the Effect of Numeric Roundness on Probability Perceptions and Choice

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Past research has predominantly shown that consumers prefer round numbers. This work documents an exception to such effect, by showing that people prefer and perceive non-round numbers as more likely to occur in cases where a numeric expression is evaluated and chosen based on its probabilities of occurrence or of being drawn in a lottery, gamble or other random selection process.

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EXTENDED ABSTRACT
Consumers often make choices associated to their preference for particular numbers (e.g. Boyd 1985; King and Janiszewski 2011; Pavia and Costa 1993; Pope and Simonsohn 2010). These choices involve preferences for brand names that may be alphanumeric (e.g. Boyd 1985; King and Janiszewski 2011; Pavia and Costa 1993), the selection of PIN numbers or passwords, sports jerseys’ numbers or even gambling or lottery tickets. This last type of numeric or lottery context differs slightly from the rest. While all of them involve the choice of numbers based on mere preference for them, in the case of lotteries the selection is closely associated to the perceived probability that the chosen number may be the winner. Despite the fact that any given number in a lottery or any random selection process has the same probability of being drawn, people often expend effort on choosing specific numbers on the hopes that their choice will increase their probabilities of winning. For this matter, they usually select numbers that have a personal meaning to them (e.g. birthdates, phone numbers, IDs, etc), that they simply like, or that they believe are more likely to result the winners.

The current paper tackles the question of what type of numeric formats consumers prefer on random selection or gambling or lottery contexts as a result of being considered to have a higher probability of occurrence or of being drawn. Specifically, we study how the roundness or oddness of a numbers affects its probability perceptions and its subsequent likelihood of being selected by a consumer. In contrast with past work on numeric fluency and roundness, which demonstrates that consumers have a preference for round numbers (e.g. Dehaene and Mehler 1992; King and Janiszewski 2011; Kirby and Schindler 1997), we show that in lottery or random selection contexts, people have a preference for odd numbers, as they believe these have higher probabilities of being drawn. These biased probability perceptions lead to a counterintuitive type of outcome: odd numbers are preferred and more likely to be chosen in this type of contexts. We propose that this occurs because odd numbers are usually interpreted as being more concrete or realistic, while round numbers are often seen as more abstract or general, as people often use them to round out numeric information (e.g. Dehaene and Mehler 1992).

The effect presented in this work focuses on the scenario of lotteries, or those where a number is selected by consumers based on how likely they think this will be the drawn or winning number in a random selection process, even though each numeric expression has the same probability of occurrence. We ran four experiments to provide evidence for the effect of numeric roundness on probability perceptions and choice. In our experiments, round numbers were operationalized as those ending on “0” or “5” (Dehaene and Mehler 1992). Experiment 1A was a computer based study where participants were told that they would be participating in a lottery in which they could pick their lottery number among four assigned two digit expressions. Two of these numbers were round and the other two were not and participants were told that if the number they selected matched the last two digits of the winning number of the upcoming Mega Millions lottery that week, they would be receiving a $20 prize. Experiment 1B was also a computer based study in which participants were told that they would be participating in a lottery game in which they would be allowed to select one number from 0 to 99. As in Experiment 1A, they were told that if their selected number matched the last two digits of the winning number of the upcoming Mega Millions lottery that week, they would be receiving a $20 prize. Both of these experiments provided evidence in favor of our hypothesis: round numbers were less likely to be selected.

Experiment 2 employed a similar design as Experiment 1B with a couple of modifications and additions. First, in this case participants were asked to select an eight-digit number as their respective playing number as opposed to one that only contained two characters as in the first two studies. This scenario more closely matched the typical lottery conditions where participants usually pick numbers that contain from eight to twelve digits. In order to keep them involved in the procedure, this time participants were told that if their picked number matched the last eight digits of the upcoming Mega Millions lottery that week, they would be receiving a $500 prize. This study also provided evidence for our proposed account, as it included a Construal Level scale that had the intention to test if the effect was stronger among participants who had a more abstract mindset, as these would avoid selecting more general and abstract round numbers because they considered them as less likely to be winners. Finally, this experiment also asked participants to explain why they made their numeric selections (Nisbett and Wilson 1977) with the intention to delve more into the underlying mechanism and rule out some alternative explanations for the effect, such as a desire to select odd numbers due to the perception that round numbers were more likely to be chosen due to their salience (Coupland 2010; Dehaene and Mehler 1992; Jansen and Pollmann 2001).

