

(03-019) - Creation of the semantic space in product design using Artificial Intelligence techniques. Case of study in the agri-food industry

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To define the semantic space in design engineering, it is necessary to obtain a bank of adjectives, called kansei, that appeal to the user's emotions. During the initial recollection of kansei, the aim is to obtain a large number of them. For this purpose, related literature, articles, journals, magazines, websites, studies, advertisements, experts, previous studies, academic papers, etc. are typically consulted. In this work, both the database of the Spanish Foundation for Science and Technology and artificial intelligence tools are utilized. Several tools based on artificial intelligence have recently been introduced in the market, and are available to anyone with access to the Internet. While there are numerous controversies surrounding their use and the impact they may have in the future, their contribution to various disciplines is undeniable. In this work, two artificial intelligences have been used to obtain kansei: ChatGPT and Bard. Lastly, more kansei have been obtained from the website of a relevant glass bottle manufacturing company, and the initial collection of kansei has been carried out for the case of a glass bottle for wine packaging.

Keywords: Artificial Intelligence; semantic space; emotional design; glass bottle

Creación del espacio semántico en diseño de productos mediante técnicas de Inteligencia Artificial. Caso de estudio en la industria alimentaria

Para la definición del espacio semántico en ingeniería del diseño es necesario la obtención de un banco de adjetivos, o kansei, que apelen las emociones del usuario. Durante la recolección inicial de los kanseis el objetivo es obtener un gran número de kansei. Para ello, se suele recurrir a literatura relacionada, artículos, revistas, páginas web, estudios, anuncios, expertos, estudios previos, trabajos académicos, etc. En este trabajo se utilizarán tanto la base de datos de la Fundación Española para la Ciencia y la Tecnología como herramientas de Inteligencia Artificial. Recientemente se han introducido en el mercado numerosas herramientas basadas en inteligencia artificial, las cuales están al alcance de cualquier persona que tenga acceso a internet. Si bien se están planteando numerosas controversias por su uso y por el impacto que puedan tener en un futuro, es indudable su contribución en distintas disciplinas. En este trabajo se han utilizado dos inteligencias artificiales para la obtención de los kansei: ChatGPT y Bard. Por último, se han obtenido kansei de la página web de una relevante empresa fabricante de botellas de vidrio, y se ha realizado la recolección inicial de los kanseis para el caso de una botella de vidrio para envase de vino.

Palabras clave: Inteligencia Artificial; espacio semántico; diseño emocional; botella de vidrio

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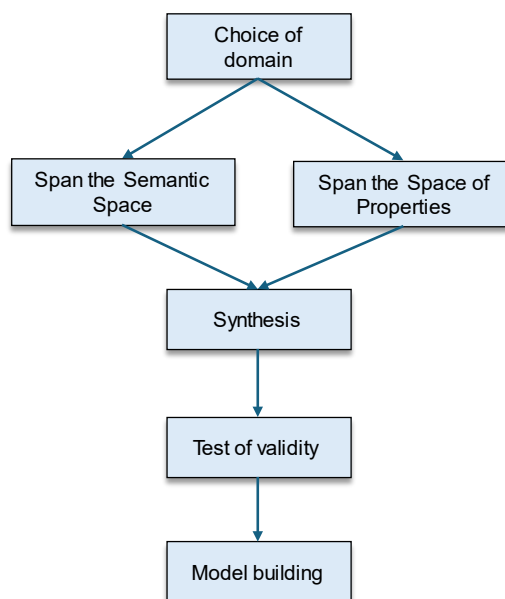
1. Introduction

In today's society, the market offers an immense number of products due to the widespread implementation of new technologies and optimized transportation. Intense competition is driving companies to develop new products that not only meet human needs but also capture the attention of the target market. In this context, emotional design methods are crucial for product designers to create unique and exceptional designs that establish an emotional connection with the future consumer. Hence, users face challenges in disposing of these items, leading to a higher probability of selling them and promoting more effective natural resource management.

