

The Role of Perceptual Bias in Estimating Quantities

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Abstract

A cognitive bias refers to a systematic (that is- a non-random and, thus, predictable) deviation from rationality in judgment or decision-making (Blanco, 2017). This implies that humans tend to deviate from the traditional concept of the 'homo-economicus' and can thus be irrational. They can pick an option that defies rational logic as they presume it to be the 'correct' option.

This paper focuses on the existence of one such bias - The Perceptual Bias, which explains how people tend to associate the height of a glass with the quantity of liquid it holds. In other words, a tall glass creates an illusion of greater quantity than a glass that is shorter and wider but holds the same quantity. People associate parameters of the glass, such as the quantity it holds, based on sensory inputs, such as sight. This paper also shows that when a tall glass and a short glass are presented individually, the bias is observed, however, when shown together to the same person, it spawns the idea of a comparison, and the effect of the perceptual bias is no longer observed.

1. Introduction

When one looks at a glass, one perceives that it can hold a specific quantity. They psychologically affiliate parameters associated with the glass to aid in determining the quantity of liquid that the glass can hold. For instance, it is common to intuitively ascertain the quantity of a glass, simply by observing the height or width of the glass. However, more often than not, we presume incorrectly, and thus we tend to correlate variables where there is no correlation at all, as an extension to the bias of *illusory correlation*- which states how people tend to incorrectly relate two unrelated behaviours, events, specifications or parameters (Hamilton & Rose, 1980); and the *Confirmation Bias*- which connotes the seeking or interpreting of evidence in ways that conform to existing beliefs, expectations, or a hypothesis in hand (Nickerson, 1998).

The following paper presents the results of an experiment that was undertaken to validate the existence of the perceptual bias and its implications. This paper will show how the experiment was conducted, what the results were and the impact of the perceptual bias on individuals and industries.

2. Hypothesis

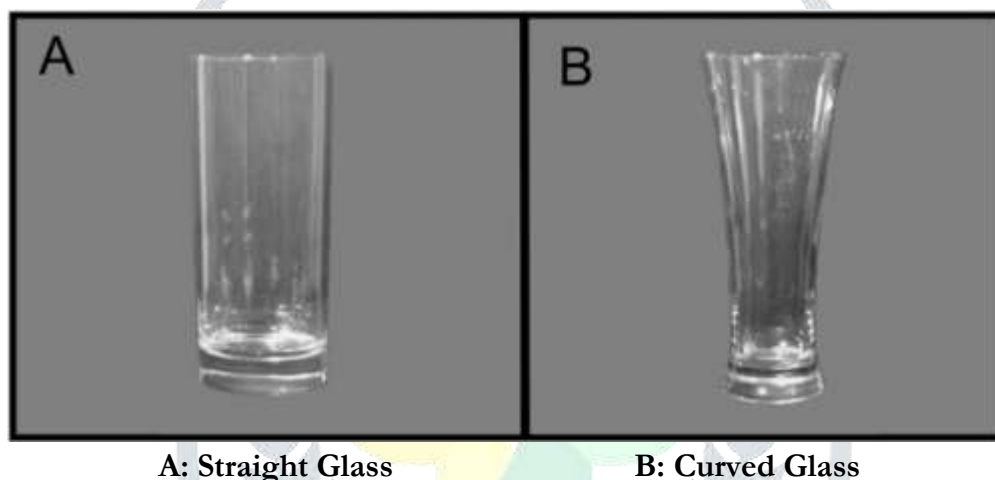
This paper hypothesises that due to the existence of a perceptual bias (bias due to changes in observers' subjective perceptual experience), people would perceive that the taller glass would hold more liquid than the shorter glass, as it would look bigger and they have no other data about the glass. This paper believes that heights play a more significant role on perception than width does, this hypothesis was extrapolated from the widely stereotypical notion that taller people are considered superior (in certain criteria) to shorter people (Anderson, 2006), (Lio, Gomez, Sirigu, 2017).

3. Display of Bias

The decision that the respondents took was that the tall glass is perceived to hold more quantity, and the short glass is estimated to hold relatively lesser quantity, only when they are presented individually. When presented together, the effect of the perceptual bias is nullified.

