

Ergonomic design of smart bags: an analytical study

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Abstract:

This research seeks to explore the ergonomics factors in smart bags designing that are covered in previous literature and reviewed by the researchers, with the purpose of examining how much contribution is made by ergonomics and thus utilizing its various axes in the design in general, bags in particular. This is in addition to illustrate its compatibility with the current era being promoted globally in product design. The significance of the research emerges from being an endeavor to keep pace with the most recent advances in smart design and wearable technology with relation to supporting the clothing accessories industry with brand-new designs that satisfy functional and aesthetic requirements.

Both researchers adopted the inductive approach based on reading the past literature and the descriptive analytical approach. The analytical part dealt with analyzing the ergonomics of a collection of smart bags via comprehending and understanding the findings of previous studies. According to the research, giving due attention to ergonomic factors during design stage contributes significantly to promoting the functional efficiency of products to be commensurate with the characteristics of the target consumer. It can be stated that the ergonomic factors of smart bags must be assessed in terms of functional and aesthetic aspects, the level of safety and a sense of comfort. Categorizing the use of ergonomic criteria in the field of smart bags is represented in a number of categories, namely the location of the bag, theft control, the ability to charge smart devices through it, and the use of ultrasound sensors to track the owner's bag. Both researchers recommend that the ergonomic aspects of fashion design and its accessories, especially smart ones, are to be considered; they also recommend conducting several research studies that address the impact of ergonomic considerations on fashion design and its accessories.

Keywords:

Bags, smart bags, ergonomics, smart design.

Introduction:

In art in general, and in design in particular, conflicts have always been present among ideas and theories leading to a breakthrough for human being in terms of identifying his/her own approach in a level of criticism and analysis. Therefore, thought and knowledge are advanced mobile systems from the very beginning of human existence to the present day (Sarhan, 2019). Therefore, any scientific study must be based on theoretical features that make it balanced in its presentation. To this end, the researchers have adopted ergonomics as a framework for their current study. (Wilson, 2001) refers to ergonomics theory as the theoretical and fundamental

understanding of human behaviour and performance in purposeful interacting socio-technical systems, and the application of that understanding to design of interactions in the context of real settings". In spite of the fact that ergonomics is not a modern theory, scarce studies have attempted to apply it in the field of bag design.

Ergonomics is an appropriate approach to this study. According to the International Ergonomics Association (IEA), ergonomics is the "Ergonomics (or human factors) the term is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human wellbeing and overall system performance, (Miqdad and Abdel Moneim, 2017). Ignoring some ergonomic aspects in the design has negatively impacted individuals' willingness to purchase these smart products or utilize them consistently. Thus, the products that contain specific technologies must be appropriate for the wearer and do not hamper their movement; they should be attractive and lightweight, as well (Nada, 2019). This is what ergonomic design offers.

Achievements accomplished in smart clothing have not been so many so far due to several factors, namely, insufficient reliability and waterproof components of clothes, the high cost of manufacturing these clothes, and the inability to wash them. Besides, some of them are uncomfortable to wear because they are fabricated from e-textiles (i.e., textiles with electrical conductivity). As such, such materials are considered impractical for daily wear (Joler and Others, 2019). Moreover, designers seek an opportunity to integrate computers and sensors with the human body in a manner that facilitates communication between the human being and the computer components that he/she wears. Such components are to be incorporated into clothes, shoes, jewelry (Ali, 2019) and bags.

Due to the fact that bags are among the separate costume accessories that have a very special significance in various arts, it is important to mention that they were primarily made of simple sacs of clothing and were hung in a person's belt. Following, ways of carrying bags evolved in the sense that they were carried in the hand or on the arm (Fawzy and others, 2020). Currently, bags have benefited from the tremendous advancement in digital technology. For instance, (Harbi, 2018), pointed out that bag industry needs to keep pace with modern developments in all stages of the production process to elevate the level of taste and quality.

