Facilitation of Holistic Word Recognition:
Rehabilitation of a Case of Letter-by-Letter Reading

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Aim

The goal of the present study was to improve the reading skills of a LBL reader. The study examined two intervention techniques for improving holistic word recognition by focussing directly on the impaired mechanism of parallel letter processing.

Introduction

The term letter-by-letter (LBL) reading describes a form of acquired dyslexia in which patients show a serial reading strategy following an occipital lesion in the dominant hemisphere. The hallmark of the deficit is a word length effect – the increase in reaction time (RT) with increasing number of letters in a word – which reflects the pre-morbidly literate patient's laborious way of reading (Patterson & Kay, 1982). One account for LBL reading is a general perceptual deficit that degrades the visual input and permits only weak activation of the letters in a word (Behrmann, Plaut & Nelson, 1998). It has been argued that the perceptual deficit of these patients is particularly noticeable in perceptual contexts that lack strong perceptual cues such as reading (Sekuler & Behrmann, 1996). Thus, it may be possible to facilitate holistic word recognition in LBL readers by adding strong perceptual cues enabling patients to "chunk" multiple letters of a word.

Subject
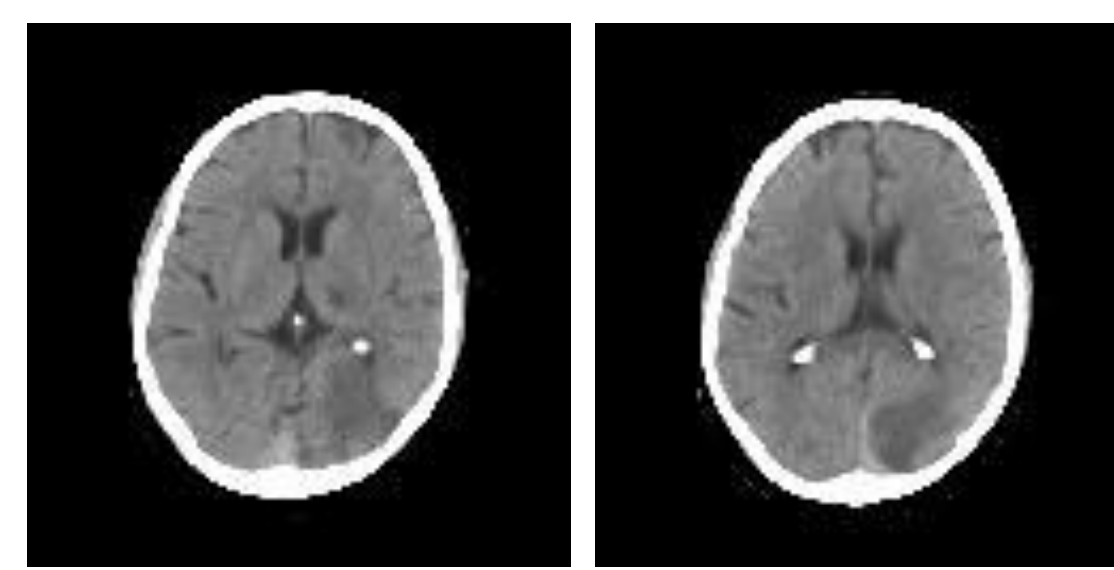
Pict. 1: **CT-Scan from May 2002**

KDA, a 65 year-old right-handed monolingual German speaking male, suffered a left posterior stroke (see pict.1) with right-sided quadrantanopsia. In several reading tasks (LeMo; Stadie et al., 1994), KDA shows a LBL reading strategy, visual reading errors (i.e. BAUM (*tree*) -> "RAUM" (*room*)) and early perceptual deficits (BORB; Riddoch & Humphreys, 1993) but there were no signs of either aphasia nor agraphia.