4. *Literature Review*

This paper references two articles that have considered similar experiments and obtained similar results, the first one is - a study conducted by the University of Bristol(Attwood A., et al. 2012), where two distinct types of glasses (one straight[A] and one curved[B]) (image of the glass is attached below) are provided to two groups of students at random, and the students are asked to drink beer from the glass while watching a documentary, they observed that the students with the straight glass (twelve minutes) finished their drink 60% slower than the students with curved glass (seven minutes). The researchers attribute the difference to the halfway point in the curved glass; in other words, they were not entirely correct about their prediction of how much they had finished drinking. If the time taken to consume was considered a litmus test for quantity perceived, which seems appropriate, the study suggests that the less broad glass holds more quantity, in our study, the less broad glass is the tall glass, and that is perceived to hold relatively more quantity than the short glass, thereby being consistent with the findings of this study.



The second core piece of literature that was considered while undertaking our research was conducted by Cornell University (mentioned earlier), which indicates that people tend to UNDER-estimate the quantity of liquid that can be poured into a shorter-wider glass. The author of the study Brian Wansink stated: “When pouring into glasses, we tend to focus on the height of the beverage and basically ignore the width”. An image of the glasses that were used in the study has been attached below. He highlights that the tendency to overpour can be reduced by increasing the attention span of the pourer, but the person would still overpour.



There are two core differences between our study and the studies conducted by the University of Bristol and Cornell University.

The first is that while their studies involved some activity done by the participants, our study did not. The Bristol Study focused on the drinking of the beer, while the Cornell study focused on pouring the alcohol. Our study created a focus on the action of estimation through realistic images. This was done to ascertain that the perceptual bias must manifest itself even in the absence of the action that follows.

Another distinction was the difference in the experiment style. Both the Bristol and Cornell studies focused on a single experiment, while this paper focuses on three different surveys that could better explain the perceptual bias than a single one. By isolating the effects, not only did this paper prove the existence of the perceptual bias, but it also has a partial (as it is subject to further empirical analysis) nudge to work against it.

5. Methodology

[See Appendix- Case 1 for the links and images concerning the survey.](#)

Three different surveys were sent out to three different groups of people. The first survey (Group 1) had an image of both glasses (one short and wide, and the other tall and narrow) to the left and right of a can of 'Dr Pepper' (respectively), the second survey (Group 2) had an image of the shorter glass with the 'Dr Pepper', whilst the third survey (Group 3) had an image of the taller glass with the 'Dr Pepper'. The images and survey-links are attached to this paper ([See Appendix Case 1](#)).

The questionnaire was presented as 'Market Research' to prevent the target audience's prior disposition from affecting our data, in an attempt to prevent them from thinking that there was a 'trick' to the question; this paper aimed to get true answers to our survey rather than biased or skewed answers. The questionnaire included two filler questions to reinforce the notion that the project was conducted for 'Market Research'. It was also ensured that the frequency (3) or difficulty of the filler questions was not large enough to distort the results.

Additionally, to avoid errors due to any sense of ennui, the survey was concise, with almost all questions having answers provided as options and the surveyed merely having to pick an answer. This paper attempted to ensure that

all three groups were identical, with minimal to no changes, to maintain statistical accuracy of the dataset. The only way the three surveys differed was with respect to the question on the glass itself, and the amount of liquid the person believed would fit in it.

The questionnaire also measured the level of confidence the person had while giving an estimate on the amount of liquid that could go into a tall or short glass.

This process was followed to isolate the effects of the perception bias on each glass individually, as it was believed (per the result of a prior field experiment) that the effect would disperse when both glasses were kept together as could perhaps be explained by the Reactance bias - which is a motivation to resist the social influence of others on them - as they perceive it as a constraint on free will (Steindl et al., 2015), and thus choose the alternate glass than to what they actually-true perceive to hold more quantity.

