MATERIAL FACTORS IN THE TACTILE PERCEPTION OF SPHERICITY

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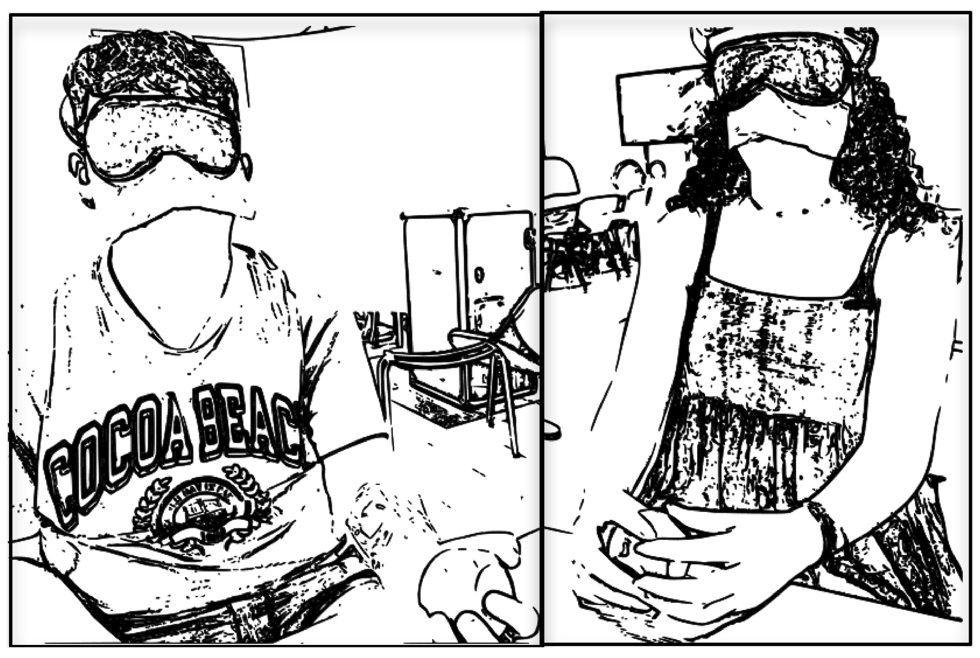
Introduction

The intelligibility of the surrounding world through the visual-tactile interrelation has been an area of cognitive sciences strongly influenced by theoretical contributions such as the perceptual-effectual differentiation of images (Von Uexküll, 1934), the construction of the real object from sensorimotor assimilation schemes (Piaget, 1977), and the theory of affordances (Gibson, 1979), establishing a framework for current lines of research such as image schemes (Lakoff, 1987), perceptual symbol systems (Barsalou , 1999), and the construction of abstract concepts (Borghi, 2022). In search of expanding the relational evidence between corporality and representations, a series of results are reported below on the role of the material arrangement of objects and their mental representation through tactile experience.

Experiment

The experimental sessions were developed on a sample of 32 students (19 women / 13 men) from *Universidad Industrial de Santander*, in the city of Bucaramanga (Colombia), in the age range of 18 to 23 years. For which a tactile recognition scenario is proposed (without visual interaction) with 9 volumetric entities in 3 scale versions, for a total of 27 stimulus elements.

