Modeling non-Expert Text Entry Speed on 12-Button Phone Keypads
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### Keypad Layouts

Traditional layout (used by Multitap, T9 and others)  
Layout used by Less-Tap

### Phone Text Entry Techniques

**Multitap**  
(1.95 keystrokes per character)  
press a key repeatedly until letter appears

**Less-Tap**  
(1.44 KSPC)  
one keystroke for most frequent letters on each key...

**T9**  
(1.0072 KSPC)  
possible interpretations of key sequence compared to words in dictionary

### Models and Text Entry

Models help developing new text entry methods. However, existing models predict only *expert* text entry rates. Since the notion of *expert text message user* is unrealistic, the existing models do not agree with experimental results for novices.

#### Existing Models:

**Keystroke Level Model** (Card et al. 1980)
- General (typing, mouse pointing, drawing etc.)
- Predicts *execution time* by accounting for times of different actions
  - key press, pointing, homing, drawing, mental preparation time, system response time, etc.
- Not specific enough – only a framework

**Fitts’ Law Based Model** (Silfverberg et al. 2000)
- Two parts: *movement model*, based on Fitts’ law, and a *linguistic model*
- Only for “experts”!

#### Non-Motor Actions in Text Entry

- Re-reading phrase to be entered
- Figuring out next letter (spelling out word)
- Determining which button to press and how many times
- Deciding if *second* key press is required
- If pressing key more than twice, keeping count of number of presses made
- [Verifying the result]

The following figure shows the Times for Various *Multiple* Presses in multipress methods and demonstrates the significance of considering cognitive components in a model.

#### New Movement Model (time to enter a character)

**Multi-press Input Methods**
1. press ($N_1, N_2 = 0$)
2. presses ($N_1 = 1, N_2 = 0$)
3. or more presses ($N_1 = 1, N_2 > 0$)

\[ T_{\text{char}} = D_{\text{init}} + T_{\text{Fitts}} + N_1 \cdot (D_{\text{repeat}} + T_{\text{repeat}}) + N_2 \cdot (D_{\text{count}} + T_{\text{repeat}}) + [T_{\text{timeout}}] \]

**Predictive Input Methods**
Since the presses of NEXT are rare (<1% of total), assume $D_{\text{init}}$ is the same as in multi-press methods

\[ T_{\text{char}} = D_{\text{init}} + T_{\text{Fitts}} \]

### Completing and Verifying the Model

Combine the Movement Model with a Linguistic Model (letter digraph frequencies $\rho_i$):

\[ T_{\text{char in corpus}} = \sum \rho_i \cdot T_{\text{char ij}} \]

Conversion to words per minute:

\[ \text{WPM} = \left( \frac{1}{T_{\text{char in corpus}}} \right) \times (60/5) \]

### Comparison with Experimental Data:

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<thead>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Multitap</td>
<td>18.35</td>
<td>22.3</td>
<td>7.98</td>
<td>7.15</td>
<td>6.97</td>
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<tr>
<td>Less-Tap</td>
<td>23.47</td>
<td>26.8</td>
<td>7.82</td>
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<tr>
<td>T9</td>
<td>24.97</td>
<td>40.6</td>
<td>9.09</td>
<td>10.07</td>
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</tr>
</tbody>
</table>

### Learning Effect

Naturally, $D_{\text{init}}$ should decrease with learning. Based on results for Multitap in [3] (0.5 hrs per session, 20 sessions), we have compiled the following graph. Note that $D_{\text{init}}$ is still 200 ms after 15 hours.

### Summary

New predictive model for text entry speed on 12-button telephone keypads
- also predicts mental overhead
- values computed by the model are reasonably consistent with experimentally observed results
- can quite accurately predict performance of novice users
- potential prediction of learning

### REFERENCES