**Supplemental material**

**Table S1**. Demographic information and clinical characteristics of all participants. Onset = disease onset (B = bulbar, S = spinal, M = mixed), Days since onset = days between recruitment and disease onset, Tot\_ALSFRS = total score on the ALS Functional Rating Scale-Revised (ALSFRS-R), Bulb\_ALSFRS = bulbar subscore on the ALSFRS-R, Intell = speech intelligibility in percentage of intelligible words during the Sentence Intelligibility Test (SIT) [Tice Technologies, Lincoln, NE], SR = speaking rate in words per minute during the SIT, slow = slow bulbar progressors as determined by the a posteriori stratification approach, fast = fast bulbar progressors as determined by the a posteriori stratification approach. Some participant information is non-retrievable, resulting in missing data.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Subject | Sex | Age | Onset | Date of diagnosis | Date of Onset | Days since onset | Tot\_ALSFRS | Bulb\_ALSFRS | Intell | SR | Group |
| ALS1 | F | 75 | M | 8/1/2006 | 3/1/2004 | 1808 |  |  | 100 | 170 | slow |
| ALS2 | M | 52 | S | 4/1/2006 | 12/1/2005 | 443 |  |  | 100 | 150 | slow |
| ALS3 | M | 56 | S | 1/1/2004 |  |  |  |  |  |  | fast |
| ALS4 | M | 50 | S |  |  |  | 48 |  |  |  | slow |
| ALS5 | M | 56 | S |  | 1/1/2003 | 1106 |  |  | 97.27 | 174 | slow |
| ALS6 | F | 54 | S |  | 4/1/2005 | 687 |  |  | 98.18 | 185 | slow |
| ALS7 | F | 51 | B | 12/1/2007 | 3/1/2006 | 714 | 45 | 10 | 30 | 57 | fast |
| ALS8 | F | 58 | M | 1/1/2008 | 11/1/2007 | 265 |  |  | 85.45 | 106 | fast |
| ALS9 | F | 65 | B | 4/1/2008 | 10/1/2007 | 471 |  |  | 99.09 | 148 | slow |
| ALS10 | F | 48 | M | 7/10/2008 | 8/1/2007 | 390 |  |  | 82.73 | 115 | fast |
| ALS11 | M | 77 | S | 9/3/2008 | 6/1/2006 | 958 |  |  | 96.36 | 163 | fast |
| ALS12 | M | 47 | S | 8/1/2009 | 2/1/2009 | 402 |  |  | 99.09 | 193 | slow |
| ALS13 | M | 70 | S | 5/9/2010 | 8/1/2009 | 551 | 41 | 12 | 100 | 218 | slow |
| ALS14 | M | 49 | S | 10/1/2009 | 4/1/2009 | 358 | 47 | 12 | 98.18 | 256 | slow |
| ALS15 | M | 77 | S | 9/1/2009 | 1/1/2008 | 931 | 34 | 11 | 96.36 | 177 | slow |
| ALS16 | F | 63 | B | 4/1/2010 | 2/1/2010 | 359 | 24 | 3 | 41.37 | 73 | fast |
| ALS17 | F | 41 | S | 6/1/2009 | 10/1/2008 | 828 | 38 | 12 | 100 | 167 | slow |
| ALS18 | M | 75 | S | 3/1/2010 | 1/1/2007 | 1535 | 38 | 12 | 97.27 | 108 | slow |
| ALS19 | M | 44 | S | 3/3/2011 | 12/1/2010 | 236 | 37 | 10 | 98.18 | 188 | slow |
| ALS20 | M | 51 |  |  |  |  | 34 | 11 | 96.36 | 160 | fast |
| ALS21 | F | 53 | S | 9/17/2014 | 4/1/2013 | 651 | 26 | 12 | 95.45 | 137 | slow |