Training methods

Method without visual cue: Following recent work by Friedmann & Nitzberg Lott (2002) this training method employed rapid presentation of words (t = 500ms) requiring word identification with feedback by the therapist.
Examples: Buch (*book*), Glück (*luck*), Kissen (*pillow*), Drachen (*dragon*)

Method with visual cue: This method used a visually cued activation of the link between perceptual analysis and orthographic representation. As the method without visual cue it employed rapid presentation of words (t = 500ms) requiring word identification with feedback by the therapist and additionally, made use of a perceptual grouping cue (red colour) in each stimuli. The visual cue always highlighted letters in the end of each word, never marking a whole syllable.
Examples.: Holz (*wood*), Feuer (*fire*), Gewinn (*profit*), Frieden (*peace*)

Hypotheses

1. Training effects were expected from both training methods resulting in decrease of reading time and word length effect.
2. The method with visual cue was expected to lead to significantly higher increase of reading speed and accuracy and decrease of word length effect compared to the method without visual cue.

Material

The stimuli (n = 480) consisted of monomorphematic German Nouns (n = 240) and pseudowords (n = 240). Word stimuli consisted of equal number of four-, five-, six- and seven-letter words. Half the words were highfrequent (> 40/ mio, mean 107.8, SD 84) and half lowfrequent (< 20/ mio, mean 6.4, SD 5.6) (CELEX). Words were divided into 3 matched sets: Set 1 was used as training stimuli for the method without visual cue, set 2 for the method with visual cue, and set 3 was used as a control set. The pseudowords were created by substituting one letter of each word.

Design & Procedure

In this present cross over study, assessment and training phases were administered by means of dmdx-software run on a portable pc. Stimuli were presented in black, lower case, 24 point Arial font on a white background, preceded by a central black fixation cross remaining on the screen for 500ms. All stimuli were presented in the intact visual field, to the left of fixation. Baselines for assessing reading abilities consisted of 3 tasks:

· lexical decision (t = 300ms; n = 480)
· letter report of the first and last letter (t = 300ms; n = 128)
· naming words (n = 240)

In the condition with unlimited stimulus presentation times, stimuli remained on the screen until response was made. The letter report in words and pseudowords was used as an indicator for the adoption of a more parallel letter processing strategy (Behrmann & McLeod, 1995). Two control tasks in untreated modalities were assessed in order to rule out spontaneous recovery. Accuracy and RT were measured via key press or voice key. Training of each method started with the list of four-letter words, continuing with the list of longer words when criterion of 18/20 correct responses was reached in two consecutive training sessions.

