INTRODUCTION

Aphasia is one of the most common and debilitating consequences of both the acute and chronic phases of stroke. Aphasia is present in 21%-38% of patients with acute stroke (Berthier, 2005; Laska, Hellblom, Murray, Kahan, & Arbin, 2001; Pedersen, Jorgensen, Nakayama, Raaschou, & Olsen, 1995), severely affecting patients’ ability to communicate, and therefore has a negative impact on
quality of life (Hilari, 2011; Spaccavento et al., 2014). Early identification and diagnosis of aphasia is an essential step toward maximizing therapy gains and improving language recovery outcomes (Salter, Jutai, Foley, Hellings, & Teassell, 2006).

Lengthy aphasia test batteries may be burdensome for stroke patients in poor health or with severe aphasia. Instead, it is reasonable to use considerably shorter aphasia screening tests in the acute phase of stroke (Al-Khawaja, Wade, & Collin, 1996). There are several aphasia screening methods reported in the literature (Hachiouai et al., 2017; Salter et al., 2006) that help with bedside evaluation to identify aphasia with the purpose of early diagnosis, therapy selection, and an improved prognosis. In this study, the MAST was chosen because it does not burden the patient and provides a broad overview of language abilities.

The MAST has become a widely used screening tool for identifying stroke patients with aphasia. The original English version of the MAST was published in 2002 (Nakase-Thompson et al., 2002) and validated in 2005 (Nakase-Thompson et al., 2005). The test has since been validated in the Czech, Spanish, Telugu, and Persian languages, but no Estonian-language version yet exists (Khatoonabadi, Nahostin-Ansari, Piran, & Tahmasian, 2015; Kostalova et al., 2008; Nagendar & Ravindra, 2012; Romero et al., 2012).

The MAST was developed as a brief, repeatable screening measure for individuals with severely impaired language skills. It was designed for a dynamic assessment of changes in language abilities over time and requires 5–10 min to administer (Nakase-Thompson et al., 2005).

Estonia participates in international stroke studies including patients with aphasia (Budincevic et al., 2015; Kõrv et al., 2014). However, standardized screening tests for aphasia are still lacking for medical personnel in Estonia. Once validated, the MAST will be able to provide more reliable data for these studies.

The aim of the present study was to linguistically and culturally adapt the MAST into the Estonian language. The discriminant validity and internal consistency of the test were examined as well as its sensitivity and specificity.

### METHODS

#### 2.1 Participants

Nonconsecutive first-time stroke patients with ischemic or hemorrhagic unilateral left hemisphere stroke (documented by neurological examination and computed tomography) admitted to the Department of Neurology of the Tartu University Hospital between 1 January 2014 and 31 April 2015 underwent nonstandard logopedic examination, and those with documented aphasia were recruited.

Persons with recurrent episodes of stroke, severe impairment of sight or hearing with no adequate correction available, or prestroke dementia diagnosis in previous medical history, and those with ischemic or hemorrhagic unilateral left hemisphere stroke without aphasia were excluded.

The CG was recruited during the same testing period as stroke patients from healthy volunteers who agreed to cooperate, who had no known or suspected speech or language impairment, and who spoke Estonian as their native language. Subjects with a history of neurological dysfunction, such as stroke, traumatic brain injury, dementia, and severe impairment of sight or hearing with no adequate correction available, were excluded.

Altogether, 50 subjects with documented aphasia who complied with the inclusion criteria, among them 20 men and 30 women, with a median age of 72.5 (range 55–90, QD = 13.75) years, were included in the LHA+ group. There were 25 patients with a basic level of education, 21 with a secondary level of education, and 4 with a high level of education (Table 1).

The CG consisted of 126 subjects (63 men and 63 women, with the median age of 54.5 years [range 18–89, QD = 35.25]). With respect to level of education, the subjects were distributed equally among basic, secondary, and high levels.

A sub-group of the CG aged ≥55 years, which corresponds to age range of left hemisphere stroke patients (CG1), comprised 63 individuals, including 30 men and 33 women (median age 72, range 50–90 years).