Regarding to the smart bags, and as concluded from the inductive study of past literature, there has been some research that addressed smart bags and that led to the emergence of some products on the market, such as bags equipped with tracking devices as (Sebin and others, 2017) they have created a bag that tracks its owner via human detection technology using ultrasound sensors. The bag can be activated by SMS and can be located using GPS. Also bags that include a safety button such as (Gayathri and others, 2014) study about interaction of smart bag using RFID Technology, it is an interactive smart bag that uses RFID technology to intelligently pack our things, with a digital lock. It can only be opened by inserting the secret code into the microcontroller. Usually, these solutions seek to handle a specific problem for which it is designed.

Apparently, there has been a shortage of solutions that aid in addressing these problems. As well as incorporating some smart features that can give smart analyses and services to the user. Therefore, **the research problem can be identified in the following questions:**

1. What is the contribution of ergonomics to the design and implementation of smart bags?

2. What are the ergonomic factors to consider when designing smart bags?

Research objectives:

The research seeks to analyze the ergonomic factors for the design of smart bags. Both researchers reviewed the past literature with the purpose of revealing the contribution made by ergonomics along with employing its various axes in the design of smart bags.

Significance of the research:

The significance of this research lies in attempting to add a new dimension to bags of technologically functional design, keeping abreast of recent advances in smart design and wearable technology, as well as support the clothing accessories industry with brand-new designs that fulfill functional and aesthetic requirements.

Methodology:

The study adopted the inductive approach based on reading the past literature, and the descriptive and analytical approach for its appropriateness to realize research objectives and verify its hypotheses. This is accomplished via describing and analyzing smart bags addressed in the past literature with the purpose of reaching a solution to the research problem. The researchers utilized the (Al-Hibri, 2016) card, which is a guiding card for analyzing the ergonomic and aesthetic aspects of smart bags in her study entitled (The Interrelationship between Aesthetics and Ergonomic Considerations in the Product Design Process). After applying the research tool (the card) according to the proposed methodology, both researchers expect that the current study will give an answer to its questions by exploring the ergonomic and aesthetic aspects that must be considered when designing in general and designing smart bags in particular.

Conceptual framework:

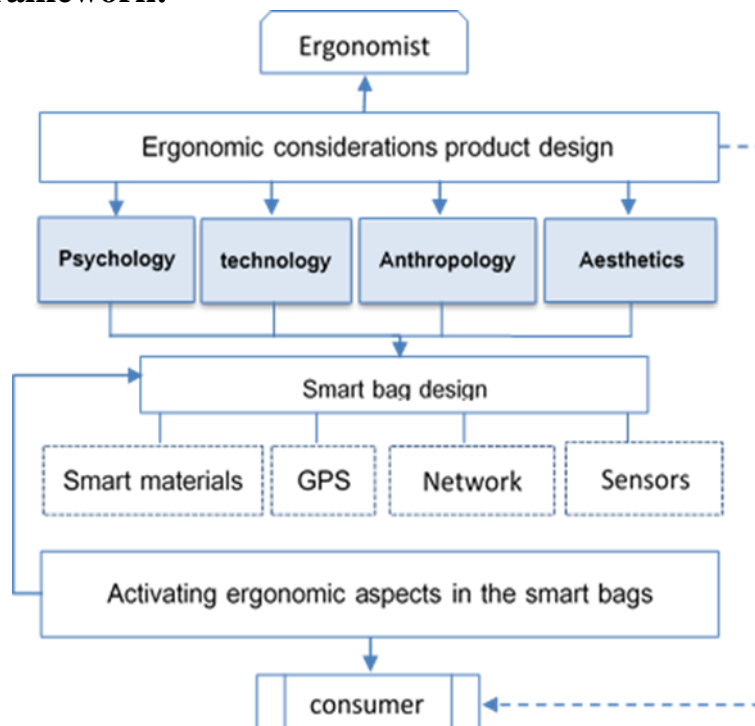


Figure (1): Conceptual framework (researcher’s design)

Terminology:

Ergonomics: It is the science concerned with arranging the relationship between people and tools used to perform a function (Shaban and others, 2019). In this research, ergonomics refers to the science concerned with human characteristics for being instrumental during design with the aim of elevating the functional performance of smart bags.