Results

Training with the method without visual cue lasted for 5 weeks, training with method with visual cue for 3 weeks. The patient was seen three times a week for an hour.
1. There were no changes in performance in the two control tasks (p > 0.05). Both methods resulted in a *significant decrease in reading times* (paired T-Test: p = 0.000) *and word length effect* (fig. 1). After each method, the improvement in reading speed was obtained for trained (*item specific effect*) and most importantly, for untrained words (*generalisation*) (table 1).
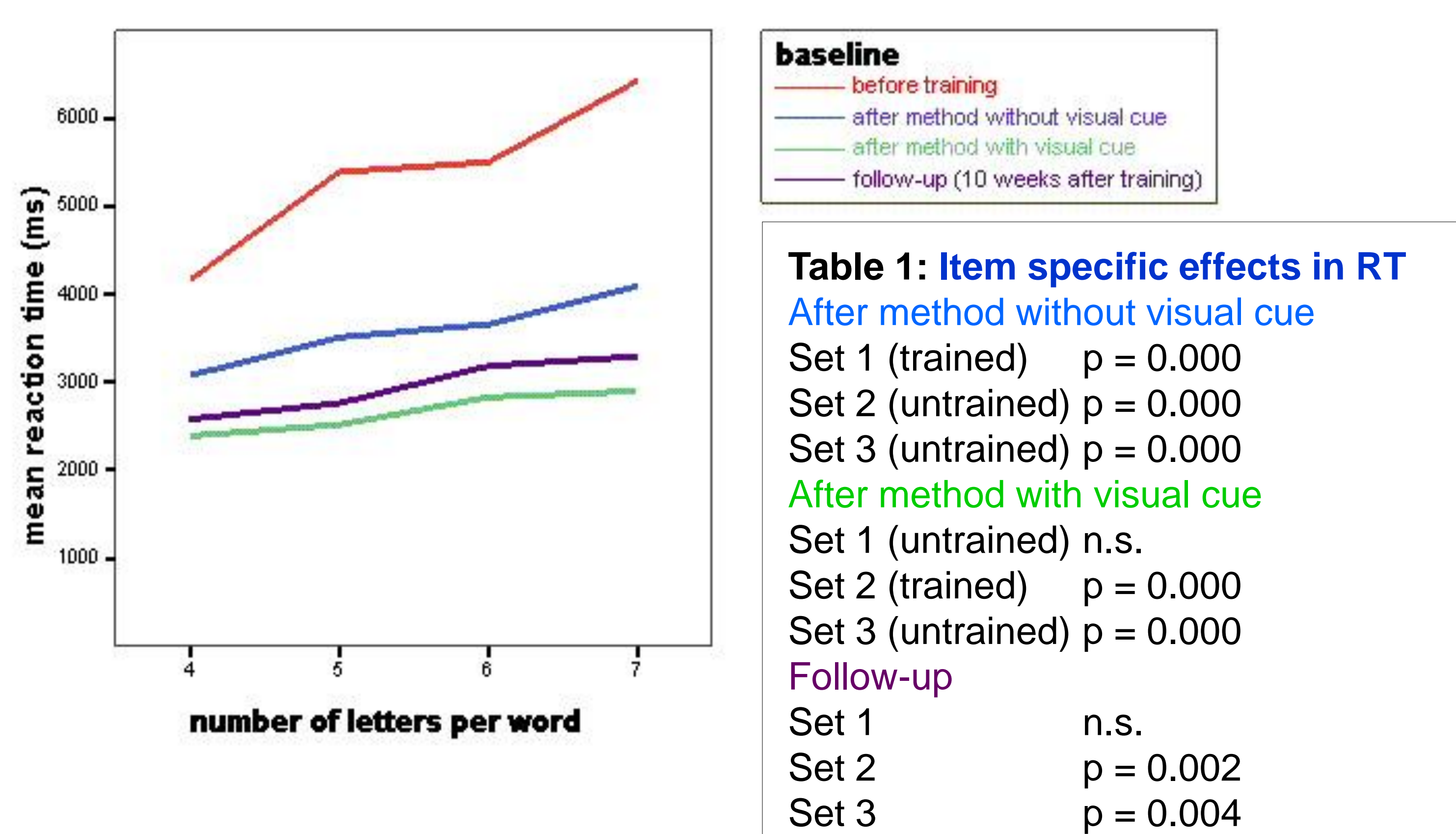
Fig. 1: **word length effect in reading**

Table 1: Item specific effects in RT

After method without visual cue	
Set 1 (trained)	p = 0.000
Set 2 (untrained)	p = 0.000
Set 3 (untrained)	p = 0.000
After method with visual cue	
Set 1 (untrained)	n.s.
Set 2 (trained)	p = 0.000
Set 3 (untrained)	p = 0.000
Follow-up	
Set 1	n.s.
Set 2	p = 0.002
Set 3	p = 0.004

