





Thermo-transferable Vinyl as High Embossment Textile Finish for the Visually Impaired Pattern Recognition by Haptics Perception - Case Study

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Abstract. This research performs a quantitative, descriptive and documental study analyzing the following factors (i) preference (ii) perception (iii) textile surface character-identification; through a vinyl thermo-transference finish complying with an inclusive fashion approach for the visually impaired. In order to achieve this process, a study case was performed at Universidad Técnica del Norte with a group of visually impaired students. Data is gathered through a survey and templates designed with letters, numbers, symbols, diverse shapes, *braille writing*, 4 types of textures and embossment thickness from 90, 110, 325 to 600 μ . Application time fluctuates between 10–20 s at 155 °C.

Keywords: Thermo-transferable · Inclusive fashion · Touch

1 Introduction

History has defined fashion as an individual's essence, a symbol of status, creed and sense of belonging according to time and space [1, 2]. Clothing provides self-sufficiency but at the same time, instills a series of inclusive and exclusive stereotypes [3]. Frequently, clothing designed according to the wearer of clothing's need not only should look good, but also should conform to the body [4]. In this context, the designer has to potentialize human diversity and residual capacities of the general public, that is to say those who overcome "sensorial channels" shortcomings [5, 6].

Clothing has an intimate relationship with each individual, beyond being a necessity, not to mention the visually impaired who represent an economically active population increasingly getting inclusively involved in normal activities of society hence challenge to design new products and services [7, 8]. At the beginning of the XVIII century, clothing was tailor made by hand [9]; Today individuals with functional diversity have access to required social benefits, including clothing.

Perhaps the concept of thinness and beauty is internalized differently among the visually impaired since having a kind of disability, deficient memory and reasoning may result in a hurdle in understanding space and environment. Such individuals may prefer to remain in one place instead of going out and explore [10–12] therefore, a designed

centered in the upper and lower part of the body and garment selection to form an outfit is desired [13].

As inclusive fashion consolidates as a field of interest, new efforts like inclusive fashion shows to increase and develop methods and tools that fulfill the need of this interest group prove that participants help the development of proposed fashion collections, methods and techniques applied to fashion design fulfilling requirements that many fashion designers disregard [14, 15]. Although fashion companies focus on fulfilling diverse segments of consumers, the need for studies and development regarding the visually impaired is vital [16]. While there are “variables” and complex challenges in this interest group, the approach of several research work is aimed to the visually impaired environment and the development of gadgets and new technology according to their needs [17, 18].

Although efforts are made to keep the designed closely linked to choice and preference [19] it should be noted that firstly, products offered to the impaired meet their expectations, secondly that inclusive garments have information not affecting the attractiveness of the garment or quality material [20].

Body senses have been extensively studied by psychologists, now it is being studied by modern science [21]; eyesight is essential for human beings, but not indispensable; the visual sensorial perception allows for the gathering, integration and data memorizing in extremely limited time, while surface and texture causes stimuli, irregularity turns into vibrations as touched by fingers traveling through two types of mechanoreceptors: *Meissner and Paccini* corpuscles signaling tactile-vibro signals perceiving minimal changes in the surface of a particular element [22–24].

Braille reading system is a consequence of *Louis Braille*’s own blindness-the inventor of this the first embossment approach translating alphabet visual environments into tactile form [25]. Meeting the “criteria” for subjective and visual aspects of fashion such as color and fabric combinations presents a challenge [15, 26].

Finally, with the development of this research, it is intended to establish the relationship between the type of relief and the ease of identification of patterns by people with visual disabilities. This pursues a primary objective that is that improvements can be granted in the degree of autonomy in the blind individual with the development of products that stimulate perception by touch [16, 27, 28].

2 Materials and Methods

The methodology applied is focused on the case study consisting of a 13-visually disabled student interview at *Universidad Técnica del Norte* (UTN), with the purpose of establishing whether the vinyl thermo-transference high embossment finish may influence of information-recognition through haptics perception as well as the identification of possible strengths so that the development of inclusive fashion textiles based on the visually impaired is highly likely in the immediate future. The study center is in Ibarra city, Ecuador geographical coordinates (0.37816764316765145, -78.12318267916226) with 35 undergraduate careers covering the northern area having a large influx of students. (See Table 1).