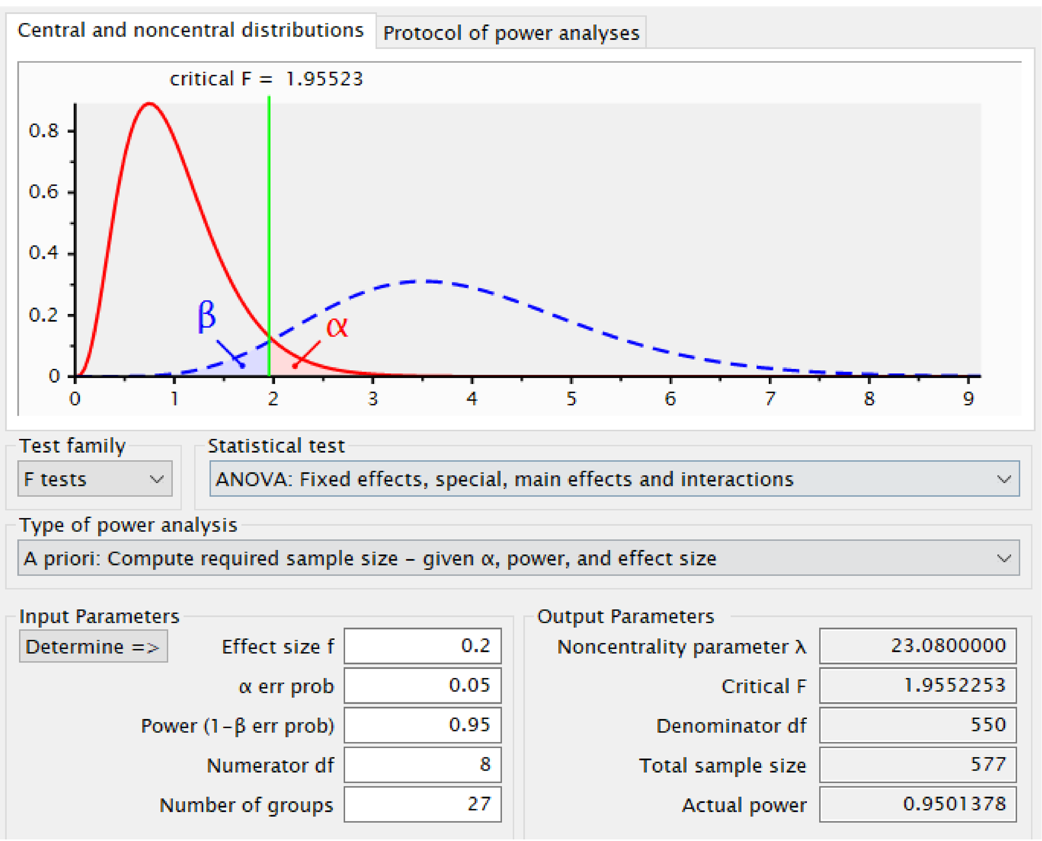
Participants palpated the objects in a random order with their non-dominant hand, and also with two hands, and issued their subjective rating on an integer scale from 0 to 10 as evidence of the degree of sphericity perceived in each stimulus object.



For the statistical treatment, a 3x3x3 factorial design with replications was contemplated (Gutiérrez Pulido & de la Vara Salazar, 2004) under the assumption of 3 primary factors involved in the perception of sphericity and 3 levels defined for each factor.

GPower - Sample size

The GPower tool (Faul, Erdfelder, Lang, & Buchner, 2007) was used to calculate the sample size.



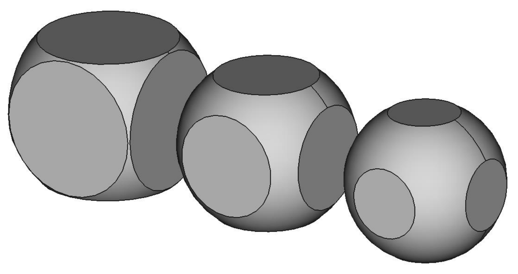
Therefore, a minimum number of 577 observations will be required for the established effect size, type I error probability and power, which in the context of a 3x3x3 factorial design with 27 treatments per subject represents a minimum number of 22 experimental subjects.

Procedure

1) Reading and acceptance of the experimental protocol by the subject
2) Demographic data collection
3) Biometric data capture (non-dominant hand silhouette)
4) Hand disinfection and drying
5) Palm friction (5 times) in order to regulate temperature
6) Placement of a mask to completely block the visual channel
7) Familiarization (two-handed) with a random subset of the test objects (3 to 5 objects)
8) Beginning of the subjective evaluation task of sphericity, in response to the question: *"On a scale from 0 to 10, where 0 is not at all spherical and 10 is completely spherical, how spherical is this object?"*
9) The subject palpates the first random object
10) The researcher will control the interaction time with the object, to prevent premature responses, managing an average of 3.5 seconds as active palpation time (per object)
11) The subject verbally issues his rating (from 0 to 10) of the object according to the perceived level of sphericity
12) The subject proceeds with the remaining 26 objects/treatments
13) The subject finishes the first experimental phase (one hand/two hands) and repeats the palpation process with the 27 treatments in a new randomized order (now two hands/one hand)
14) End of the session and removal of the mask

