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BACKGROUND

The dCDT computerized scoring system measures quantitative and process variables of clock drawings captured by a digitizing ballpoint pen (Anoto). Although reliable and accurate (typically achieving 84% accuracy on routine protocols), the dCDT classification of pen strokes can err on some strokes due to unique drawing characteristics resulting from clinical syndromes. We developed the dCDT Classification Assist Tool (CAT) to improve the stroke classification in digitized clock drawings.

SUBJECTS AND METHODS

CAT enables clinicians to reclassify pen strokes into operationally defined categories (e.g., hands, spokes). Six clinicians learned the CAT tool from the dCDT manual and tutorial, then classified 6 standardized training clock protocols and received classification feedback. After demonstrating proficiency, clinicians analyzed 5 dCDT test protocols (270 strokes) pre-selected to require a high level of clinical judgment.

Computer and clinician-analyzed protocols were compared along four types of scoring classifications: corrected (computer error reclassified correctly by clinician); uncorrected (computer error left uncorrected by clinician); reclassification (computer correct reclassified incorrectly by clinician); incorrect (computer error reclassified by clinician to another error type). Figure 1 shows the copy and command clock for protocol 1; Table 3 gives the analysis of computer scoring on this protocol.

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Table 1. Error Analysis by Clinician using CAT Total Raw Errors

Clinician	Corrected	Uncorrected	Reclassification	Incorrect
1	127	0	0	0
2	118	5	0	6
3	117	2	4	10
4	113	3	0	13
5	117	6	7	6
6	111	3	17	14

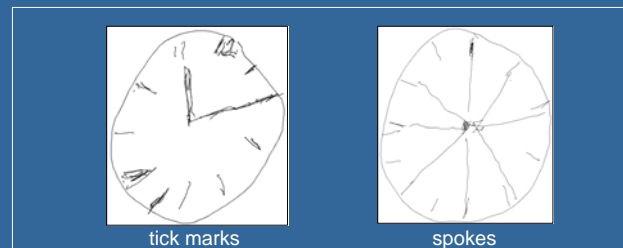
Table 2. Error Analysis by Clinician using CAT Total Percents

Clinician	Corrected	Uncorrected	Reclassification	Incorrect
1	99.26%	0.00%	0.00%	0.00%
2	95.93%	3.88%	0.00%	4.65%
3	95.56%	1.55%	3.10%	7.75%
4	94.07%	2.33%	0.00%	10.08%
5	95.56%	4.65%	5.43%	4.65%
6	93.33%	2.33%	13.18%	10.85%

Table 3. Error Analysis by Clinician using CAT dCDT Protocol #1

Clinician	Corrected	Uncorrected	Reclassification	Incorrect
1	51	0	0	0
2	47	2	0	4
3	44	1	2	8
4	40	2	0	11
5	47	1	7	5
6	44	1	12	8

Figure 1: Copy and command clock for Protocol #1



RESULTS

On these challenging protocols dCDT incorrectly classified 48% of the strokes (128/270) when compared to expert clinician standard. Of these errors, 73 (57%) were stroke types classifiable only by clinicians, e.g., the “tick marks” and “spokes” in protocol 1 (Figure 1). These are not identified by the computer program and require clinician scoring.

Use of the CAT improved overall classification significantly (mean = 94.01%, SD= 3.86%). Rater accuracy was high at 93% – 99% errors corrected (Tables 1 & 2).

CONCLUSIONS

Clinicians 1 and 2 were involved in the development of the CAT, had more familiarity with the tool than the other clinicians, and thus unsurprisingly had higher accuracy of stroke classification (0 and 11 total errors, Table 1) for all 5 command and copy clock protocols. Clinicians 5 and 6 were the least familiar with the program and also had lower accuracy (19 and 34 errors) using the CAT. Although overall rater accuracy was high at 93% – 99%, results suggest that user accuracy may increase with user experience.

The dCDT is a highly accurate scoring system that achieves 84% accuracy on routine protocols. Idiosyncratic strokes and some error types produced by patients may be incorrectly classified by the computer program. These strokes are easily reclassified correctly by use of the CAT when used by trained clinicians improving scoring precision.