Visual Checking: Why Take The Risk?

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Abstract

Data entry errors can reduce reliability and invalidate statistical analyses (Barchard & Pace, 2011). Researchers therefore use a variety of data checking methods to ensure accuracy. Double entry is more accurate than visual checking and read aloud (Barchard & Pace, 2011; Kawado et al., 2003; Reynolds-Haertle & McBride, 1992), but also takes longer **(**Barchard & Pace, 2011; Reynolds-Haertle & McBride, 1992). The purpose of this study was to determine if the reason that double entry is more accurate is that people spend more time on the data checking.

A total of 117 undergraduates were randomly assigned to three data checking methods: double entry, read aloud, and visual checking. First, they watched an instructional video that explained their method. Next, participants practiced their assigned method by checking the entries in the computer against five data sheets. In the main part of the study, participants were timed while they checked the entries for 20 additional data sheets, containing a total of 680 values.

To determine if differences in accuracy are due to differences in time, we used a two step procedure. First, we predicted accuracy using time, and saved the residuals. Second, we predicted the residuals based upon which method was used. Method significantly predicted accuracy after controlling for time (adjusted R-squared = .066, beta = -.27, $p < .001$). Double entry was still the most accurate. The mean number of correct entries was 678.06 for double entry, 677.72 for read aloud, and 677.28 for visual checking. Tukey's HSD showed that all pair-wise differences were significant at $p < .001$. Researchers often use visual checking despite its lower accuracy. Our study clearly shows double entry is worth the extra time: One hour of double entry corrects more errors than one hour of visual checking.

Introduction

The quality of our research studies depends upon the quality of our data. Data entry errors can completely change (and invalidate) our results. A single data entry error can make a significant t-test non-significant, and can change a moderate correlation to zero (Barchard & Pace, 2011). Understandably, researchers spend considerable effort locating and fixing data entry errors. Several data checking methods exist. In the visual checking method, one person looks back and forth between the original data sheets and the computer screen to check the data were entered correctly. In the read aloud method, one person reads the original data out loud while a second person looks at the computer screen. Finally, in the double entry method, a person enters the data a second time, and then the computer compares this new entry with the original entry to determine if there are any mismatches or values that are outside the allowable range (Barchard & Pace, 2008; Beaty, 1999).

Not all data checking methods result in equal accuracy rates. For example, empirical research has demonstrated that double entry is more accurate than visual checking. Among undergraduate students, visual checking resulted in 2958% more errors than double entry, and was not significantly better than simply entering the data once (Barchard & Pace, 2011). Similarly, among paid professionals, double entry detected 73% more errors than the read aloud method (Kawado et al., 2003). Reynolds-Haertle and McBride (1992) recommend double entry be used routinely. However, double entry is also more time-consuming (Barchard & Pace, 2011; Kawado et al., 2003). Barchard and Pace (2011) found that double entry took 33% longer than visual checking, which took 25% longer than single entry. The question is whether the increases in accuracy are worth the extra time that double entry takes.

The purpose of this study is to examine the relationship between accuracy rates and the time spent on data checking. Is double entry more accurate simply because it takes longer? Previous research has not yet explored this topic.

Method

Participants

A total of 117 participants (53 males and 64 females) participated in this study for credit towards their psychology courses. Ages ranged from 18 to 67 (mean 21.9, standard deviation 6.9). Participants identified their ethnicities as Caucasian (36.8%), Asian (24.8%), Hispanic (16.2%), African American (14.5%), Pacific Islander (6.8), and other (.9%).

Procedures

Participants in this study are taking the role of research assistants. They pretend that they are checking the data for a study. The data has already been entered, but there are may be some errors in the Excel file. Their job is to locate and correct the errors.

Participants completed the study in a single 90-minute session. First, participants watched a short instructional video on how to use Microsoft Excel. Then participants were randomly assigned to one of three data checking methods: visual checking, double entry, and read aloud. Participants watched a second instructional video on how to use their assigned data checking method. Next, participants practiced their assigned technique by checking five data sheets and correcting any errors. Finally, in the main part of the study, participants checked 20 additional data sheets.

Measures

Accuracy was measured as the number of correct entries in the main part of the study. An entry was considered correct if it was identical to the data on the paper data sheet. Time was calculated as the difference between the start time and end time for the main part of the study.

Results

Visual checking was faster than read aloud, which was faster than double entry. We compared the time it took to complete the data checking with the three methods using a one-way ANOVA. The overall ANOVA was significant, $F(2, 114) = 22.46$, $p < .001$. Tukey's HSD showed that each of the methods was significantly different from the other two. See Table 1 for the mean time for each of the three methods.

Visual checking was less accurate than read aloud, which was less accurate than double entry. We compared the three methods in terms of accuracy using a one-way ANOVA. The overall ANOVA was not quite significant, $F(2, 114) = 2.41$, $p = .094$. However, the mean accuracy values showed the expected differences, with double entry being the most accurate and visual checking being the least accurate. See Table 1 for these three means.

Finally, we wanted to determine if the greater accuracy of the double entry method could be explained by the additional time spent on the data checking. A two step process was used. First, we predicted accuracy using time. We conducted this analysis to get the residuals; which is a pure measure of accuracy once time has been taken into account. Second, we predicted the residuals based upon which method was used. Method significantly predicted accuracy after controlling for time (adjusted R-squared = .066, beta = -.27, $p < .001$). To determine where the differences lay, we compared the residuals across the data checking conditions using one-way ANOVA. The results were significant, $F(2, 185)= 40.99$, $p < .001$. Tukey's HSD showed that all pair-wise differences were significant at $p < .001$. Thus, once we controlled for time, visual checking was still less accurate than read aloud, which was still less accurate than double entry. See Table 1 for the means of each group, after controlling for time.

Table 1
Comparing Three Data Checking Methods

Method	Time (in min)	Raw Accuracy	Accuracy Controlling for Time
Double Entry	39.49	679.71	678.02
Read Aloud	34.78	677.69	677.71
Visual Checking	28.00	675.11	677.28

Discussion

Previous research has shown that visual checking is less accurate than read aloud, which is less accurate than double entry. We replicated those findings, showing that visual checking is faster but less accurate than read aloud, which is faster but less accurate than double entry. The purpose of this study was to see if the time spent on each method of data checking can account for the differences in accuracy. Our results showed that differences in accuracy remained significant after controlling for time. Tukey's HSD showed that all pairwise differences between the conditions were significant: Double entry was still the most accurate and visual checking was still the least accurate. We conclude that double entry is not only the most accurate, it is also the best use of one's time.

Given the catastrophic effect that data entry errors can have on research results, these results may convince researchers and others to use double entry. Future research should examine additional data checking techniques, but for now, these results reinforce the previous conclusions that double entry is the best. Table 2 summarizes a variety of free and commercial programs that are available to make double entry easy.

Table 2
Commercial and Free Double Entry Systems

Double entry systems	Reference
SPSS	SPSS (1996)
SAS	SAS (1990)
EpiData (stand alone program)	Lauritsen & Bruus (2008)
REDCap (Internet based program)	Harris et al. (2009)
PowerChecker (add on for Access)	Beaty (1999)
Poka-Yoke Data Entry System (add on for Excel)	Barchard & Pace (2008, 2010, 2011)

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