Data Article

Functional magnetic resonance imaging data of incremental increases in visuo-spatial difficulty in an adult lifespan sample

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**Abstract**

These data provide coordinates generated from a large healthy adult lifespan sample undergoing functional Magnetic Resonance Imaging (fMRI) while completing a spatial judgment task with varying levels of difficulty, as well as a control categorical condition. The data presented here include the average blood-oxygen-dependent (BOLD) response to the spatial judgment vs. the control task, as well as the BOLD response to incremental increasing difficulty; see also "Age-related Reduction of BOLD Modulation to Cognitive Difficulty Predicts Poorer Task Accuracy and Poorer Fluid Reasoning Ability" (Rieck et al., 2017) [1].

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**Specifications Table**

| Subject area                      | Cognitive Neuroscience |
|-----------------------------------|-----------------------|
| More specific subject area        | Functional Magnetic Resonance Imaging of spatial judgment |
| Type of data                      | Coordinate tables, figures |

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How data was acquired | Philips Achieva 3 T whole body scanner
---|---
Data format | Analyzed using Statistical Parametric Mapping 8
Experimental factors | Participants performed a spatial judgment task in which they conducted two types of judgments. A categorical (LEFT/RIGHT) judgment was used as a control condition and a coordinate (NEAR/FAR) judgment was used with three levels of difficulty.
Experimental features | Dallas, Texas, United States of America
Data source location | Data provided in article
Data accessibility | This dataset provides a sizable sample of healthy adults who performed a spatial judgment task. These data show differential BOLD responses for varying levels of visuo-spatial difficulty across the sample. The data provide specific MNI coordinates of brain regions evoked by the task. These data are potentially useful to investigators studying differences in fMRI activation to non-verbal, spatial stimuli across the adult lifespan.

1. Data

While undergoing fMRI, healthy adult participants completed a blocked-design spatial judgment task with three levels of difficulty (Easy, Medium, and Hard). These data have previously been analyzed with regard to age [1]. The data shown here represent the group level analyses examining the effect of the distance judgment task (Easy, Medium, Hard vs. Control – Table 1 and Fig. 1) as well as the effect of incremental increasing difficulty (Medium vs. Easy – Table 2 and Hard vs. Medium – Table 3, both shown in Fig. 2).

2. Experimental design, materials and methods

2.1. Participants

Participants included 161 healthy adults, ages 20–94 (mean age = 51.93 ± 18.9 years; 95 women; 66 men) who volunteered from the Dallas-Fort Worth area. Inclusion criteria for the study required that all participants be right-handed, fluent English speakers, and have normal or corrected-to-normal vision (at least 20/40). Participants were also screened for dementia using the Mini Mental State Examination (MMSE; [2]), with a cutoff of 26; volunteers were also required to have no history of neurological or psychiatric conditions, head trauma, drug or alcohol problems, or significant cardiovascular disease (however, n = 32 with a self-reported diagnosis of hypertension). Participants were compensated for their time and informed consent was obtained in accordance with protocol approved by the University of Texas at Dallas and the University of Texas Southwestern Medical Center.

2.2. Experimental design

The data shared here are from a large lifespan dataset in which 161 healthy adults completed a blocked-design distance judgment task while undergoing fMRI. The spatial judgment task involved two types of judgments (modeled after [3] and [4]). The first type of judgment, which served as the
control condition, required participants to make a categorical (LEFT/RIGHT) judgment. Participants saw a dot on the left or right side of a horizontal bar and had to indicate using a button press on which side of the bar the dot was present.