Smart bags: Bags are considered as separate clothing accessories and their shapes and sizes vary according to the conditions of each community and the fashion prevailing (Fawzy and others, 2020). According to the researcher, smart bags are procedurally defined as innovative bags designed according to adaptive advantages and associated with the interactive design in it with smart technology so that the interaction between it and the user becomes realistic. This is because it has security features appropriate for the modern era such as linking, for example, between them and smart phones.

Theoretical framework:

Ergonomics:

Ergonomics is the science that designers have been using to refer to a set of knowledge and skills utilized in building and designing products to ensure optimal performance in human service (Fargali and others, 2016). Ergonomics is an interdisciplinary science as mentioned by (Hassan, 2019) in his book on "Persuasion Technology in Design. According to) Amin, 2019), interdisciplinary science refers to studies composed of two or more leading fields of knowledge, or the process by which some questions are answered, some problems are solved, or a very broad or very complex topic that is difficult to deal with adequately by one system or discipline. Also, (Wahed, 2010) defines ergonomics as the art of design for optimizing human wellbeing being a field of science which designers have been using to refer to a set of knowledge and skills utilized in building and designing products.

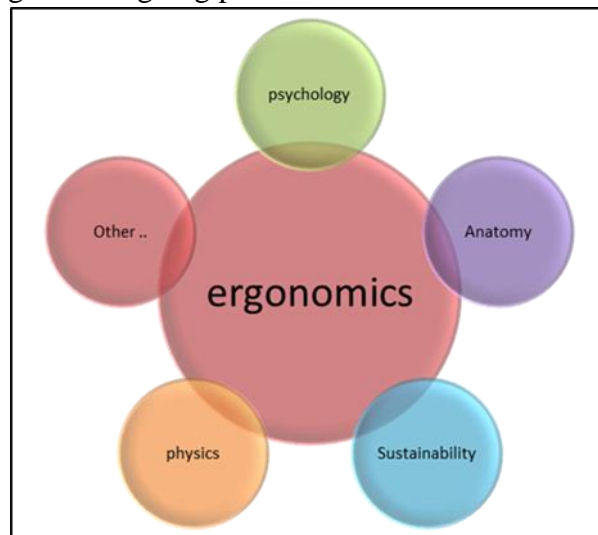
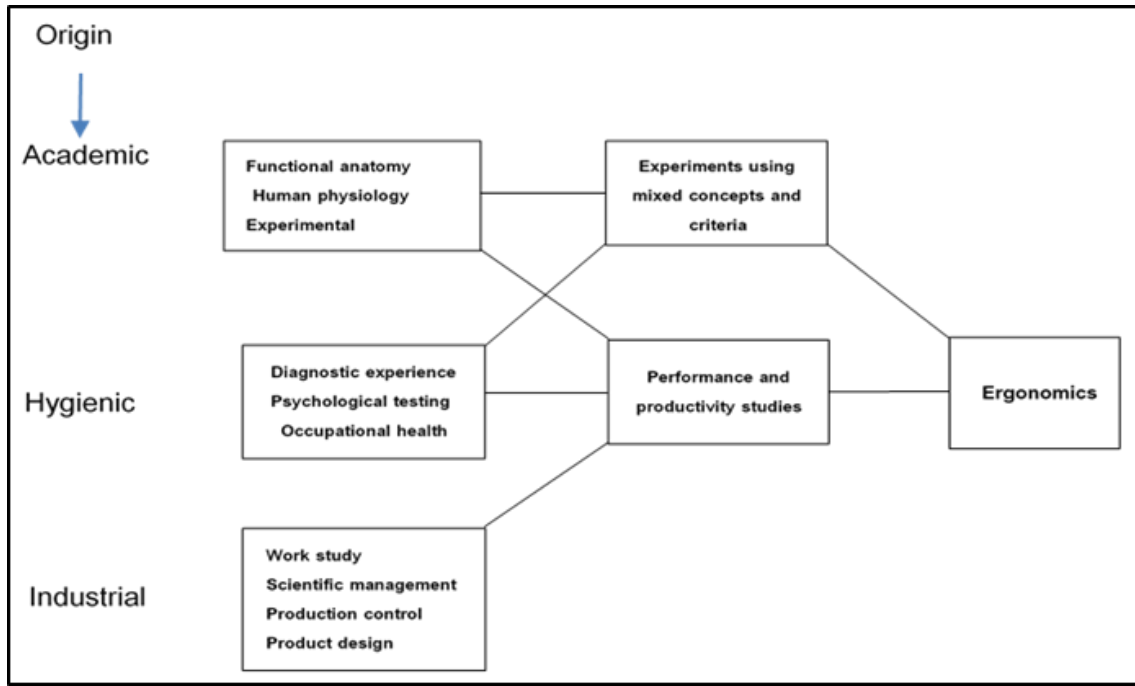


