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Data Article

Towards a computerized estimation of visual complexity in images: Data to assess the association of computed visual complexity features to human responses in visual tasks

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ABSTRACT

Artificial vision has been extensively studied in the mathematical and computational Sciences. Concurrently, psychological studies attempt to describe visual cognition and the complexity of visual tasks as perceived by humans. The methods and the definitions of vision used by these two disciplines are disjointed. Particularly, an explanation of computer vision performance by human-perceived attributes, if attempted, can only be inferred.

This article describes a dataset collected to explore the association between computer-extracted visual attributes and human-perceived attributes in the context of cognitive tasks. The data was acquired from a cohort of 406 subjects, ages 40–90, in the presence of a healthcare professional who assessed that the subjects had no cognitive or motor disorder. The subjects performed computerized cognitive tests which entailed tasks of recognition or recall of an image in a set of three images, presented on the computer screen. The images were simple black and white abstract square shapes. The latencies of the subjects' responses, by keyboard key press, to each task were logged.

The data contains 3 parts: the images presented in each task, described by binary vectors for black and white coding, a response time logged for each task and the subjects' age, gen-

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der, and computer proficiency. A preliminary comparison of computationally-extracted complexity features and subjects' performance is provided in the article entitled "Linking computerized and perceived attributes of visual complexity" [1].

Specifications Table

Subject	Computer Vision and Pattern Recognition
Specific subject area	The narrower subject area involves image complexity, the processing of visual cognitive tasks, and visual recognition and recall.
Type of data	Tables
How data were acquired	Original data was collected through a cohort of volunteers who performed computerized visual cognitive tasks. The tasks are described and illustrated in this article. The data was consolidated with the subjects' performance and demographic details.
Data format	Raw
Parameters for data collection	Population consisted of a sample of 406 subjects, 256 females, age range between 40 and 90 years, who performed computerized cognitive tasks. Clinical assessments were performed by a neuropsychologist and excluded people with cognitive or motor disorders, and vision impaired individuals.
Description of data collection	Visual tasks were presented to subjects as part of a computerized cognitive test, and their performance per task was logged.
Data source location	City/Town/Region: Country: Israel 32.0803° N, 34.7901° E
Data accessibility	https://data.mendeley.com/datasets/chh5w7njwm/draft?a=72aa5883–562f-453f-9caa-2b4b3551b877
Related research article	Babshet, K. and V. Aharonson, *Linking computerized and perceived attributes of visual complexity.* The Twelfth International Conference on Advanced Cognitive Technologies and Applications, ComputationWorld 2020, 2020: p. 79–84.

Value of the Data

- This data can be useful since it provides a framework to test associations between computer-extracted attributes - artificial performance - and human performance in cognitive visual tasks. It therefore has the potential to provide insights to technologies such as computer vision as well as insights to the sciences of cognition.
- This data can be used by researchers of human visual perception and cognition, as it provides a quantitative measure for the response of cognitively intact persons to visual-cognitive tasks. The tasks measured in the dataset are two of the most pertinent functions of the visual system – recognition and recall.
- The data contained in this article was acquired from a cohort of the age group from 40 to 90 years old, and from strictly cognitively intact persons. It can therefore be compared with other samples of subjects with cognitive decline, to examine trends in cognitive decline and cognitive impairment in the elderly.

1. Data description

The data represents the performance results of certain visual recognition and recall tasks [2,3] which were previously presented to several volunteers. In a recognition task, three images would be presented on the screen, and the volunteer was required to recognize which of the three images was different. Fig. 1 illustrates an example of three images presented in a recog-