Experiment 3 tested the external validity of the effect and employed real life data from the Mega Millions lottery. We looked at the winning numbers of this lottery during the last 13 years and a half and analyzed those drawings for which there was a winner, that is, those where someone picked it as their playing number. Consistent with our hypothesis, odd numbers were significantly less likely to be selected as playing numbers, even though naturally, they were as likely to be drawn as winners.

Together, this set of studies document a new effect: odd numbers are more preferred in situations where the choice of a numeric expression is associated to its perceived likelihood of occurrence or of being drawn in a random selection process.

The effect of numeric roundness on probability perceptions and choice
Consumers often make choices based on their preferences for particular numbers (e.g. Boyd 1985; King and Janiszewski 2011; Pavia and Costa 1993; Pope and Simonsohn 2010). These preferences influence choices of alphanumeric brand names (e.g. Boyd 1985; King and Janiszewski 2011; Pavia and Costa 1993), the selection of PIN numbers or passwords, sports jersey numbers, and even impact gambling and lottery ticket contexts. While in all contexts the choice of numbers reflects mere preferences, in the case of lotteries, the selection reflects an individual’s assessments of the perceived probability of that number being chosen as a winner. Despite the fact that any given number in a lottery or any random selection process has the same probability of being drawn, people often expend effort on choosing specific numbers in order to increase their probabilities of winning. Therefore, individuals often select numbers that have a personal meaning to them (e.g. birthdates, phone numbers, student
IDs, etc), that they simply like, or that they believe are lucky or more likely to result the winners.

We investigate how consumers select from among different types of numbers—such as round, odd—in lottery contexts. Round numbers are numbers that end in “0” or “5” (Dehaene and Mehler 1992), while odd numbers are not divisible by two. Specifically, we study how the roundness or oddness of numbers affects assessments of how likely it is to be drawn in a lottery, and therefore its subsequent likelihood of being selected by a consumer. While much prior research demonstrates that consumers have a preference for round numbers (e.g. Dehaene and Mehler 1992; King and Janiszewski 2011; Kirby and Schindler 1997), we show that in lottery or random selection contexts, odd numbers are preferred more. This occurs because odd numbers are perceived to have higher probabilities of being drawn. Delving deeper, we propose this occurs because odd numbers are considered as being more concrete or realistic, while round numbers are more abstract or general, as people often use them to round out numeric information (e.g. Dehaene and Mehler 1992).

Indeed, an understanding of how consumers interpret numbers in gambling and lottery contexts is important for many reasons. From a theoretical perspective, these contexts provide a deeper understanding of how numbers are fundamentally perceived. While typical marketing contexts (e.g., pricing) do provide insights on how size of numbers (e.g., numerosity) and other affiliated qualities are interpreted, they rarely provide insights on understanding of a core feature of numbers—their distribution and properties thereof. For instance, when a number is drawn from a distribution, is it totally random or does it follow systematic patterns? Studying lottery behaviors also provides insights on individuals' understanding of probabilities. Indeed, such behaviors form a core tenet of behavioral decision theory where lotteries are used to infer rational behavior (von Winterfeldt and Edwards 1986). From a practical perspective too, an understanding of this marketplace is important. As of 2009, the legal gambling industry was estimated to be $355 billion dollars around the world (The Economist, 2010), while the lottery industry in the US accounted for more than $50 billion dollars (Reutters, 2011). From a public policy and social welfare perspective too, lotteries are important. The more frequent players come from lower socioeconomic groups (Beckert and Lutter 2012), and these individuals often spend up to 10% of their income on lottery tickets (Dustan 1997).

We focus on lottery contexts or contexts where a number is selected based on how likely it is expected to be drawn or to be a winning number in a random selection process, even though normatively all numbers have the same probability. We conducted four experiments to provide evidence for the effect of numeric roundness on perceptions and choice. In experiment 1A respondents were asked to pick a two-digit lottery number from among four two digit numbers (two round and two odd), and were told that if their selected number matched the last two digits of the winning number of the upcoming Mega Millions lottery, they would be receiving a cash prize. Experiment 1B was similar to 1A (the incentive structure was similar), but respondents were asked to pick a number from 0 to 99. Both experiments provide evidence supporting our hypothesis: round numbers are less likely to be selected.