#### Sociodemographic variables

| Variable                  | LHA+ group (n = 50) | CG (n = 126) | CG1 (n = 63) | Level of significance (LHA+ group vs. CG1) |
|---------------------------|---------------------|-------------|-------------|------------------------------------------|
| Age (years) (median and range) | 72.5 (55–90)       | 54.5 (18–89) | 72 (55–89)  | p > 0.05                                 |
| Sex (males)               | 20 (40.0%)          | 63 (50.0%)  | 30 (47.6%)  | p > 0.05                                 |
| Handedness (% right handed) | 50 (100%)          | 126 (100%)  | 63 (100%)   | p > 0.05                                 |
| Level of education: Basic | 25 (50.0%)       | 42 (33.3%)  | 22 (34.9%)  | p > 0.05                                 |
| Secondary                 | 21 (42.0%)          | 42 (33.3%)  | 21 (33.3%)  | p > 0.05                                 |
| High                      | 4 (8.0%)            | 42 (33.3%)  | 20 (31.7%)  | p < 0.01**                               |

Note. LHA+ group: left hemisphere stroke patients with aphasia; CG: control group; CG1: sub-group of CG aged ≥55 years, which corresponds to age range of stroke patients.

**p < 0.01 according to Kruskal-Wallis test.
is needed.

Field of Five and Written/Spelling to Dictation, a table or hard folder

jects (e.g., pen, keys, watch). In the subtests Object Recognition from

perseveration, and orientation. These do not affect the MAST-T.

maximal and the translation) were compared and adaptations were made

language (subtests 4–7: Yes/No Accuracy, Object Recognition from

Field of Five, Following Verbal Instructions, Reading Instructions

subtest). The only exception is the Verbal Fluency subtest in which the

performed in the Estonian lan-

Procedure

| 2.3

The MASTest consists of nine subtests for assessing expressive (sub-

tests 1–3 and 8–9: Naming, Automatic Speech, Repetition, Verbal

Fluency and Written/Spelling to Dictation subtest) and receptive

language (subtests 4–7: Yes/No Accuracy, Object Recognition from

Field of Five, Following Verbal Instructions, Reading Instructions

subtest).

Two points are given for each correct answer and zero points for

each incorrect answer. The only exception is the Verbal Fluency sub-

test in which the scoring is different (0 points given for 0–5, 5 points

for 5–10, and 10 points for 11 and more intelligible verbalizations).

There are two possibilities for analyzing patients' performance: (a) to

write all words that the patient verbalizes and code unintelligible ut-

terances with a dash; (b) to tape the patients' response and transcribe

it afterward. Each subtest adds up to 10 points, except for the fourth

subtest (Yes/No Accuracy), which adds up to 20. The sum of subtests

1–3 and 8–9 scores forms the MAST-E (range 0–50), while the sub-
tests 4–7 form the MAST-R (range 0–50), and the sum of all subtests
forms the MAST-T (range 0–100). The MAST-T helps to determine

the presence of aphasia and its severity. By comparing MAST-E and

MAST-R, it is possible to get a primary impression of which language

domain is more damaged: expressive or receptive language.

In the original version of MAST, there is a possibility to give op-
tional ratings (presence or absence), such as dysarthria, paraphasia,

perseveration, and orientation. These do not affect the MAST-T.

Stimulus materials include one photograph, five written instructions

(each instruction on a separate page) and five common everyday ob-

jects (e.g., pen, keys, watch). In the subtests Object Recognition from

Field of Five and Written/Spelling to Dictation, a table or hard folder

is needed.

2.3 | Procedure

The English version of the MAST was translated into the Estonian lan-
guage and then back into English. After that, the versions (the origi-
nal and the translation) were compared and adaptations were made

with respect to language and cultural specifics. The changes made
to the MASTest compared to the original MAST are listed in Table 2.

No adaptations were made in the Naming, Object Recognition from

Field of Five, Following Verbal Instructions, or Reading Instructions

subtests.

The adjusted MASTest was then applied by expert speech and

language therapists to five people with and five people without

aphasia to test the usability and interpretability of the translated

version of the test. Based on the expert speech and language ther-
apists' judgments about the content of the tasks, the comprehen-
sibility of the instructions, the procedure of administering the test

and evaluating the results, and the test's content validity were rated

"good" and no further alterations were made.

The LHA+ group was assessed at the hospital. The CG was as-

sessed at home or other places (such as a home for the elderly, a
daycare center for the elderly, and army bases).

An evaluation was performed within 2–4 days of the onset of

stroke. The MASTest was performed at the patients’ bedside. A letter
chart was used in some cases where stroke patients were unable to

use their right hand due to right side hemiparesis and refused to write

with their left hand. In a verbal fluency subtest, the patients’ response

was tape-recorded and transcribed afterward. A rating form was filled
out while administering the test. The Minimental State Examination

(MMSE; Folstein, Folstein, & McHugh, 1975) was performed on all

recruited healthy controls (controls <24 points were excluded).

