On the Choice of Browser and Numerical Intelligence

or: Chrome Users are Smartest, then Firefox Users, then IE Users

Patrick Min

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Abstract

We provide a web site (`www.calcudoku.org`) where people can solve a specific type of number puzzle called "Calcudoku". One needs a combination of number skills and logic reasoning to solve this type of puzzle. On the site it is possible to create an account and score points for solved puzzles. Users are ranked by their number of points, and separately by how quickly they solve certain puzzles. We analyzed usage data for the years 2010 and 2011, consisting of over 1 million solved puzzles, attempting to determine the numerical intelligence of users of Internet Explorer (IE), Firefox, and Chrome[1].
For the *regular puzzles* (that must be solved within a 24 hour period in order to score points), we found no significant difference in the average difficulty of solved puzzles for the various browser users. However, for a subset of the available puzzles, which are solved "against the clock" (*timed puzzles*, of similar difficulty level), we did find statistically significant differences: (1) Chrome users were faster than Firefox and IE users, and (2) IE users were more likely to give up on a puzzle than Firefox or Chrome users. We conclude that Chrome users have the highest numeric intelligence, followed by Firefox users, then IE users.

Keywords: calcudoku, numerical intelligence, numeracy, number puzzles, logic puzzles, web browser

1 Introduction

There is a lot of interest in the possibility of a correlation between a user's preferred web browser and certain personality traits (e.g. [Gill 2011; BBC 2011; Jakobus 2011]). As far as we know, there have been no thorough investigations into this subject. In this paper, we present the results of an analysis of usage data of a website with online number puzzles, and show that there is a difference in numerical intelligence between different browser users.

We provide a web site (`www.calcudoku.org`) where people can solve a specific type of number puzzle called "Calcudoku". The puzzle requires number skills (numerical intelligence, or *numeracy*) and logic reasoning to solve. On the site it is possible to create an account and score points for solved puzzles. Users are ranked by their number of points, and separately by how quickly they solve certain puzzles ("puzzles against the clock" i.e. *timed puzzles*).

We analyzed usage data for the years 2010 and 2011, consisting of over 1 million solved puzzles, attempting to determine the numerical intelligence of users of Internet Explorer, Firefox, and Chrome (insufficient data was available for users of other browsers). Solutions that could not be used (e.g., puzzles solved by users who were not logged in, puzzles solved after the solution became available, etc.) were removed from the analysis.

Each day, 12 or 13 new *regular puzzles* are published on the site, which can be solved anytime in a 24 hour period in order to score points. In addition, 9 puzzles each day can be solved "against the clock" (*timed puzzles*). For the regular puzzles, we found no significant differences in the average difficulty level of the solved puzzles between different browser users. For the timed puzzles, however, we found that: (1) Chrome users solved them considerably faster than Internet Explorer and Firefox users, and (2) Internet Explorer users gave up on a puzzle more often than Firefox or Chrome users. Both these differences were statistically significant.

The rest of this paper is organized as follows. The next section discusses previous work. Section 3 describes the number puzzle itself. Section 4 presents results. Finally, Section 5 has conclusions and future work.

2 Previous work

As far as we know, there have been no scientific studies attempting to investigate the correlation between intelligence and choice of browser.

In July 2011, a widely reported study by AptiQuant claimed that IE users had a much lower IQ than average [Gill 2011]. This study was quickly revealed to be a hoax [BBC 2011].

In December 2011, a short online report was published by Projection Point, claiming that IE users have lower "risk intelligence" [Jakobus 2011]. This report does not seem to be a hoax, but: (1) the results are from an online poll, which means the participants self-selected, (2) no error margins are given, (3) users could have googled the answers, and (4) it is not clear if the (small) differences shown are statistically significant. The conclusions in the report are appropriately weakly formulated ("they do suggest an interesting possibility", and "Perhaps the use of Microsoft Internet Explorer should be considered an indicator of poor risk intelligence"), however the title is not: "Internet Explorer users have low Risk Intelligence (RQ)".