| ALS22 | M | 55 | S | 11/25/2014 | 9/1/2013 | 696 | 31 | 12 | 96.36 | 219 | slow |
| ALS23 | M | 61 | S | 5/1/2014 | 5/1/2013 | 1057 | 45 | 12 | 79.09 | 121 | fast |
| ALS24 | F | 62 | B | 1/27/2015 | 9/1/2014 | 161 | 44 | 8 | 94.55 | 111 | fast |
| ALS25 | M | 46 | S |  |  |  | 40 | 12 | 99 | 109 | slow |
| ALS26 | F | 70 | B | 4/27/2015 | 1/1/2014 | 518 | 37 | 7 | 94.55 | 118 | slow |
| ALS27 | F | 54 | S | 1/4/2015 | 1/9/2015 | 460 | 40 | 11 | 99.09 | 192 | slow |
| ALS28 | M | 81 | S | 1/3/2014 | 3/11/2015 | 252 | 38 | 6 | 87.27 | 113 | fast |
| ALS29 | M | 42 | S | 8/5/2015 | 12/2/2016 | -317 | 38 | 12 | 97.27 | 168 | slow |
| ALS30 | F | 60 | S | 3/23/2016 | 1/1/2016 | 159 | 33 | 9 | 99.09 | 115 | slow |
| ALS31 | F | 52 | S |  |  |  | 39 | 10 | 100 | 127 | slow |
| ALS32 | M | 52 | B | 3/4/2014 | 6/1/2013 | 718 | 38 | 10 | 93.64 | 142 | slow |
| ALS33 | M | 57 | S | 1/12/2014 | 1/1/2010 | 2020 | 23 | 9 | 99.09 | 171 | fast |
| ALS34 | F | 56 | B | 3/1/2015 | 9/1/2014 | 471 | 39 | 8 | 98.18 | 82 | slow |
| ALS35 | F | 46 | S | 9/1/2015 | 5/1/2014 | 728 | 38 | 12 | 100 | 128 | slow |
| ALS36 | M | 49 | S | 12/25/2012 | 6/1/2012 | 1432 | 22 | 10 | 98.18 | 95 | slow |
| ALS37 | M | 49 | S | 4/1/2013 | 8/1/2012 | 1387 | 33 | 8 | 97.27 | 123 | slow |
| ALS38 | M |  | M | 5/1/2015 | 6/1/2011 | 1882 | 30 | 11 | 98.18 | 229 | slow |
| ALS39 | M | 54 | S | 2/1/2015 | 1/1/2012 | 1248 | 36 | 10 | 100 | 156 | slow |
| ALS40 | M | 73 | S | 11/1/2014 | 1/1/2009 | 2349 | 44 | 10 | 99 | 155 | slow |
| ALS41 | M | 48 | S | 2/1/2014 | 4/1/2014 | 450 | 36 | 12 | 99 | 156 | fast |
| ALS42 | M | 42 | S | 7/1/2014 | 5/1/2015 | 80 | 42 | 12 | 100 | 160 | slow |
| ALS43 | F | 55 | S | 4/1/2013 | 6/1/2009 | 2314 | 34 | 9 | 100 | 142 | slow |
| ALS44 | M | 54 | S | 9/1/2015 | 1/1/2014 | 909 | 41 | 12 | 97.27 | 117 | slow |
| ALS45 | F | 48 | S | 8/1/2015 | 5/1/2014 | 623 | 45 | 12 | 98.18 | 195 | slow |
| ALS46 | F | 61 | S | 10/1/2015 | 10/1/2014 | 533 | 46 | 12 | 97.27 | 161 | slow |
| ALS47 | F | 70 | S | 12/1/2015 | 2/1/2016 | 63 | 44 | 12 | 92.73 | 155 | fast |
| ALS48 | M | 72 | S | 1/1/2016 | 9/1/2015 | 238 | 38 | 12 | 97 | 146 | slow |
| ALS49 | M | 60 | S | 7/1/2014 | 6/1/2012 | 1509 | 18 | 11 | 100 | 122 | slow |
| ALS50 | F | 58 | S | 3/1/2016 | 6/1/2012 | 1511 | 36 | 10 | 100 | 218 | slow |
| ALS51 | M | 58 | S | 10/1/2015 | 1/1/2013 | 1325 | 37 | 9 | 100 | 155 | slow |
| ALS52 | M | 64 | S |  | 6/1/2014 | 834 |  |  | 100 | 178 | fast |
| ALS53 | M | 52 | S | 5/1/2016 | 5/1/2015 | 504 | 36 | 9 | 98.18 | 196 | slow |
| ALS54 | F | 68 | S | 1/1/2016 | 3/1/2014 | 956 | 40 | 12 | 99.09 | 161 | slow |