Experiment 2 was similar to 1B, with a few exceptions. First, participants were asked to pick an eight-digit number, as they might in a typical Mega Millions lottery (which has between 8-12 digits). As in previous studies, participants learned they would receive a cash reward if their picked number matched the last eight digits of the upcoming Mega Millions lottery. This study also provides process support. We included a Construal Level scale to test if the effect was stronger among participants who had a more abstract mindset, as these would avoid selecting more general and abstract round numbers because they considered them as less likely to be winners. Finally, we asked participants to explain the logic underlying their numerical selections.

In experiment 3 we analyze 13 years of data from the Mega Millions lottery, and show that round numbers are purchased less often, even though naturally, they were as likely to be drawn as winners. This provides external validity for our findings.

Theoretical Background

Preference for Round Numbers

Research on numerical cognition focuses on two types of numbers—round (Dehaene and Mehler 1992) and odd numbers. Round numbers are considered to be more salient (Dehaene and Mehler 1992; Schindler and Kirby 1997) than odd numbers. Consequently, when asked to generate numbers, participants are more likely to name round numeric expressions (Hornik, Cherian, and Zakay 1994; Hultsman, Hultsman, and Black 1989; Huttonlocher, Hedges, and Bradburn 1990; Tarrant and Manfredo 1993). The same effect holds when consumers are asked to recall numerical information, such as the price of a product (Schindler and Wiman 1989). These effects occur because the human mind has limited cognitive capacity, and people utilize easily processed numbers more (Dehaene and Mehler 1992), especially for higher denominations (Kaufman et al. 1949). This phenomenon extends to alphanumeric brand names, where consumers favor those that include round (Kirby and Schindler 1997) or fluent numbers (King and Janiszewski 2011).

Another stream of research has demonstrated that consumers often treat round numeric expressions as goals or reference points (Pope and Simonsohn 2010). This research finds that people expend more effort towards a goal and perform better when they are close to reaching a performance indicator represented by a round number than when they have already reached such milestone. Similarly, Isaac and Schindler (2014) recently introduced a phenomenon coined as the “Top Ten Effect”, which demonstrates that consumers will react more favorably to improvements in rank that exceed round-numeric-category boundaries (e.g. changing from rank 11 to rank 10) than improvements in rank that cross place-value-category-boundaries (e.g. changing from rank 10 to rank 9). This phenomenon occurs because round numerical expressions are cognitively more available due to their prevalence in daily communication. Together, this stream of work further demonstrates that consumers have a preference for round numbers.

Round Numbers and Random Selection Processes

The current research investigates if the favorable perceptions and choice shares obtained for round numbers in multiple domains extend to that of random selection processes, lotteries, and other related gambling activities. We propose and provide evidence for a counterintuitive finding: despite consumers favoring round numbers in most domains, this will not occur in contexts where the selection of a numeric expression does not only reflect preference, but it is also associated with naïve beliefs relating to the likelihood that this target number will be drawn as the winner. While objectively speaking, any given number participating in a lottery, gamble or any other random selection process has the same probability of being drawn, we predict that in these contexts consumers will be more likely to select numbers that are odd versus round. This contradicts past research showing that when asked to generate numbers, people are more likely to come up with round expressions due to their fluency and ease of processing (Hornik, Cherian, and Zakay 1994; Hultsman, Hults-
man. and Black 1989; Huttenlocher. Hedges, and Bradburn 1990; Tarrant and Manfredo 1993). We make this counterintuitive prediction because we believe that round numbers are perceived as being more abstract or general, which is the reason why they are often used to round out numeric information (e.g. Dehaene and Mehler 1992). Conversely, due to their specificity, we propose that odd numbers are perceived to be more concrete or realistic, which makes them more likely to be randomly drawn as a winner in a lottery.