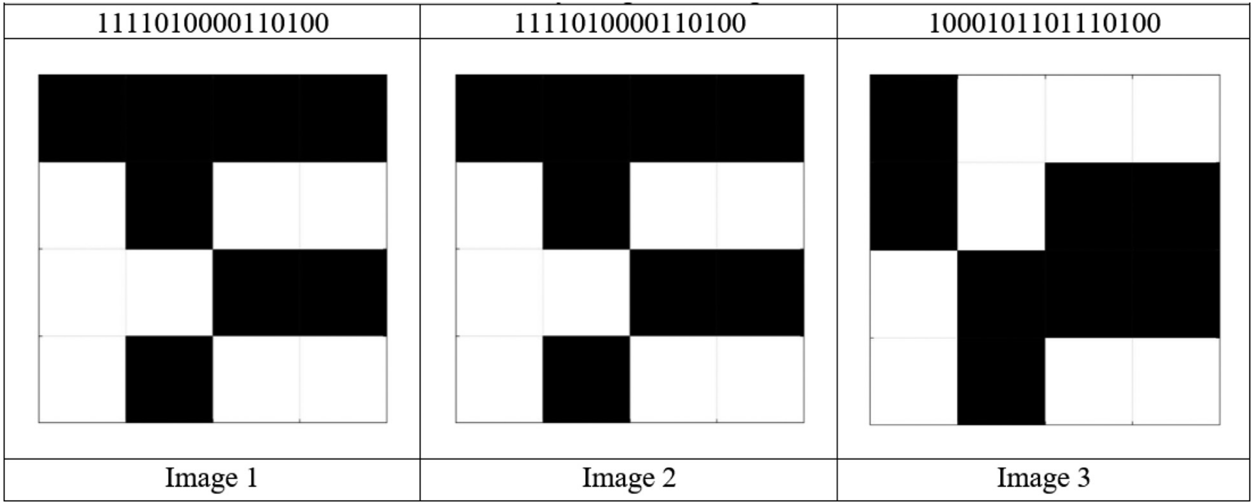

Fig. 1. The translation of the binary codes in the dataset columns labeled “image 1” “image 2” and “image 3” into the images displayed to the subjects on the computer screen. The example illustrates the images from the first row of Table 1.

nition task. In a recall task, a single image would be presented on the screen for a few seconds and was then erased. Several seconds later, three images would be presented on the screen, in a display similar to the recognition task and the volunteer was required to remember and select the one which was previously displayed. These tests were employed to detect cognitive decline.

The data is stored in two tables: one table for the recognition task, and the other for the recall task. Each row in both tables represented a task instance.

Table 1 presents a snippet of the table corresponding to a recognition task. The first column in the table contains the task number – from 1 to 10 tasks per subject, followed by the subject's ID, a randomly generated number. The next three columns contain the binary codes of the three images in the task, in their screen display order, 1, 2 and 3, from left to right. This sixteen-bit arrays coding can be easily translated into the four-by-four squares image, starting from the top left square, going left to right, and then downwards row-by-row. A white square in the image was represented by a "0" and a black pixel by a "1". The translation from the three images code in the table to the images displayed on the screen to the subject is illustrated in Fig. 1. The example depicts the three images corresponding to the first row of Table 1. The labels under the images are the corresponding table columns: "image 1" , "image 2" and "image 2". The labels above the images are their binary codes. The code under the columns "image 1" in the first row in the table is 1111010000110100, the second, under "image 2" is identical: 1111010000110100, and the third, in "image 3" column in the table, is different: 1000101101110100. The images translated from each code are the ones presented below the code in Fig. 1.

Following the three images code columns is a column containing the correct (expected) answer for the task: 1, 2 or 3. In the first row of table 1 and the images illustrated in Fig. 1 the correct answer, aka the odd image is number 3. This column is followed by a column that contains the subject's answer to the task: 1, 2 or 3. In the first row of table 1 the subject answered 3. The last column contains the response time of the subject, in milliseconds.

A separate, third table lists the age, gender, and computer proficiency of each participant. The categories of computer proficiency are "I do not use a computer at all / None", "I use a computer very rarely / Poor", "I use a computer from time to time / Mediocre", "I use a computer often / Good", "I use a computer every day / Excellent", coded as 100, 101, 102, 103 and 104, respectively.

Figures 9–11 of [1] illustrate the distribution of each of these characteristics (age, gender and computer proficiency) respectively, and were drawn in order to verify that the difference in categories within each characteristic do not have a significant impact on the distribution of the response times.

2. Experimental design, materials, and methods

The data in the tables described in the previous section was acquired using computerized neuropsychological tests that were designed by the authors of this paper in a large-scale experiments of Dementia in the elderly [5]. A detailed description of the computer methods employed in the design and implementation of these tests and their graphical user interface can be found in [6]. The following sections shortly describe the elements relevant for the data in the current paper.

1. Ethics
   The data collection was carried out in accordance with the recommendations of the Ethics Committee of the Sourasky Medical Center, Tel Aviv, Israel. All subjects signed an informed consent and all data was fully anonymized.
2. Cognitive screening
   A mini-mental state examination (MMSE) was performed by a healthcare professional – a neurologist or a neuropsychologist, prior to taking the computerized tests. The MMSE is a quick and simple screening tool that is most commonly used in clinical trials and in general practice to detect cognitive decline. It is a thirty-points questionnaire where zero points

Table 1
A snippet of the data table of the recognition test.