Table 1. Student population UTN

Academic period	Female	Masculine	Total
September-February 2022	5757	5193	10950

2.1 Instrument Construction

Work Plan Outline—after getting feedback from the socialization project students, questionnaire is generated with questions aimed to determine haptics perception levels. Team work is comprised by 3 research professors, 2 technical professors and 3 students so field work has 4 pollsters. Work material has: (i) printed forms (ii) 2 vinyl finishing-fabric sampling kits (Figs. 1 and 2).

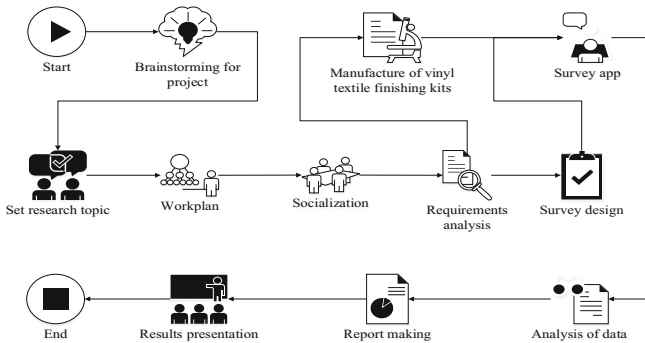


Fig. 1. Research work-plan diagram

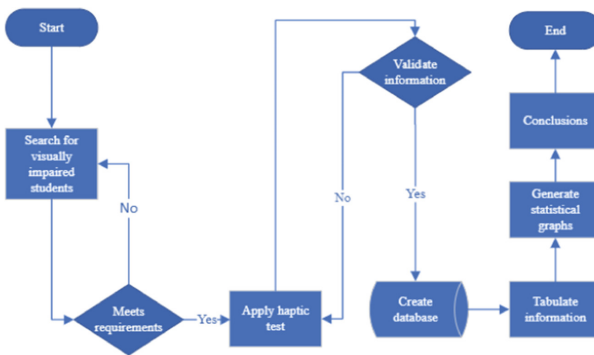


Fig. 2. Research flowchart

A survey data-gathering instrument was created and denominated: “Manufacturing of textile products based on inclusive fashion for the haptics perception analysis”.

The document has 5 well-defined sections: a) Respondent profile b) visual impairment information c) fabric preference d) texture and size perception) symbol recognition and information by haptics perception. The instrument has Likert-scale type of questions ranging from 1–5 (1 minimum level and 5 the best), close-ended YES/NO questions to include open-ended varied questions.

Kit's Design Based on Thermo-Transference for Haptics Perception. Kit A, (shown in Fig. 3), is intended to determine the sensibility degree that a visually impaired individual develops over time to the use of textiles, the respondent should strive to recognize textile conditions such as softness or roughness, as for fabric density thinness or thickness.

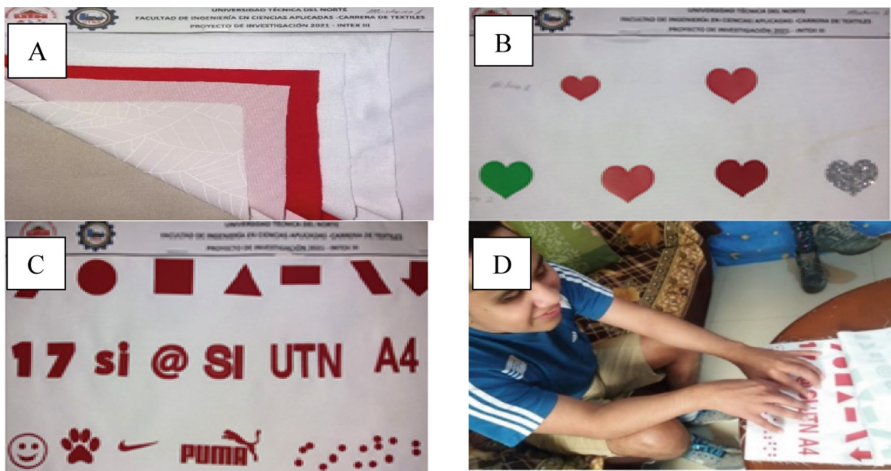


Fig. 3. Haptics perception Kits (kit A, B, C, D)

Textile substrate used for the preference are detailed in Table 2 are made of materials, and knitting in the most common daily wear garment presentations.

