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Data Article

# Brain-anatomy image data set for problem solving associated with reversal error: Volumetric data

N. Ventura-Campos [a,b], L. Ferrando-Esteve [a,b,*], A. Miró-Padilla [b], C. Ávila [b]

[a] Department of Education and Specific Didactics. Universitat Jaume I, Castellón, Spain
[b] Neuropsychology and Functional Neuroimaging Group, Universitat Jaume I, Castelló, Spain

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ABSTRACT

Reversal Error (RE) is a common error in algebra problem solving. This error occurs when students recognize the information in the statement but make mistakes when translating some sentences from natural language to algebraic language, reversing the relationship between two variables in comparison word problems. Structural Magnetic Resonance Image (sMRI) data were collected with the purpose of identifying brain anatomical regions related to the RE phenomenon. The aim of the research was to investigate the brain anatomy differences between participants who failed more than 50% of the answers on the task (N=15) and those who responded correctly 100% of the time (N=18). sMRI analysis revealed differences between the two groups, and details about these data can be found in Ventura-Campos et al. (2022) [1]. This data set contains the sMRI (raw data, pre-processed images), and an excel file with personal information such as age and gender, the scanner with which their sMRI were collected, and the group to which each of the 33 subjects belonged.



* Corresponding author.
*E-mail address:* lferrand@uji.es (L. Ferrando-Esteve).
*Social media:* @LaraaFe (L. Ferrando-Esteve)

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## Specifications Table

| | |
|---|---|
| Subject | Neuroscience and education |
| Specific subject area | Neuroimaging |
| Type of data | MRI data |
| How the data were acquired | A 1.5 T Siemens Symphony scanner and a 3 T Philips scanner were used to obtain the images.<br>Pre-processing and analysis were performed using the Computational Anatomy Toolbox 12 (CAT12.5, Gaser et al. (2022) [2]), a toolbox from the software: Statistical Parametric Mapping (SPM12; v7219), Wellcome Trust Centre for Neuroimaging, London, UK, http://www.fil.ion.ucl.ac.uk/spm/software/spm12) run under MatLab software language (version 9.2, R2017a). |
| Data format | - Raw data<br>- Pre-processed data (only the smoothed grey matter (GM) images are included, smooth = 8mm FWHM [Full-Width Half-Maximum])<br>- Excel file |
| Description of data collection | 33 structural MRI were collected using a 1.5 T Siemens Symphony scanner (TR = 2200 ms, TE = 3 ms,matrix size (MS) = 256 × 256 × 160, voxel size (VS) = 1 × 1 × 1 mm) and 3 T Philips scanner: (TR = 8.4 ms, TE = 3.8 ms, MS = 320 × 320 × 250, VS = 0.75 × 0.5 × 0.8 mm).<br>The MRI study with healthy participants requires some exclusion criteria, which were the presence of neurological and medical illness, trauma with loss of consciousness lasting more than one hour, and the typical resonance exclusion criteria such as iron prostheses and dental implants. |
| Data source location | Institution: Universitat Jaume I<br>City/Town/Region: Castellón<br>Country: Spain |
| Data accessibility | Repository name: FAIRsharing<br>Data identification number: 10.6084/m9.figshare.21393936<br>Direct URL to data:<br>https://figshare.com/articles/figure/Datos_zip/21393936 |
| Related research article | N. Ventura-Campos, L. Ferrando Esteve, A. Miró-Padilla, C. Ávila, Brain-anatomy differences in the commission of reversal errors during algebraic word problem solving, Mind, Brain Educ. (2022) https://doi.org/10.1111/mbe.12333 |

## Value of the Data

- The current dataset makes it possible to investigate the associations between the brain structure and the learning of algebra problem solving with RE.
- Data are motivated by a real and important neuroeducational problem.
- The present data set is useful for reproducibility and to further studies on this problem.
- These data can become part of a sMRI database that helps to answer other research questions. In addition, raw data can be used to test different pre-processing strategies and perform other types of analyses for anatomical study (cortical thickness, ROI analysis, etc.).
- These data can be used in a complementary way with the database that contains the segmentation of the putamen of these same subjects (Ferrando et al. (2020) [3]).

## 1. Objective

The objective of publishing this dataset is to incorporate sMRI data associated with algebraic problem solving with competent and non-competent participants in this type of task. This gives the research community the opportunity to replicate our results or perform complementary analyses.

So, the data article adds value to Ventura-Campos et al. (2022) [1] because the data set is useful for reproducibility and to further studies on this problem.

## 2. Data Description

The sMRI of 33 participants were collected. The files presented in these data are, briefly, the following:

An Excel file containing the following information: gender, age in years, the scanner with which the images were collected, the group to which each subject belongs and the number of correct and incorrect answers obtained by the Application implemented for data collection in studies on the RE (see details in Table 1 and Table 2, Ventura-Campos et al. (2022) [1]).

The Philips folder (corresponding to that scanner) contains two folders:

- RE: the subjects who commit RE.
- Non-RE: subjects who do not make this error.

Each participant's data folder contains two types of images:

- anatomy.nii, which contains the raw data from the anatomic image of the subject (nifti format with extension nii).
- s8mwp1anatomy.nii, which corresponds to the pre-processed image (normalized, grey matter segmented, modulated and smoothed with a Gaussian filter 8mm).

The Siemens folder (corresponding to that scanner) contains two folders:

- RE: subjects who commit RE.
- Non-RE: subjects who do not make this error.

Each participant's data folder contains three types of images:

- anatomy.hdr and anatomy.img, which contain the raw data from the anatomic image of the subject (nifti format with extension hdr/img).
- s8mwp1anatomy.nii which corresponds to the pre-processed image (normalized, grey matter segmented, modulated and smoothed with a Gaussian filter 8mm).