Kansei Engineering (KE) is a product design methodology developed by Mitsuo Nagamachi in 1989. The term 'kansei' is of oriental origin and is composed of the prefix 'kan-', which means sensitivity, and the suffix '-sei', describing nature, characteristics, and quality (Córdoba Roldán et al., 2015). According to Nagamachi, Kansei Engineering is a technology that allows the transformation of the consumer's feelings into design elements, thus influencing his or her psychological feeling towards a certain product (Nagamachi, 2003).

Since its introduction, several authors have made contributions to Kansei Engineering. For example, in 2005 Shütte proposed the stages of the method illustrated in figure 1.

Figure 1: Stages of Kansei Engineering proposed by Shütte (2005)



During the 'Choice of Domain' stage, the target market is defined, and product specifications are selected to determine the business strategy. The company's mission, vision, and values shall also be taken into account. In the 'Span the Semantic Space' stage, a comprehensive list of adjectives expressing consumer feelings is compiled. It is common to draw on various sources of information, such as related literature, websites, and magazines, to obtain 'low-level Kansei Words' (Alves, 2018). Qualitative and quantitative tools, such as Principal Component Analysis and Affinity Diagrams, are used to obtain a manageable number of 'high-level Kansei Words'. Simultaneously, the process of 'Spanning the Space of Properties' is carried out to gather as many physical properties and their corresponding levels as possible. A selection of properties is then made based on their relevance, as determined by expert opinion and Pareto Chart analysis. During the 'Synthesis' phase, the relationship between the Kansei Words and

the properties is studied and quantified. This can be achieved through the use of Quantification Theory Type I, neural networks, fuzzy logic, and other tools can be useful in this phase. Finally, validation is performed, which may involve testing a physical prototype with volunteers, and creating a physical model.

The significance of KE in creating and innovating new products and experiences based on consumers' psychological responses is evident from its diverse and numerous applications. In the field of industrial design, Val-Carreres Azofra & Aguayo González (2012) created a luminous product inspired by a renowned architectural work of the architect Jürgen Mayer in the city of Seville using KE. Zamora-Polo et al. (2021) used KE to assess the preferences and perceptions of sundry means of transportation among engineering students in the field of sustainable transportation. Córdoba et al. (2016) suggested the application of KE in the redesign of work cells under the scope of industry 4.0, to create more intuitive and pleasant workspaces.

In recent years, the development of Artificial Intelligence (AI) tools, particularly advances in Natural Language Processing, has made this technology accessible and available to a wide range of users and uses, including companies, product designers, and customers. According to Füller et al. (2022), many innovation managers acknowledge the potential benefits of the AI to improve certain innovation-related tasks. For example, AI has great potential in developing and generating ideas because it excels at combining and modifying pre-existing ones. Table 1 outlines the main strengths of using AI in innovation according to a study by Haefner et al.(2021).

Table 1: Benefits of Artificial Intelligence in tackling barriers to innovation. Source: Haefner et al.

INNOVATION PROCESS			
		Develop ideas	Generate ideas
BARRIERS TO INNOVATION	Information processing constraints	AI system is able to identify and evaluate more information that can be used to develop ideas.	AI system is able to recognize more problems, opportunities and threats that may be used to generate new ideas.
	Ineffective or local search routines	AI system is able to identify and evaluate more creative/exploratory ideas.	AI system is able to recognize and create more creative/exploratory problems, opportunities, and threats to generate new ideas.

The public market has seen a significant increase in the number of available AI tools in the last couple of years. ChatGPT was the most popular AI chatbot from September 2022 to August 2023, accounting for 60.2% of the market with over 14.6 billion visits. Google Bard (currently renamed to Gemini) also ranked high with over 241.6 million visits. Despite the number of visits, the date of release should be considered when interpreting these figures - Bard was released five months after ChatGPT, so it's understandable to expect the number of visits to be much lower.

