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Data Article

Demonstration and validation of Kernel Density Estimation for spatial meta-analyses in cognitive neuroscience using simulated data

Michel Belyk [a,b,*], Steven Brown [b], Sonja A. Kotz [a,c]

[a] *Faculty of Psychology and Neuroscience, Department of Neuropsychology and Psychopharmacology, University of Maastricht, Maastricht, The Netherlands*
[b] *Department of Psychology, Neuroscience & Behaviour, McMaster University, Hamilton, Ontario, Canada*
[c] *Department of Neuropsychology, Max Planck Institute for Human and Cognitive Sciences, Leipzig, Germany*

A R T I C L E I N F O

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A B S T R A C T

The data presented in this article are related to the research article entitled “Convergence of semantics and emotional expression within the IFG pars orbitalis” (Belyk et al., 2017) [1]. The research article reports a spatial meta-analysis of brain imaging experiments on the perception of semantic compared to emotional communicative signals in humans. This Data in Brief article demonstrates and validates the use of Kernel Density Estimation (KDE) as a novel statistical approach to neuroimaging data. First, we performed a side-by-side comparison of KDE with a previously published meta-analysis that applied activation likelihood estimation, which is the predominant approach to meta-analyses in cognitive neuroscience. Second, we analyzed data simulated with known spatial properties to test the sensitivity of KDE to varying degrees of spatial separation. KDE successfully detected true spatial differences in simulated data and displayed few false positives when no true differences were present. R code to simulate and analyze these data is made publicly available to facilitate the further evaluation of KDE for neuroimaging data and its dissemination to cognitive neuroscientists.

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* Correponding author at: Faculty of Psychology and Neuroscience, Department of Neuropsychology and Psychopharmacology, University of Maastricht, Maastricht, The Netherlands.
E-mail address: belykm@gmail.com (M. Belyk).

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Specifications Table

Subject area	*Cognitive Neuroscience*
More specific subject area	*Validation of Statistical Method*
Type of data	*Analysis, Figure, Code*
How data was acquired	*Meta-analysis, Simulation*
Data format	*Analyzed, Simulation*
Experimental factors	1) *Affective vs. linguistic prosody* 2) *Simulated spatial locations in the inferior frontal gyrus*
Experimental features	1) *Replication: We used KDE to replicate a previous meta-analysis that used the standard activation likelihood estimation approach.* 2) *Simulation: We used KDE to analyze simulated brain-imaging meta-data with known spatial properties.*
Data accessibility	*The data can be simulated using the R scripts in the supplementary materials of this article.*

Value of the data

- The data provide a means of evaluating Kernel Density Estimation (KDE) as a novel statistical approach to neuroimaging data.
- The R code included with this article will facilitate cognitive neuroscientists in simulating data to perform their own evaluations of KDE and applying it to other datasets.
- KDE allows researchers to restrict analyses to regions of interest in stereotaxic space for the purpose of testing a priori hypotheses without mandatory whole-brain exploratory analyses.
- Implementation in the publicly available R statistical computing language facilitates interfacing KDE with flexible and cutting-edge statistical tools for further methodological development.
- KDE may be computed at a higher spatial resolution than other methods, although at the cost of computational efficiency.

1. Data

1.1. Demonstration by replication

Fig. 1 presents a comparison of Activation Likelihood Estimation (ALE) across GingerALE software versions. GingerALE v2.3.6 detected all major areas of interest from the original analysis, but failed to detect any differences in direct contrasts.

Fig. 2 presents a replication of the same analysis using the KDE approach described in Belyk et al. [1], but restricted to an area of interest in the inferior frontal gyrus (IFG). Localization of linguistic prosody to the IFG pars opercularis was observable using the KDE approach. Affective prosody was localized to the IFG pars orbitalis, but only if sub-sampling procedures were omitted. This may be due to the very small sample size for linguistic prosody.

1.2. Demonstration by simulation

Fig. 3 presents density distributions for data simulated around idealized non-overlapping centroids within the three major divisions of the IFG. Fig. 4 presents the results of statistical contrasts between each simulated IFG location. KDE correctly localized each simulated brain area and distinguished each location from the others (cluster sizes ranging from 2392 mm^3 to 4184 mm^3).