



HAL
open science

Perceptual Foundations of Euclidean Geometry

Véronique Izard, Pierre Pica, Elizabeth Spelke

► **To cite this version:**

Véronique Izard, Pierre Pica, Elizabeth Spelke. Perceptual Foundations of Euclidean Geometry. Meeting of the European Society for Cognitive Psychology, Sep 2019, Tenerife, Spain. , 2020. halshs-02424874

HAL Id: halshs-02424874

<https://shs.hal.science/halshs-02424874v1>

Submitted on 28 Dec 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Perceptual Foundations of Euclidean Geometry



Véronique Izard^{a,b,c}, Pierre Pica^{d,e} & Elizabeth S. Spelke^{c,f}

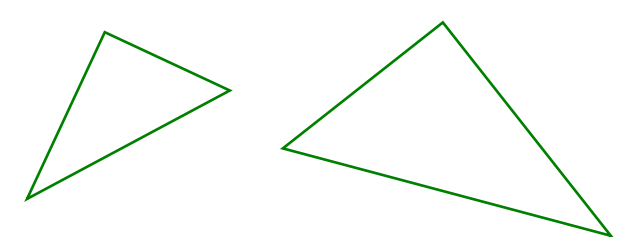
^a CNRS (Integrative Neuroscience and Cognition Center, UMR 8002), Paris, France; ^b Université Paris Descartes, Paris, France; ^c Department of Psychology, Harvard University, Cambridge MA, USA; ^d Instituto do Cérebro, Universidade Federal do Rio grande do Norte, Natal, Brasil; ^e UMR 7023, Structures Formelles du Langage, Université Paris 8, Saint-Denis, France; ^f NSF-STC Center for Brains, Minds and Machines, Cambridge MA, USA

INTRODUCTION

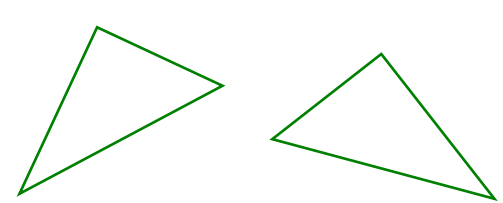
Euclidean geometry has historically be regarded as the most “natural” form of geometry (for an overview, see Hatfield, 1998). Here, we investigated whether the perception of small, 2-dimensional visual forms could provide cognitive foundations for Euclidean knowledge.

EUCLIDEAN GEOMETRY AND ITS CLOSEST VARIANTS

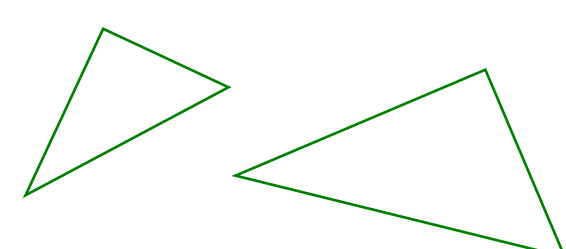
(Euclid’s) Euclidean geometry:
scale- and sense-invariant (Heath, 1956)
Relevant: metric proportions
Irrelevant: position, orientation, sense, global size



(modern) Euclidean geometry:
scaled but sense-invariant
Relevant: metric proportions, global size
Irrelevant: position, orientation, sense

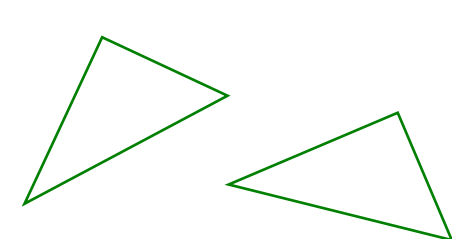


Scale-invariant sensed geometry
Relevant: metric proportions, sense
Irrelevant: position, orientation, global size