Kit B has vinyl finishes. In the upper part there is a “heart” symbol in two sizes 1, 5 cm and 3 cm., while in the lower part of the film there are vinyl thermo-transference finishes in 4 presentations: 90-micron smooth, 110-micron smooth, 600-micron highly embossed smooth finish and 325-micron, shiny-effect finish. This spreadsheet is intended to study the degree of sensitivity by size, embossment and texture.

Perception by Size. Determines whether a shape is adhered to the knitting surface and also enlightens the effects that size have on sensitivity degree and how it may influence the information presented.

Embossment and Texture Perception- with the help of touch the visually impaired can determine the type of vinyl adhered to a surface thus enhanced shape recognition.

Information Identification—Kit C has 3 geometric shapes rows, alphanumeric characters and symbols. A different type of finishing vinyl is assigned to each film intended to

determine if the information complexity has an influence on processing and identifying characters by sense of touch.

Table 2. Textile Substrate characteristics

Textile substrate	Category	Composition	Woven fabric-density (g/m ²)	Common use
Knit fabric	Jersey	Pes/Co 65/35	117	T-shirts, underwear,
	Perched fleece	Pes 100%	250	Sports clothing
	Piqué	Pes/Co 65/35	268	Polo shirts
Flat cloth	Fine taffeta	Co 100%	107	Shirts, blouses (formal wear)
	Average taffeta	Co 100%	155	Table linen, bed sheet (house linens)
	Industrial trench coat	Pes/Co 65/35	219	Work clothes

2.2 Participants

Before the study a general university population is performed to establish whether there are students registered as “visually impaired” as shown in Table 3 meeting the ideal analysis profile.

2.3 Selection and Preparation Material for Vinyl Based Thermo-Transference

Preparation and Vinyl Design Cut—Vinyl graphic design is performed with the Adobe Illustrator Cs6 vectorial program.

Design Cut Over Vinyl—A cut-plotter is used for Graphteccorp CE6000–60 vinyl, the vinyl films and the cutting blade are set up in a 45 to 65 inclination degree. A stiletto separates the area to be thermo-transferred to waste.

Cut Vinyl Application Over Textile Products—A transfer plate applies heat which activates vinyl’s adhesive over the fabric web under conditions presented in Table 4.

2.4 Research Questions

Under the determined structure in [29], questions are raised to establish the following degrees: (i) preference (ii) texture and size perception (iii) thermo-transference textile based products information identification by embossment.

Table 3. Frequency chart—respondents information

Respondents' characteristics		n	%	% Accumulated
Gender	Women	6	46, 2	46, 2
	Men	7	53, 8	100
Age	18–28	9	69, 2	69, 2
	1	1	7, 7	76, 9
	40–50	2	15, 4	92, 3
	51–61	1	7,7	100
Program	Applied science engineering	1	7,7	7,7
	Education, science and technology	9	69, 2	76, 9
	Administrative and financial sciences	2	23, 1	100
Type	In-person	7	53,8	53,8
	Blended learning	1	7, 7	61, 5
	Online	5	38, 5	100
Impairment degree	Low	7	53,8	53,8
	Moderate	4	30, 8	84, 6
	Severe	2	15, 4	100

Table 4. Technical vinyl datasheet: Application [27].

Commercial name	Easy weed	Easy wed Sub-blog	Brick 600	Glitter
Temperature (°C; °F)	150 °C 305 °F	130 °C 265 °F	155 °C 311 °F	160 °C 320 °F
Application time (s)	10–15	10–15	20	10–15
Pressure	Average	Average	Average/high	Highs
Composition	Polyurethane	Polyurethane	Polyurethane	Polyurethane
Thickness (microns)	90	110	600	325
Finish	Smooth	Smooth	High embossment	Shiny effect

Preference Analysis Questions. Do the visually impaired address their textile preference based on information sensed by touch?

In the survey, questions a - g grades this item.

Size Perception Analysis Questions. Are haptics perception determinant factors closely related to shape size?

In the survey, questions “h”, “i” y “j” grades this item.

Texture Perception Analysis Questions Texture embossment in a thermo-transference vinyl textile product influence on selecting of them?

In the survey, questions “k”, “l” y “m” grades this item.