The presence of aphasia was determined during a bedside clinical

logopedic examination with a nonstandardized test which was per-

formed by a qualified speech and language therapist. The MASTest

(both in the LHA+ and CG) was performed by a qualified speech

and language therapist and three previously instructed speech and lan-

guage therapy students.

Information about patients’ education was obtained from the

patients or their relatives. Patients’ level of consciousness and coop-

erability were assessed by a neurologist and a speech and language

therapist by using the Glasgow Come Scale (GCS). Patients with GCS

corresponding to degree >14 were included.

Demographic data (age) and medical information (neuroimaging

findings, stroke onset, recurring stroke, and prestroke dementia diag-

nosis) were obtained from patients’ medical history. The study was ap-

proved by the Research Ethics Committee of the University of Tartu.

Written informed consent was obtained from stroke patients or their

relatives. Participants in the CG signed the consent form themselves.

2.4 | Statistical analysis

The program SPSS (version 17.0) was used to analyze the data.

Frequency calculation, mean values, dispersion, Pearson correla-
tion coefficient, and bar charts were used to describe the subjects.

Cronbach’s alpha (α) was used to evaluate the internal consistency of

the MASTest. The results are considered acceptable α ≥ 0.7 (George

& Mallery, 2003). The distribution of the MASTest-T, MAST-E, and

MAST-R scores was nonnormal both in the CG and in the LHA+ group
(p < 0.01; χ² test). As the distribution of data did not corre-

spond to the normal distribution, nonparametric tests were applied.

To compare the groups, the Mann–Whitney U test, the Kruskal–Wallis

test, and χ² tests were used. The result was considered statistically

significant when the p-value was <0.05. To assess the sensitivity and

specificity of the MASTest-R program, ROC analysis was used.

3 | RESULTS

3.1 | MASTest scores according to age and level of education

The MASTest summary statistics and median score values strati-

fied by age, gender, and level of education are presented in
Table 3. MASTest scores were significantly associated with both age (Mann–Whitney U test; MASTest-T: U = 1,142.50, Z = 4.101, p = 0.000***; MASTest-E: U = 1,353.00, Z = 3.079, p = 0.002**; MASTest-R: U = 1,372.00, Z = 2.986, p = 0.002**) and level of education (Kruskal–Wallis test: MASTest-T: χ² = 13.640, p = 0.000***; MASTest-E: χ² = 8.923, p = 0.012**; MASTest-R: χ² = 10.241, p = 0.006**).

Proposed normative values for CG1 stratified by level of education are shown in Table 3. Within CG1, no significant correlation between MASTest scores and age was recorded (MASTest-T: p = 0.05). The MASTest-T in the LHA+ group varied between 14 and 98, which means that there was no ceiling or floor effect in respect to the MASTest-T. In subtests and MASTest-R, some patients of the LHA+ group achieved the maximum values. However, the ceiling effect was obvious in the CG (57 out of 126 persons scored 100 points on the MASTest-T), and in the Object Recognition from Field of Five subtest all 126 persons scored 10.

### 3.3 Validity of MASTest based on diagnostic accuracy

The sensitivity and specificity of MASTest were first evaluated using the 5th percentiles of the values in the CG (Kostalova et al., 2008) using empirical cutoff values (82.5 for MAST-T, 41.5 for MASTest-E, 40 for MASTest-R).

The sensitivity of the MASTest (correct detection of abnormal MASTest scores in the LHA+ group) was 74% for the MASTest-T, 82.5% for MASTest-E, and 40% for MASTest-R.

### Comparison of the values of MASTest scores between LHA+ group and CG

MASTest scores and subtest values were significantly different (p < 0.001) in the LHA+ group and CG (Table 4).

### Validity of MASTest based on diagnostic accuracy

The sensitivity and specificity of MASTest were first evaluated using the 5th percentiles of the values in the CG (Kostalova et al., 2008) using empirical cutoff values (82.5 for MAST-T, 41.5 for MASTest-E, 40 for MASTest-R). The sensitivity of the MASTest (correct detection of abnormal MASTest scores in the LHA+ group) was 74% for the MASTest-T.
and the MASTest-E (13 out of 50 in the LHA+ group) had a normal MASTest-T or MASTest-E), and 64% for the MASTest-R (18 out of 50 patients had a normal MASTest-R).

