

# ReSmart-15 : An Information Gain based Questionnaire for Early Dementia Detection

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## Abstract

To build an effective questionnaire for detecting early dementia, we propose ReSmart-15 which is a dementia detection questionnaire that includes daily behavior-based questions in five categories (i.e., attention (3Q), spatial ability (3Q), spatiotemporal ability (3Q), memory (3Q), and thinking ability (3Q)). As for the evaluation, we first collected responses from two different screening tests with 87 participants. Then we used a machine learning method called "information gain" ranking to show the effectiveness of ReSmart-15 compared to another representative screening test. As a result, we found that the top 2 questions were from ReSmart-15, and 60 percent of ReSmart-15 questions were in the top 10.

## Keywords

early dementia, questionnaire, information gain

## 1. Introduction

Existing screening tools for dementia have several limitations. For example, Mini-Mental State Examination (MMSE) [1], one of the widely used tests for measuring the clinical dementia rating scale (CDR) [2], is insensitive to detecting the early stages of dementia [3], especially for highly educated individuals [4, 5].

Using a screening test with low specificity could lead to an incorrect diagnosis of dementia in elderly individuals. Therefore, SED-11Q [6] aimed to investigate the state of daily activities performed in various aspects by including questions that dealt with social interactions and personality. In this study, inspired by the SED-11Q, we propose a questionnaire named ReSmart-15 by modifying the existing MMSE questionnaire for better detection of early dementia. The questionnaire consists of daily behavior-based questions in five categories (i.e., attention (3Q), spatial ability (3Q), spatiotemporal ability (3Q), memory (3Q), and thinking ability (3Q)), which are explained by CogniFit<sup>1</sup> which designed cognitive assessment through monitoring the patient's cognitive rehabilitation process [7].

As for the evaluation, we collected responses from 87 participants who were asked to answer 27 questions from two different screening tests for dementia, ReSmart-15 and NMD-12 [8]. NMD-12 uses automated feature

selection through information gain to rank the importance of all features and then filter out the low-ranking features. In information gain, each question in the questionnaire was treated as a feature when it had different importance in the prediction of a dementia diagnosis. In the same way, we computed the information gain to see if ReSmart-15 is ranked higher than NMD-12 [8]. The results show that most questions in ReSmart-15 were ranked higher than the NMD-12 questionnaire. This suggests that ReSmart-15 was composed of influential questions filtered by information gain, which may increase the accuracy of the early diagnosis of dementia.

## 2. Method

We collected audiences from SurveyMonkey<sup>2</sup> to recruit 87 participants (53 female) excluding four who dropped out. Their average age was 38.0 ( $SD=13.4$ , range=18-65). To show the effectiveness of ReSmart-15 compared to another existing screening questionnaire for early dementia detection, we conducted a user study where participants were asked to submit their responses to 27 different questions: 15 questions from ReSmart-15 and 12 questions from NMD-12 [8]. It took 4 minutes and 25 seconds on average to complete the task.

## 3. Evaluation

To evaluate the importance of the questions in ReSmart-15 compared to NMD-12, where it uses the information gain (IG) ranking in machine learning [8]. Let  $E(D)$  be an entropy, and  $E_q(D)$  be the amount of information to

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<sup>1</sup><https://www.cognifit.com/>