**Articulation rate calculation**

Articulation rate was calculated in words per minute (WPM) as the ratio of the total number of words to articulation time (i.e., total reading time minus pause time) during the reading of the Bamboo passage as shown below for all participants and sessions. Pause time is excluded in calculating articulation rate because it is susceptible to respiratory and cognitive-linguistic deficits in ALS, which can confound the detection of articulatory deficits. Yunusova et al. [11] has demonstrated that articulation rate can effectively distinguish bulbar ALS from other phenotypes of ALS [11].

Bamboo passage:

Bamboo walls are getting to be very popular.  They are strong, easy to use, and good-looking. They provide a good background and can create a look of a Japanese garden. Bamboo is one of the largest and most rapidly growing grasses all over the world. Many varieties of bamboo are grown in Asia, although it is also grown in America.  Last year we bought a new home and have been working on the flower garden. In a few more days, we will be done with the bamboo wall in our garden. We have really enjoyed the project.

**A posteriori stratification of participants by the rate of bulbar disease progression**

This a posteriori stratification approach was developed in a prior study [9] based on the well-established relationship between speech intelligibility and speaking rate declines over time in ALS [12]. Specifically, it is known that, once speaking rate drops to 100~120 words per minute (WPM), patients can exhibit different trajectories of bulbar decline. In fast bulbar progressors, speech intelligibility declines precipitously over a relatively short period of time, while slow bulbar progressors are able to maintain intelligible speech. Therefore, the rate of bulbar disease progression in an individual can be indexed by the rate of speech intelligibility decline relative to speaking rate, based on which patients could be stratified as fast or slow bulbar progressors.

In the current study, we used this stratification approach to divide the participants into two groups based on their rates of bulbar disease progression. As in [9], the rate of bulbar disease progression was measured as the percentage decrease of speech intelligibility per unit (i.e., 1 WPM) drop of speaking rate throughout all sessions for each individual. Because this study is part of a larger ongoing longitudinal project, the participation duration varied across the 54 participants by the time data analysis was completed, which ranged from 1 to 681 days (M = 124 days, SD = 184). For individuals who only participated in a single session, their bulbar disease progression rates were estimated based on the single observation relative to the hypothetical bulbar disease onset, which was derived from the group data in the statistical model. To stratify the participants, an optimal cutoff of bulbar disease progression rate was derived using an optimization algorithm, which minimized the within-group variance while maximizing the between-group difference. The optimal cutoff was derived as 0.1% intelligibility decrease per unit decrease in speaking rate. Based on this cutoff, the participants were divided into two groups (i.e., fast and slow bulbar progressor groups). Specifically, the fast-progressor group included 14 participants with bulbar progression rates greater than the cutoff; the slow-progressor group included 40 with bulbar progression rates lower than the cutoff.

As an additional note, the stratification approach and the measure of bulbar disease progression rate derived in this approach are independent of the bulbar assessment tool based oral DDK. The stratification in [9] is based on a posteriori knowledge of bulbar declining patterns, which are derived from the measures of speech intelligibility and speaking rate tracked over an extended time period in the participants. On the other hand, the bulbar assessment tool predicts the bulbar declining patterns using oral DDK measures acquired at a single time point during the early stage of the disease (i.e., while speaking rate remains within the normal range), which does not require longitudinal tracking. Thus, these two approaches are based on different measures acquired within different time frames.