For this paper, we have attempted to process the data as carefully as possible in order to produce meaningful results: data related to solved puzzles during a period of two years has been analyzed.

*We expect to update this paper with more information, and as the result of reader feedback, hence the version number

[1] insufficient data was available for users of other browsers

3 The Calcudoku puzzle

In this section we briefly describe the Calcudoku puzzle and how it is solved. This type of puzzle was invented in 2004 by a Japanese primary school math teacher named Tetsuya Miyamoto [Shortz 2009]. It is known by many names, including Calcudoku, Kashikoku Naru, Kenken, Mathdoku, Minuplu, Newdoku, etc.

Puzzles are in the form of a square grid of cells, with typical puzzles ranging in size from 4×4 to 9×9. Given a puzzle of size $n \times n$, the solution is always a Latin square of that size, i.e. each row and each column contains each digit from the set $\{1, ..., n\}$ exactly once. Grid cells are grouped into "cages" (groups of cells with a thick border), and marked with a clue, in the form of a result and an operator (e.g. $+$ or $\times$). The operator applied to the numbers in the cage must produce the result shown. The ordering of the numbers in the cage is irrelevant (as long as there exists an ordering that produces the result). Evidently one needs both logic reasoning and number skills to solve this puzzle.

Figure 1 shows an example simple 4×4 puzzle and its solution. Figure 2 shows a much harder 6×6 puzzle. The difficulty of a puzzle is estimated by averaging the natural logarithm of the number of possible permutations for each row and each column (after applying the restrictions imposed by each cage)(for example, the puzzle in Figure 1 has a rating of 0, the puzzle in Figure 2 a rating of 62). All published puzzles have a single solution.

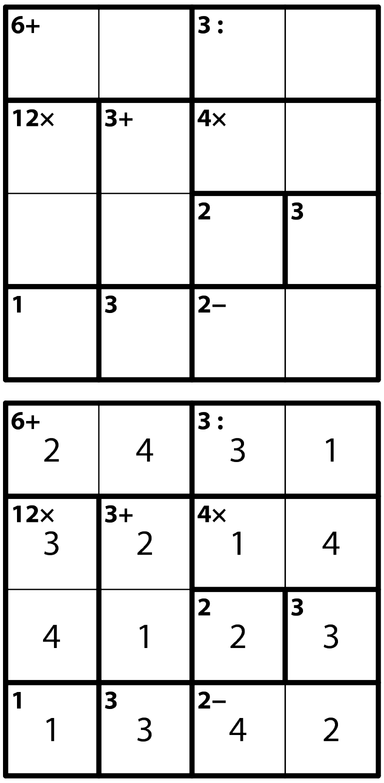

Figure 1: An example simple 4×4 Calcudoku puzzle and its solution (the : operator denotes division)

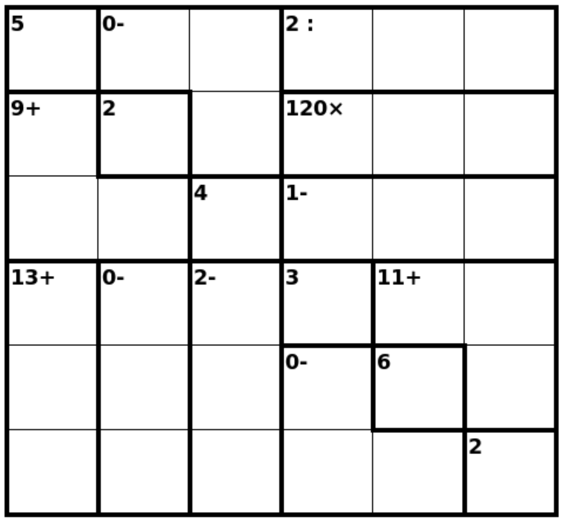

Figure 2: An example difficult 6×6 Calcudoku puzzle (the : operator denotes division)