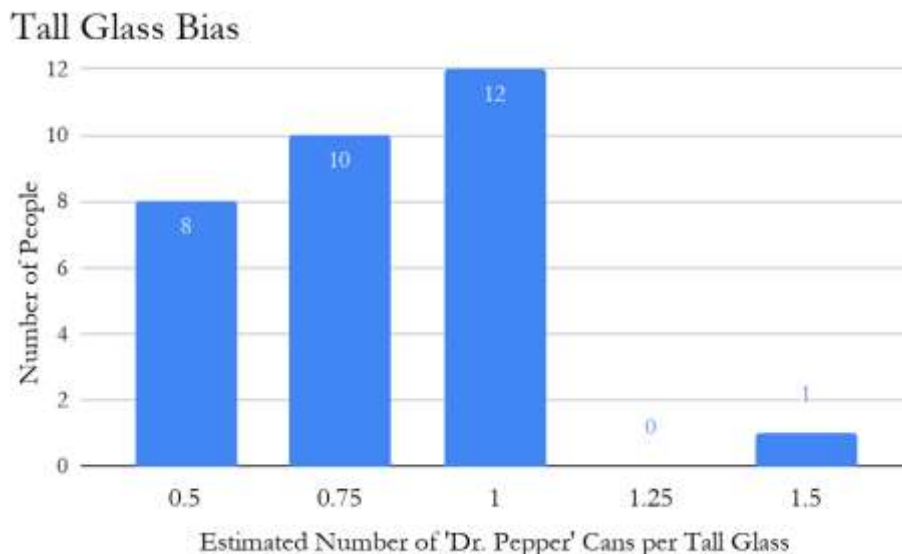
6. Results

The results of our study quite satisfactorily validated the hypothesis and the existence of the perceptual bias.

It is notable to mention here, that the surveys conducted did have a 'right answer', with respect to the question with the glass quantity estimation, which was 1.0. In other words, the answer to the question 'How many of these (Dr Pepper) cans do you think could fit in this glass (Tall [Group 3], Short [Group 2] or both [Group 1] depending on the survey)?' was one can.

6.1 Survey with the Taller Glass:

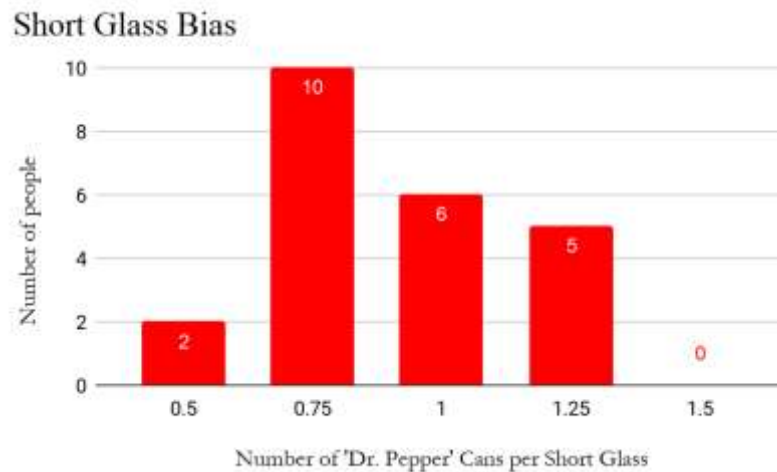
The responses of the survey that asked respondents to estimate (perceive) the quantity of the tall glass, in terms of the number of 'Dr Pepper' cans, were analysed, and the following graph shows the results for the same:



The results above clearly highlight that a large proportion (38.7%) of the participating population of thirty-one (n=31) people believes that one (1) can of 'Dr Pepper' can fit into the tall glass.

6.2 Survey with the Shorter Glass:

The second survey targeted the estimated quantities in the shorter and wider glass and has proved that the majority of people perceived the quantity estimated in the shorter glass, to be lower than the quantity measured in the taller glass survey. The results are given below:



In the case of the Shorter glass, 43.5% (10) of the surveyed population felt that only three-quarters (0.75) of a 'Dr Pepper' can could fit into the wider glass. It is interesting to note here that the second most estimated quantity (21.7%) is one (1) whole can, the same as the most estimated quantity for the Taller glass. This could explain an underlying psychological notion, that a significant proportion of people did subconsciously perceive that the quantity of 'Dr Pepper' cans that could be held in the shorter glass was indeed one, however further experiments would have to be conducted to validate this notion.

