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*Published in:*  
Alzheimer's & dementia : the journal of the Alzheimer's Association

*DOI:*  
[10.1002/alz.051698](https://doi.org/10.1002/alz.051698)

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*  
Publisher's PDF, also known as Version of record

*Publication date:*  
2021

[Link to publication in University of Groningen/UMCG research database](#)

### *Citation for published version (APA):*

Muurling, M., Reus, L. M., de Boer, C., Jagesar, R., Vorstman, J. A., Kas, M. J. H., & Visser, P. J. (2021). Social behavior assessment in cognitively impaired older adults using a passive and remote smartphone application. *Alzheimer's & dementia : the journal of the Alzheimer's Association*, 17(S11), [e051698]. <https://doi.org/10.1002/alz.051698>

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# Social behavior assessment in cognitively impaired older adults using a passive and remote smartphone application

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## Abstract

**Background:** In Alzheimer's Disease (AD), loss of social interactions has a major impact on well-being. Therefore, AD patients would benefit from early detection of symptoms of social withdrawal. Current measurement techniques such as questionnaires are subjective and rely on recall, in contradiction to smartphone applications, which measure social behavior passively and objectively. Here, we examine social interactions through passive remote monitoring with the smartphone application BEHAPP in cognitively impaired participants. This study aims to investigate (1) the association between demographic characteristics and BEHAPP outcome variables in cognitively normal (CN) older adults, (2) if social behavior as measured using the passive smartphone app BEHAPP is impaired in cognitively impaired (CI) participants compared to subjects with subjective cognitive decline (SCD), and CN older adults. In addition, we explored in a subset of individuals the association between BEHAPP outcomes and neuropsychiatric symptoms.

**Method:** CN (n=209), SCD (n=55) and CI (n=22) participants, older than 45 years, installed the BEHAPP app on their own Android smartphone for 7-42 days. CI participants had a clinical diagnosis of mild cognitive impairment or AD-type dementia. The app continuously measured communication events, application usage and location. Neuropsychiatric Inventory (NPI) total scores were available from 20 SCD and 22 CI participants.

**Result:** We found that older cognitively healthy participants called less frequently and made less use of apps. No sex effects were found. Linear models corrected for age, sex and education showed that compared to the CN and SCD groups, CI participants called less unique contacts and contacted the same contacts relatively more often (Figure 1). They also made less use of apps, visited less unique places and traveled less far from home. Higher total NPI scores were associated with more unique stay points and further travelling. Similar behavior patterns were found when correcting for multiple comparisons.

**Conclusion:** Cognitively impaired individuals show reduced social activity, as measured by the smartphone application BEHAPP. Neuropsychiatric symptoms seemed only marginally associated with social behavior as measured with BEHAPP. This research shows that a passive and remote smartphone application is able to objectively and passively measure altered social behavior in a cognitively impaired population.



Figure 1: Association between the BEHAPP variables, the three diagnostic groups and the NPI total score.

**Column 1-3:** Differences in BEHAPP variables between the three diagnostic groups, e.g. CI, SCD and CN participants. Green squares indicate that the first mentioned group shows on average higher values on that BEHAPP variable than the second mentioned group. Red squares indicate that the first mentioned group shows on average lower values on that BEHAPP variable than the second mentioned group. All analyses are corrected for age, sex and education (i.e., 'BEHAPP outcome ~ Diagnostic group + Age + Sex + Education').

**Column 4:** Association between BEHAPP variables and the NPI total score. Green squares indicate that the BEHAPP variable is positively related to the NPI, while red squares indicate that the BEHAPP variable is negatively related to the NPI. All analyses are corrected for age, sex and education (i.e., 'BEHAPP outcome ~ NPI total score + Age + Sex + Education').

\*\* indicates  $p < 0.01$ ; \* indicates  $p < 0.05$ ; · indicates  $p < 0.1$ . Abbreviations: SCD, subjective cognitive decline; CN, cognitively normal; CI, cognitively impaired; NPI, Neuropsychiatric Inventory.

FIGURE 1