Modeling the Speed of Text Entry with a Word Prediction Interface

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Abstract—**This study analyzes user performance of text entry tasks with word prediction by applying modeling techniques developed in the field of human-computer interaction. Fourteen subjects transcribed text with and without a word prediction feature for seven test sessions. Eight subjects were able-bodied and used mouthstick typing, while six subjects had high-level spinal cord injuries and used their usual method of keyboard access. Use of word prediction decreased text generation rate for the spinal cord injured subjects and only modestly enhanced it for the able-bodied subjects. This suggests that the cognitive cost of using word prediction had a major impact on the performance of these subjects. Performance was analyzed in more detail by deriving subjects' times for keypress and list search actions during word prediction use. All subjects had slower keypress times during word prediction use as compared to letters-only typing, and spinal cord injured subjects had much slower list search times than able-bodied subjects. These parameter values were used in a two-parameter model to simulate subjects' word entry times during word prediction use, with an average model error of 16%. These simulation results are an encouraging first step toward demonstrating the ability of analytical models to represent user performance with word prediction.**

I. Background

COMPUTER-BASED augmentative and alternative communication (AAC) systems provide people who have severe disabilities with the opportunity to communicate independently in the areas of speech, writing, and computer applications. A major goal in the design and prescription of these systems is to provide the user with the fastest means of communication possible. A variety of techniques designed to enhance user performance are currently used in AAC systems, including word abbreviations [1], [2], message encoding [3], [4], and word prediction [5], [6]. There continues to be a need for greater understanding of the efficacy of these systems.

A primary aim in most rate enhancement approaches is to reduce the motor requirements placed on the user. This is clearly an important goal, since the vast majority of users have severe physical impairments. However, a frequent consequence of reducing motor requirements is to increase the cognitive and perceptual loads on the user [4], [7], [8]. The net balance of this trade-off determines whether the user's overall performance will be enhanced or inhibited with a system [9].

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This paper focuses on user performance with word prediction systems in particular and how it is affected by the trade-off between decreased motor and increased cognitive loads. Word prediction systems attempt to predict the word intended by the user by presenting the user with a set of word choices. Word prediction choices are typically displayed in a short list and are refined as the user selects additional letters. Since many words can be completed by choosing from the list rather than through letter-by-letter spelling, the number of selections required per word can be substantially reduced. Keystroke savings provided by several commercial word prediction systems have been measured in the range of 37–47% [10], with clinical reports ranging from 23–58% [5], [11]-[13].[1]

Keystroke savings represents the extent to which word prediction reduces the motor requirements on the user relative to letter-by-letter spelling. This benefit comes at the cost of additional cognitive and perceptual activities required to use the system. These include the visual search of the word list and the subsequent decision about whether the list contains the desired word. An additional source of cognitive load may be the processing involved in planning use strategies (e.g., deciding when to search) and guiding overall activity [14]–[16].

Evidence that these additional cognitive loads can have a negative effect on user performance is shown in Fig. 1. The figure shows the improvements in text generation rate with word prediction as reported in the literature for 13 individuals, relative to the keystroke savings achieved by these individuals [5], [11], [12], [17], [18]. It also shows what the rate improvements *would be* if there were no time cost due to additional cognitive and perceptual activities [9]. All but two of these individuals achieved less than this ideal improvement, which provides indirect yet strong evidence that the additional cognitive and perceptual activities reduce the benefit of decreased motor requirements. More direct evidence comes from our recent study on able-bodied users of scanning systems, in which use of word prediction slowed the rate of selecting items (i.e., letters and/or words) by 30–40% compared to letters-only typing [17].

In addition to providing evidence of cognitive cost, these data also show a large diversity in the effect of word prediction on text generation rate. This diversity may be partially due to differences in methodologies between studies, but it also suggests that the effect of word prediction depends on the

[1] Keystroke saving is measured as 1-(keystrokes required/ characters generated). Keystrokes are broadly defined to include keypresses in a direct selection system, as well as items selected in other ways, such as through scanning or Morse code.