In the field of product design, it is becoming more common to see papers discussing the integration of machine learning techniques. Filippi (2023) conducted research to explore the potential of ChatGPT in the concept generation stage. To achieve this, a group of participants were split into two groups and asked to develop ideas using traditional methods such as the "Theory of Inventive Problem Solving" (TRIZ) and ChatCPT, respectively. The researchers concluded that AI was useful in generating a large quantity of ideas, but less effective in producing feasible and creative concepts. It is important to note that ChatGPT is a pre-trained model and lacks neither real-world context nor human aspects. In the case of Kansei

Engineering methodology, Zamora-Polo et al. (2022) compiles some machine learning tools used in the synthesis phase, such as user-generated comments based on social media or e-commerce platforms.

Finally, Kansei Engineering facilitates the establishment of an emotional connection between the consumer and the product. This emotional bond can lead to users keeping the product for a longer period of time and taking better care of it. According to most literature, a company's environmental performance is based on three pillars: social, environmental, and economic dimensions. This is the Triple Bottom Line model, which states that sustainable development is achieved only when policies and actions aimed at economic growth align with social equity and respect for the natural environment (Elkington, 1998; Zamora-Polo et al., 2022).

2. Objectives and methodology

2.1 Objectives

On a general scope, the objectives of this paper are the following:

- To analyze of the scientific research that has been conducted in the past years, with special attention to the agri-food sector.
- To collect a huge amount of Kansei Words for the design of a wine bottle, using different sources of information.
- To utilize AI tools to collect Kansei Words for the design of a wine bottle, and to analyze the results to reach conclusions about the utility of these tools in the Kansei Engineering methodology.
- To develop sustainable products which minimize the environmental impact.

This paper focuses on 'Span the Semantic Space' stage in the agri-food industry, and more specifically, for glass bottles of wine.

2.2 Methodology

To establish the semantic space for the design of a wine bottle, three different sources of information have been used: Web of Science (WOS) for doing a more academic and traditional searches, Artificial Intelligence tools such as ChatGPT and Google Bard which compile a highly heterogeneous number of unknown sources, and ESTAL, a leading company in the sector.

WOS is accessible through the Spanish Foundation for Science and Technology (FECyT), and it is one of the major scientific databases. The research concentrated exclusively on the timeframe from 2019 to 2023, with the search conducted in early January and early March 2024. All kinds of documents from the database were used, including articles, conference papers, and chapter from books, amongst others.

Searches were conducted in two stages with different objectives. The first stage aimed to obtain a general understanding of the fields of study where Kansei Engineering has been applied in recent years. Despite it can seem a trivial search, it is relevant to know how the semantic space of different fields are shared. The keywords employed for this point were: (kansei AND engineering AND case AND study).

In the second stage, the main goal was to obtain kansei words from papers in the specific domain of the problem. For this purpose, the following keywords were chosen: (kansei AND engineering AND packaging) OR (kansei AND engineering AND wine) OR (kansei AND engineering AND beverages). Once the results were obtained, they were sorted based in descending order of citations. Kansei were exclusively acquired based on their relevance and sourced from documents with citations.

As previously mentioned, the second source of information for extracting kansei words were ChatGPT and Bard due to their impact in the preceding year. The same initial hypothesis for the specific domain was introduced in Spanish language in both tools. This hypothesis covered:

- Objective: it was specified that the goal was to obtain a list of Kansei Words (no specification of the meaning of kansei was introduced).
- Contextualization: including both the methodology employed (Kansei Engineering) and the object of design (wine glass bottle).
- Requirements: some constraints were introduced, such as the number of Kansei Words (this number was set on 30 words), and the reliability of the sources from where it could obtain the information.

Once the responses were obtained, they were evaluated. To assess response appropriateness, a comparison was drawn against the pre-existing Kansei Words' bank obtained through bibliographic search. If a response was deemed inadequate, iterations were conducted. Once a response was deemed satisfactory, the Kansei Words were integrated into the bank of adjectives. This process was conducted in early January 2024 and early March 2024 to examine whether responses improved over time due to the process of continuous learning from data.

