank = 81.08) than for participants from Malaysia (Mean Rank = 66.96), U = 3074, P = 0.037.

4 Findings

The test revealed that Saudi participants associated material from coffee ground waste with the Memorabilia Product Category. In contrast, Malaysians associated the same material with the Food-Related Product Category, including lunchboxes and cutlery. Saudi participants linked the coffee substances with the word 'sentimental', whereas Malaysians associated them with 'indulgent'. The comparison of associations is shown in Fig. 3.

This study demonstrates that cultural connections with material substances can influence the potential product applications the intended market prefers. The products suitable for use with coffee substances vary across cultures. For example, Malaysians may accept the material positively if applied to food-related products. In contrast, Saudis may positively accept it if it's used for products related to their daily cultural rituals. This difference in acceptance is because Malaysians associate coffee as an edible substance, while Saudis associate coffee with lifestyle or the essence of heritage.

Designers should be mindful of the association attributed to the origin of substances, especially for materials with natural smells, as it should align with the context of the product application. For example, if coffee ground waste is turned into a new material, the application should match its properties, including its distinct smell. The positive association derived from the coffee experience should be fully utilised with suitable products with a congruent product identity.

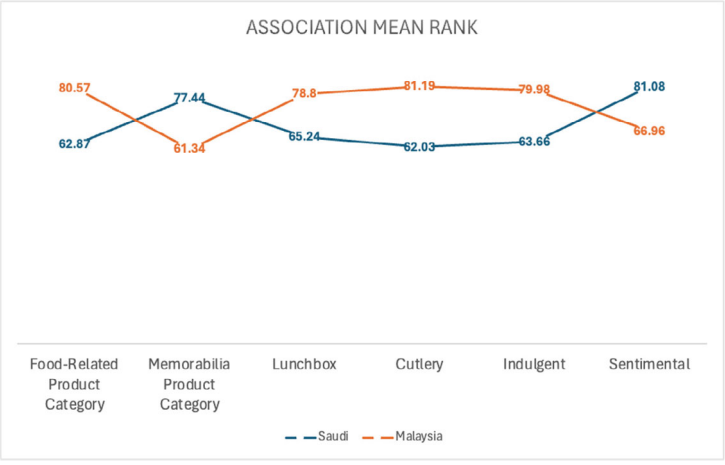

Fig. 3 Association mean rank comparison graph

5 Conclusion

In conclusion, materials are constantly being explored and developed in industrial design, including materials with natural smell associations. Product designers and material developers should leverage or use the smell-associated value from a material's substance origin. The positive olfactory identity may enrich the user experience with a product and hold immense potential to be designed with congruent surface qualities to convey a compelling sustainability narrative. The study has shown that designers must carefully oversee perceived values to mitigate challenges and foster positive reception in the intended market when employing distinctive materials like coffee ground waste in non-food products. Future studies could benefit from this method of investigating different materials with various sensorial associative values.

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