Positive Effects of Odd Numbers

As discussed earlier, past research suggests that round numbers are usually more preferred (e.g. Dehaene and Mehler 1992; Kirby and Schindler 1997). However, there is one exception. Thomas, Simon and Kadiyali (2010) showed that in the context of price bargaining, it is more favorable to list sale prices in odd numeric formats as opposed to round ones. This because odd price formats are judged to be relatively smaller in magnitude than equivalent round ones, which leads to positive reactions from consumers as these are judged to be better deals. This seems to occur because odd numbers are more often used for smaller numeric denominations (Dehaene and Mehler 1992), while round expressions are more common for larger numbers. Consequently, the authors suggest that odd numbers are considered smaller than equivalent round expressions. While in our case, our results do not depend on an odd number being perceived to be smaller or larger but instead more likely to be drawn in a random selection process. Further, like Thomas et al. (2010), we document a new context in which odd numbers may evoke higher preference than round ones.

Experiment 1A

Experiment 1A (N=450) was a computer-based study in which participants were told they would be participating in a lottery. Participants were asked to select one out of four two-digit numbers (10, 89, 50 and 37). They were told that if their selected number matched the last two digits of the winning number of the next Mega Millions lottery drawn that week, they would receive a $20 prize. We expected the two round numbers—“10” and “5”—to be chosen less often than the two odd numbers—“89” and “37”.

Results and Discussion

As expected, round numbers were significantly less likely to be selected (M=31%) than odd numbers (M=69%). Moreover, the choice shares for both groups were significantly different from 50% (p < .0001).

In this study participants had to choose from a pre-determined set. In the next study we accord consumers more flexibility in their number selection.

Experiment 1B

In this study (N=449) we asked participants to pick a number from 0 to 99. Once again, participants were told that if their number of choice matched the last two digits of the winning number of the next Mega Millions lottery drawn that week, they would receive a $20 prize.

Results and Discussion

As expected, we find that when given the option to pick a lottery number from 0 – 99, only 11% of participants chose a round one instead of the expected 20% (p < .0001).

This experiment extends the effect to contexts where participants have more flexibility in selecting numbers (pick on their own) instead of being constrained to a fixed set of options. Our findings are divergent from past research, which suggests that consumers are more likely to mention round numbers when asked to generate numeric expressions (Hornik, Cherian, and Zakay 1994; Hultsman, Hultsman. and Black 1989; Huttenlocher, Hedges, and Bradburn 1990; Tarrant and Manfredo 1993). This suggests that these effects may be moderated by the context in which the numeric expressions are generated, as round formats will not prevail in cases where numbers are being selected based on their likelihood to be drawn in a random selection process. We conducted a subsequent study in which we tested the effects in a more general setting, with eight digit numbers. This experiment provides additional evidence in favor of our effect mechanism.

Experiment 2

Experiment 2 (N=407) had three objectives. First, we test our findings using eight digit lottery numbers. This is consistent with major, national lotteries, which usually use tickets that range from eight to twelve digits. We also investigate the moderating role of construal level on choice, and show that our effects are stronger among participants with a more abstract mindset. We believe this occurs because an abstract mindset makes the round numbers (which are fundamentally abstract) seem more abstract and general, and, therefore less likely to be drawn. Finally, we also asked participants to explain (Nisbett and Wilson 1977) the strategies underlying their choice of lottery numbers. We expect to show that odd numbers are believed to be more likely to occur, and are therefore chosen more often in lotteries or in random selection processes.

The design was similar to that used in Experiment 1B. However, in this case participants were told that they would be selecting an eight-digit number for their lottery ticket. Participants were told that if their eight-digit number matched the last eight digits of the next drawing of the Mega Millions lottery that week, they would be receiving $500 (due to the higher challenge the game involved). We also rule out other explanations. It is possible that participants may feel that other participants would select round numbers and so if the participant wins (with a round number), they may have to share their winnings with others, as their likelihood of picking the same round number may be higher. Therefore, we told participants explicitly that each number could only be selected once and that they did not need to worry about sharing their prize.

At the end participants were asked to explain why they made their choice and were administered the 25-item Behavioral Identity Form (BIF; Vallacher and Wegner 1989), used to measure construal level (e.g. Trope and Liberman 2010).