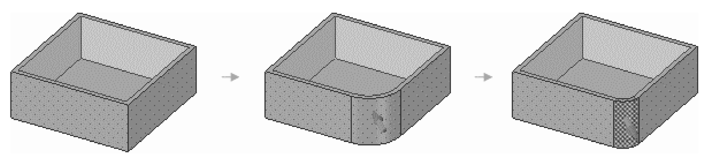
Face factor

The presence of flat faces in the object would have the purpose of evoking the cubic shape in the process of tactile perception, therefore, the percentage of flat area on the surface was gradually reduced until defining 3 geometries.



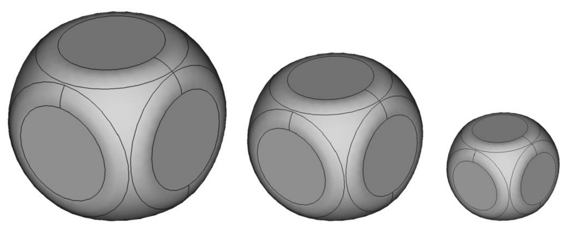
Edge factor

The protuberance of the edges derived from the angle present between adjacent faces of the solid (an element typically characteristic of non-spheroidal bodies) will be manipulated by incorporating a radius of curvature, until 3 levels of rounding are defined.



