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Adult cognition of large-scale geometric facts

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Project description

Objectives

1. Adult cognition of large-scale geometric facts

The primary objective of this study is to assess *adult cognition and understanding of large-scale geometric facts*. The hypothesis, suggested by some pilot testing by Casati, is that such a cognition and understanding is not properly functioning. One reason could be that spatial cognition and understanding are biased towards small-scale objects and situations. Typically, when examining the geometry of a small-scale situation, such as the arrangement of objects on a table-top, or the shadow cast by a furniture item on a wall, the subject can readily assess the consistency of the stimuli, give approximately correct values for angles and sizes, and adequately evaluate alignments. It is hypothesized that such readiness is not available in open spaces or when the objects are too large or too distant. This is not due to a perceptual bias only. The difficulty concerns mainly the construction of an adequate representation of the situation that is being geometrically evaluated. The test concerns non-perceptual representation and reasoning about large-scale geometric facts.

The experimental design relies on some basic astronomical knowledge, such as the phenomenon of phases of the moon, or of lunar eclipses. Asking for explanation about these astronomic phenomena suggests a way to test the subjects' understanding of some simple geometrical relations among large-scale objects (sun, earth, moon).

2. Efficacy of basic education about astronomy

It will also be possible to indirectly test the efficacy of basic education about astronomy, for those subject that received formal astronomical education. For instance, answering questions about the expected visibility of a lunar eclipse requires not only the notional knowledge of the eclipse's basic mechanism, but also a certain amount of reasoning about this mechanism. The subject must implement notional knowledge in a geometric model of the relations among celestial bodies in order to come up with a correct answer.

Phasing

The project will consist of four phases.

1. A set of empirical tests, to be administered to undergraduates in several universities in 1a) the United States, 1b) the United Kingdom, 1c) France, and 1d) Italy.
2. Comparison between data sampled in countries with different educational curricula.
3. Construction of an explanation for the data.
4. Further testing to confirm the hypothesis.

The present test belongs to phase 1.

Expected outcome

We look forward to an understanding of the mechanisms behind the intuitive cognition of large-scale geometric facts. If, as we expect on the basis of pilot testing, this cognition is seriously impaired even in subjects that do have some astronomical education and if this impairment depends upon the difficulty of building adequate representations of the geometrical situation to be evaluated, it will become important to study some educational designs that could obviate this situation.

If the subjects cannot indeed draw the correct inferences, this could be due to a number of factors. In the theory of mental models, inspection of the rather simple models of basic astronomic facts (such as the phases of the moon) could deliver the correct predictions. Hence it must be postulated that subjects do not construct adequate models, and it would be interesting to study why it is so. In the propositional (mental logic) theory of mental representation, the inferential relations between the descriptions of astronomic facts are not accessible to the subjects.

Subjects – Recruitment and Confidentiality

The questionnaire (described below) will be given first in the English language, using volunteer subjects who are undergraduate students at the University of Buffalo (Mark, Casati). A further phase of the study will be to translate the instruments into French and Italian and administer the test (Casati, Noveck) to individuals with different instructional curricula. The following colleagues have given a preliminary consent:

Italy: Vittorio Giroto, University of Trieste

We will ask instructors to allow us to conduct the experiment at the beginning or end of one of their classes. We will ensure that it is easy for the students in those classes to opt out of participating in the experiment without making their non-participation known to us or to their regular instructor (i.e. the test administrator will be a different individual from the instructor and/or the students may return the questionnaire to the test administrator with all the questions unanswered). The test administrators will be briefed on the nature and purpose of the research study so that they may be able to respond to any inquiries the students may have. The test administrators will also be asked to inform the subject that they may contact the project researchers via e-mail if they have any further questions about the project, or to request a copy of the results of the study.

To the maximum extent possible, we will choose subjects from a broad-enrollment non-astronomy courses. We will record the gender, age, native (first) language spoken, acquaintance with the basics of astronomy, and handedness of each subject for background. We do not expect any of these to show significant associations with any results. However, protocols from students with a formal training in astronomy will be handed separately. Mark has considerable experience with this form of human-subject testing in his work on spatial relation and naive geographical categorization and we anticipate no difficulty in getting high participation rates both from instructors and from their students.

Students will be informed by the administrator of the test, as well as in written statement at the beginning of the questionnaire, that they are free to choose not to answer any or all of the questions in the survey. The administrators of the tests will direct the students that they should not write their names anywhere on the tests, and the returned tests will be sealed in envelopes and returned to the researchers. No lists of the names of the people in the subject pools from which the respondents were drawn (i.e. course registration lists) will be collected.

As the students may be interested in knowing the correct explanation for the phenomena concerned by the questions, the test administrator will circulate a sheet with some diagrams and will be available for discussion after the test.

Experimental protocol

The instrument will be a printed questionnaire consisting of approximately 10 questions of various types (multiple choice, open ended, rank order) and should take the respondents no more than 20 minutes to complete. Examples of the questions which will be asked appear below.