Figure (2): ergonomic science as one of the Interdisciplinary (researchers' design)

Historical background of ergonomics:

Providing some historical details will assist with accentuating the current need to re-examine the ergonomic aspects, since ergonomics is a relatively modern science. However, its roots date back to 1900 AD (Fekry and others, 2019). The modern history of ergonomics ran from 1939 through 1945 AD during the World War II in the UK, where a synergy of ideas and experiences

from different disciplines concerned with the effectiveness of human performance (anatomy, physiology, psychology, industrial medicine, design engineering, and architecture) combined with a focus on theory and methodology yielded in the formation of ergonomics as a discipline with two powerful subgroups: Anatomy / Physiology and Experimental Psychology (Wilson, 2001).



FIGUER (3 (: Historical development of ergonomics (Singleton, & WHO, 1972)

The discovery of ergonomics dates back to the ancient Greek civilization, as there is a lot of evidence that the Hellenic civilization in the fifth century BC used the principles of ergonomics (Wahed, 2010). (Syed, 2017) points out that the term "ergonomics" was not coined by Murell in 1849 AD. Rather, it dates back to 1857 AD when Polish scholar, Wojciech Jastrzebowski coined the word "ergonomics".

Design theorists have contributed to the development of multiple definitions of ergonomic design and the design process. Most of these definitions share a convergence in meaning in determining its meaning. Jalil and Wael (2017) explained in their research on ergonomics that ergonomics in design is an intellectual and methodological framework that interacts with problems related to human wellbeing and translates the elements of this environment into structural formulation and material creation by integrating technology with environmental systems to create an environment conductivity for performing human activities and striking equilibrium and compatibility in the relationship among man, product and the environment, by diminishing the negative effects of each element on its wider surroundings.

Bin Issa (2017) quoted a definition by Bruce Archer (1969) of ergonomic design as a concept a specific description of the system adopted to design the artificial approach or the process of assembling the manufactured designs in a form that fulfills the desired goal. Giving due attention to enhancing human performance, reducing injuries, and realizing acceptable performance, this may rely on the proper application of the aspects of ergonomics when designing, which seeks to apply theories, principles, data and methods to design in order to

optimize human wellbeing (Haraz and others, 2017). Thus, there are ergonomic design considerations that must be considered for the success of the design process (E. nada, 2019) pointed out that the unavailability of these ergonomic aspects and the requirements of accessibility in many smart designs is a major issue due to the limited user interface options.