<sup>2</sup><https://www.surveymonkey.com/>

**Table 1**

The Questions ranks through information gain

Rank	IG	Questionnaire	Questions
1	0.28	<b>Resmart-12</b>	Do you often forget the points that you want to talk about?
2	0.27	<b>Resmart-9</b>	Are you having a hard time remembering where things are usually kept?
3	0.25	NMD-8	Is it difficult to learn how to use tools or equipment?
4	0.23	<b>Resmart-3</b>	Do you suspect others of hiding, or stealing items when they cannot find them?
5	0.22	NMD-2	Do you forget the correct year and month?
6	0.22	NMD-6	Are regular activities or ordinary hobbies less than before?
7	0.21	<b>Resmart-8</b>	Do you have trouble concentrating more than an hour?
8	0.20	NMD-11	Are working or professional skills getting worse?
9	0.17	<b>Resmart-5</b>	Do you often forget appointments?
10	0.16	<b>Resmart-4</b>	Do you have trouble handling money, such as when giving tips or calculating change?
11	0.15	<b>Resmart-7</b>	Do you become disoriented in unfamiliar places?
12	0.15	<b>Resmart-15</b>	Do you confuse names of family members or friends?
13	0.14	<b>Resmart-14</b>	Do you feel that learning a new stuff takes longer than before?
14	0.14	NMD-9	Is it difficult to get out (ride or drive to destination)?
15	0.14	NMD-7	Is it difficult to take medicine by yourself?
16	0.14	<b>Resmart-11</b>	Are you getting lost in familiar surroundings such as their own neighborhood?
17	0.14	NMD-3	Is it difficult to remember the time of appointment?
18	0.13	NMD-10	Is it getting worse to manage money?
19	0.13	<b>Resmart-10</b>	Do you repeat questions or statements or stories in the same day?
20	0.13	NMD-5	Is it difficult to learn how to use tools or equipment?
21	0.12	<b>Resmart-1</b>	Is cognitive function significantly worse than before?
22	0.12	NMD-4	Is it difficult to deal with complicated financing issues?
23	0.11	NMD-12	Do you often forget what you've talked about recently?
24	0.11	NMD-1	Has cognitive impairment influence daily life, social networking and work?
25	0.11	<b>Resmart-2</b>	Do you misplace items more than once a month?
26	0.08	<b>Resmart-13</b>	Do you have to drink coffee to wake yourself up?
27	0.01	<b>Resmart-6</b>	Do you remain energetic in every day life?

make an exact classification based on the partition by questions  $q$ , where  $D$  is the data sample in the training set. Then,  $E(D)$  and  $E_q(D)$  can be calculated as follows:

$$E(D) = - \sum_{i=1}^k p_i \log_2(p_i),$$

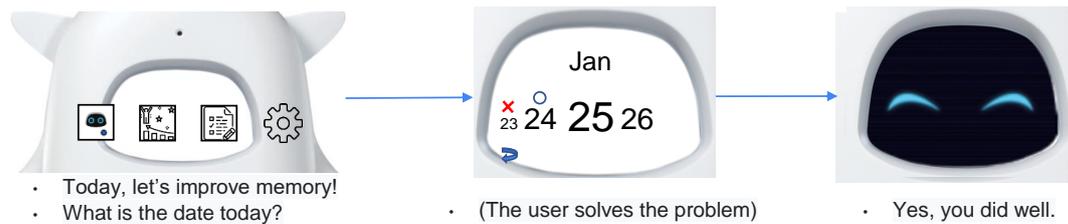
$$E_q(D) = - \sum_{j=1}^l \frac{|D_j|}{|D|} \times E(D_j),$$

where  $k$  is the number of classes,  $p_i$  is the probability that an arbitrary tuple in  $D$  belongs to class  $i$ , and  $l$  is the number of distinct values in  $q$ . In this study, we make total two classes where each class represents whether the user is in early dementia or not, which makes  $k = 2$ . Also, each questionnaire in ReSmart-15 and NMD-12 can only be answered by either yes or no, which makes  $l = 2$ . For simplicity, we diagnose early dementia when the number of "yes" answers is 14 or more, i.e., more than half of the total 27 questions. IG of each questionnaire  $q$  can be calculated by the difference between  $E(D)$  and  $E_q(D)$ .

## 4. Findings and Future Work

The purpose of this experiment was to select influential questions based on a machine learning technique called information gain. This technique treats each question as a feature and each of them has a different level of importance in the prediction of a dementia diagnosis. As shown in Table 1, our experiment found that the top 2 questions were from ReSmart-15, and 60 percent of ReSmart-15 questions were in the top 10. This suggests that ReSmart-15 was composed of influential questions filtered by information gain, which may increase the accuracy of the early diagnosis of dementia. Furthermore, information gain can be used to remove redundant or unnecessary features with low importance (i.e., ReSmart-13 and ReSmart-6), and can simplify the procedure of diagnosis.

In the next experiment, to make our social robot as a health care device, we would like to examine whether the questions with the high impact selected by the machine learning technique is likely to be more effective with a conversational voice-based interactive chatbot interface where it is known to have several benefits. It has the potential to act as a doctor for people with de-



**Figure 1:** Questionnaire Interface.

mentia by providing deep learning chat and awareness combination of information. It helps users [9] to drive conversations with users rather than simple Q&A services, and to ease technical barriers and build intimacy. We would like to experiment with a conversational voice-based user interface called *Musio*<sup>3</sup> as shown in Figure 1. It is deployed with *Muse*, which has a natural language processing (NLP) engine. *Musio* introduces himself at first and asks the questions (ReSmart-15) in a conversational format and we expect that *Musio* will relieve the users' burden of testing their cognitive abilities by providing a user interface with a familiar voice [10].

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<sup>3</sup><https://akaintelligence.com/>