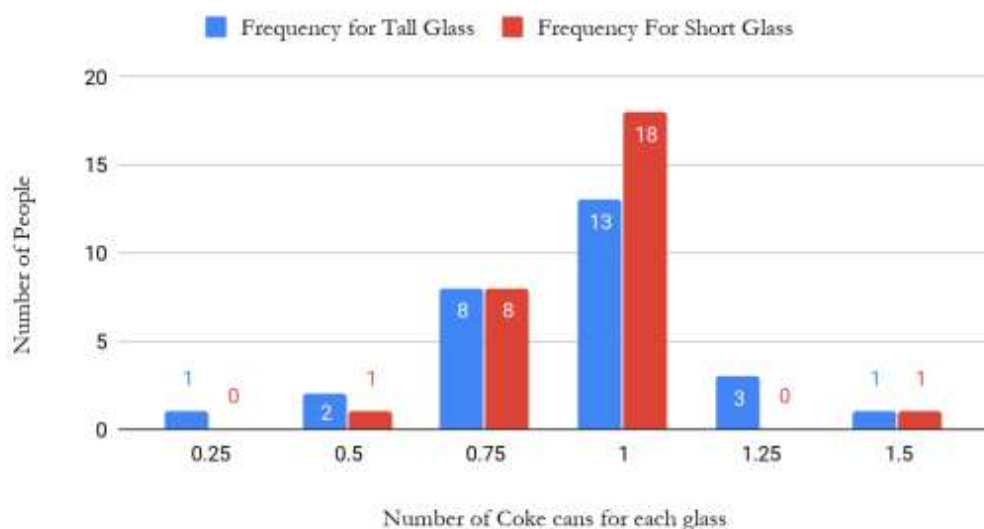
Another takeaway from the graph above is that there are several people (21.7%) who have also chosen the value of 1.25 cans per short glass, while there are none who chose 1.5 cans(0%); this is fascinating as nobody surveyed from the Tall Glass group, seems to believe that the taller glass could hold 1.25 cans(0%), while one person estimates that 1.5 cans would fit into the taller glass (3.2%). This suggests that the variation is similar (but not the same) among both groups, as was expected.

6.3 Survey with the Short and Tall Glass:

These results are arguably the most informative and intriguing results of the survey.

As is observed in the chart below, the majority in both groups have chosen the 'right answer' of a single can per glass. The second majority is also the same at three-quarters (0.75) of a glass.

Estimation of Number of 'Dr. Pepper' Cans for each glass



53.5% of people estimated the same quantity for both glasses. This implies that when both glasses are presented together, 53.5% (13) of people believed that both glasses hold the same quantity. Among the other two surveys, such a large figure was unobserved. The reasoning for this phenomenon is subject to further empirical evidence, as mentioned earlier, however, what I hypothesise to be the most likely case, is the notion that 'if both glasses were presented together, they must be the same quantity', I believe that this hypothesis is likely to hold due to the evidence presented from the earlier surveys that have shown that the majorities have varied. If people truly believed that the estimated quantity of the tall glass was close to one can per glass, then the survey with the short glass would have highlighted the same effect.

Furthermore, the respondents here are one single group, who have estimated quantities for both glasses, therefore it is fascinating to witness such a discrepancy in variation between the two estimates (contrary to the variation in the other two surveys). While the estimates for the Tall Glass seem to vary with people selecting anywhere from one-fourth(0.25) of a glass to three-halves(1.5) of it, the estimates for the shorter glass seem to be less varied, and more skewed towards a three-fourths(0.75) and one full glass(1)(contrary to the earlier estimates, where the data was almost evenly varied).

A common confidence-level question was asked through all surveys which resulted in the following findings. The individual surveys saw an identical variation in the data and identical higher confidence on average between both the Second and Third Groups, however, the First Group(both glasses) saw a huge difference in the variation of the Confidence data between the taller(high variation) and shorter(low variation) glasses with an average level of confidence lower than the individual surveys. For graphs and further analysis, please refer [Appendix Case 2](#)

There also seems to be a few overarching phenomena observed in the results of the survey and the preceding field experiment. For instance, men consistently underestimate the quantities in the two glasses, but they are also more (over)confident than women. However, this claim is too bold to be made with such a small sample size and therefore does not warrant a detailed analysis.