The last source of information employed in this paper was the website of Estal, a company specializing in glass manufacturing. While not the largest player in the industry, Estal distinguishes itself through a meticulous emphasis on customization, positioning it as a formidable competitor in the Spanish market. Additionally, Estal demonstrates a strong commitment to sustainability, producing all its products from 100% recycled materials.

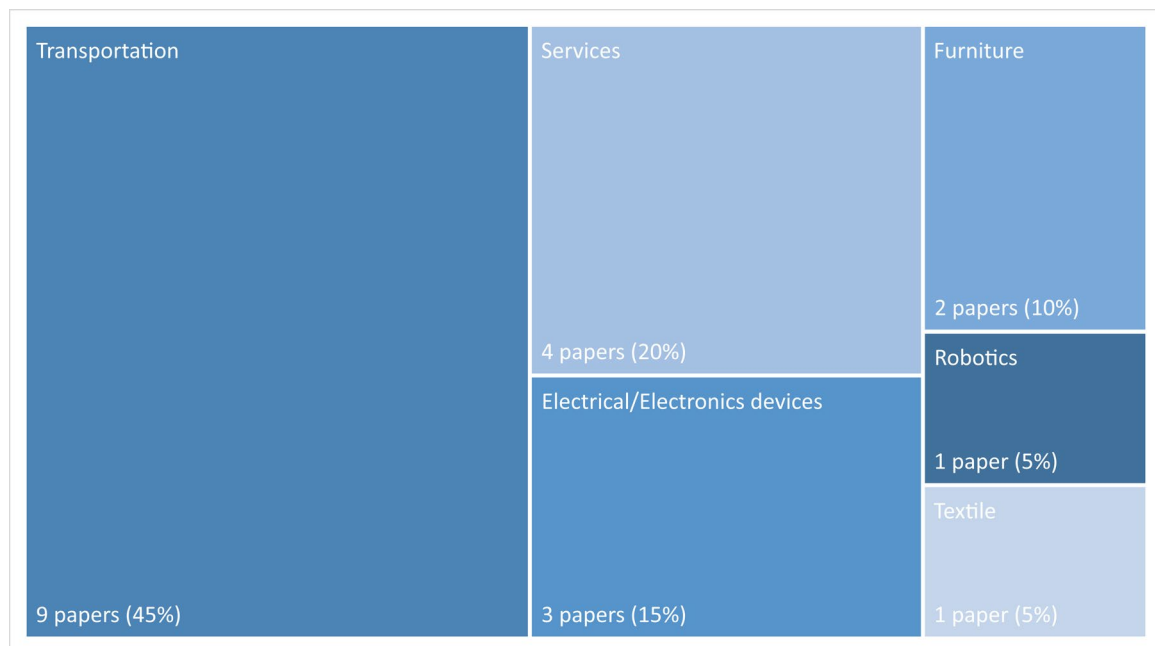
3. Results

3.1 Kansei Engineering case study searching.

Following the criteria explained in the previous section for the bibliographic search, 26 documents were obtained. The number of texts analyzed was reduced to 20 due to restriction of access of 6 of them. Figure 2 shows that most publications were related to the transportation sector. Papers in the field of transportation addresses the design of train seats (Xue et al., 2020), bicycle helmets (X. Li et al., 2021), electric bicycles (Cong et al., 2023), and more specifically urban e-bikes (Čok et al., 2022), and cars (Su et al., 2020). Related to cars, numerous topics are covered, such as car profile design (Y. Li & Zhu, 2020), automobile booth design (Kang, 2020), exterior design of new energy vehicles (Lai et al., 2022), and sedan (Q. Zhang et al., 2022).

The service sector has been the second most studied industry, accounting for 20% of the papers received, with cases of study related to campus express delivery service (Yan & Li, 2021), a last-mile delivery service (Restuputri et al., 2022), an in-flight service of a Chinese airline (Cai et al., 2023), and an intelligent waste classifying system (Rianmora et al., 2023).

Figure 2: Areas of application of Kansei Engineering within the search “kansei AND engineering AND case AND study”.