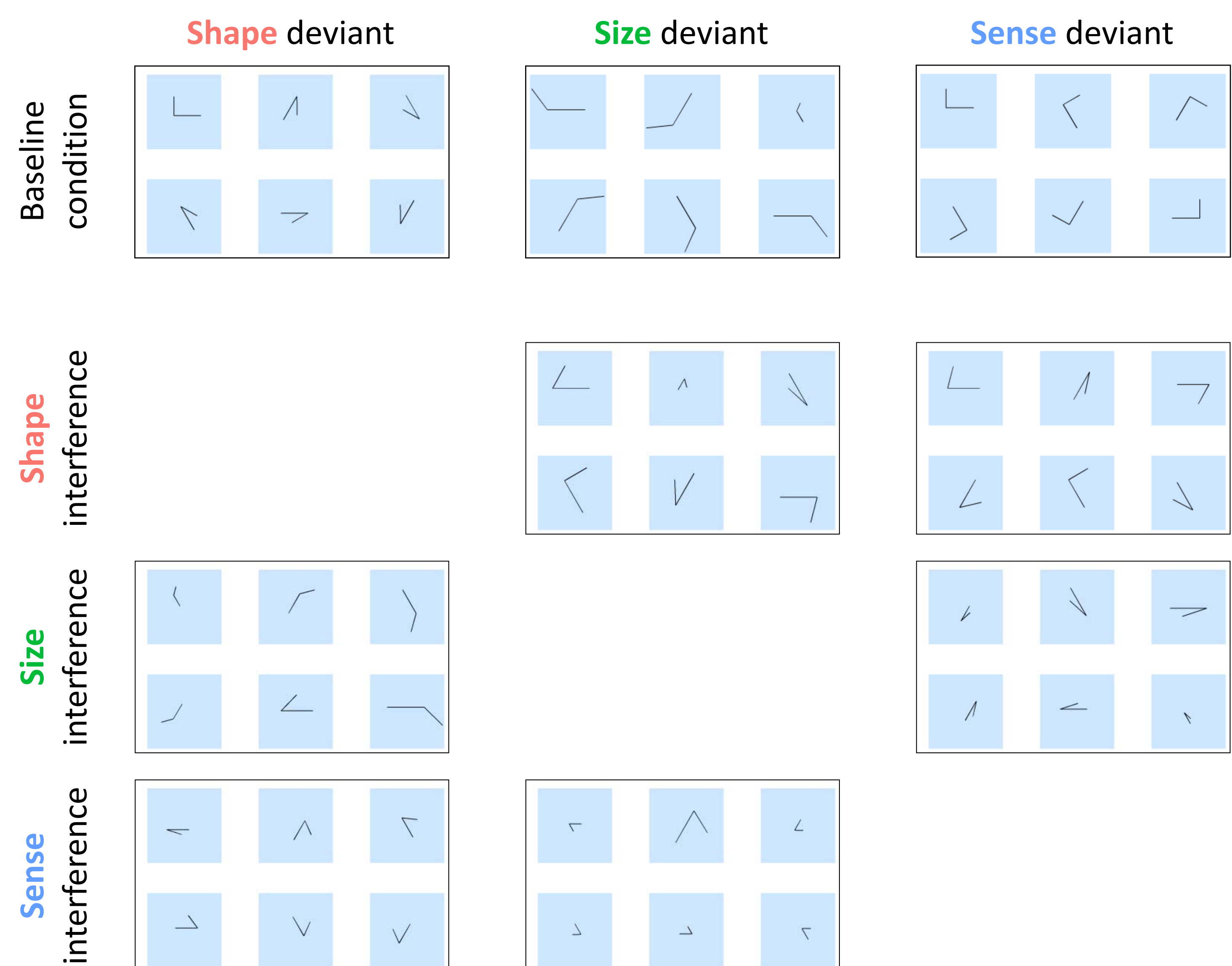
Geometry of solid objects:
scaled and sensed

Relevant: metric proportions, global size, sense
Irrelevant: position, orientation



TASK AND DISPLAYS: « Which picture is most/very different? »