Smart design:

In Lee's study in (2020) on smart-fashion product, the researcher highlighted some endeavors to bring fashion and technology together to render digital advantages to users. This study sought to explore that optimal way to develop smart fashion models that provide multiple user-oriented functions to promote the potential features of fashion. According to the market analyses, it is expected that there will be steady growth in this category of smart design market at an annual rate of 12%, and up to 25% until 2222 AD (Joler and others, 2019).

Through a research study by Mania and Chouk, 2016, models that offer various functions have been developed. Such functions include: Redetection, which refers to detecting vehicles or people approaching the user's back side as it warns them through vibrations. A Bluetooth provides remote control functions (so that the user becomes hands-free) and vital signal monitoring which offers dynamic monitoring that measures and displays heart rates and the user's body temperature through a smartphone application for the user's health care. In a nutshell, smart products usually contain: sensors that collect data about the environment, and “operators” who activate a specific procedure controlled by others, and a “network connection” that can take many forms, including Wi-Fi, Bluetooth, or RFID.

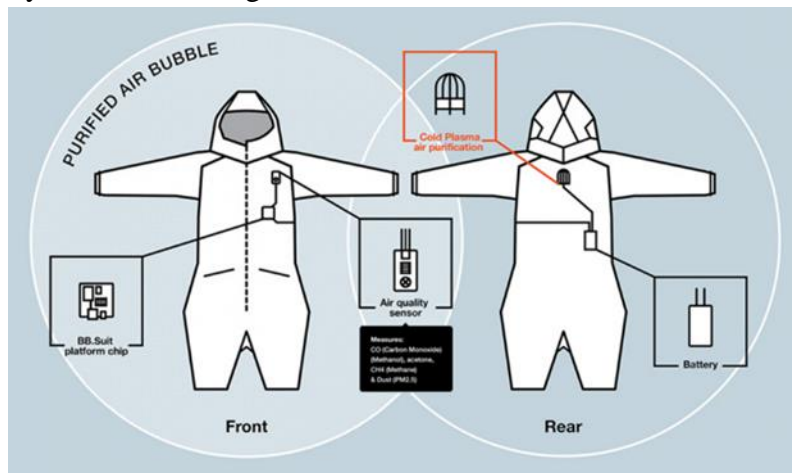


Figure (4): Smart design by Akkersdijk Borre 3D designer for NFC, GPS, Bluetooth and Wi-Fi. (byborre.com)

Designing of smart bags:

Bags are considered clothing accessories and they constitute one of the areas of design characterized by a peculiar nature. The success of the design process primarily relies on the ability of the designer to comprehend the nature of the accessory's domain, and the relevant foundations associated with the design formulation (Shakir and Almadah, 2017). Among these foundations are the ergonomic and aesthetic values. In the contemporary era, the designer links his designs to the user and the product to achieve the best possible design values.

This makes incumbent upon us to study a set of modern technological and visual traits - such as form, color and interactive effects – that can be utilized in a new style based on inventive


thinking and out-of- the box strategies to realize creative thought. Therefore, this shall pique the attention of the target group (Shaban and others, 2019).

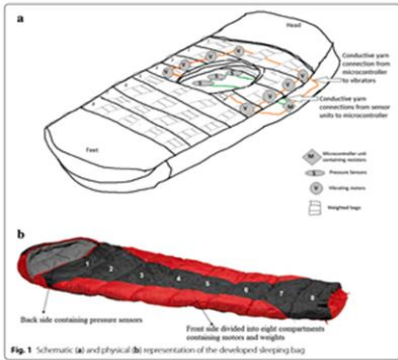

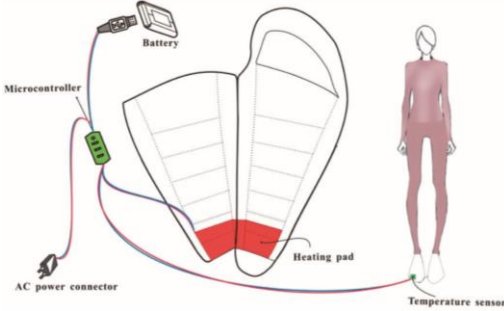
Table (1): advantages and disadvantages of using smart bags (researchers)