In the case of electrical and electronic devices, the following examples have been found: a hand drill (X. Li et al., 2021), wrist wearables (Jia & Tung, 2021), and cameras (Hu et al., 2022). Moreover, Kansei Engineering has also been used in the furniture field, from the design of cradles (Akgül et al., 2022) to the design of outdoors leisure chairs (Zhong et al., 2022).

The number of papers in the robotics sector is on a par with the textile industry, covering examples such as social robots (Gan et al., 2021) or the design of suits (J. Zhang & Mu, 2021).

3.2 Obtaining specific domain Kansei Words through bibliographic search.

In this instance, the three sets of keywords, described in the methodology, were employed. Only papers with citation were selected, resulting in a significant decrease in the number of documents obtained compared to the initial search, as shown in figure 3. Due to the limited number of results, the publication year was enlarged to the past ten years.

All the documents obtained underwent analysis. Among the 15 documents, 4 were excluded: Half of them were due to access restrictions, and the remaining documents were deemed irrelevant. The papers encompassed the design of a wine glass (Kittidecha et al., 2015), a candy packaging (Effendi et al., 2020), a saffron packaging (Papantonopoulos et al., 2021), generic beverage bottles (Luo et al., 2012; S. Zhang et al., 2021; Azrifirwan & Djatna, 2014), bottled tea (Kim et al., 2013), a package delivery and tracking service (Restuputri et al., 2020), and the implementation of industry 4.0 in small and medium companies of the food and beverage industry (Ushada et al., 2021; Ushada et al., 2022; Ushada et al., 2024). A total of 118 distinct Kansei Words were identified from the documents. After applying an initial filter where irrelevant nor inadequate Kansei Words were discarded, 86 Kansei Words were ultimately chosen and presented in table 2.

Figure 3: Number of documents obtained based on bibliographic search.

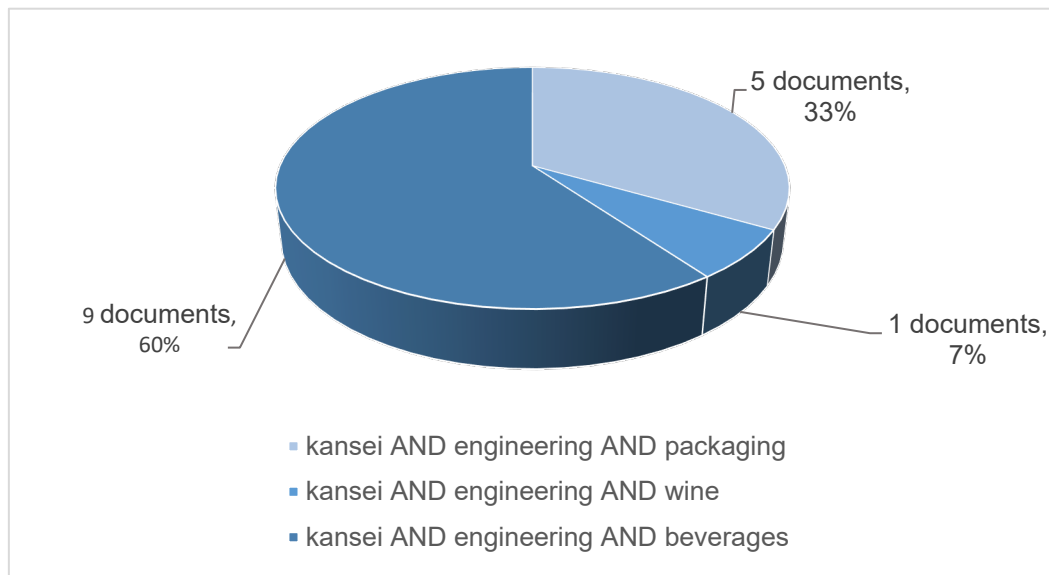


Table 2: Kansei Words obtained from bibliographic research.