Figure 2 shows the significant improvement in accuracy for report of the last letter after both training methods.
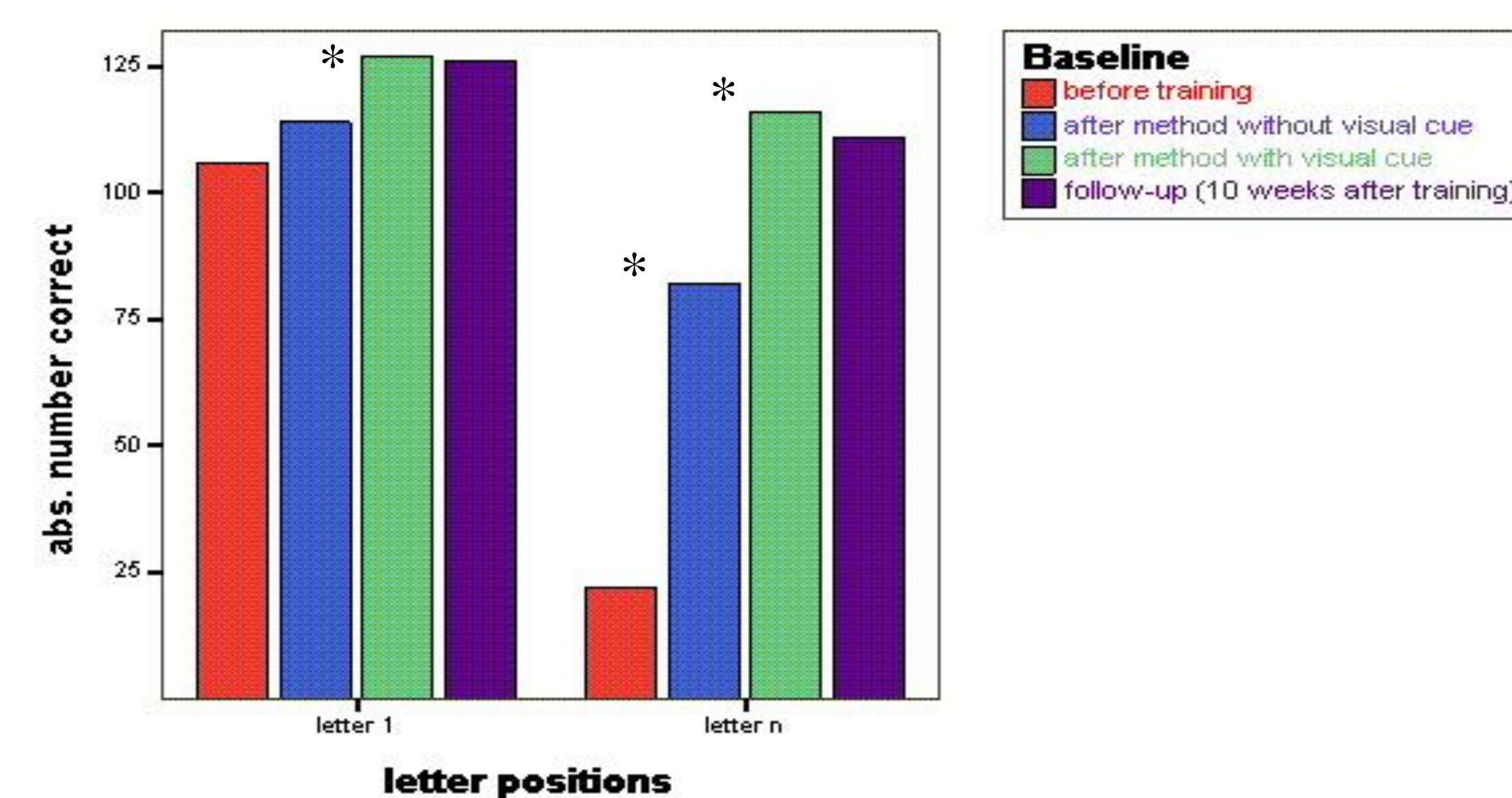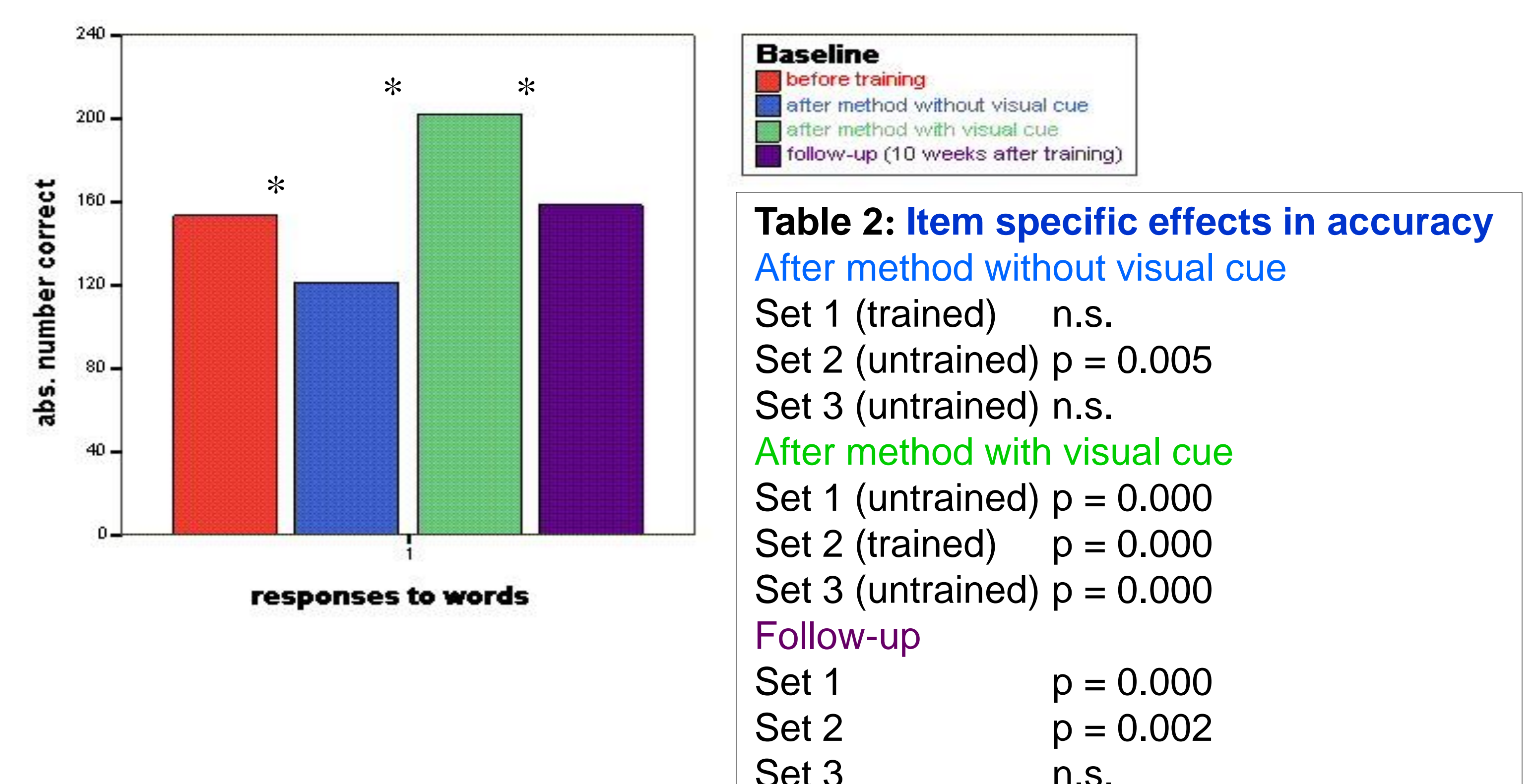**2.** A *method specific effect was obtained after application of the method with visual cue*, resulting in significant improvement in accuracy for reporting not only the last (p = 0.000) but also the first letter (p = 0.001) of a string.

