# Breathing affects reaction time in simple and delayed naming tasks

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In psycholinguistic research reaction time has often been utilized as a measure for incremental speech planning of different linguistic stages (e.g. [1]). However, physiological and phonetic factors, that may interact with representational level, have been rarely investigated.
The aim of this study is to investigate whether and how respiratory activity affects the planning time during a simple and a delayed naming experiment. Evidence for the role of respiration in speech planning has been found from pre-speech phases and inter-speech pauses in read speech (e.g. [2]). For example, prior to speech, speakers inhale deeper for longer utterances [3]. In our own pilot experiment [4] we adopted Sternberg and colleagues [5] seminal work to German. In their delayed naming experiment four female speakers were presented with sequences of 1-5 digits in ascending order and were instructed to utter the list as soon as possible. Sternberg et al. found that planning time, i.e. the time before starting to speak, increased linearly with the number of digits which was interpreted as an effect of locating, unpacking and activating of a larger number of subprograms. In Mooshammer et al. (2019) [4] nine native speakers of German were recorded acoustically and by means of inductance plethysmography. We could replicate Sternberg's effect of word length. Furthermore we found that in 72% percent of all trials the beep occurred during or before the inhalation phase. On average reaction time was 80 ms longer if the stimulus trigger occurred prior or during the inhalation phase. In the current study we increased the number of subjects to 20 and included two new conditions: additional to ascending numbers we added random number sequences (e.g. 7253). We expect planning of random sequences to take longer. Furthermore, the simple naming condition was compared to a delayed naming experiment for which we assumed that the speakers can control their breathing behavior before the trigger signal.

## METHOD

20 native speakers of German (10 f, 11 m) were recorded at 16 kHz with inductance plethysmography (Respitrace), simultaneously with the audio signal. Two flexible bands were wrapped around the torso of the speaker, one around the rib cage and the other around the abdomen. Via amplifiers changes in rib and abdomen volume were registered. The task consisted of reading ordered sequences of 1 to 5 digits. Ascending sequences started with numbers from 1 to 5, randomized sequences with 2 or 3. In the simple naming condition the stimuli were presented as numbers on a screen at the same time as an acoustic beep and a change of color on the frame of the screen. In the delayed naming condition, the beep was delayed by a randomized interval between 500 and 1000 msec after stimulus presentation. The planning time RT was defined as the interval from the beep to the acoustic onset of the response. We calculated the respiratory signal (RSUM) as the weighted sum of the thorax and the abdomen signals. The respiratory and acoustic data were labelled using Praat and EmuR ([6,7]). The inhalation phase was defined as the interval from the respiratory minimum prior to speech (=onset of inhalation) to the maximum of the RSUM signal and the expiration phase from the maximum (=onset of expiration) to the next minimum. Based on the timing of the respiratory activity and the beep the trials were categorized for phase: <I if the beep occurred at the end of the expiration prior to the next inhalation, I if the beep occurred during inhalation and E if the beep occurred during expiration.

## RESULTS

In 72% of the cases the beep occurred during or before the inhalation phase. Contrary to our expectation there was only a slight difference between the naming conditions (68% in the delayed naming condition, 76% in the simple naming condition). In both conditions the phase in which the trigger occurred had a huge effect on reaction time as can be seen in figure 1.
For the delayed naming condition (figure 1 left) the planning time was longest ($\overline{x}$= 534 ms) if

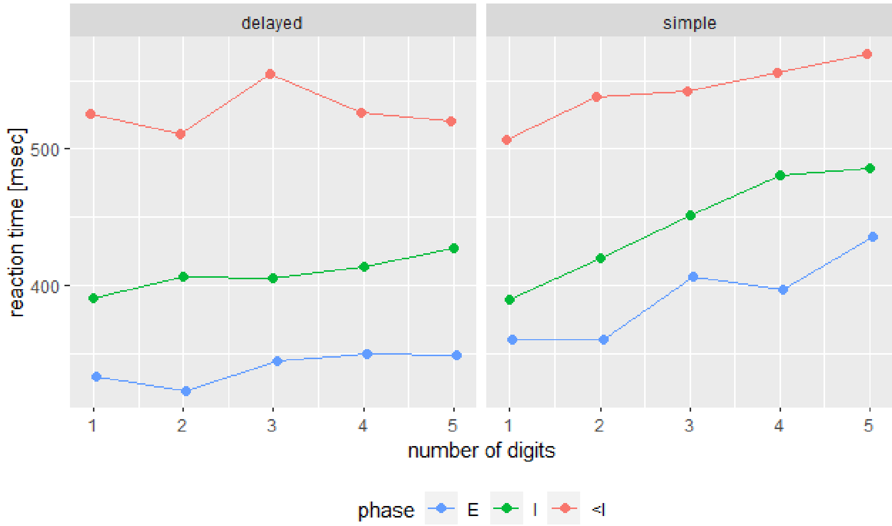


*Figure 1 Acoustic reaction times split by phase in which the beep triggers the reaction: <I = beep before inhalation, I = during inhalation, E = during exhalation, for the delayed and simple naming condition.*

the beep occurs before the speakers initiated inhalation, shorter if it is during inhalation ($\overline{x}$= 409 ms) and shortest during expiration ($\overline{x}$= 334 ms). A linear mixed model with speaker as random effect showed a significant main effect for number of digits, for phase and for initial segment (fricative vs. stop). There were no significant interactions and no effect of order (ascending vs. random). For the simple naming condition (figure 1 right) the planning time was longest ($\overline{x}$= 551 ms) if the beep occurs before the speakers initiated inhalation, shorter if it is during inhalation ($\overline{x}$= 451 ms) and shortest during expiration ($\overline{x}$= 389 ms). A linear mixed model with speaker as random effect showed a significant main effect for number of digits, for phase and for order (ascending vs. random). There was a significant interaction between number of digits and phase. The phase also affected the inhalation duration and depth.

## DISCUSSION

This study confirms our previous results that planning time is strongly affected by the respiratory phase during which the trigger signal occurs. Compared to linguistic conditions this physiological effect is quite large and exists also if the breathing activity could be planned in advance in the delayed naming condition. Nevertheless, the linguistic condition of word length is still significant. We conclude that breathing should be monitored during reaction time experiments to avoid potential biases by means of respiration.


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