Results and Discussion

As predicted, participants picked numbers ending in round digits (“0” or “5”) less than the expected 20% of the time (M=12.5%; p < .0001). Furthermore, participants who were more prone to think abstractly were less likely to pick round numbers ($\chi^2 = 4.89; p < .03$), probably because they saw these as being less concrete than those who were prone to thinking more concretely. Finally, verbal protocols showed that aside from cases where participants made their choices based on numbers that conveyed special meaning to them (e.g. birthdays, PIN numbers, Student ID Number, etc.) or based on pure random selection (e.g. typed 8 digits without thinking), more than 50% of participants made their choices based on a number’s perceived likelihood of being drawn as the winner. On the other hand, these results rules out the alternative explanation that the effect may be due to participants’ picking an odd number to reduce their likelihood of having to share the price, as less than 2% of subjects provided such explanation. The fact that we get significant results despite the large proportion of people who selected numbers
that has a special meaning to them provides evidence for the robustness of our effects, as this was stronger when we excluded such cases (p < .001).

This experiment demonstrates the robustness of our results and shows they occur even with eight digit numbers. Moreover, our effects are associated with how abstract consumers perceive the round or odd numbers to be. When in an abstract mindset, the round numbers are seen as being more general or abstract, and hence less likely to be drawn, and is therefore chosen less often. Finally, verbal protocols (Nisbett and Wilson 1977) provide conclusive support; individuals make choices based on how likely they think their picked number is to be drawn. We also analyze secondary data from the Mega Millions lottery to explore if the documented effects hold in real world contexts.

Experiment 3

We analyze data from more than 13 years of the Mega Millions lottery (August 2000 to October 2013) to test the external validity of our effects. This lottery is held twice a week, thus providing us with a total of 1382 observations. We had information about the date each lottery was played, the size of the prize, and the drawn number. The data did not explicitly indicate if on a given week the prize had been sold or claimed, however, we were able to determine this based on each drawing’s prize. Specifically, if the prize for a given lottery increased (decreased) relative to the previous drawing, this meant that the previous lottery was not won (won and a prize was claimed). We also tried to obtain data on all of the purchased numbers for this lottery, in order to analyze the overall frequency of odd versus round numbers sold, however, this information is not made public due to privacy and security concerns. We predicted that while a lottery ticket ending with a round number would be as equally likely to be drawn as any other number (10%), this would be less likely to be sold, and consequently, be less likely to be claimed by a consumer. These effects occur as consumers believe lottery tickets ending with a round number to be less likely to be a winner.

Results and Discussion

As expected, we find that 20.69% of the time the lottery number drawn as the winner was round (this includes all numbers regardless of whether these numbers were picked by consumers or not). Indeed, this result is not significantly different from the expected proportion of 20% (p > .26).

However, focusing on the winning drawings—that is, 161 (i.e., those purchased by a consumer during this time)—out of the total 1382 (11.65%), only 14.29% of these (23 out of 161) corresponded to a lottery ticket that was round, which is significantly less than the expected 20% (p < .05). It is worth noticing that we demonstrate that this effect is not driven by increased purchase rates for lottery tickets ending on “7”, as these only represented 8.1% of the sold winning numbers, directionally less than the expected 10%.

This study provides external validity for our effects; the winning numbers sold by the Mega Millions lottery during the analyzed 13 year period were less likely to be round. Moreover, this experiment also shows that this effect is not due to increased choice shares for lottery numbers ending on “7”, as sales for these were actually below their expected 10% share.

General Discussion

Across four experiments, we show that despite past research documenting preference for round (e.g. Dehaene and Mehler 1992; Kirby and Schindler 1997) and fluent numbers (e.g. King and Janiszewski 2011), these numbers are less likely to be selected in lotteries, as consumers believe these numbers have a lower probability of being a winner. This may be because round numbers are usually used to round out numerical information, and hence are considered as being more abstract or general (e.g. Trope and Liberman 2010). The present findings also rule out alternative explanations such as consumers resorting to odd numbers as a strategy to avoid having to share their prizes with someone who picked the same numeric expression as they did, or related to an increased incidence of sold prizes ending on number “7”. Finally, we show the external validity of our findings, by replicating the effect using more than 13 years of data of the Mega Millions lottery.

Future Research

While we investigate the effect of numeric roundness on probability perceptions and choice in contexts involving random selection processes or lotteries, it is possible that this phenomenon may also apply to other domains. For example, it may be the case that consumers may evaluate events with probabilities that end with an odd number (e.g., 68%) as being more likely to occur relative to those of a higher magnitude but ending with a round number (e.g. 70%). Future work in this area should investigate if the documented effects can be extended to this and other contexts.

REFERENCES


