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Computerized Adaptive Assessment of Infant-Toddler Language Development: Demonstration and Validation of an App for Screening

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Purpose

We have developed a computerized adaptive test (an app), based on the MacArthur-Bates Communicative Development Inventories (CDI), that can rapidly gauge infant and toddler language development based on parent report. The app can be very useful in screening for developmental disabilities in IDEA Part C or Section 619. We will demonstrate the app and present validation data for toddlers.

Introduction

We have developed a computerized adaptive test (an app), based on a previously validated paper-and-pencil instrument called the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 2007). The app can rapidly gauge infant and toddler language development. The innovation is that the app is much faster than the existing paper-and-pencil CDI and uses sophisticated scoring. The app could therefore be very useful in screening for developmental disabilities in IDEA Part C or Section 619. It could improve child find and progress monitoring in both early intervention and early childhood special education, thus helping young children with disabilities that impact their language development get the supports and services they might need.

The CDI comes in two versions: CDI: Words and Gestures (CDI:WG—the "infant" test) and CDI: Words and Sentences (CDI:WS—the "toddler" test). The CDI and the computerized adaptive test are both parent-report instruments. (The tests do not assess the child directly. Instead, the parent reports to the test about the child.)

The paper-and-pencil infant test (CDI:WG) is normed for children 8 to 18 months. It has 492 items, mostly about child's expressive and receptive vocabulary (words the child understands and words the child says). See parts of first two pages in Figure 1.

The paper-and-pencil toddler test (CDI:WS) is normed for children 16 to 30 months. It has 797 closed-ended items, mostly about child's expressive vocabulary (words the child says). The paper-and-pencil version also has three items about how long a child's sentences are, but the app does not use them. See parts of first two pages in Figure 2.

Figure 1   Figure 2

The App

The adaptive CDI draws on the same items but customizes order of presentation depending on child's age and parent responses to earlier items. Applying Bayesian principles, the adaptive test terminates upon reaching criterion confidence about child's overall language age. Additionally, the adaptive test was configured to terminate in no fewer than 20 trials. See splash screen in Figure 3, main menu in Figure 4, and screens from two toddler items in Figures 5-6. (Come by when authors are at posters to see the app!)
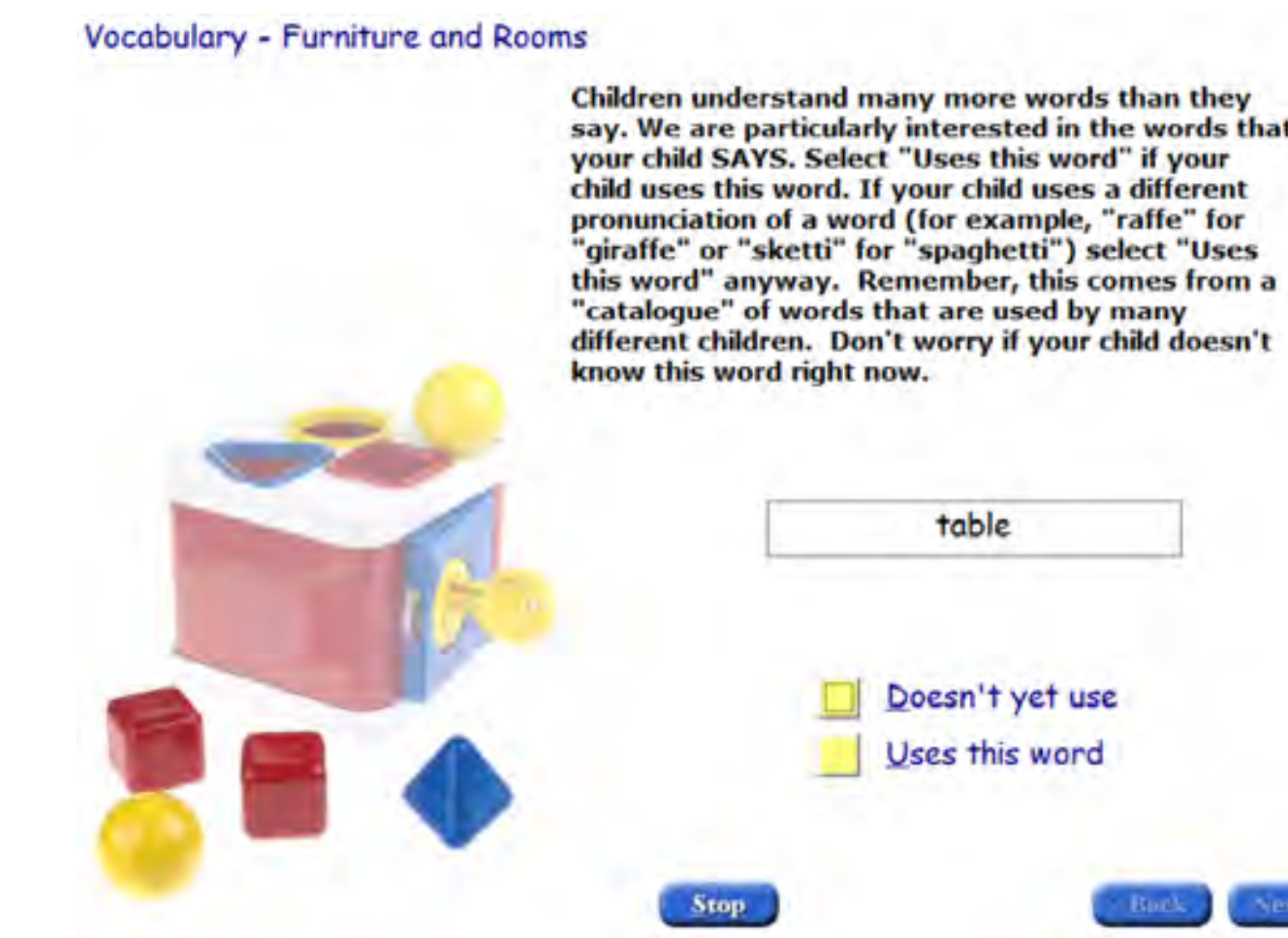