| Table 1 | Cluster peaks for the whole sample effect of distance judgment task [Easy, Medium, Hard vs. Control]. |
|---------|-----------------------------------------------------------------------------------------------------|
|         | A. Positive effect cluster-level                                                                 |
|         | **BA** | **k** | **X** | **Y** | **Z** | **t-value** | **p<sub>fwe</sub>** |
| L/R superior occipital gyrus and R precuneus | 18 | 7013 | -6 | -102 | 6 | 17.3 | <.001 |
| L/R middle frontal gyrus | 7 | 7 | 27 | -72 | 36 | 13.94 | <.001 |
| R middle and inferior frontal gyrus | 6 | 745 | 6 | 21 | 42 | 12.82 | <.001 |
| L inferior frontal gyrus and insula | 46 | 1409 | 45 | 36 | 18 | 12.54 | <.001 |
| R middle frontal gyrus | 13 | 33 | 21 | -3 | 11.55 | |
| L/R middle frontal gyrus | 44 | 48 | 6 | 24 | 10.99 | |
| R thalamus/caudate | 47 | 1305 | -30 | 21 | -3 | 11.6 | <.001 |
| L/R thalamus/caudate | 6 | 45 | -45 | 6 | 27 | 10.64 | |
| B. Negative effect cluster-level                                                                 |
| **Cluster Label** | **BA** | **k** | **X** | **Y** | **Z** | **t-value** | **p<sub>fwe</sub>** |
| R lingual gyrus | 18 | 332 | 21 | -90 | -3 | 12.86 | <.001 |
| L inferior occipital gyrus | 18 | 238 | -21 | -96 | -9 | 16.21 | <.001 |
| R superior and middle temporal gyrus | 22 | 2342 | 60 | -45 | 12 | 14.8 | <.001 |
| L/R medial orbital and middle frontal gyrus; anterior cingulate | 39 | 60 | -60 | 21 | 12.59 | |
| L/R posterior and middle cingulate gyrus | 21 | 57 | -9 | -15 | 10.48 | |
| L middle occipital and posterior parietal gyrus | 10 | 3230 | 0 | 57 | -3 | 12.61 | <.001 |
| L/R posterior parietal and L/R medial occipital and middle frontal gyrus | 8 | -21 | 33 | 42 | 11.57 | |
| L/R posterior parietal and middle cingulate gyrus | 9 | 54 | 12 | 11.16 | |
| R middle occipital and anterior cingulate | 23 | 1959 | -3 | -45 | 33 | 12.46 | <.001 |
| R middle occipital and posterior parietal gyrus | 24 | 3 | -21 | 39 | 10.6 | |
| L middle occipital and L/R posterior parietal and L/R medial occipital and middle frontal gyrus | 39 | -45 | -75 | 39 | 11.8 | <.001 |
| L middle occipital and R middle occipital and anterior cingulate | 39 | -57 | -63 | 27 | 10.44 | |
| L middle temporal gyrus | 19 | -57 | -69 | 9 | 10.4 |
| L orbital frontal gyrus | 21 | 278 | -54 | -9 | -15 | 8.55 | <.001 |
| R orbital frontal gyrus | 47 | 95 | -33 | 33 | -15 | 7.75 | 0.003 |
| R hippocampus | 47 | 93 | 36 | 36 | -12 | 7.06 | 0.003 |
| R hippocampus crus 2 | 45 | 54 | 33 | 0 | 5.93 | |
| L hippocampus and fusiform gyrus | 54 | 112 | 27 | -12 | -18 | 6.61 | 0.001 |
| L hippocampus and fusiform gyrus | 39 | -24 | -81 | -36 | 5.74 | 0.031 |
| L inferior temporal gyrus | 54 | 65 | -27 | -15 | -18 | 5.61 | 0.008 |
| L inferior temporal gyrus | 37 | -30 | -33 | -15 | 5.44 | |
| R hippocampus crus 2 | 20 | 41 | -45 | 3 | -36 | 5.1 | 0.022 |
| R hippocampus crus 2 | 38 | -33 | 3 | -39 | 4.51 | |
| R cerebellum crus 2 | 46 | 21 | -87 | -39 | 5.06 | 0.031 |

