Exposure to air pollution and noise is associated with cognition and brain structure in older adults

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Introduction:

Aging is associated with decreases in brain structure and cognitive performance [1,2]. However, during older ages, high inter-individual variability has been reported, with age explaining only minor parts of this variance [3]. Thus, other factors come into focus, such as environmental exposures to air pollution (AP) and noise. Previous studies have shown adverse associations of long-term AP and noise exposure with global cognitive abilities in older adults [4], implying a relation between the two exposures, cognitive abilities and brain structure. Therefore, the current study aimed at identifying exposure-related differences of AP and noise on cognitive abilities and structural atrophy in cognitive brain networks in older adults.

Methods:

The 615 older adults who were included in the current analysis (mean age: 61.5 ± 6.7, 271 f), were recruited as part of the population-based 1000BRAINS study [5], an extension of the preceding Heinz

Nixdorf Recall study [6]. Residential long-term exposures to AP included particulate matter (PM10, PM2.5, PM2.5abs), accumulation mode particle number (PNAM), nitrogen oxides (NOX, NO2) and distance to the nearest major road. Residential exposure to noise was modeled for weighted 24h (LDEN) and nighttime (Lnight) noise (for details about AP/ noise modelling, see [4]). Linear regressions were used to discover relations between AP/noise exposure and cognitive performance in five cognitive domains (Attention, Executive Function, Episodic Memory, Working Memory, Language). Based on the resulting associations, cognitive brain networks were extracted from functional resting state images using independent component analysis (voxel size: 2.4mm3; FSL [7]). Structural brain atrophy was measured using the local gyrification index (LGI; FreeSurfer [8]) on T1 weighted structural brain images (available n=590; 3 Tesla MR-Scanner, voxel size: 1mm3). Afterwards, AP/noise exposure was related to LGI values within the extracted networks (covariates: age, sex, education, neighborhood unemployment, alcohol consumption, smoking, physical activity; results were significant at p <.05).

Results:

We found negative associations between AP (PM2.5, PM2.5abs, NOx, PNAM) and language, as well as noise (NDEN, Nnight) and working memory performance. Based on these results, LGI values within the frontoparietal network were extracted (bilateral: dorsolateral prefrontal cortex [DLPFC], posterior cingulate cortex [PCC]/precuneus and inferior parietal lobule [IPL]). AP (PM10, PM2.5, NO2, and NOX) was negatively associated with LGI values in the right PCC/precuneus and IPL. Distance to major roads showed negative associations with LGI values in right DLPFC and PCC/precuneus. Further, PNAM showed negative associations with the right DLPFC. In contrast, noise (LDEN, Lnight) was positively associated with LGI values in the right DLPFC.

Conclusions:

The current study investigated associations between environmental exposure to AP/ noise and cognitive abilities and structural atrophy in the frontoparietal network. Long-term exposure to AP was adversely associated with language functions, suggesting an accelerated cognitive decline in older adults who are more strongly exposed to AP. These associations were accompanied by a more pronounced right hemispheric structural brain atrophy, especially in posterior parts of the frontoparietal network, thereby providing structural correlates for two major functionally based aging theories, i.e. posterior to anterior shift in aging [9] and the right hemi aging theory [10]. Notably, noise exposure, modeled at the outdoor façade, was associated with a preseveration of brain structure, which could be explained by protective behaviors in those exposed to more noise, e.g. window closing, and needs further investigation. Our results suggest that exposure to AP may be one important factor that contributes to the high inter-individual variability of brain structure and cognitive decline in older adults.

Imaging Methods:

Anatomical MRI [2]

Lifespan Development:

Aging [1]

Keywords:

Aging
Cognition

NORMAL HUMAN
STRUCTURAL MRI

[1|2]Indicates the priority used for review

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No

Please indicate below if your study was a "resting state" or "task-activation" study.

Resting state
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Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

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Was any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

Yes

Was any animal research approved by the relevant IACUC or other animal research panel? NOTE: Any animal studies without IACUC approval will be automatically rejected.

Not applicable

Please indicate which methods were used in your research:

Functional MRI
Structural MRI
Neuropsychological testing

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

FSL
Free Surfer

Provide references using author date format

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