Adaptative	Dense	Expensive	Masculine	Simple
Ancient	Dignified	Fashionable	Modern	Simplistic
Aromatic	Durable	Fancy	Monotonous	Smooth
Attractive	Easy of handle	Feminine	Natural	Sophisticated
Beneficial	Easy to open/close	Flashy	Neat	Splendid
Boring	Easy to store	Fresh	Nostalgic	Streamlined
Bright	Easy to use	Friendly	Novel	Stimulating
Careless	E-commerce beneficial	Functional	Old	Tasty
Cheap	Economical	Gentle	Original	Textural
Cheerful	Effective	Hard	Premium	Tidy
Classic	Efficient	High quality	Pretty	Traditional
Clear	Elegant	Informative	Pure	Unique
Clean	Energetic	Innovative	Rapid	Valuable
Complex	Environmentally friendly	Interesting	Realistic	Youthful
Comfortable	Ergonomic	Ladyish	Reliable	
Cool	Excessive	Lightweight	Ridged	
Coordinated	Exhilarating	Luxurious	Rounded	
Dark color	Exquisite	Mature	Safe	

3.3 Obtaining Kansei Words from Artificial Intelligence tools (January 2024)

The initial hypothesis introduced in Spanish was as follows: *“I am undertaking a design project using the Kansei Engineering methodology. I require a list of 30 Kansei for the design of a wine bottle. Use reliable sources”*.

On the one hand, the result obtained with Bard on a first iteration included the following words: *“Elegance, tradition, modernity, nature, art, elegance, quality, prestige, luxury, aroma, flavor, texture, weight, size, shape, color, materials, label, cork, and box”*. As it can be inferred, no adjectives were included (Kansei Words shall be adjectives), and it did not meet the specification of the number of words. Moreover, some of the words, such as "shape", "color", and "materials", amongst other, are related to the properties space, not the semantic space. The reply was declared as not valid, and a new iteration was made.

During a subsequent iteration, it was specified that Kansei Words should be adjectives. This was to enable the study of the relationship between these adjectives and the properties of the designed product. The hypothesis introduced was as follows: *“I am undertaking a design project using the Kansei Engineering methodology. I require a list of adjectives (called kansei) for the design of a wine bottle. These adjectives will be used to establish a quantitative relationship between the emotions represented by these adjectives and the design characteristics of the products. Use reliable sources”*. The resulting list included adjectives such as *“shape, size, color, material, texture, weight, scent, flavor, temperature, sound, and touch”*. For each word, subcategories were also provided, such as “smooth, rough, silky, hot, and cold” for the word “touch”. Once again, most of the words obtained pertained to physical attributes rather than emotions or perceptions, rendering the answer invalid.

A third iteration was carried out, with emphasis on ensuring that the Kansei Words represented the possible emotions that the wine bottle could evoke in the user: *“I am undertaking a design project using the Kansei Engineering methodology. I require a list of kansei for the design of a wine bottle. These kansei represent the emotions that the product can evoke in the user. Use reliable sources”*. The resulting words were: *“Elegance, sophistication, modernity, tradition, smoothness, robustness, weight, fragrance, vinegar, wood, sweetness, acidity, tannins.”* Even though they were not adjectives, they were changed into their adjective form and compared with the ones obtained through bibliographic research.

Table 3: Comparison of Kansei Words obtained through bibliographic search versus Bard (January 2024) .

Kansei Words obtained from both sources	Kansei Words with similar meaning (Bard – Bibliographic Research)	Kansei Words with no synonyms
Elegant	Fragrant - Aromatic	Robust
Sophisticated	Sweet - Tasty	Weighty
Modern		Vinegary
Traditional		Woody
Smooth		Sweet
		Acid
		Tannic

Table 3 shows that only 50% of the Kansei Words provided by Bard were the same or synonyms of the Kansei Words obtained through the bibliographic search. Therefore, the results were deemed invalid.

