Zebra Striping: Does it Really Help?

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ABSTRACT
'Zebra striping' – also known as half shadow – is the application of a faint shadow to alternate lines or rows in data tables or forms to aid readability. Zebra striping has been in use on paper and in electronic mediums for almost half a century, however, there is practically no evidence that it actually assist users.

We conducted an online experiment to measure the impact of zebra striping on accuracy and speed when answering a series of questions using a table of data. Surprisingly, zebra striping did not consistently deliver gains in either measure.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation (e.g., HCI)**]: User Interfaces---*Graphical User Interfaces (GUI)*

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Design, Human Factors.

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Zebra striping, half shadow, shading, data tables, forms, formatting.

1. INTRODUCTION
The term 'zebra striping' refers to the application of a faint shadow to alternate lines or rows in data tables or forms. It is also sometimes referred to as 'half shadow'. See Figure 1 for an example.

Figure 1 is evidence that zebra striping has been in use since at least 1961. In recent times, zebra striping has been applied to the electronic medium, and can now be found in the background of many tables and forms published on the Internet.

Although one can find a wealth of instructions on **how** to implement such zebra striping (e.g. [1] [2] and [3]), there is a distinct lack of previous research on **why** zebra striping should be used.

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Figure 1. A half shadow advertisement from 1961 [4].

A widely held belief appears to be that zebra stripes aid readability. First principles of visual processing and design support this belief. For example, alignment of elements into rows can "make explicit the relatedness of elements sharing those rows and…lead the eyes left-to-right" [5]. Zebra striping may to visually reinforce these rows.

The use of alternate shading is also likely to imply connection between elements in a given row because of the Gestalt law of similarity. This law refers to the way that things which share visual characteristics – such as the presence or absence of shading – tend to "band together" [6].

However, it is very difficult to find any empirical evidence that zebra striping does help with readability of forms and/or data tables. An extensive review, conducted in June and July 2007, yielded absolutely no information on the origins, rationale or research behind zebra striping or half shadow. This review included sources such as the International Association of Paper Historians, the Business and Forms Management Association and the IEEE Annals of the History of Computing.

Given that applying zebra striping in an electronic medium is a nontrivial task, we decided to conduct a study to see whether it really did aid the user, as commonly believed. The findings of that study are presented in this paper.

2. METHOD

2.1 The experiment
To test whether the presence or absence of zebra striping affected accuracy and/or speed, an experiment was designed whereby participants were given data in a tabular form, both with and without zebra striping, and asked to answer six questions by referring to that data.

The experiment was conducted via the Internet, which was considered the most cost effective, time efficient and reliable approach. Participants were recruited using a 'snowballing' method: the researcher sent out an invitation to approximately 180 known contacts (via email) and two mailing lists. Many of these contacts then proceeded to forward the invitation to their contacts, or write about their study on their own websites.

2.1.1 *The table*

The data table, shown in Figure 2, had 15 rows (including a heading row) and nine columns. It contained artificial data, which was loosely based on common descriptors for screws. The aim was to construct a table that:

- was large enough to provide a cognitive challenge for participants;
- was not so large as to require scrolling, either horizontally or vertically, in the majority of cases[1];
- contained data that was not particularly familiar to participants, reducing the chance that they would just 'know' the answer without having to use the table; and
- had data in a number of different forms, including numeric and alphabetic, names, symbols, prices and quantities.