7. Limitations of the paper

No experiment is free of flaws. Since the respondents are unobserved at the time at which they undertake the survey, a problematic issue could be the possibility of external influence, by factors beyond our control. For instance, a third person might influence the respondent's choices to match his/her own, and the respondent may have adapted his response, the third person anchors the view of the respondent, and this leads to the results being distorted.

Another limitation that deals with the consequences of the results observed, witnesses that the bias's effects are shown only individually and not when the glasses are placed next to each other, it is plausible that the bias only dissipated because our respondents have relied on significant computational thinking, which requires an abundance of time and cognitive capacity, but as Herbert A. Simon(1997), human beings do not always make completely optimal decisions, they are *boundedly rational* and make satisficing decisions. Therefore, as a consequence, the purpose of adding the second glass as a de-biasing nudge is quite questionable, because, in venues such as bars, and public houses, the human brain cannot make such a decision in absolute optimality.

These are of utmost relevance, as it is imperative to understand the cause of the bias's disappearance; without this, it will be challenging to analyse and create an accurate nudge.

An additional but relatively insignificant limitation in our survey would be the discrepancy in the sample sizes. It would have undoubtedly been better to have a much evened and larger sample distribution, however, the lack of it is not a cause of immense concern, as the existing data still gives us a functional analysis.

Although there might be a few other limitations that plagued this survey, they are not as consequential as the limitations highlighted above, and therefore, for this paper, feel the need to mention them to be quite trivial.

8. Implications of the Bias

In terms of the glass-experiment itself, the bias clearly shows that people underestimate a short glass's quantity when examined individually. This has severe connotations in the alcohol industry, studies have already shown that there are difficulties in estimating alcohol levels (Stockwell T., & Stirling L., 1989). For the average drinker, this could be potentially catastrophic, as increased-repetitive alcohol intake can very likely increase the alcohol dosage and unwittingly intoxicate the drinker. For the bartender/owner, he could very well price the tall glass higher, and make more significant profits banking on the perceptual bias.

Aside from the rather prominent drinking connotation is the implication of the perceptual bias in person's heights, as is shown in Anderson(2006), taller people are associated with superior qualities, such as athleticism, physical attractiveness, masculinity and so on, the study also found that shorter people are more likely to be associated with femininity. These findings were quite robust and provided additional support to the liabilities of being short. This was also studied in Linda A. Jackson & Kelly S. Ervin (1992) examining the same effects but based on gender. The bias has also been known to have effects on mate selection in humans and has persisted for more than twenty-five years (Ryan M. J. and Cummings M. E., 2013).

In short, the evidence towards the implications of this bias is extensive and widely covered, especially in the present day, verifying the perceptual bias's increasing importance.

9. *Intervention*

The interventions focus on how one would de-bias the perceptual bias, originating due to sensory inputs such as sight, touch, or smell.

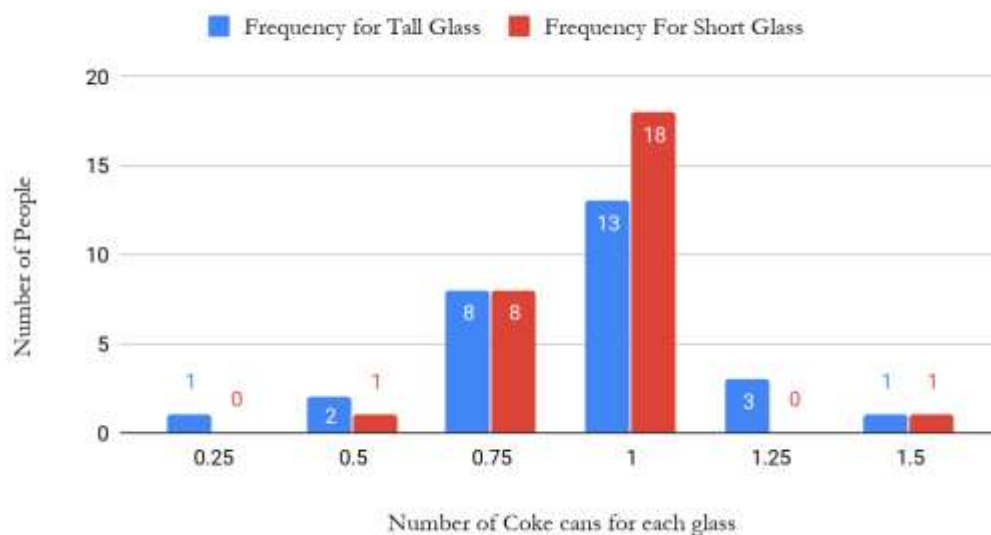
When working with any bias, awareness of the bias can severely aid in reducing, and in many cases eliminating the effects as was shown by Savitsky and Gilovich (2003) where they show that raising awareness amongst public-speakers about the *illusion of transparency* drastically reduces its effects in both the speaker's perspectives and the eyes of the observer. Awareness can be increased by spreading information on the quantity of the glasses in bars, for instance- by tagging the quantity figure at the bottom of the glass.