no.	Advantages of smart bags	Disadvantages of smart bags
1	It is difficult to be lost or misplaced.	often, it is linked to a compatible application on the user's phone.
2	It gives an immediate response to the user.	High temperature of some of the used batteries.
3	Empowering the user to perform some tasks easily and smoothly.	it is difficult to apply data security standards due to the small size of the data processor.
4	Promoting productivity to integrate many functions into an integrated system.	
5	Increasing the link between the user and the surrounding environment.	


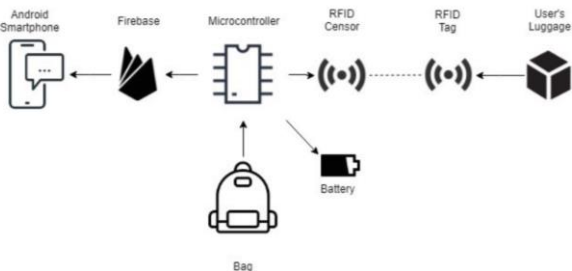
An analysis of the smart bags highlighted in past literature:

Table (2): Smart bags description (researchers reviewed from previous studies)

Bag1	
Reference	Gindi and others (2016). Smart Bag Using Solar and RFID Technology,
analysis	This smart bag provides a mobile phone battery at the lowest cost. The battery will be charged during the day using solar energy; moreover, it can be used to charge electronic devices when necessary, such as smartphones, laptops.... etc. The person's daily schedule also appears on the LCD screen at the front of the bag. RFID is employed to guarantee that all textbooks are in the bag and a notification will be sent to the student with regard with any book missing according to the school schedule

<p>Bag 2</p>	 <p>Fig. 1 Schematic (a) and physical (b) representation of the developed sleeping bag</p>
<p>Reference</p>	<p>Biswas, T. T., Infirri, R. S., Hagman, S., & Berglin, L. (2018). An assistive sleeping bag for children with autism.</p>
<p>Analysis</p>	<p>A smart sleeping bag based on sensors integrated with the fabric is used to the waking stage of autistic child; it has also triggered to calm the child down in order to sleep. To this end, a precise body motion detection sensor, which relies on conductive strings attached to the vibration motor. In the interior part of the sleeping bag, there are balanced holes to provide deep touch and relaxation sensation in the form of wearable technology.</p>
<p>Bag 3</p>	
<p>Reference</p>	<p>Jokić and others. (2019). Comparative analysis of cryptocurrency wallets vs traditional wallets.</p>
<p>Analysis</p>	<p>It is smart digital wallet equipped with a USB made for cryptocurrencies. It provides special security services along with an option to lock the wallet using a secret code and back up information. It has a small screen in front of the device so it can be managed without any difficulties. Several functions are available such as digital currency exchange, transfer of funds from one account to another.</p>
<p>Bag 4</p>	

Reference	Zhang and others (2017). Designing a smart electrically heated sleeping bag to improve wearers' feet thermal comfort while sleeping in a cold ambient environment.
Analysis	It is a smart sleeping bag that is electrically heated through integrating a harmonious and integral heating control system into the traditional sleeping bag. Its objective is to keep the temperature of the human feet within the neutral temperature range (i.e. from 25.0 to 34.0 ° C) by automatically adjusting the thermal energy to the area of the feet based on the human toe temperatures in real time. This is to enhance human thermal comfort through human experiments.
Bag 5	
Reference	Sheth, and others. (2019). Smart Laptop Bag with Machine Learning for Activity Recognition.
Analysis	It is a smart laptop bag, making it easy for the user to track and monitor their valuables in real time. The bag design uses cloud computing and machine learning algorithms to monitor user's health. It also uses several devices, including RFID, LCD, Bluetooth and SOS. The emergency alert system in this bag can be adjusted to send real time notifications to the user's contacts in case of emergencies such as abnormal health conditions or bag theft. This bag utilizes a deep neural network.
Bag 6	
Reference	Shweta and others (2016). Multipurpose Smart Bag.
Analysis	This smart bag is smartly designed to execute various features for daily use. A solar panel attached on the front part of the bag will charge not only the electronic such as cell phones, laptops, and etc. but will also power the entire system. RFID technology is used to solve the problem of forgetfulness when packing the required items. In dangerous situations, there is an emergency button which when pressed a buzzer will get