Name	Thread pitch (mm)	Minor diameter tolerance	Nominal diameter (mm)	Head shape	Price for 50 screws	Available at factory outlet?	Number in stock	Flat or Phillips head?
M4	0.70	4g	4	Pan	$10.08	Yes	276	Flat
M5	0.80	4g	5	Round	$13.89	Yes	183	Both
M6	1.00	5g	6	Button	$10.42	Yes	1043	Flat
M8	1.25	5g	8	Pan	$11.98	No	298	Phillips
M10	1.50	6g	10	Round	$16.74	Yes	488	Phillips
M12	1.75	7g	12	Pan	$18.26	No	998	Flat
M14	2.00	7g	14	Round	$21.19	No	235	Phillips
M16	2.00	8g	16	Button	$23.57	Yes	292	Both
M18	2.10	8g	18	Button	$25.87	No	664	Both
M20	2.40	8g	20	Pan	$29.09	Yes	486	Both
M24	2.55	9g	24	Round	$33.01	Yes	982	Phillips
M28	2.70	10g	28	Button	$35.66	No	1067	Phillips
M36	3.20	12g	36	Pan	$41.32	No	434	Both
M50	4.50	15g	50	Pan	$44.72	No	740	Flat

Figure 2. Data table used in the study (screen shot of zebra striped version).

Participants were randomly assigned to one of two groups:

- data table presented without zebra striping for the first questions and then with zebra striping for the last three questions; or
- data table presented with zebra striping for the first three questions and then without zebra striping for the last three questions.

Other than the application of zebra striping, no other changes were made to the table's formatting.

2.1.2 *The questions*

The six questions asked of participants were:

1. Is the screw with minor diameter tolerance of 6g available at the factory outlet?
2. What is the name of the screw that costs $33.01?
3. There are 292 screws of what thread pitch?
4. Is the screw with nominal diameter of 8 a flat head?
5. What is the name of the screw that costs $35.66?
6. There are 664 screws of which minor diameter tolerance?

In order to accurately determine the effect of zebra striping, the questions were 'paired' between the first set of three and the second set of three. This pairing is described below and illustrated in Figure 3 to Figure 5.

[1] Most participants with a screen resolution of at least 800 x 600 pixels, using a text size of no more than 14 points, would have been able to see the entire table without any scrolling.

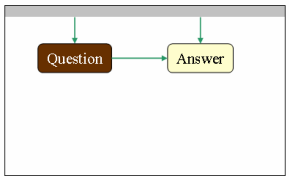

Figure 3: Answering questions 1 and 4.

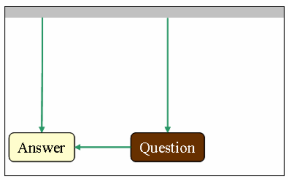

Figure 4: Answering questions 2 and 5.

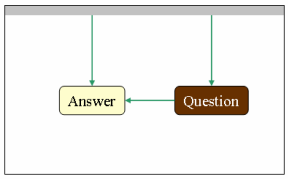

Figure 5: Answering questions 3 and 6.

Questions 1 and 4 both required the participant to search down a column that was not on the edge of the table, and find the appropriate row in another column, also not on the edge of the table. The distance between the two data points was 4 and 5 columns respectively.

Questions 2 and 5 required the participant to search down a column in the middle of the table, and find the appropriate row in another column on the left-most edge of the table. The distance between the two data points was 5 columns in both cases.

Questions 3 and 6 required the participant to search down a column almost on the far right-hand-side of the table, and find the appropriate row in another column that was towards the left-hand-side of the table. The distance between the two data points was 5 and 6 columns respectively.

The questions were also 'paired' in the degree to which they required users to move down the table (also illustrated in Figures 3 to 4):

- questions 1 and 4 used the 5th and 4th rows respectively;
- questions 2 and 5 used the 11th and 12th rows respectively; and
- questions 3 and 6 used the 8th and 9th rows respectively.

The questions were constructed this way on the assumption that the following attributes may influence the effect of zebra striping:

- the distance of a row or column from the edge of the table; and
- whether the participant is reading from right to left versus left to right.

In an attempt to ensure participants did not get all of the answers right, participants were asked to answer questions as quickly as possible. The time taken to complete each question was measured.

After finishing the six questions, participants were asked which set of questions they found easier to answer: the first three, the last three or neither set. From this we were able to ascertain whether or not the participant found the task easier when zebra striping was present.