4 Results

4.1 Regular puzzles

Most of the puzzles published on the site should be solved within 24 hours in order to score points (from midnight CET). The puzzles range from trivial (4×4 "easy", rated "zero stars", worth 1 point) to very hard (e.g. 9×9 "difficult", rated "five stars", worth 10 points). We would like to know if there is any correlation between a user's preferred browser and the difficulty level of successfully solved puzzles. First, all data that cannot be used for the analysis has to be removed:

4.1.1 Data preparation

Only puzzles solved in 2010 and 2011 were considered (1,122,986 solved puzzles). Next, the following records were removed:

- "twin puzzles" (two puzzles presented side by side, with the same solution but with different cages), because we currently don't have a good method for estimating their difficulty level
- puzzles solved by users who were not logged in
- "bonus puzzles" (extra puzzles only available when a certain number of points is reached)
- puzzles solved by the author of this paper
- puzzles solved after the solution became available
- puzzles solved by users who solve puzzles via Facebook (these tend to be more casual users who find the page through a friend instead of actually searching for this type of puzzle)
- puzzles solved by users who have solved less than 10 puzzles, or who have been solving puzzles for less than 7 days

These filtering steps left $487,898$ solved puzzles for consideration, from 743 distinct user accounts.

4.1.2 Primary browser

We will call a browser type a user's *primary browser* if it was used for solving at least 90% of her/his solved puzzles. The browser types we considered were: Internet Explorer, Firefox, Chrome, Safari, Safari on the iPad, Opera, and "Other". Browser type detection was done from the "user agent string", using a publicly available PHP script [Hope 2011]. We found that relatively many users are faithful to a single browser type: out of the 743 distinct user accounts mentioned above, 580 had a primary browser (so almost 80%) (for a breakdown of browser share over time, see Section 4.4). Only IE, Firefox, and Chrome had a sufficient number of users to enable us to test statistical significance of differences.

4.1.3 Regular puzzle results

For each user with a "primary browser" (see the previous section) we computed the average number of points achieved per solved puzzle. Internet Explorer had 250 users, Firefox 193, and Chrome 98. The overall averages were 3.25 points for IE, 3.33 for Firefox, and 3.21 for Chrome. As with all our results, we do have to test if the differences are statistically significant: our null hypothesis is that each of the sets of averages is drawn from the same distribution. For each significance test in this paper, we used a randomization test (not knowing the underlying distribution) [Green 1977]. Our t_{obj} is the difference of the means, the number of iterations 1 million, and $p = 5\%$ in all tests. We found that for the sets of the average number of points scored per puzzle, the difference between the browsers was *not* statistically significant. This means that on average, users typically select a similar set of puzzles to solve each day.

4.2 Timed puzzles

We believe that the time someone takes to solve a puzzle is more indicative of their numerical intelligence. Since February 2011 it is possible to solve puzzles "against the clock". Each day, a user can solve a maximum of three 4×4, three 5×5, and three 6×6 puzzles. Each such puzzle is picked randomly from a pool of 5,000 puzzles of approximately the same difficulty level.

In 2011, $58,742$ timed puzzles were solved (again not counting the puzzles solved by the author nor by Facebook users), by 609 distinct users. Next, users who had solved less than 10 timed puzzles of each puzzle size were removed, leaving $30,113$ puzzles solved by 119 users. There were 42 IE users, 40 Firefox users, and 25 Chrome users.

For each user, we computed the average time taken to solve each puzzle type (i.e. 4×4, 5×5, and 6×6). Times were then normalized using the median of all averages. We found that for each puzzle type Chrome users were fastest on average, followed by Firefox, then Internet Explorer (see Table 1). Figure 3 shows the average solving times as a percentage of that of Chrome users. For Chrome vs. Firefox and Chrome vs. IE this difference was statistically significant ($p = 5\%$). The difference between IE and Firefox was not.