On the other hand, ChatGPT's first iteration produced the following Kansei Words: *“Elegant, sophisticated, classic, modern, traditional, minimalist, luxurious, attractive, subtle, stylized, harmonious, tactile, ecological, innovative, seductive, fresh, rustic, youthful, timeless elegance, resilient, easy to handle, refined, dynamic, environmentally friendly, artisanal details, evocative, sensual, inclusive, joyful, intriguing.”* In this case, the adjectives were proper in

number and manner (they were adjectives). To confirm the accuracy of the answer, Kansei Words were compared with the ones obtained through bibliographic search in table 4.

Table 4: Comparison of Kansei Words obtained through bibliographic search versus ChatGPT (January 2024).

Kansei Words obtained from both sources	Kansei Words with similar meaning (ChatGPT – Bibliographic Research)	Kansei Words with no synonyms
Attractive	Minimalistic – Simplistic, streamlined	Sensual
Classic	Stylized - Fashionable	Inclusive
Easy to handle	Harmonious - Coordinated	Subtle
Elegant	Tactile - Ridged	
Environmentally friendly	Ecological - Enviromentally friendly	
Fresh	Seductive - Attractive	
Innovative	Rustic - Traditional	
Luxurious	Timeless elegance - Classic	
Modern	Resilient - Durable	
Sophisticated	Refined - Sophisticated	
Traditional	Dynamic - Energetic	
Youthful	Artisanal details - Unique	
	Evocative - Stimulating	
	Joyful - Cheerful	
	Intriguing - Interesting	

As shown in the table 4, 90% of the Kansei Words provided by ChatGPT were either identical or synonyms of the Kansei Words obtained through bibliographic research. Therefore, the results were deemed valid, and the 30 Kansei Words were added to the words' bank.

3.4 Obtaining Kansei Words from Artificial Intelligence tools (March 2024)

Artificial Intelligence-based tools are constantly being updated, which means they do not provide the same response twice.

Therefore, a second attempt was made to obtain Kansei Words two months later to verify if the results provided by Bard were more accurate. The same initial hypothesis was introduced, and the feedback was as follows: "*Elegant, sophisticated, minimalist, traditional, modern, innovative, attractive, eye-catching, distinctive, functional, ergonomic, durable, sustainable, eco-friendly, lightweight, heavy, smooth, rustic, fine, delicate, sturdy, solid, balanced, comfortable, exclusive, luxury, quality, value, brand, prestige*". On first inspection, the presented Kansei Words were adjectives and they seemed to be more appropriate than the first time. Table 5 shows that 90% of the thirty Kansei Words were similar or even identical to those obtained through bibliographic search. For instance, the response was considered valid, and the words were added to the bank of adjectives.

The same process was carried out for ChatGPT, to ensure that the answers could still be considered valid. The Kansei Words provided were not adjectives. However, they were

converted into their adjective form and compared to those obtain through the bibliographic search (table 6).

Table 5: Comparison of Kansei Words obtained through bibliographic search versus Bard (March 2024).

Kansei Words obtained from both sources	Kansei Words with similar meaning (Bard – Bibliographic Research)	Kansei Words with no synonyms
Elegant	Minimalistic	Sturdy
Sophisticated	Sustainable - Environmentally friendly	Solid
Traditional	Eco-friendly – Environmentally friendly	Brand
Modern	Rustic - Traditional	
Innovative	Fine - Elegant	
Attractive	Balanced - Coordinated	
Functional	Exclusive - Luxurious	
Ergonomic	Prestige – Premium	
Durable	Eye-catching - Attractive	
Lightweight	Distinctive – Original, unique	
Smooth	Heavy – Dense, excessive	
Comfortable	Delicate – Fine, elegant, gentle	
Quality	Sturdy – Durable, reliable, hard	
Value		

Table 6: Comparison of Kansei Words obtained through bibliographic search versus ChatGPT (March 2024)

Kansei Words obtained from both sources	Kansei Words with similar meaning (Bard – Bibliographic Research)	Kansei Words with no synonyms	
Elegant	Bright	Harmonious - Coordinated	Sensual
Sophisticated	Pure	Prestigious – Premium	Powerful
Classic		Exclusive - Luxurious	
Traditional		Hand-crafted - Unique	
Modern		Ecological – Environmentally friendly	
Quality		Vintage – Old, traditional	
Durable		Respect for the environment - Environmentally friendly	
Simple		Tactile-sensitive – textural, ridged	
Innovative		Timeless - Classical	
Fresh		Refined - Fine, elegant, gentle	