Informed Consent Statement/ Debriefing (to appear at top of instrument):

The following questionnaire consists of 15 questions, and should take you no more than 20 minutes to complete. Your completion of this questionnaire is voluntary, and you may skip any or all questions you choose to not answer, and there will be no penalty if non-participation is chosen. Your responses will remain anonymous, please do not write your name anywhere on this form. You might want to add comments and drawings to your answers; feel free to do so.

This questionnaire is being administered in three languages (English, French and Italian) to groups of students in four countries (United States, United Kingdom, France and Italy). It is part of a university conducted research study comparing the ways in which people from different educational curricula represent some astronomical facts and evaluate geometrical reasoning concerning large-scale objects such as the moon. The results will help suggest ways to improve some parts of those curricula. The project researchers are Dr. David Mark (of the State University of New York at Buffalo, Buffalo, NY, USA) Dr. Roberto Casati (of the French National Center for Scientific Research and State University of New York at Buffalo, Buffalo, NY, USA) and Dr. Ira Noveck (University of Grenoble and may be reached by e-mail at dmark@acsu.buffalo.edu (Dr. Mark), at casati@acsu.buffalo.edu (Dr. Casati) and at noveck@poly.polytechnique.fr if you have any questions.

I. The following questions will be asked for categorization purposes.

Gender: (male) (female)

Native (first) language spoken _____

Have you even been taught basic astronomical facts? (Yes, in high school) (Yes, at the University) (Yes, self-taught), (Yes, other _____) (No)

Age: _____

Are you: (right-handed) (left-handed)

II. Sample test questions

A1.

The set of phases, from new moon to first quarter, full moon, last quarter are due to the shadow projected by the earth.

Is this true or false? True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

A2.

The set of phases, from new moon to first quarter, full moon, last quarter are due to the relative positions of sun, moon, and observer on earth.

Is this true or false? True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

B1.

A lunar eclipse is due to the fact that the moon is smaller than the earth.

Is this true or false? True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

B2.

A lunar eclipse is due to the fact that the earth intercepts the sun's rays directed to the moon.

Is this true or false? True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

C.

The moon always presents the same face to the earth. It follows that

1. The moon spins on its axis.
2. The moon does not spin on its axis.

Which of these statements is true? 1--2

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

D1.

Is the following true or false?

The change in the season is due to the inclination of the earth's axis.

True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

D2.

The change in the season is due to the change in distance between the earth and the sun.

Is this true or false? True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

E.

Is the following true or false?

A lunar eclipse is more frequent when the moon is full.

True / False

How sure are you?

1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

F1.

Is the following true or false?

A lunar eclipse is more frequent at night.

How sure are you?

1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

F2.

Is the following true or false?

A lunar eclipse is more frequent during the day, although it is more difficult to notice.

How sure are you?

1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

I1.

Is the following true or false?

The visible face of the moon is periodically not lit by the sun because the moon spins on its axis.

True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

I2.

Is the following true or false?

The visible face of the moon is periodically not lit by the sun because the moon rotates around the earth.

True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

J1.

Is the following true or false?

During a lunar eclipse, the shadow of the earth moves across the moon because the earth spins on its own axis and drags its own shadow around.

True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

J2.

Is the following true or false?

During a lunar eclipse, the shadow of the earth moves across the moon because the moon orbits the Earth.

True / False

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

K.

The line dividing light from shade when the moon is halved is approximately a north-south line. Why is it so?

1. The moon's axis does not change its approximate inclination relative to the Earth.
2. The moon orbits in a plane which is approximately normal to the Earth's axis.

Choose what you think is the best explanation.

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

L.

How many times approximately the sun is more distant from the earth than the moon?

1. Actually, The sun and the moon are at the same distance.
2. The sun is twice more distant than the moon.
3. Actually, the moon is more distant than the sun.
4. The sun is more than 50 times more distant than the moon.
5. The sun is more than 500 times more distant than the moon.

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

M.

During a solar eclipse, the moon is in between the earth and the sun and hides the latter almost perfectly. It follows that:

1. The sun is much bigger than the moon.
2. The sun is approximately of the same size as the moon.

How sure are you? 1--2--3--4--5--6--7--8--9
Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

N.

In which direction should one point to find the sun's position at midnight?

1. Just below the horizon.
2. Opposite, relative to the observer, to where it was during the day.
3. Downwards, towards one's feet.

How sure are you? 1--2--3--4--5--6--7--8--9
 Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

O.

Suppose on a given day the moon looks from the North Pole as follows:



How would the moon look like from the equator?



1



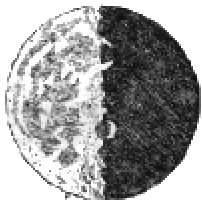
2

How sure are you? 1--2--3--4--5--6--7--8--9
 Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

P.

Keep this page at arm's length. Which of these drawings would cover the moon in the sky exactly?



1



2



3

How sure are you? 1--2--3--4--5--6--7--8--9
 Not sure Sure

Did you know this answer in advance or did you arrive at it on the spot? Advance / On the spot

BAG

How much of the moon gets lit? ~~1/4~~, according to the period of the moon?

Is the sun greater when it is closer to the horizon? ((this question just to see whether it is so considered))