Fig. 2: **accuracy in letter report**

A second *method specific result* is the significant improvement of correct responses to words in the lexical decision task (p = 0.000) after application of the method with visual cue (fig. 3). This improvement in accuracy is item specific and general (table 2).

Fig. 3: **number of correct responses to words in lexical decision**

Table 2: Item specific effects in accuracy

After method without visual cue	
Set 1 (trained)	n.s.
Set 2 (untrained)	p = 0.005
Set 3 (untrained)	n.s.
After method with visual cue	
Set 1 (untrained)	p = 0.000
Set 2 (trained)	p = 0.000
Set 3 (untrained)	p = 0.000
Follow-up	
Set 1	p = 0.000
Set 2	p = 0.002
Set 3	n.s.

Conclusion & Interpretation

1. Both intervention methods were effective in decreasing reading time and word length effect in a LBL reader.
2. The results of lexical decision and letter report can be interpreted as a method specific effect in favour of the method with visual cue. Because of limited stimulus presentation (t = 300ms), KDA was not able to use a serial reading strategy in either of the two tasks. There was a significant improvement in accuracy compared to results after the method without visual cue which can be interpreted as a better adoption of a parallel letter processing ability. In sum, visual cues seem to facilitate the activation of holistic word recognition in LBL reading.
3. Why do we not find a maintenance effect in the follow-up assessment after 10 weeks? A possible explanation could concern activation efficiency and/or the need of continuous training. This certainly needs further evaluation.

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