Another way to reduce the effects of this bias would be to provide additional attention and time. A study, similar to ours, conducted by Cornell University (Wansink, B., 2005), highlighted that if you ask a pourer to take more time and attention to pour, the tendency to overpour reduces significantly, but it is important to note here that over-pouring persists.

However, what I believe to be the most interesting part of our survey is the de-biasing idea through the introduction of a nudge (Sunstein, 2014). When one presents both the tall glass and the short glass right next to each other [as shown in the results by group 1 (the survey with both glasses), the severity of the bias drastically falls, as people perceive the shorter glass to hold the same quantity as the taller glass, which is indeed the case. As I hypothesise that the majority of people (46.4%) begin to perceive through comparisons and inevitably begin to contrast the quantities that could potentially be held by both glasses, this results in the conclusion that there should be no disparity between the quantities of both glasses (see figure below).

Although, it is worth noting here that this nudge is subject to various hypotheses - as the reason behind the effect of the bias waning, is unsupported by empirical evidence as of yet, nevertheless, a series of surveys and experiments and the ensuing informal feedback has helped us reduce the error of this Subjectivity.

Estimation of Number of 'Dr. Pepper' Cans for each glass



10. Conclusion

Therefore, the bias has successively proven its existence and growing importance. However, further empirical analysis is needed to understand whether presenting both glasses could result in a nudge to correct the perceptual bias or increased cognitive strain (Simon, 1997). Needless to say that, based on the first set of results that gathered and presented here in this paper, the bias could very well be countered by the second(shorter) glass just being present near the taller one, if the determining of glass quantity was not a subconscious exercise for the person, as then he/she would simply ignore the second glass altogether.

In short, the perceptual bias is widely covered and yet relatively unknown to people, and its lack of awareness has become the medium for its increasing growth. Analysing and eliminating variables that do not affect the bias and are merely deviations from it can aid behavioural economists to create suitable nudges against the bias; however, this would require further research and experimentation, but as of now the perceptual bias is still persistently changing perceptions.