Figure 3   Figure 4

Figure 5   Figure 6

The app outputs a "language age" (age-equivalent score) and a percentile, and estimates the number of words the child would understand/say on the paper-and-pencil app. It includes 95% credible intervals for all these measures.

The app also outputs the estimated probability that the child falls below a specified percentile. This could be used in a screening protocol to help decide who to refer for evaluation.

We have previously validated the computerized adaptive CDI:WG (the app for infants; Cobo-Lewis et al., 2011). Today we validate the computerized adaptive CDI:WS (the app for toddlers).

Methods

Parents of 76 toddlers and young children, 17 (22%) of whom knew or suspected that their child had developmental delays, completed the paper-and-pencil CDI:WG and the computerized adaptive CDI:WG (the app).

For children without developmental delays, median age was 26.3 months (range 16.6–39.9 months).

For children with developmental delays, median age was 42.2 months (range 21.2–62.6 months).

We compared the app results to the paper-and-pencil CDI results. For some children, more than one parent participated, so we had a total of 86 data points in this validation study.

Results

Speed. The app completed in a median of 20.5 items. Two-thirds of parents finished the app in 30 trials or less, and none took longer than 61 trials. In other words, the app was just 3-8% of the length of the 797-item paper-and-pencil version.

Accuracy. The app gave results that were highly predictive of results on the much longer paper-and-pencil test. Figure 7 shows accuracy in predicting "language age." Median absolute error for the app was 1.9 months of "language age," and results of the app and the paper-and-pencil CDI had a correlation of 0.96 (Spearman rho).
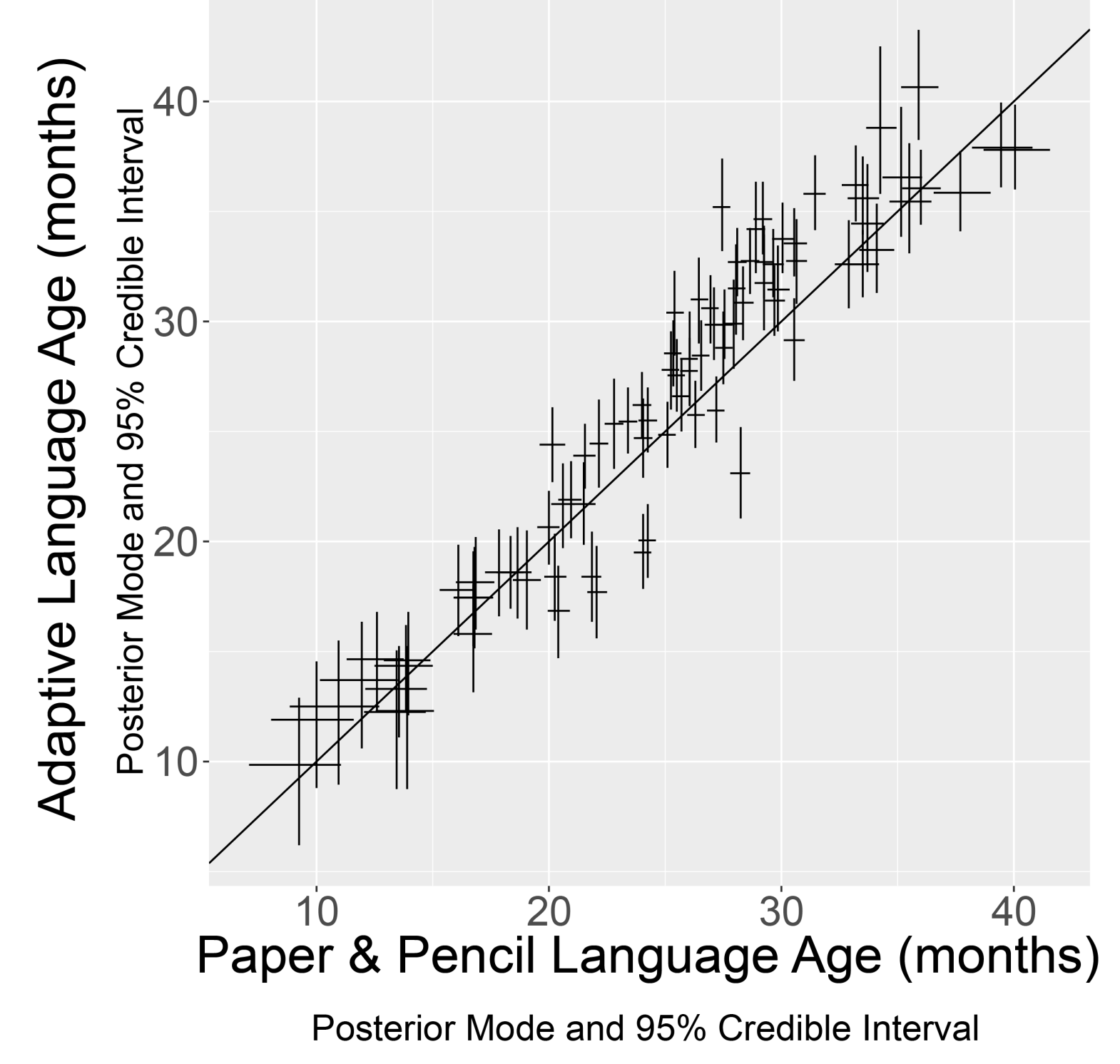

Figure 7

Identifying Children Who Experience Delays. We also tested how well the app identified children with delays (below a specified percentile). See Figure 8 for Receiver Operating Characteristic (ROC) curves. Sensitivity and specificity were both high, summarized by "area under curve" (auc) being close to 1. For example, to identify children at or below the 5th percentile (middle panel), sensitivity of essentially 100% was achieved with specificity over 95%.
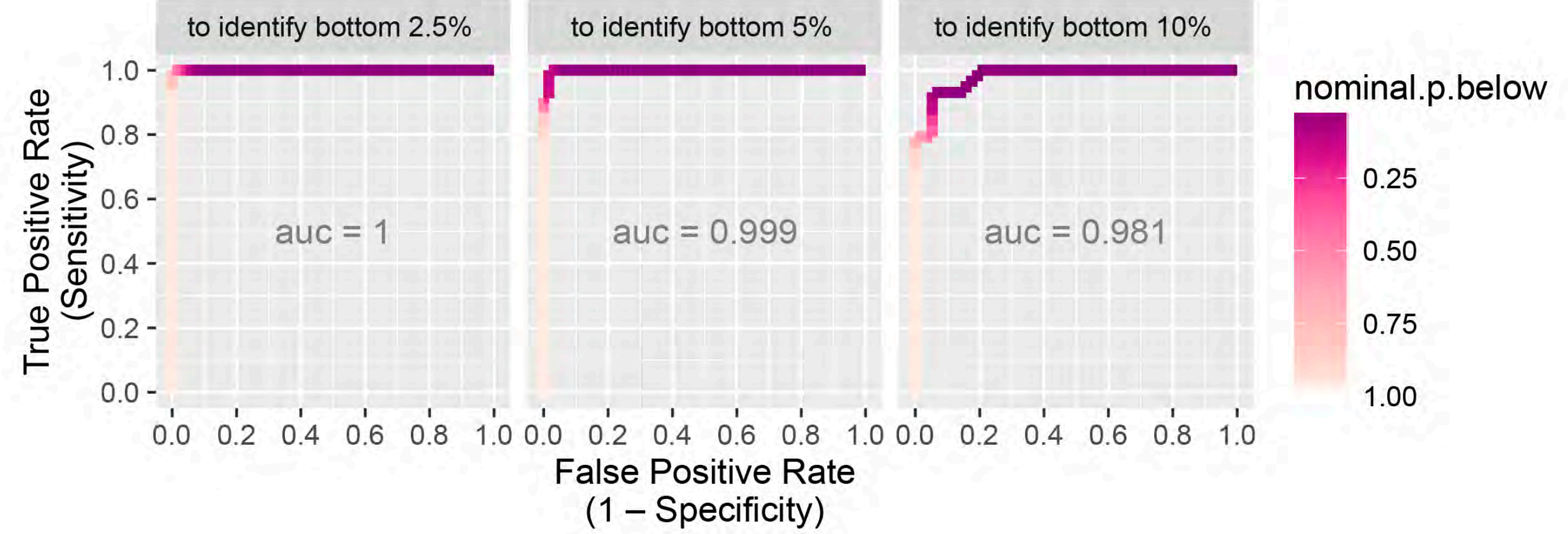