Vinyl Thermo-Transference by Embossment Textile-Based Products Identification of Information Analysis Questions. Does the complexity of the information in thermo-transference vinyl hinder the visually impaired a degree of autonomy when selecting textile products?

3 Results and Discussion

The thermo-transference vinyl haptics perception survey is subject to a statistical analysis using IBM SPSS Statistics software; reliability results from the instrument using Cronbach alpha preference sections in respect to textiles, size perception and texture, finally information identification by haptics perception are classified within robust and reliability ranges [30] (Table 5).

Table 5. Reliability analysis

Survey section	Cronbach alpha
Preference	0,851
Perception	0,826
Information identification	0,933

3.1 Preference

The first elements refer to the visually impaired students among low, moderate and severe who regularly attend class 53,8% men and 46,2% women. The age category in this group is mainly comprised by young adults between 18 and 28 years old, representing 69,2% of total respondents whereas the remaining respondents ranged between 29–39, 40–50 years old and 51–61 hold 7,7%, 15,4% and 7,7% respectively.

Qa data gathered, determined that respondents associate texture with colors vital to identify the garment to be worn; they consider this factor as essential—46,15% while only 7,69% of respondents said that texture is not important. Therefore, a visually impaired individual prefers a textile fabric or functional product as seen in **Qb** since 53,85% of respondents favor detail, while usability and fashion are not meaningful having each factor a percentage value of 23,08% (Fig. 4).

Fabric softness, roughness, thinness and thickness are important points to be considered since, according to data gathered in **Qc**, the visually impaired associate these elements for daily garment selection, that is, they identify textile substrate and their characteristics determined by weigh per unit area (g/m^2), surface finish and /or woven type.