2.2 The data

2.2.1 Cleaning the data

In total, 281 people started the experiment. Out of these 281:

- 24 people didn't proceed past the first question;
- 3 people went through every question but did not provide any answers; and
- 10 people answered only one or two questions.

After removing these sessions from the data file, clean data from 244 people remained for use in analysis. Out of these 244, 114 participants were presented with zebra striping on the first three questions and 130 participants were presented with a 'plain' data table (i.e. no zebra striping) first.

2.2.2 Removing outliers

The time taken to answer varied considerably between questions and between participants, but six observations were more than four standard deviations above the mean and were therefore treated as outliers. The size of these outliers – the greatest was just under 13 minutes – suggest that these participants were interrupted.

These times were replaced with the mean time across all questions (calculated excluding the outliers). This ensured that these sessions could be used without the overall distribution of time being affected.

3. FINDINGS

3.1 Accuracy

Table 1 shows that most questions were answered correctly. Participants had greatest difficulty with questions 3 and 6. This is not surprising – we suspect that these questions were the hardest because the relevant data was in the 'middle' of the table and had to be read from right to left.

Table 1. Participant answers.

Answer	Q1	Q2	Q3	Q4	Q5	Q6
Correct	240 (98%)	238 (98%)	215 (88%)	226 (93%)	239 (98%)	222 (91%)
Incorrect	4 (2%)	6 (2%)	29 (12%)	18 (7%)	5 (2%)	22 (9%)

The low number of incorrect answers for questions 1 & 2 and 4 & 5 would make any analysis unreliable, so this data were excluded from the remainder of the analysis. But as Table 2 shows, there is essentially no difference in accuracy between plain and striped answers for either question 3 or question 6. Between 8% and 12% of participants made a mistake regardless of whether or not the data table they were using had zebra striping.

Table 2. Analysis of striped and plain answers for accuracy.

Type	Q3			Q6		
	Correct	In-correct	**Total**	Correct	In-correct	**Total**
Plain	88%	12%	**100%**	89%	11%	**100%**
Striped	89%	11%	**100%**	92%	8%	**100%**

Taking the data from questions 3 and 6 we had one 'plain' answer (given when the table was shown without zebra striping) and one 'striped' answer (given when the table was shown with zebra stripes).

The proportion of plain answers that were correct was 94.3% compared to 93.9% of striped answers that were correct. By constructing binomial confidence intervals we confirmed that this difference is not statistically significant (see Table 3 below), as the intervals are overlapping.

Table 3. Confidence intervals for proportion of correct answers.

Statistic	Plain	Striped
Proportion	0.943	0.939
Lower bound of 95% confidence interval	0.918	0.913
Upper bound of 95% confidence interval	0.967	0.964

Finally, examination of the paired data showed that there were 27 cases where the participant answered one of the questions in the pair incorrectly. Of these 27 cases, there was an even split between giving the right answer when the table had zebra striping and giving the right answer when the table was plain, as shown in Table 4.

Table 4. Comparing paired answers for questions 3 and 6.

Type		Number of cases		
Plain	**Striped**	**Plain first**	**Striped first**	**Total**
Correct	Incorrect	9	5	14
Incorrect	Correct	5	8	13

3.2 Speed

The analysis suggest that zebra striping has negligible positive impact on task accuracy. Next we considered the time taken to complete those tasks. An improvement in speed would be beneficial even if there were no improvement in accuracy.

Figure 6 shows that the time taken to answer a question follows a positively skewed normal distribution (skewness = 2.5).

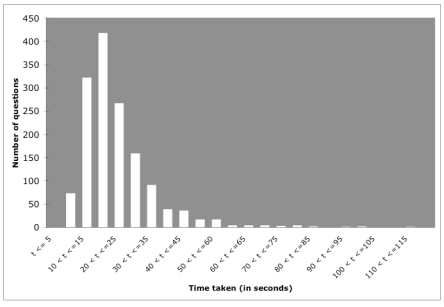

Figure 6. Frequency distribution for time taken.