Luxurious	Historical – Traditional, old
Ergonomic	Symmetric - Coordinated
Original	Delicate – Fine, elegant, gentle

Table 6 shows that 93% of the Kansei Words provided were similar or even identical to those obtained through bibliographic search. Moreover, just 7 of the Kansei Words were the same as the ones provided two months before. Consequently, the new list of Kansei Words was incorporated to the Kansei Words' bank.

3.5 Obtaining Kansei Words from a website

The last resource employed for obtaining Kansei Words was the website of Estal. Twenty words were extracted from the descriptions of its products and marketing slogans (table7).

Table 7: Kansei Words obtained from the website of Estal.

Adaptable	Authentic	Balanced	Natural	Temporary
Artisanal	Creative	Imperfect	Organic	Traditional
Asymmetrical	Ecological	Lightweight	Simple	Unique
Attractive	Elegant	Minimalist	Sustainable	Timeless

In conclusion, a total number of 196 Kansei Words were gathered by searching on research papers through "Web of Science" (86), the website of the company Estal (20), and the use of chatbots, such as ChatGPT (60), and Bard (30). Nonetheless, to make this list more manageable for future analysis, it is necessary to reduce this number. This aspect will be explored in forthcoming research.

4. Conclusions

In the past years, applications of Kansei Engineering have focused mainly on field of transportation. According to a research study carried out by Zamora-Polo et al. (2022), one of the most researched fields of applications was also transportation, proving that this topic remains of the top rank of tendency even two years later. After the transportation sector, the service sector follows in the number of case studies, with a special focus on the last-mile delivery market. This is due to the increasing demand for this type of services (which hold a compound annual growth rate of 11.71%) and, therefore, the necessity of the companies to provide better services than their competitors.

Since the emergence of Kansei Engineering, countless study cases have demonstrated its versatility and adaptability to all fields of study and cases. However, for the "Span the Semantic Space" phase, it is highly recommended that designers obtain a large number of Kansei Words from multiple sources of information. As is well known, this process can be time consuming. For this reason, this paper has demonstrated that by using Artificial Intelligence-based tools, it is possible to obtain a significant number of Kansei Words with a very significant reduction in time for the designer: where traditional methods can take hours or even days, AI-based tools can provide acceptable answers within seconds. However, as this paper has shown, AI answers are constantly changing. While ChatGPT was shown to give better answers in a first iteration, its response changed slightly two months later. In the case of Bard, a few iterations were needed on the first attempt and more context and explanation had to be provided to get acceptable answers, but a massive change was seen in its response two months later, where the answers provided were very acceptable on just one iteration. Although neither ChatGPT nor Bard are connected to the internet, they provide answers based on the information in the

database on which they have been trained. These databases are usually updated from time to time to keep the chatbots up to date with general knowledge. According to Thorp (2023), "ChatGPT sometimes writes plausible-sounding but incorrect or nonsensical answers".

The limitations of the current work are due to the nature of the technology on which modern AI tools such as ChatGPT rely. This makes it practically impossible to create a predictable model that replicates that solution. Therefore, it is a tool that solves problems, but we are unaware of how it works, and it could provide an incorrect answer, which we would not be able to identify. Therefore, despite its potential and time reduction, it should always be just another tool within the designer's reach, with the designer's criteria and sense always taking precedence. However, the future remains unwritten.

Regarding sustainability, it is noteworthy that in all cases where the list was considered acceptable, there is at least one Kansei Word related to sustainability. This fact proves the emergence of environmental awareness in the design process.

Finally, this research has focused on the "Span the Semantic Space" stage. Therefore, future studies can investigate the use of AI-based tools in the other stages of Kansei Engineering.

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Communication aligned with the Sustainable Development Goals