Note. p < .0001 uncorrected, cluster-level FWE p < .05 correction. BA = Brodmann’s area.
Participants also made a coordinate (NEAR/FAR) distance judgment which had three levels of difficulty: Easy, Medium, and Hard. First, participants saw a vertical reference line, next they were shown a horizontal line with a dot either above or below the line; the judgment required participants to determine whether the dot was “nearer to” or “farther from” the horizontal bar, given the previously seen vertical line. As difficulty increased, the distance between the dot and the horizontal line became harder to determine the “nearness” or “farness” compared to the reference line. A schematic of the task can be found in Fig. 1 of Rieck and colleagues [1]. Prior to the scanning session, participants completed a practice session to ensure that the participants were comfortable with the instructions. Each participant completed three runs of the task, resulting in ~15 min of scan time. The task was presented using PsychoPy v1.77.02 [5,6].

2.3. Image acquisition

Data were acquired on a single Philips Achieva 3 T whole body scanner using a 32-channel head coil. BOLD fMRI data were collected using a T2*-weighted echo planar imaging sequence in 29 interleaved axial slices parallel to AC-PC line, 64 × 64 × 29 matrix, 3.4 × 3.4 × 5 mm³. Field of View (FOV) = 220 mm, Echo Time (TE) = 30 ms, Repetition Time (TR) = 1500 ms. High-resolution anatomical images were also acquired with a T1-weighted MP-RAGE sequence with the following parameters: 160 sagittal slices, 1 × 1 × 1 mm³ voxels; 256 × 204 × 160 matrix, FOV=256 mm, TE=3.8 ms, TR=8.3 ms, Flip angle=12°.

2.4. Image processing

Data from each individual were preprocessed using SPM8 (Wellcome Department of Cognitive Neurology, London, UK). Preprocessing included the following steps: slice time acquisition correction, motion correction, normalization, and smoothing (using an isotropic 8 mm³ full-width-half-maximum Gaussian kernel). In order to identify runs with motion outliers, ArtRepair [7] was used to determine potential outlier volumes for each participant. We examined all three runs for each participant, and runs that had more than 15% outlier volumes (~30 volumes) with greater than 3% deviation from the mean in global intensity spikes or greater than 2 mm of motion displacement.

![Fig. 1. Effect of Easy, Medium, and Hard Tasks vs. Control. Hot blobs indicate regions in which there was greater activity during all levels (Easy, Medium, Hard) of the coordinate distance judgment task versus the coordinate control task. Cool blobs indicate regions in which there was greater activity during the left-right coordinate control condition. Color scale indicates t-values; Abbreviations: LH – Left Hemisphere; RH – Right Hemisphere.](image-url)
were flagged. Five participants had one run with more than 15% percent outlier volumes, so that run was excluded.

At the individual subject level, BOLD response to each condition (Control, Easy, Medium, Hard) was modeled in SPM as a block convolved with a canonical hemodynamic response function; six directions of motion-estimates for each volume generated from ArtRepair were also included as nuisance covariates. Several contrasts of interest were computed at the individual level for subsequent analysis at the group level: Easy + Medium + Hard vs. Control (Table 1, Fig. 1), which represents the effect of the distance judgment task; and Medium vs. Easy (Table 2, Fig. 2), Hard vs. Medium (Table 3, Fig. 2) to examine the brain regions responsive to increment increases in difficulty for visuo-spatial judgments.

Table 2
Cluster peaks for the whole sample effect of increasing difficulty from Easy to Medium.