Similarly, the specificity of the MASTest (correct detection of MASTest scores in the CG) was 94% for the MASTest-TI and MASTest-EI (119 out of 126 patients) and 95% (120 out of 126) for the MASTest-RI.

### 3.4 | ROC analysis of the MASTest scores

The sensitivity and specificity of MASTest scores in detecting aphasia were also assessed with ROC analysis, which yielded higher cutoff values than the empirical cutoff values in the previous test (88 for MASTest-T, 44 for MASTest-E and MASTest-R). All fitted curves revealed statistically significant AUC ("area under curve"; Figure 1). The MASTest-T as well as the MASTest-E, and to a lesser extent, the MASTest-R provided sufficiently high sensitivity and specificity for diagnostic differentiation between the LHA+ group and the CG.

### 3.5 | Internal consistency of MASTest

The internal reliability of the MASTest-T, MASTest-E, and MASTest-R, assessed using Cronbach’s alpha, was good both in the LHA+ group and in the CG (0.885–0.947). Acceptable results with consistent responses were obtained with the CG MASTest-T and MASTest-R (0.730–0.776). However, with the CG MASTest-E, values were inconsistent (0.400; Table 5).

### 4 | DISCUSSION

In this study, we presented our process of adapting and validating the MASTest for Estonian-speaking persons. The process of translating and adapting the MASTest was in line with the translational versions of the MAST (Khatoonabadi et al., 2015; Kostalova et al., 2008; Nagendar & Ravindra, 2012; Nakase-Thompson et al., 2002, 2005; Romero et al., 2012). The equivalency of the MASTest with the original English version (Nakase-Thompson et al., 2005) ensures
that the results of the MASTest are comparable to the results of the MAST in English as well as other languages. The standard methodology used in developing the MASTest ensured the face and content validity of the MASTest. Our results further demonstrated that the MASTest has a high discriminative validity and a high internal consistency for the whole sample and the LHA+ group.

This study on the MASTest was performed on the LHA+ group in the acute phase of stroke (on the 2nd to 4th day of hospitalization). In other studies (including the original study by Nakase-Thompson et al.), patients were screened at a later time, in the subacute or chronic phase of stroke (Khatoonabadi et al., 2015; Kostalova et al., 2008; Nagendar & Ravindra, 2012; Nakase-Thompson et al., 2002, 2005; Romero et al., 2012). Our results suggest that the MAST can also be effectively used in the acute phase of stroke, which is important for the early diagnosis of aphasia and to determine the localization and extent of brain injury, which can maximize the benefits of therapy. Screening tests give information on the severity of language disorder in the fields of language production, comprehension, and oral and written language (Pedersen, Vinter, & Olsen, 2004; Vogel, Maruff, & Morgan, 2010). Based on the data collected during the short period of hospitalization (during the acute phase), decisions for further treatment and rehabilitation can be made (Inatomi et al., 2008).

MASTest scores in the CG were associated with age and level of education. Younger and more educated healthy individuals achieved higher MASTest scores, which is in accordance with other studies (Nagendar & Ravindra, 2012; Romero et al., 2012). We did not reveal a significant correlation between MASTest scores and age within CG1 (individuals corresponding by age to the LHA+ group). Therefore, normative score limits for CG1 were stratified by level of education (Table 3). However, stroke with aphasia can also be diagnosed in persons <55 years old (Singhal et al., 2013). In these rare cases, higher normal score limits should be considered.

Median MASTest scores across the three summary scores (MASTest-T, MASTest-E, MASTest-R) and the nine subtests were all significantly different in the LHA+ group and CG, demonstrating the high sensitivity and specificity of MASTest in detecting language impairment. This was also demonstrated in the original (Nakase-Thompson et al., 2005) and translated tests (Khatoonabadi et al., 2015; Nagendar & Ravindra, 2012).