The average observed time taken to answer questions 1 and 2 was greater when the table was zebra striped, but for the remaining four questions, the time taken was less when the table was zebra striped (see Table 5). However, only the difference in time taken for question 6 was statistically significant ($p = 0.011$).

Table 5. Average time taken to answer.

Type	Q1	Q2	Q3	Q4	Q5	Q6
Plain	26.6	20.3	23.7	22.4	16.2	23.5
Striped	28.1	21.2	22.7	20.5	15.5	19.8
Difference	-1.5	-0.8	1.0	1.9	0.7	3.7

There is some evidence of a 'learning effect' whereby participants took less time to answer the questions as they became more familiar with the study. As the moving average on Figure 7 shows, there is a downward trend in the time taken.

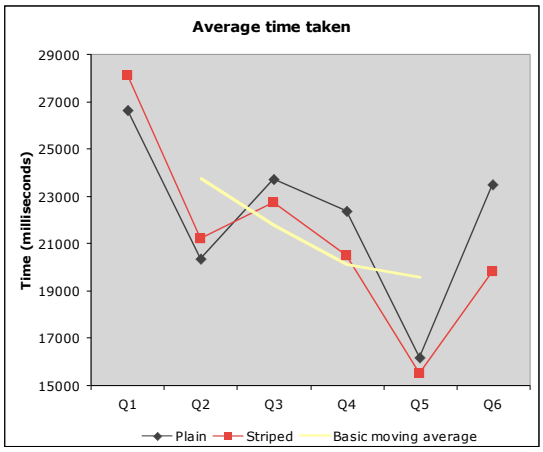

Figure 7. Time taken to answer: plain versus striped.

3.3 Subjective Preference

At the end of the six questions that referred to the data table, participants were asked their personal preference with regards to zebra striping. Overall, the greatest proportion of participants preferred zebra striping (46%), but a significant portion had no preference (33%).

Interestingly, participants who had the plain table first had stronger preferences for the zebra striping than those who had the striped table first.

Table 6. Subjective preferences.

Preference	Format of first 3 questions		Overall
	Plain	Striped	
Plain	15 (12%)	35 (31%)	50 (21%)
Striped	73 (56%)	40 (35%)	113 (46%)
Neither	42 (32%)	39 (34%)	81 (33%)
Total	**130 (100%)**	**114 (100%)**	**244 (100%)**

4. DISCUSSION

This analysis shows no evidence that zebra striping consistently improves the accuracy of tasks.

There was some improvement in task completion times when zebra striping was present. However, this improvement was only seen when participants were answering the last question, which was also one of the more difficult questions. This suggests that perhaps zebra striping is only helpful when there are a large number of tasks, leading to user fatigue, and/or the tasks are cognitively difficult.

This hypothesis is supported by the pattern of subjective preferences reported by participants. When participants had zebra striping to begin with, they reported being just as comfortable having zebra striping as not. But when participants had the plain table to begin with, they reported a strong preference for zebra striping.

One possible explanation for this is that the application of zebra striping to the last three questions helped participants who were fatigued from learning the task without the presence of zebra striping for the first three questions. Conversely, for those participants who had zebra striping initially, the loss of zebra striping for the last three questions may have been balanced by the effect of learning the task.

It is also important to note that a few participants spontaneously reported that they used their finger, on or over the computer screen, to follow down columns and across rows. Other participants used their mouse to highlight rows of interest, in effect creating their own 'temporary zebra striping'.

In summary, the arguments for zebra striping are weak:

- no significant improvement in accuracy;
- marginal improvement in speed; and
- some anecdotal evidence that it saves people from engaging other 'manual' methods to aid readability.

However, there is clearly a need for additional studies to investigate how task difficulty and the size of the table/form influence the effect of zebra striping.

For the time being, the decision about whether to use zebra striping probably comes down to a **subjective** assessment of likely gains versus the cost of implementation.

5. REFERENCES

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