## 3. Experimental Design, Materials and Methods

### *3.1. Participants*

Thirty-three student volunteers at the University Jaume I (20 females) from 18-26 years old (mean age: 22.03, SD: 2.36) participated in this study. These subjects were divided into two groups: the non-RE group (18 subjects, 9 females; mean age: 22.5, SD: 2.53), who responded correctly 100% of the time, and the RE group (15 subjects, 11 females, mean age: 21.466, SD: 2.1), who failed more than 50% of the answers on the RE task.

The exclusion criteria for this MRI study were the presence of neurological and medical illness, trauma with loss of consciousness lasting more than one hour, and the typical resonance exclusion criteria such as iron prosthesis and dental implants.

### *3.2. Acquisition images*

Two scanners were used for the acquisition of images. On the one hand, a Siemens Symphony scanner (High-resolution T1-weighted, TR = 2200 ms, TE = 3 ms, flip angle = 90, matrix size = 256 × 256 × 160 and voxel size = 1 × 1 × 1mm) and, on the other, a Philips scanner (High-resolution T1-weighted, TR = 8.4 ms, TE = 3.8 ms, matrix size = 320 × 320 × 250 and voxel size = 0.75 × 0.5 × 0.8 mm.) The scanner acquisitions were performed in parallel to the anterior commissure-posterior commissure plane (AC-PC). The sMRI scans were acquired while subjects were at rest.

### 3.3. Data pre-processing

The pre-processing of the images was carried out with SPM (SPM12 (v7219), Wellcome Trust Centre for Neuroimaging, London, UK, http://www.fil.ion.ucl.ac.uk/spm/software/spm12), using the methodology VBM with the CAT12 toolbox (Gaser et al. (2022) [2]) to perform the pre-processing steps. We used the standard procedure suggested by CAT12, which included: (a) normalization and segmentation of the images into GM, white matter (WM), and cerebrospinal fluid; (b) alignment of the GM and WM between the images; (c) using the DARTEL-template in the VBM analysis to obtain the GM and WM tissues, which were normalized to MNI standard space; (d) modulation by the "affine + nonlinear" components derived from spatial normalization; (e) estimation of the total intracranial volume (TIV) for each subject; (f) quality check of the images; no outliers were identified; and (g) finally, spatial smoothing of the images using a Gaussian filter (8 mm Full-Width Half-Maximum, FWHM).

### 3.4. Behavioural task

The app used to do the task for the reversal error assessment is an application implemented for data collection in studies on the RE (González-Calero et al. (2015) [4]). This task consisted of a collection of 16 items where participants were presented with statements of problems that led them to do the EI. The statements were different: contextual cues could appear or not, with discrete or continuous quantities. Therefore, subjects could only use multiplication/division or addition/subtraction to express the equation. In order to construct the equation, they were provided with the variables and quantities that had to be used (as can be seen in Fig. 1); thus, by clicking on each of the variables and signs, they built the equation that they later validated.

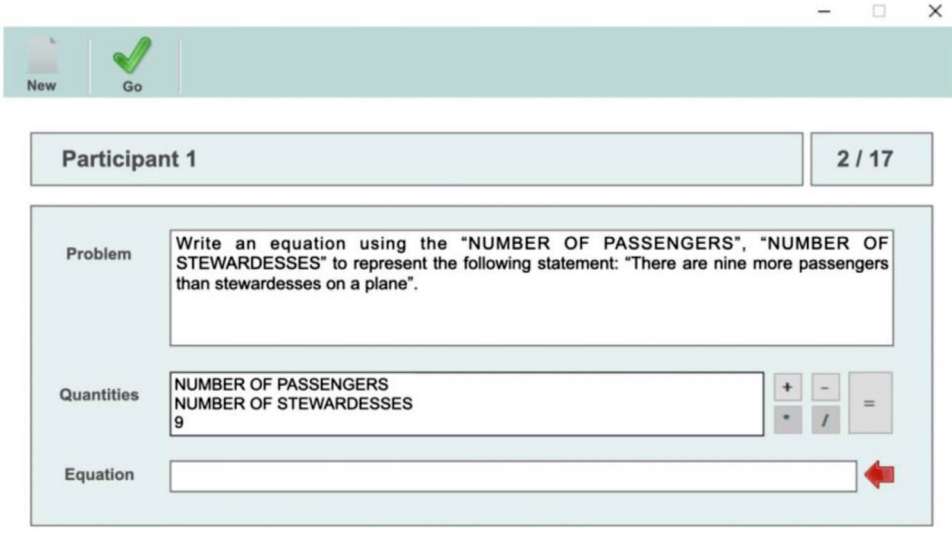


**Fig. 1.** Application implemented for data collection in studies on the RE (González-Calero et al. (2015) [4]). Note: By clicking on each of the variables (quantities) and operation signs (+, −, *, / and =; right to quantities), participants had to write the equation that corresponded to the statement of the problem. The rectangle called Equation contains the variables they clicked. After that, they validated their equation by pressing the Go button.

## Ethics Statements

All participants were students of the Universitat Jaume I. Before participating, they signed a written consent form. All experimental procedures followed the guidelines of the research ethics committee at the Universitat Jaume I, Castellón, Spain. CD/11/2021

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data Availability

sMRI_RE_data (Original data) (FAIRsharing).

## CRediT Author Statement

**N. Ventura-Campos:** Conceptualization, Methodology, Writing – review & editing; **L. Ferrando-Esteve:** Data curation, Writing – original draft, Writing – review & editing; **A. Miró-Padilla:** Visualization, Investigation; **C. Ávila:** Supervision, Validation.

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