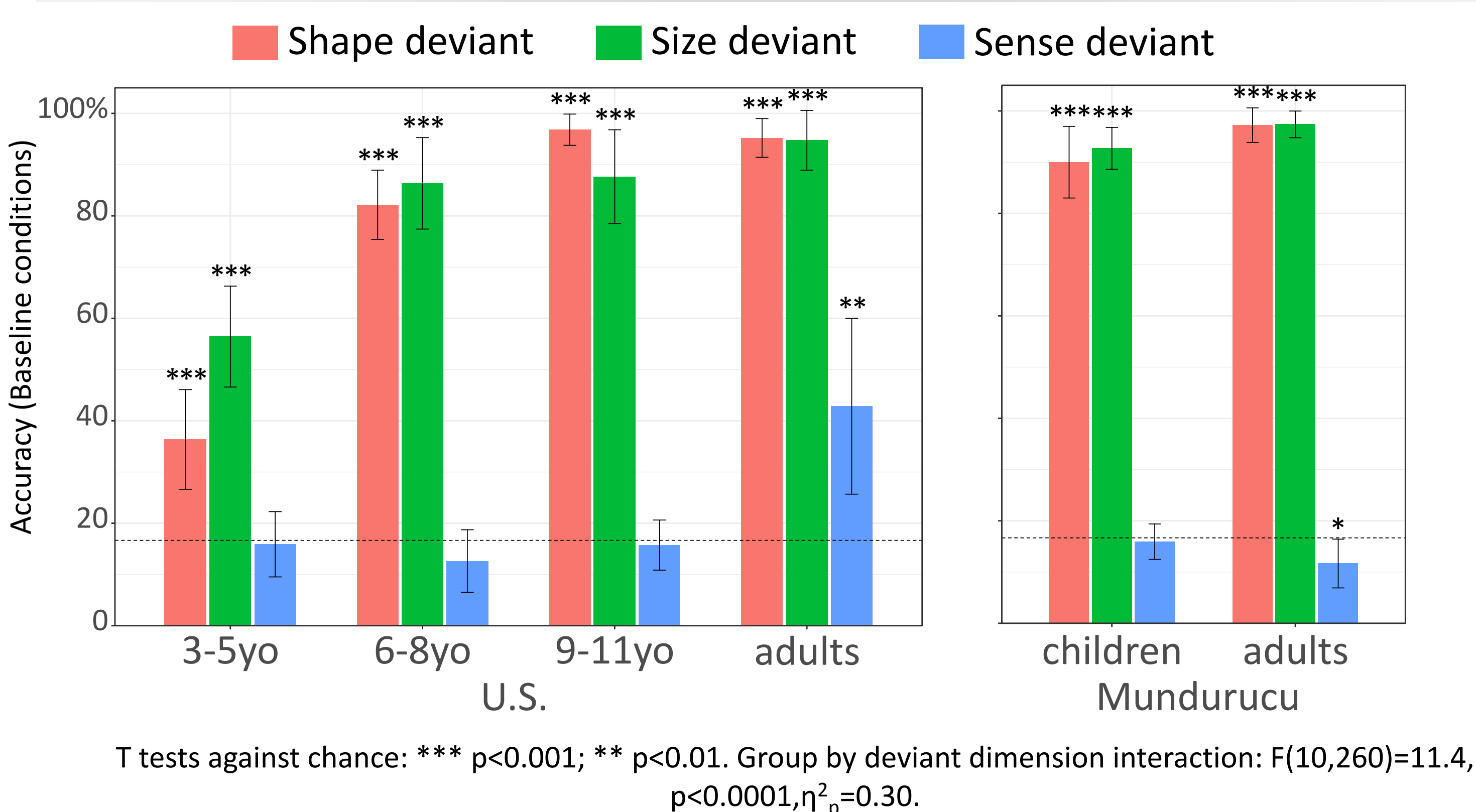
27-162 trials per participant



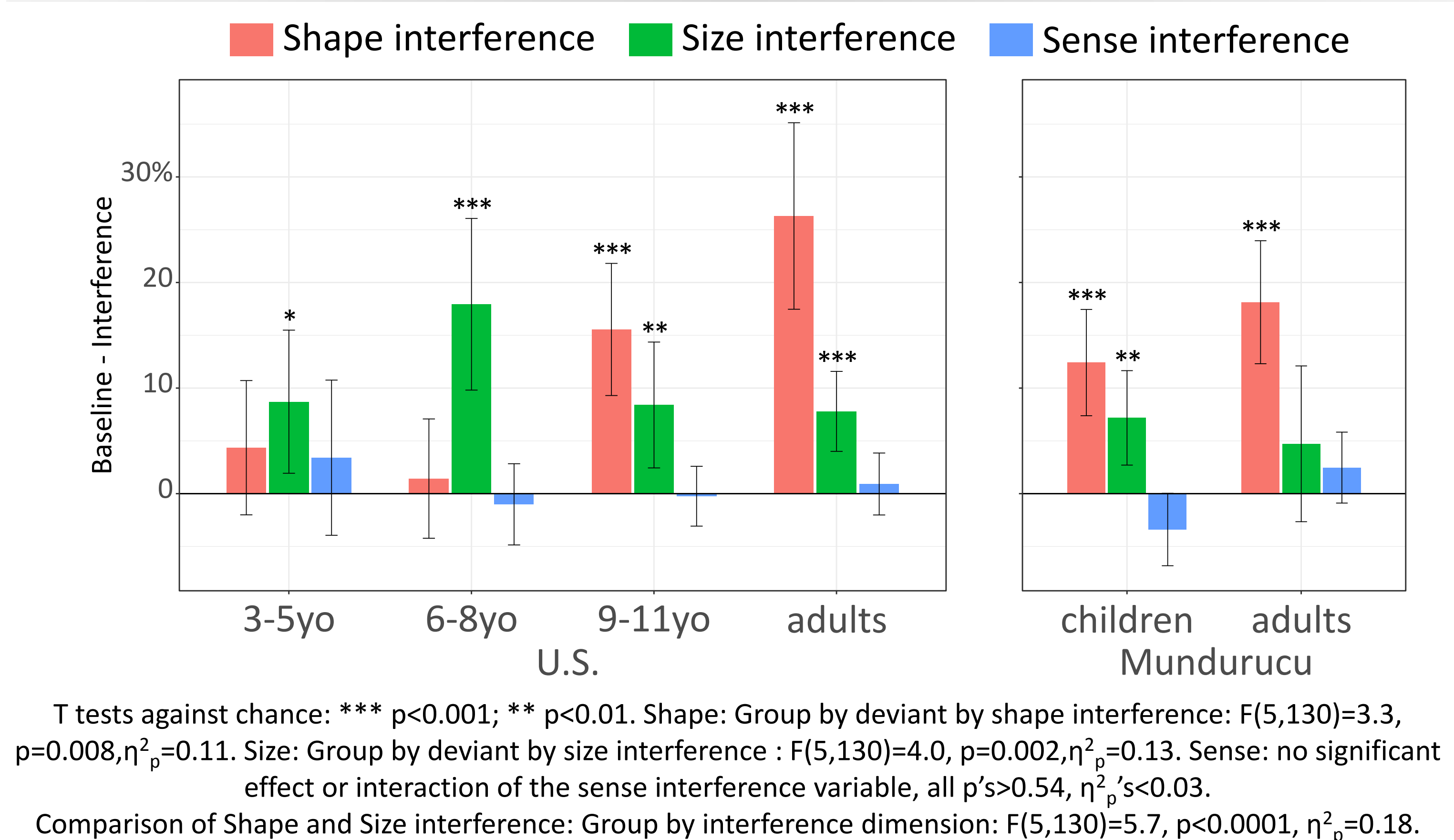
PARTICIPANTS

U.S. 3-5yo children	U.S. 6-8yo children	U.S. 9-11yo children	U.S. Adults	Mundurucu children	Mundurucu adults
N=44	N=26	N=21	N=20	N=15	N=10
Age 3.1-5.9 y	Age 6.3-8.9 y	Age 9.4-11.8 y	Age 18-24 y	Age 5-15 y	Age 24-67 y
23 female	13 female	10 female	10 female	7 female	3 female
				14 monolingual 3 unschooled	5 monolingual 5 unschooled

DETECTION OF SHAPE, SIZE AND SENSE DEVIANTS



INTERFERENCE OF SHAPE, SIZE AND SENSE



CONCLUSIONS

In all groups, participants detected shape and size deviants more easily than sense deviants. Moreover, irrelevant variations of shape and size induced interference costs, but irrelevant variations of sense had no impact on performance.

→ **(Modern) Euclidean geometry corresponds to the « natural » geometry captured by perception.**

In detail, we also found some differences across groups:

Younger children suffered greater interference of size than shape, while the reverse was true in older children and adults of both cultures.

→ During childhood, human perception evolves towards a non-scaled geometry (Euclid’s geometry).

U.S. adults chose the sense deviants, unlike every other groups.

→ Geometry-educated adults exhibit greater flexibility to switch between a sensed and a non-sensed geometry

REFERENCES

Hatfield, G. (1998). *The Natural and the Normative: Theories of Spatial Perception from Kant to Helmholtz*. Cambridge, Massachusetts and London, England: The MIT Press.
Heath, T. L. (1956). *The Thirteen Books of Euclid’s Elements* (2 ed.). New York: Dover Publications.

FUNDING: ERC FP7 Project 263179 MathConstruction (to V.I.), ANR JCJC Geometries (to V.I.), CNPq grant Processo 400002/2013-2 (to P.P. and Sidarta Ribeiro), d’Or Foundation (to P.P.), NIH grant HD 23103 (to E.S.S.), NSF STC award CCF-1231216 (to E.S.S.), Center for Brains, Minds and Machines (to E.S.S.).