4.3 Abandoned timed puzzles

Because for each attempted timed puzzle the start time is logged, we can also measure the average percentage of abandoned puzzles for each user: typically a user gives up on a puzzle if they are "stuck" and/or no good time can be achieved for it anymore.

Table 1: Average solving time in seconds for 4×4, 5×5, and 6×6 timed puzzles by Internet Explorer, Firefox, and Chrome users

browser	4×4	5×5	6×6
Internet Explorer	30.9	73.4	262
Firefox	29.4	70.2	245
Chrome	22.0	61.1	233

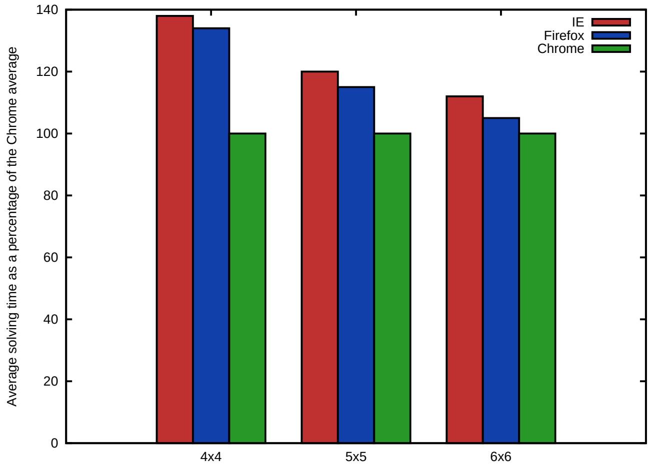

Figure 3: Average solving time for 4×4, 5×5, and 6×6 timed puzzles, relative to that of Chrome users

We found that for each puzzle type IE users were more likely to abandon a timed puzzle than Firefox or Chrome users, with the difference being statistically significant for the 4×4 and 5×5 puzzles (see Table 2 and Figure 4). Overall (when combining percentages for each puzzle size) the difference was significant as well. Note that this result reinforces the result of the previous section: if somehow a user could be forced to always finish a puzzle, the average solving times achieved by IE users would increase even more.

Table 2: Average percentage of abandoned timed puzzles for 4×4, 5×5, and 6×6 timed puzzles by Internet Explorer, Firefox, and Chrome users

browser	4×4	5×5	6×6
Internet Explorer	13	34	36
Firefox	6.1	21	26
Chrome	6.3	18	31

4.4 Browser share

In addition, we were interested in how browser share evolved over time. Figure 5 shows the percentage share of unique visitors per day, averaged per week, during 2010 and 2011. Because in the first 30 weeks the number of visitors was relatively small (about 5% of new users in 2010 and 2011 had signed up by then), the graph is noisy for that period.