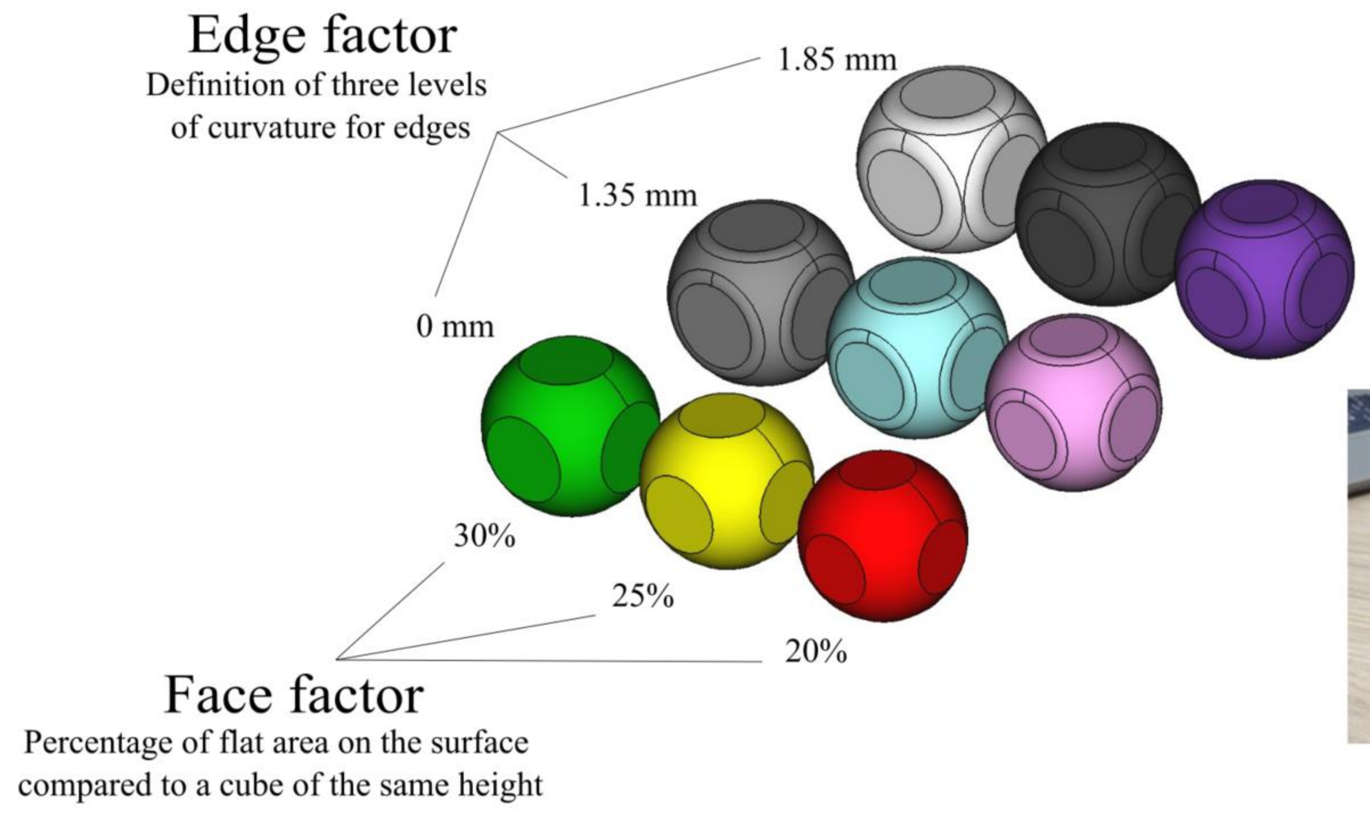
Grip factor

Regarding the role of hand proprioception in the phenomenon of tactile perception, the grip required for the interaction of each object will be manipulated through changes in size, for which 3 different heights will be defined.



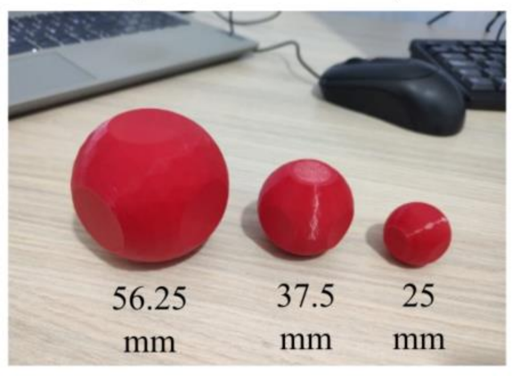
Stimulus objects

Volumetric elements within the cube-sphere gradient



Grip factor

Definition of three heights for 3D printed stimulus objects



Results

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Non-dominant hand

Response: Sphericity

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Face	2	312.52	156.260	51.3072	< 2.2e-16	***
Edge	2	137.86	68.931	22.6329	2.674e-10	***
Grip	2	15.92	7.962	2.6142	0.07382	.
Face:Edge	4	1.68	0.420	0.1380	0.96822	
Face:Grip	4	7.68	1.920	0.6305	0.64087	
Edge:Grip	4	3.30	0.825	0.2708	0.89685	
Face:Edge:Grip	8	12.62	1.577	0.5179	0.84356	
Residuals	837	2549.16	3.046			