	<p>activated and the location of the victim will be sent via SMS to three contacts as well as to the police control room. Another feature is an anti-theft feature which will track the mobile phone in case of any theft. Bluetooth Module is used for tracking purposes.</p>
<p>Bag 7</p>	
<p>Reference</p>	<p>Chun, Jaehoon & Lee, Myungsu. (2016). Developing a SEIL (Smart Enjoy Interact Light) bag utilizing LED display.</p>
<p>Analysis</p>	<p>It is a smart bag manufactured for cyclists using LED and smartphone applications. The bag can allow cyclists to communicate with others. A compact backpack is developed to support all outdoor activities. Traffic lights can appear using a wireless controller. Design features include a fabric used for IT devices, thick and heavy-duty fabric for flexible LED lamps; a thin mesh which allows air and light; a flexible circuit board designed to absorb different shocks; UV coating to stop water leakage as well as provide durability. The bag can be useful in a variety of outdoor sports and in commercial applications as well. The detachable part can be used as a separate bag. The bag can protect cyclists from traffic accidents, and can also be used to express information or images. This is because it is an interactive fashion item that focuses on communication.</p>
<p>Bag 8</p>	
<p>Reference</p>	<p>Akbar, and others (2019) Smart Bag Prototype with Apriori Algorithm.</p>
<p>Analysis</p>	<p>This smart bag is designed using an Android based algorithm and application. The bag uses RFID technology to track the needed items, i.e. to read or discover the items contained in the bag. The owner of the bag will be notified when any item is missing via an Android mobile phone application.</p>

Results and discussion:

Both researchers utilized the card proposed by (Al-Hibri, 2016) for introducing the indicative requirements of ergonomic values after making some necessary adjustments in order to comply with the current research. With the help of this card, it was made clear how to gauge the degree of importance of each of the ergonomic elements through the designer. Data were then analyzed so that the designer could easily synergize the aesthetic and the aromatic elements according to the degree of importance. Here is an analysis of the smart bags mentioned in the past literature:

Table (3): Ergonomic aspect’s analysis Card of the smart bags

Ergonomic aspects	Bag ١	Bag ٢	Bag ٣	Bag ٤	Bag ٥	Bag ٦	Bag ٧	Bag ٨	total	%
minimum acceptance	53	٤٧	٤٧	٤٥	٣٤	٥١	٥١	٤١	369	76.8%
Easy to control	58	٤٠	٣٦	٤٤	٣٦	٣٦	٤٥	٣٥	330	%68.7
Needs codes	39	٣٨	٤١	٣٨	٤٤	٤٧	٤٤	٥٠	341	%71
Foldable	35	٥٠	٣٨	٤٧	٣٨	٣٥	٣٨	٣٧	318	66.2%
Functional	53	٥٥	٥٤	٥٥	٤٨	٥٧	٥٨	٤٩	429	89.3%
Security	52	٤٥	٥٥	٤٦	٤٦	٥٦	٥٣	٤٩	402	83.7%
Detachable	44	٤٣	٣٥	٤١	٤٠	٣٥	٤٣	٣٩	320	66.6%
Large	49	٤٥	٢٤	٤١	٤١	٥٠	٤٨	٤٣	341	71%
For a certain age	45	٥١	٣٨	٤٣	٤٠	٤٧	٤٧	٤٢	353	73.5%
Understandable	57	٥٢	٥٤	٥٧	٤٣	٥٦	٥٧	٤٣	419	87.2%