Task #	Subject ID	Image1	Image2	Image3	Expected Response	Actual Response	Response Time
1	1111617147578100	1111010000110100	1111010000110100	1000101101110100	3	3	2297
2	1111617147578100	1011011101100000	0111011110010000	0111011110010000	1	1	1891
3	1111617147578100	0000111101101010	1011001001100100	0000111101101010	2	2	3719
4	1111617147578100	0001111010101001	0001111010101001	0110001101110010	3	3	1765
5	1111617147578100	1111101000100000	0011001111100001	1111101000100000	2	2	2297

indicates severe cognitive impairment, and 30 points indicates no cognitive impairment [4]. Only subjects who had an MMSE value of 30 and were assessed by a neuropsychologist to be cognitively intact, were included in this dataset. The data is therefore potentially unbiased by aspects of cognitive decline.

3. Demographic data and computer skill collection
   The demographic data and computer skills level data were collected by the healthcare professionals, who questioned the subjects and filled their answers unto a table.
4. Computerized cognitive tests
   The computerized visual-cognition tasks in the data are a part of a larger battery which contain cognitive assessments of multiple cognitive domains. These assessments were used in previous research as well as in clinical settings [5,7].
   4.1 Visual stimuli
      The visual stimuli displayed in the tests are simple images contain the sixteen black or white images, as illustrated by the three images of Fig. 1.
      The philosophy behind the choice of these images is that the lack of color, and the small size of the images, would allow for a more objective, visual-only perception of the images by the subject. Cognitive tests often present elaborate and colourful visual stimuli, containing objects, faces, scenes and more. These images, or parts of these images, may trigger emotional or cultural associations or memories of a subject. These triggers could distract the subjects and bias their performance in the visual perception tasks associated with the images.
      The images chosen for these cognitive tests are therefore small, black and white, simple and abstract, while the tasks involved are similar to those in traditional cognitive assessments.
   4.2 Visual tasks
      Two types of visual tasks were carried out: recognition and recall tasks. In a recognition task three images were presented on the screen, and the subject is required to recognize which of the three images was different. An example of three images of a recognition task is illustrated in Fig. 1. The images were encoded in the columns “image 1“, image 2“ and “image 3 ” in the data table. In a recall task a single image was presented on the screen for a few seconds, and was then erased. Thereafter, the subject was presented with three images and was required to remember and select which of the three has been the one previously displayed. The numbers “1”, “2” and “3” were displayed below the three images presented on the screen in large font. In both recognition and recall tasks, the images were randomly generated for each task [6].
      In all tasks, the subjects responded by pressing a key on the computer keyboard, indicating the number corresponding to the image they selected: 1, 2 or 3. The response time is defined as the latency from the task display time to the key press.
      The performance of the subjects, in terms of answer correctness and response time were logged in the data table, in the last three columns.
      Each subject was given a full description and explanation of the tasks and was told to respond by pressing the selected key as quickly as possible. Two examples of the task were given to the subjects to ensure they understood the instructions. Each subject then performed 10 recognition tasks and 10 recall tasks.
   4.3 Computer software
      As this is a *computerized* test, a software automatically generates the images from the database. The image generating software reads the 16-bits binary codes of the 3 images column of the database: the columns are named “Image 1”, “Image 2” and “Image 2”, and *generates* the images on the screen, drawing a black square for each “1” in the code and a white square for each “0” in the code, in a 4-by-4 m^2atrix, as portrayed in Fig. 1. An example of the database table is given in Table 1.
      The computerized test is designed for comfortable usage of the elderly, therefore the images are displayed across the entire screen , with big numbers below “1”, “2” and

"3". Moreover, there is No written questionnaire involved: a recorded voice explanation of the task was provided prior to the task screens [6].

In example, the voice explanation for the recognition task was: "In the next screens, three images will be displayed on the screen, with the numbers one, two and three below the images. Two of the images are similar and one is different. You will need to recognize which is the different image and press on the keyboard the number underneath it: one, two or three".

Following the voice explanation, the subjects were given two practice examples, with a vocal feedback. In example, if a user performed the practice example correctly, the feedback was "Correct! The different image is one, you have correctly pressed the key one on your keyboard".

A detailed description of the software is provided in [6].

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at Mendeley Data repository: https://data.mendeley.com/datasets/chh5w7njwm/draft?a=72aa5883-562f-453f-9caa-2b4b3551b877.

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