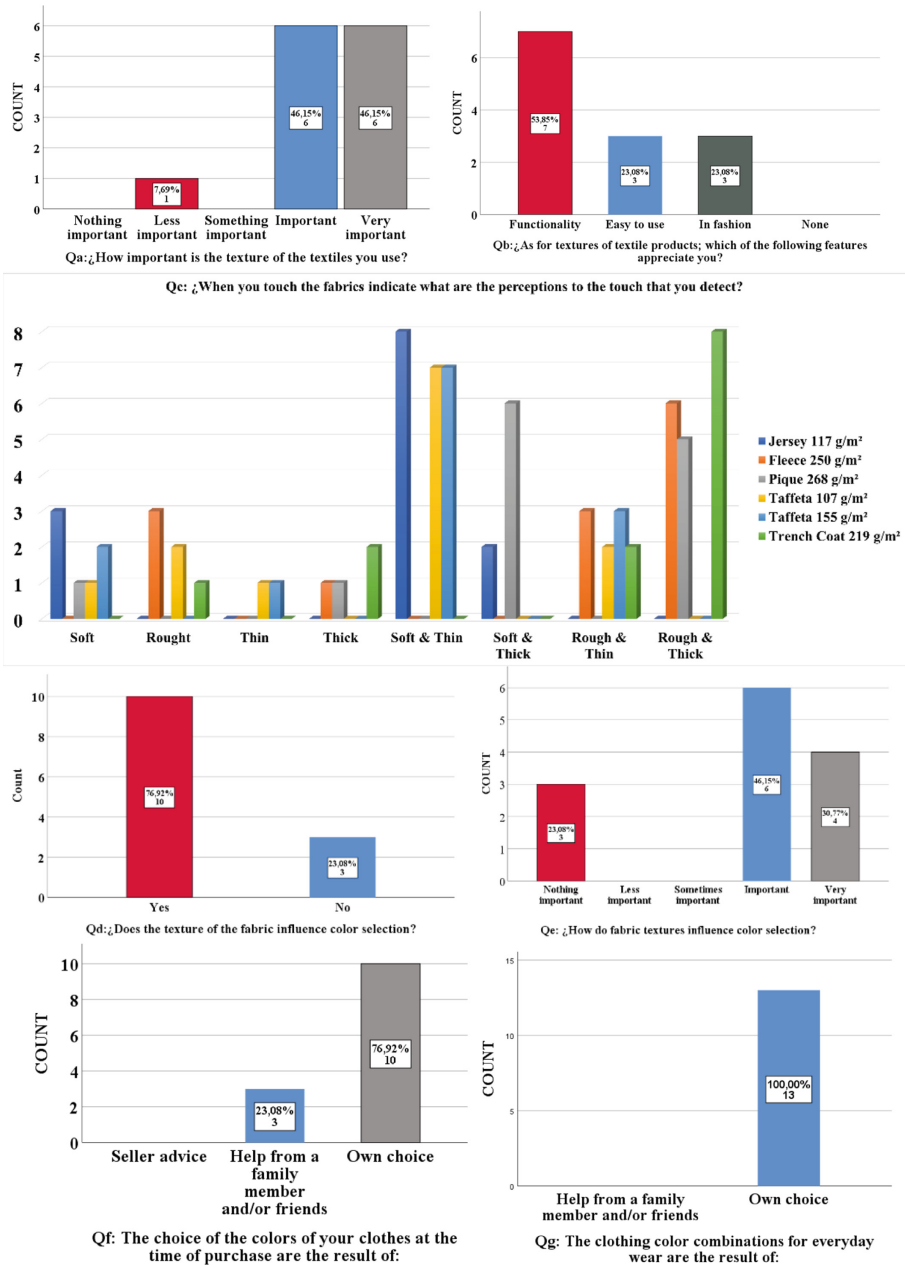


Fig. 4. Section-survey preference analysis; Q: a, b, c, d, e, f, g

Qd statistical results show that fabric texture serves as a guide to determine color to be worn, 76,2% of respondents agree to this reality while the rest, that is 23,08% do not take into account texture for color association. According to information collected,

there are dark tones not associated to delicate textures and to the contrary, White color for instance is associated to fine textures, concept enforced by the analysis in question **Qe where respondents considered important and extremely important** texture for color association, obtaining percentual figures 46,15% and 30,77% respectively.

Finally, preference results associated to questions Qf and Qg indicate that a visually impaired individual has a considerable autonomy degree since, when asked about color combination at the time of purchasing clothing 76,92% get their clothing voluntarily and by their own taste, while 23,08% buys clothing suggested by family members.

As per daily use according to color combination, 100% of the visually impaired choose garments voluntarily owing to their memory associating distinct elements in each garment such as texture, accessories, embossed identifiable elements allowing for a comprehensive concept what they wish to express through the clothing worn.

3.2 Perception by Size

Related questions intend to determine whether each individual’s grade of sensibility has an impact on the selection, interpretation and information identification through embossed elements, using thermo-transference vinyl directly linked to size and texture (Fig. 5).

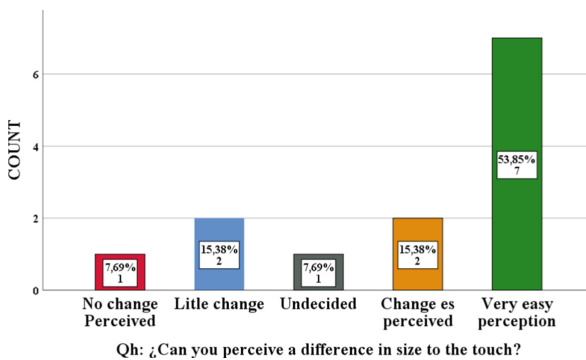


Fig. 5. Perception survey analysis Q: h

To this effect, as observed in **Qh** regarding symbols sensed by touch, the respondents may identify information related to shape size using thermo-transference vinyl. Results show that 53,85% are able to easily identify information sensed, likewise 15,38% perceive certain changes while 15,38% perceive small changes helping identify elements and 7,69% of respondents do not perceive any changes. Finally, 1% of visually impaired students are undecided (Fig. 6).

Analysis results in question **Qi** rule that thinness, embossment level and texture facilitate information identification. “Easy weed” vinyl sampling (90 microns) and “easy weed” sub-blog vinyl (110 microns) do not generate enough embossment level on textile substrate making information identification difficult therefore, 7,69% cannot achieve information identification whereas 15,38% poorly defines information and 23,08% is uncertain when identifying information.