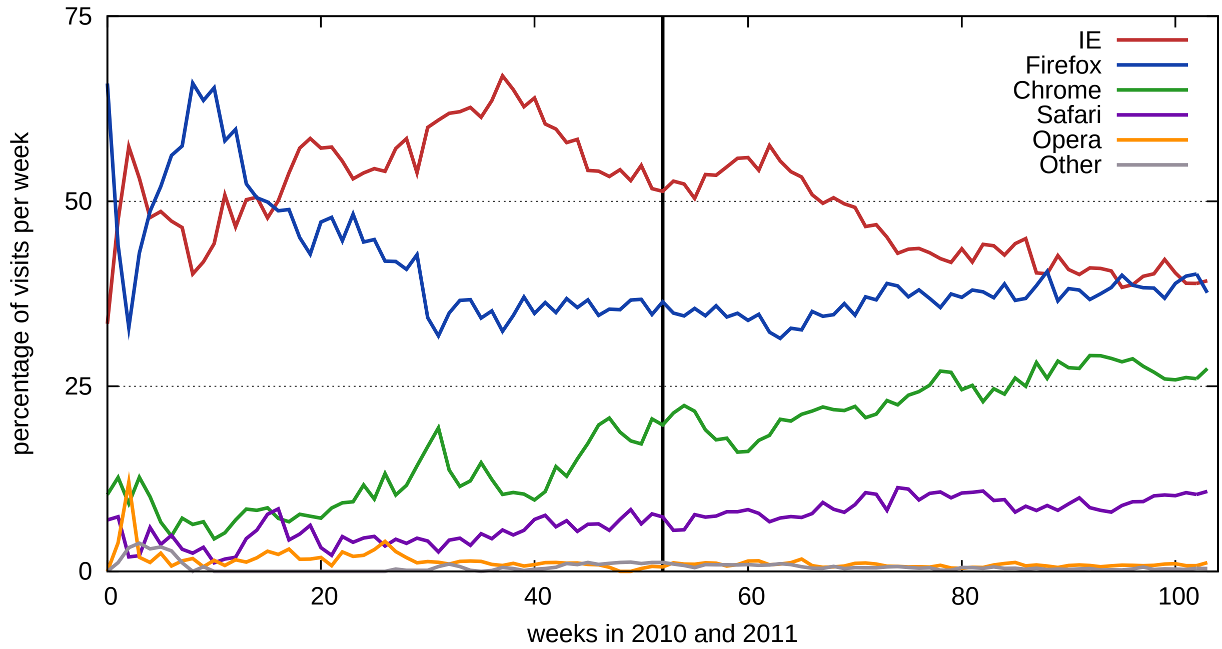

Figure 5: Browser percentage per week in 2010 and 2011. The graph is a bit noisy for the first 30 weeks because of small visitor numbers.

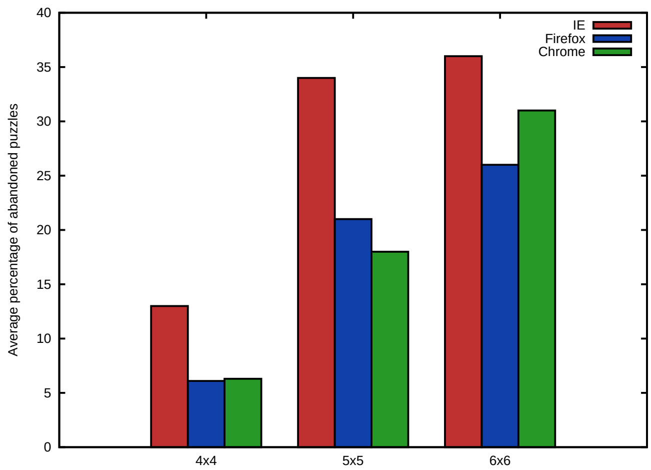

Figure 4: Average percentage of abandoned timed puzzles for 4×4, 5×5, and 6×6 timed puzzles by Internet Explorer, Firefox, and Chrome users

At the end of 2011, browser shares were 39% for IE, 38% for Firefox, 27% for Chrome, and 11% for Safari (the version breakdown for IE was 1% for IE 6.0, 13% for 7.0, 53% for 8.0, and 33% for 9.0).

5 Conclusions and future work

In summary, based on the findings that Chrome users solve Calcudoku number puzzles the fastest, and that IE users give up on solving them the most, it appears that Chrome users have the highest numerical intelligence, followed by Firefox users, then by Internet Explorer users. Note that it does not follow that using Chrome makes you smarter, for example ("correlation does not imply causation"). Also, we can only speculate about the causes of the differences: perhaps Chrome is the browser of choice for more technically inclined people, who tend to have better number skills. And maybe because IE is the default browser for Windows, people who do *not* choose a different browser possibly are less technically skilled.

In future work, once sufficient data is available, we would like to include Safari users in our tests. It may also be interesting to look at differences between IE versions (6.0 through 9.0), as well as between Facebook and non-Facebook users. We are also planning to publish all usage data on which this paper is based (after proper anonymization).

Your comments and suggestions are very welcome at `calcudoku@gmail.com`.

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