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12. *Appendix*

12.1 Case 1 - The survey links and images.

Group1: http://bit.ly/Group1_MG311



Group2: http://bit.ly/Group2_MG311

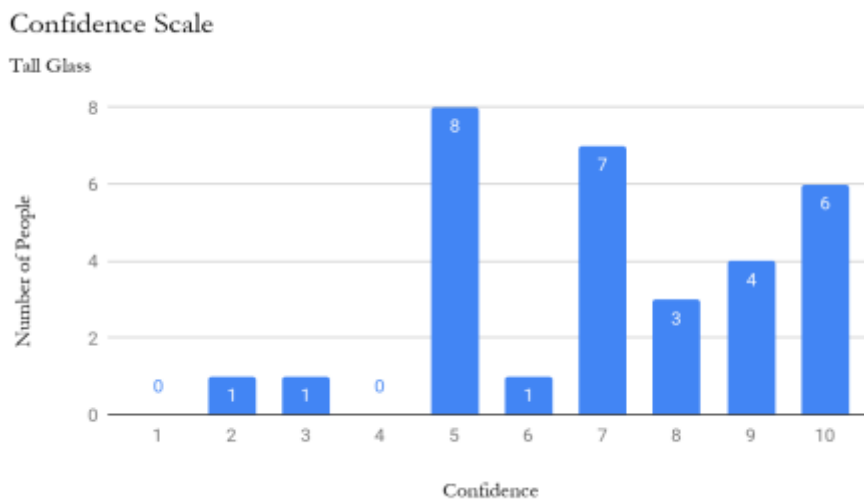


Group3: http://bit.ly/Group3_Mg311



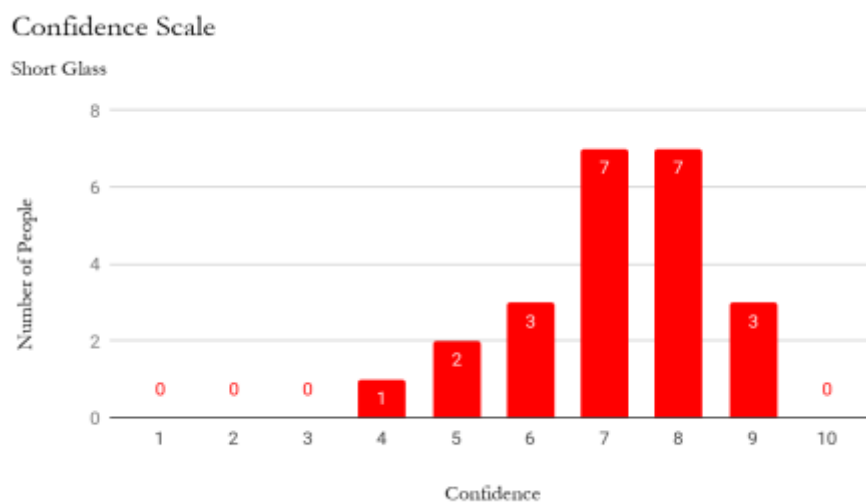
12.2 Case 2- Confidence measures of the surveys.

Tall Glass:



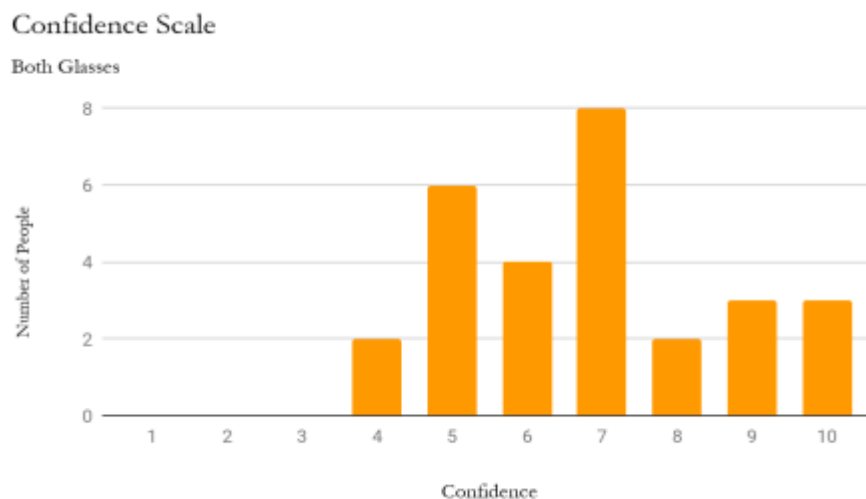
The chart displays the level of confidence for the tall glass survey has shown that the level of confidence varies significantly amongst the respondents, wherein the confidence figures range from two to ten with the modal level being five (25.8%). Considering that the Compromise Effect (Shafir E., et al, 1993) may be at play here, this could imply that the respondents were relatively unsure about their results and thus subconsciously chose a middle point over an extreme. The average here was 7.09, which is high.

Short Glass:



The results on the confidence levels for the short glass have been very different from those of the tall glass. In this case, the effect is skewed towards the rightward side of the confidence scale, with the modal confidence levels being seven and eight, whilst the average is 7.1 almost the same as the average of the tall glass confidence levels. This could once again imply that the respondents of this survey were more confident personalities; however, it could also be the case that the estimation of the short glass's quantity was easier for the average respondent.

Both Glasses:



The Confidence Scale for this survey, shows a similar discrepancy. The data suggests the confidence to be widely varied, ranging from four to ten on the confidence scale, however, the confidence is still varied towards the higher side, with the modal value being eight, and the second majority being five. These are the same majorities found in the tall glass and short glass surveys above. However the average of 6.8 is quite different from the other relatively higher averages of the tall and short glass confidence levels