Two hands

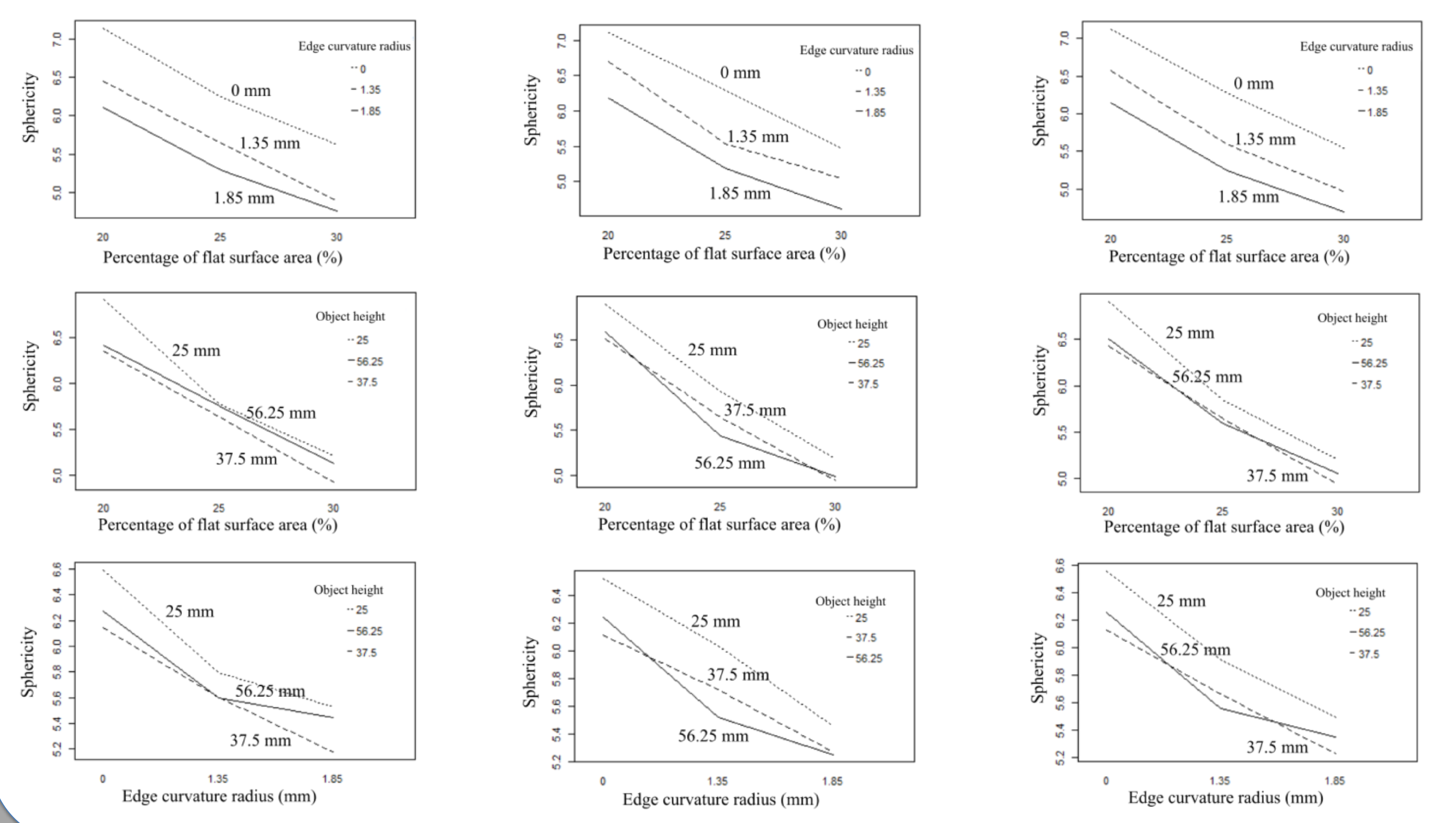
Response: Sphericity

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Face	2	385.01	192.503	57.6942	< 2.2e-16	***
Edge	2	134.69	67.347	20.1843	2.747e-09	***
Grip	2	19.52	9.760	2.9252	0.0542	.
Face:Edge	4	3.99	0.997	0.2987	0.8789	
Face:Grip	4	3.26	0.816	0.2446	0.9130	
Edge:Grip	4	4.03	1.009	0.3023	0.8765	
Face:Edge:Grip	8	17.24	2.155	0.6460	0.7392	
Residuals	837	2792.75	3.337			

One and two hands

Response: Sphericity

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Face	2	695.2	347.59	110.0402	< 2.2e-16	***
Edge	2	270.5	135.25	42.8175	< 2.2e-16	***
Grip	2	33.3	16.67	5.2785	0.005184	**
Face:Edge	4	2.4	0.59	0.1860	0.945735	
Face:Grip	4	5.8	1.44	0.4554	0.768541	
Edge:Grip	4	4.9	1.24	0.3913	0.814977	
Face:Edge:Grip	8	16.1	2.02	0.6380	0.746287	
Residuals	1701	5373.0	3.16			



Discussion & Conclusions

- There is greater significance of the face and edge factors with respect to the grip factor.
- It is confirmed that a lower percentage of flat surface is correlated with a greater perception of sphericity.
- By applying the same rounding parameter for all edges, the object tends to become "cubified", reducing the subject's perception of sphericity.
- Even under the presence of sharp edges, the perception of high levels of sphericity by the subjects was reported.
- Smaller objects correlate with higher levels of perceived sphericity.
- No appreciable differences are reported in tactile recognition ability comparing non-dominant hand and two hands.
- The following research question is posed for future work: "Why does the reduced size of objects seem to favor the perception of sphericity?" as input for the development of new corporeal models of representation

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