The data included in the above-mentioned table was analyzed to get frequencies, ratios and descriptive statistics. According, to (table 3). The results of the analysis came as follows: The highest percentage of ergonomic aspects in the smart bags for (12) specialists in clothing and textile, lies in, its functionality with (89.3%). And how much understanding of the characteristics of the bag with (87.2%) and the level of security with rates (83.7%). These scores were relatively high. However, each of the following ergonomic considerations got a rate of importance ranging from (76 %) to (71%) which is the least aesthetically acceptable of the smart bag need is the size and if the bag needs codes or not. The other considerations got a rate of (66%) which is the bags being” foldable or detachable” got the lowest scores among the ten ergonomic aspects mentioned above.

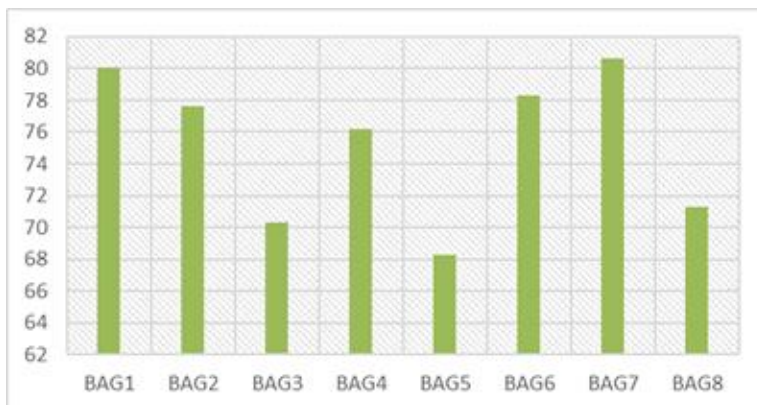


Figure (5): Shows the ergonomic aspects degrees of the smart bags

The earlier graph illustrates the score of ergonomic factors obtained by each smart bag studied earlier. The seventh bag got the highest score (80.6) as it combines aesthetic value, functionality, comfortability and safety in bag design, followed by the first bag and at last the sixth bag got a score of (7[^].3) in terms of having ergonomic factors. The fifth bag got the lowest score of ergonomic evaluation among the other smart bags with the lowest rating on design aesthetics. Although, there are many functional features, and this indicates the importance of minimum acceptance of aesthetics in bag design.

The remaining bags obtained scores ranging between (77.6) and (70.3). Moreover, the graph generally depicts the affinity of the bags' scores and this reflects that taking the ergonomic factors is both a need and an inherent in smart design.

The results can be concluded as follows:

1. Applying ergonomic standards in smart design enhances the relationship between the consumer and the bag. This shall give to prolong the product life cycle.
2. Categorizing the use of ergonomic criteria in the field of smart bags are represented in a several categories, namely the location of the bag, theft control, the ability to charge smart devices through it, and the use of ultrasound sensors to track the owner's bag.
3. Most of the smart bags that have been analyzed have RFID technology to solve the issue of forgetting when filling the required items.

Conclusion:

In this paper, we conducted a study on smart bags that were covered in past literature. This academic attempt would offer solutions to the problems encountering the user. Through the analytical study in this research, some ergonomic factors that must be considered when designing or developing clothing accessories in general and smart bags in particular future have been revealed. To move forward in this research attempt on ergonomics of bags, we have considered the applicability of these ergonomic aspects in the design of new smart bags with the addition of several interactive functions. In conclusion, both researchers recommend the necessity of the ergonomic aspects in fashion design and its accessories, especially smart ones. Furthermore, they recommend conducting a lot of research and studies that address the impact of ergonomic considerations on fashion design and its accessories.

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