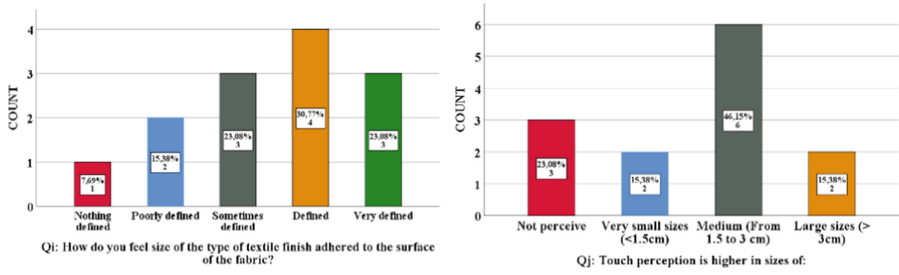


Fig. 6. Perception survey analysis Q: i, j

On the other hand, Brick vinyl (600 microns) facilitates symbol recognition with 30,77% positive responded. Similarly, Glitter vinyl (325 microns) is perceived as explicitly defined identifying and interpreting information easily. **Qj** results prove that 46,15% of respondents sense changes in the textile product measuring between 1,5 and 3 cm while diminutive or huge shapes perception hinders information identification obtaining 15,38% results for each type of referred size comparable to 23,08% who did not differentiate size in vinyl finish.

3.3 Texture Perception

An important factor to consider consists of finding out whether the texture type that thermo-transference vinyl has facilitates the interpretation of characters or even information.

In this context, results indicate that the type of texture is essential for touch stimuli. Forty-six percent of respondents (46,15%) easily identify information while 30,77% perceive changes, in 1% of each option no changes are perceived and respondents feel a slight change or are undecided (Fig. 7).

When analyzing **Qk**, **Ql** y **Qm** it was determined that the smoother the finish is through thermo-transference, the easier the character interpretation. In terms of percentages, 69,23% has difficulty in identifying 90 and 110-micron vinyl information. Equally, vinyl with pronounced thickness like **Brick 600** and 300-micron **glitter** facilitate typography on fabrics owing to embossment and texture found in the previously mentioned vinyl. Finally, as respondents were asked about different vinyl information identification 46,15% think this type of finish has a powerful impact on this finish, while 23,08% says the type of texture is notable definitely influencing the decision process when identifying information. 15,38% believe that vinyl texture sometimes may have an influence on character interpretation and the position of no-influence or somehow influence is perceived by 7,69%.

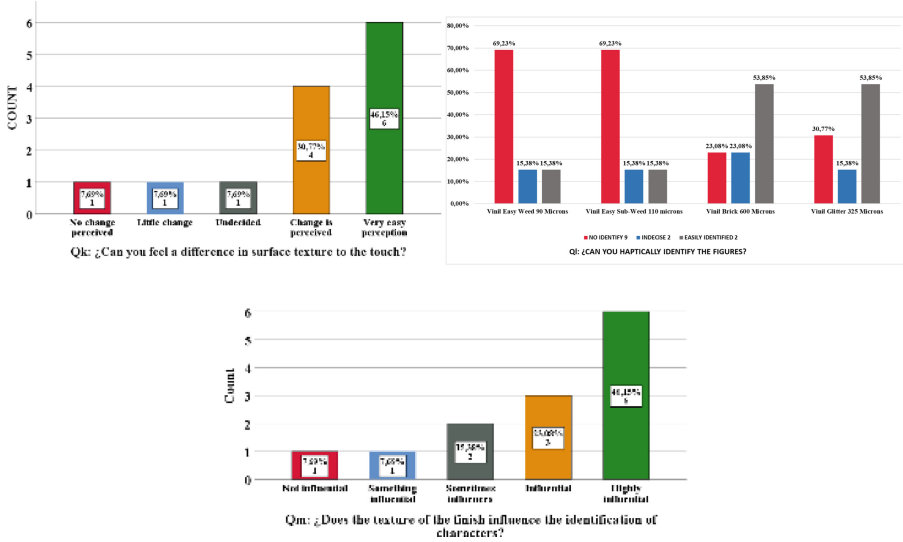


Fig. 7. Texture perception graph

3.4 Information Identification

The third part of the haptics perception evaluation instrument is aimed to determine whether the type of finish in thermo-transference vinyl affects information identification used on a daily basis by a student. For this purpose, thermo-transference-based characters correlate three scenarios: basic shapes, alphanumeric characters and symbology—unusual for the visually impaired, in other words complex information. Firstly, the level of information identification relies on 2 well-defined elements such as thermo-transference vinyl type and the kind of information in themselves.