| Cluster Label | BA | k | X  | Y  | Z  | t-value | p_fwe |
|---------------|----|---|----|----|----|---------|-------|
| L superior and middle occipital gyrus | 18 | 344 | −9 | −102 | 9 | 9.58 | <.001 |
| R cuneus and middle occipital gyrus | 18 | 536 | 12 | −96 | 15 | 9.51 | <.001 |
| L/R anterior cingulate gyrus | 8 | 71 | 6 | 21 | 42 | 5.48 | 0.008 |
| R inferior occipital gyrus | 18 | 200 | 24 | −93 | 9 | 9.99 | <.001 |
| L inferior occipital gyrus and cerebellum crus 1 & 2 | 18 | 379 | −18 | −93 | −9 | 8.68 | <.001 |
| R middle temporal and gyrus angular gyrus | 39 | 747 | 54 | −60 | 21 | 7.63 | <.001 |
| L/R posterior cingulate gyrus and precuneus | 23 | 814 | 6 | −45 | 30 | 6.32 | <.001 |
| L middle and superior frontal gyrus | 8 | 215 | −30 | 27 | 48 | 6.12 | <.001 |
| R cerebellum crus 1 | 358 | 54 | −66 | −33 | 45 | 6.02 | <.001 |
| L posterior parietal and middle temporal gyrus | 39 | 573 | −39 | −72 | −33 | 5.14 | <.001 |
| R middle frontal gyrus | 8 | 74 | 27 | 30 | 45 | 5.35 | 0.007 |
| R middle temporal gyrus | 21 | 94 | 60 | −9 | −18 | 5.33 | 0.003 |
| L inferior temporal gyrus | 37 | 99 | −57 | 51 | −6 | 5.2 | 0.003 |
| L/R superior medial frontal | 10 | 37 | 12 | 63 | 15 | 4.99 | 0.039 |

Note. p < .0001 uncorrected, cluster-level FWE p < .05. BA = Brodmann’s area.
Table 3
Cluster peaks for the whole sample effect of increasing difficulty from Medium to Hard.

### A. Increased activation from medium to hard cluster-level

| Cluster Label                           | BA  | k    | X    | Y    | Z    | t-value | p fwe  |
|----------------------------------------|-----|------|------|------|------|---------|--------|
| R inferior and superior parietal lobule | 7   | 1315 | 42   | −51  | 54   | 8.6     | <.001  |
| R inferior frontal and insula          | 9   | 2220 | 48   | 33   | 21   | 8.38    | <.001  |
| L cerebellum crus 1 & 2                | 476 |      | −9   | −81  | −33  | 8.29    | <.001  |
| R superior medial frontal gyrus        | 8   | 432  | 9    | 27   | 45   | 7.21    | <.001  |
| R lingual gyrus                        | 18  | 37   | 18   | −87  | −6   | 6.75    | 0.04   |
| L insular cortex                       | 13  | 99   | −33  | 21   | −3   | 6.42    | 0.003  |
| L middle occipital gyrus               | 44  | 53   | −57  | 21   | 30   | 5.45    | 0.019  |
| L orbitofrontal gyrus                  | 47  | 41   | −45  | 45   | −6   | 5.06    | 0.033  |
| L inferior and superior parietal lobule| 40  | 141  | −39  | −48  | 48   | 4.81    | 0.001  |

### B. Deceased activation from medium to hard cluster-level

| Cluster Label                           | BA  | k    | X    | Y    | Z    | t-value | p fwe  |
|----------------------------------------|-----|------|------|------|------|---------|--------|
| L/R posterior and anterior medial wall and precuneus | 18  | 10811| 0    | −72  | 24   | 10.96   | <.001  |
| L middle temporal and angular gyrus     | 39  | 1846 | −42  | −57  | 21   | 8       | <.001  |
| L superior frontal gyrus                | 8   | 222  | −18  | 33   | 42   | 7.06    | <.001  |
| L orbital frontal gyrus                 | 47  | 69   | −27  | 36   | −15  | 6.31    | .014   |

Note. p < .0001 uncorrected, cluster-level FWE p < .05. BA = Brodmann’s area.

Fig. 2. Effect of incremental increasing difficulty across the entire sample. Panel A shows the contrast of activation for Medium > Easy trials. Panel B shows the contrast of activation to Hard > Medium trials. Color scale indicates t-values. Abbreviations: LH – Left Hemisphere; RH – Right Hemisphere.
Conflict of Interest

The authors (KMK, JRR, MAB, KMR) of this manuscript (Functional magnetic resonance imaging data of incremental increases in visuo-spatial difficulty in an adult lifespan sample) have no conflicts of interest to report.

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