The ceiling and floor effects of the MAST have been studied in respect to the MASTest-T of the LHA+ group and CG. In our study, no patients scored 0 or 100 on the MASTest-T (limits 14 and 98). The lack of floor or ceiling effects further verifies the content validity of the MASTest. The floor or ceiling effects were also not reported for the original English (Nakase-Thompson et al., 2005) and some translated versions (Khatoonabadi et al., 2015; Nagendar & Ravindra, 2012; Romero et al., 2012). However, a ceiling effect was reported in some subtests within the LHA+ group and it is common in the CG (Khatoonabadi et al., 2015), which indicates that the MASTest is easy to perform for many of the healthy

![FIGURE 1](image)

**FIGURE 1** Fitted receiver operating characteristic curves for CG. Cutoff values in solid numbers, Sens and Spec: sensitivity and specificity; PV+ and PV−: positive and negative predictive values. AUC (area under curve) with 95% confidence limits is also shown. N = 126 (all education levels included)

| Score | LHA+ group, n = 50 | CG, n = 126 | LHA+ group and CG, n = 176 |
|-------|------------------|-------------|--------------------------|
| MASTest-E | 0.885 | 0.400 | 0.905 |
| MASTest-R  | 0.936 | 0.776 | 0.911 |
| MASTest-T  | 0.940 | 0.730 | 0.947 |

Note. LHA+ group: left hemisphere stroke patients with aphasia, n = 50; CG: control group, n = 126.

**TABLE 5** Internal consistency (Cronbach’s alpha) of MASTest
persons in the CG. This probably also affected the sensitivity and specificity of the MASTest.

The sensitivity and specificity of the MASTest were assessed using both the 5th percentiles of the values in the CG and ROC analysis. The specificity of the MASTest evaluated using 5th percentiles of the MASTest-T was good (94%), but sensitivity was lower (74%), which is lower than in some other studies (Kostalova et al., 2008; Romero et al., 2012). In the original version of the MAST (Nakase-Thompson et al., 2005) 62%–76% (depending on which subtests or summary scores were used) of the LHA+ group, members were correctly classified. In our study, aphasia was not detected by the MASTest in 26% persons in the LHA+ group. However, 6% of persons in the CG had MASTest-T results below the cutoff point (82.5%). This might have been due to the fact that some elderly individuals in the CG had mild cognitive impairment which was not detected by the MMSE. ROC analysis yielded higher cutoff values (88% for the MAST-T) and sensitivity (88.9%), but lower specificity (80.0%) values than the first method. A smaller proportion of the LHA+ group (11.1%) and a higher proportion of the CG (20.0%) are not correctly classified. This means that more persons in the CG have to be thoroughly tested for the presence of aphasia.

In both cases (5th percentiles and ROC analysis), the sensitivity and specificity were lower for the MASTest-R than for the MASTest-E and MASTest-T. In two other studies where ROC analysis was performed (Kostalova et al., 2008; Romero et al., 2012), MAST-R sensitivity and specificity were also lower than in the case of the MAST-T and MAST-E. It seems that language comprehension tasks are harder to correctly accomplish than language production tasks for the CG.

The internal reliability of the MASTest (Cronbach’s alpha) was good for the whole sample and the LHA+ group, acceptable for the CG for the MASTest-T and MASTest-R, and low for the CG for the MASTest-E. The low internal consistency of the MASTest-E in the CG probably indicates the low variability of indices of language production with assessing tasks in this group.

In our study, we were unable to assess the convergent validity of the MASTest as no other screening or comprehensive test batteries for aphasic patients are available in Estonian. Also, intra-observer validity and test–retest reliability were not assessed. Our CG consisted only of healthy individuals, and patients with right-hemisphere stroke were neglected as their performance in the MAST has been described in earlier studies (Nakase-Thompson et al., 2005; Romero et al., 2012). In addition, our LHA+ group consisted of only a few individuals with a high level of education.

Our study was performed during the acute phase of stroke; all earlier studies, including the original study (Nakase-Thompson et al., 2005), were conducted during the subacute or chronic phase of stroke. Early detection of aphasia will enable early rehabilitation and thereby improve language recovery outcomes.

The MASTest is the first validated aphasia screening test for Estonian-speaking people, who number less than one million worldwide. Our experience indicates that the MAST can be used for small nations, but getting a comprehensive sample of the LHA+ group for test validation may be complicated. Simultaneously, collecting data in several hospitals and rehabilitation centers may be a useful strategy to shorten the period of validation.

The MASTest was developed as a brief screening tool that could be administered at the bedside or during clinic appointments by a variety of healthcare providers. Medical personnel are often asked to comment on patients’ cognitive abilities, including language function and communication skills, which has implications for implementing medical and rehabilitation interventions and monitoring the course of recovery (Nakase-Thompson et al., 2005). The original English version as well as the Estonian and other translated versions have proved to be valid and reliable instruments to assess language disorder in patients with post-stroke aphasia. To facilitate its practical use for medical personnel, complementation of the test manual, which the author is planning to compile, is needed.

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CONFLICT OF INTEREST

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