As seen in Fig. 8-A The better the thermo-transference vinyl has embossment or texture characteristics as the ones found in *Brick 600 or glitter*, the better the degree of correctness regarding the symbology presented to each respondent. Likewise, when associated to commonly memorized basic symbology learned at an early age used on a daily basis, the degree of correctness improves making the information homogeneous.

In the case of Fig. 8-B, alphanumeric characters are not readily identifiable since there are unusual elements students are unfamiliarized with, however once memorized may facilitate information identification.

In Fig. 8-C results determined that the degree of correctness is reduced compared to previously analyzed characters. This allows determining that a visually impaired individual is not familiarized with characters a person not having this disability is, i.e., emoticons, clothes brands, and varied information owing to the little or no use of such elements by the visually impaired. However, cognitive memory quickly stores character shapes, thus making possible identification information.

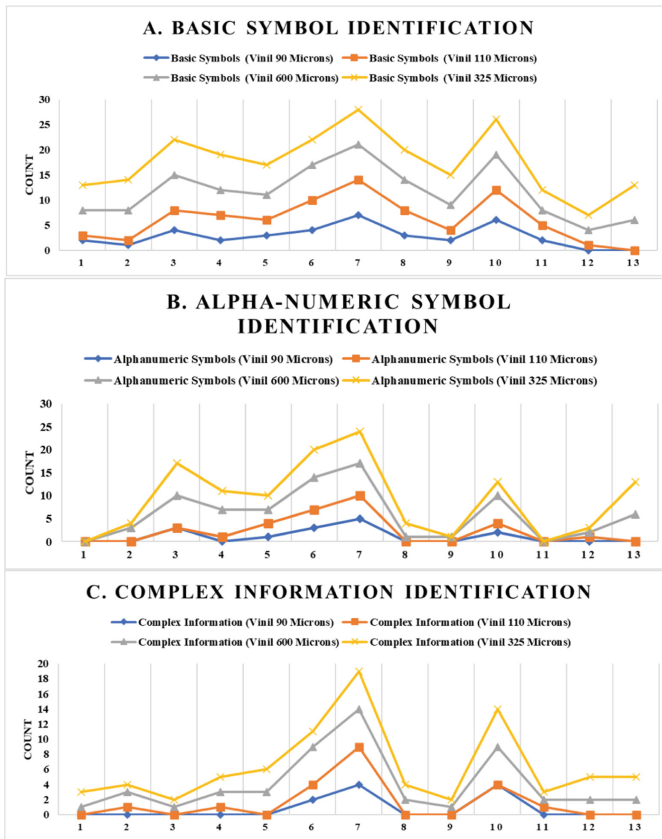


Fig. 8. Análisis de Identificación de caracteres

4 Conclusions

Visually impaired inclusive fashion para personas based on thermo-transference vinyl is considered a textile finish modern option. Moreover, this study is the first of its kind even using textile as a sustainable alternative for haptics stimuli.

As far as daily clothing worn by a visually impaired individual, the decision is by self-choice and / or by family and friends' assistance. In a certain way, the influence of fashion does not affect their personality, nonetheless it is related to customs and society. Although garment selection depends on the occasion, these individuals respect conventional dress code ruled by society. For instance, dark colors and formal wear are common in parties so they try to fit in by respecting outfit rules.

Toch evaluations performed by the visually impaired on several textile substrates make it clear that for them that functionality and usability are critical; having a notable development in the sense of touch able to recognize textures, thickness, softness and elasticity effortlessly; situation that a person with no disability would not be able to recognize, neither the use of cognitive memory for patter recognition.

Respondents of this survey have considerably developed the sense of touch thus they are capable of detect minimal changes in texture facilitate pattern-identification and shapes over finished vinyl textile substrates. Moreover, they are able to neatly identify diverse shapes size. However, we should acknowledge that this is relative, since without previous storage of a shape in an individual's mind, he will not be able to describe the element displayed.

The color-combination system from the visually impaired is associated with pattern, texture, shapes or decor cognitive memory perception found in a garment complemented by the association of colloquial vocabulary used by family members creating color references to garments. Daily practice of color memory and texture, grant a visually impaired person a certain level of autonomy as outfit selection takes place.

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