Figure 8

Conclusions

The app is much faster than the paper-and-pencil test but still yields a good estimate of a child's "language age." It is also very good at identifying children whose percentile (performance for their age and sex) is very low. This makes the app potentially useful in screening for developmental delay.

References

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Acknowledgments

Disclosure

Development of the computerized adaptive CDI is a joint project of Trefoil Corporation and the University of Maine. Cobo-Lewis, Markowsky, Trefoil, and the University of Maine have proprietary interest in the computerized adaptive CDI, and Markowsky has equity interest in Trefoil.

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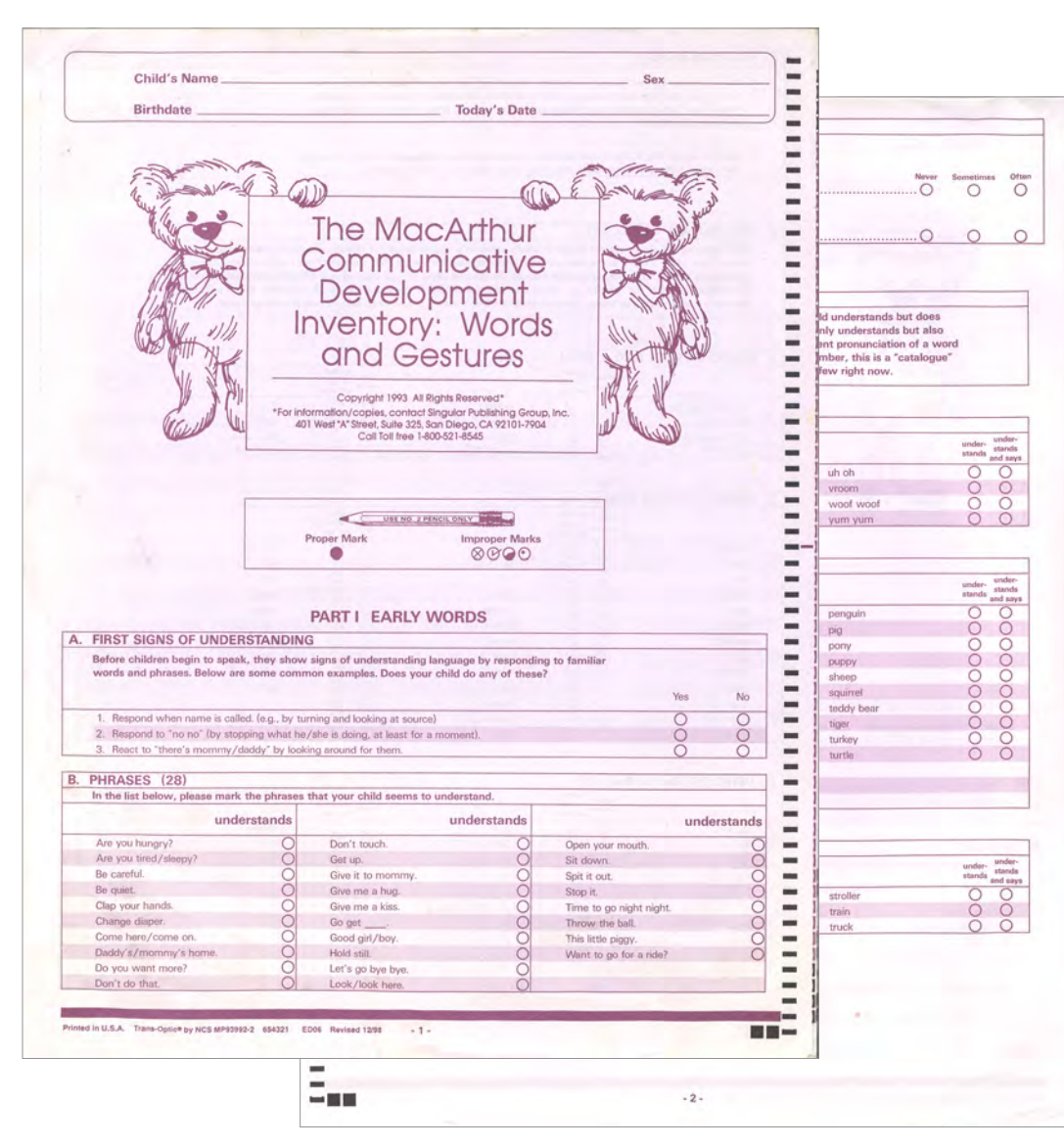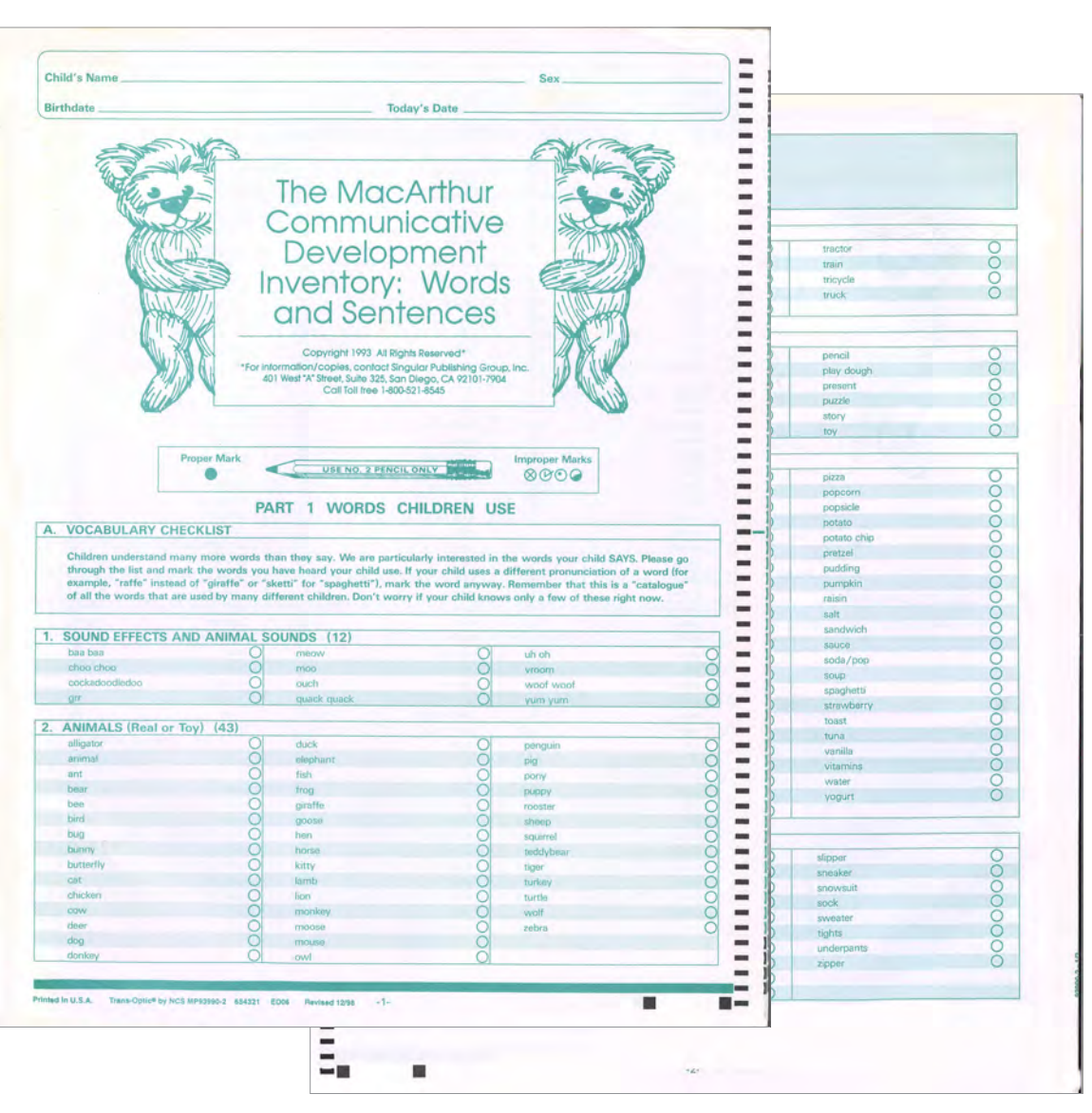
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