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Numerosity and allocation behavior: Insights using the dictator game

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Abstract

This paper investigates how the numerosity bias influences individuals' allocation of resources between themselves and others, using the backdrop of the traditional dictator game. Across four studies including both hypothetical and real exchanges of money, we show that the form of the numerical value representing the quantity of the resource (e.g., $20 vs 2000 cents) systematically biases the decision-maker to perceive the quantity s/he is thinking of allocating as being "less than adequate" or "more than adequate". Essentially, such a biased perception of adequacy with respect to the quantity of the resource consequently influences the decision-maker's final allocation decision. We attribute this systematic bias to the "numerosity" of the resource. We find that bigger numerical values representing quantity (e.g., 2000 cents) bias decision-makers to over-infer the quantity, thus inducing them to allocate less to the entities they are focusing on.

Keywords: numerosity, framing, dictator game, allocation, behavior, resource allocation

1 Introduction

We often have to decide how to allocate resources between ourselves and others. For instance, individuals must decide how to allocate available resources, be it money or time, between their own financial needs and other social causes they support. The traditional Dictator game is an excellent representation of such an allocation context and is probably the most frequently used tool to study allocation behavior. In the standard Dictator game, the "dictator" is allotted an initial sum of money in the form of an initial endowment and is asked to allocate a portion of it to another individual who must accept the allocated amount (Forsythe, Horowitz, Savin & Sefton 1994). On the basis of self-interest alone, the dictator should ideally take all the money for herself and allocate nothing to the recipient. However, past research has demonstrated that many who are put in the position of the dictator allocate a substantial share of their initial endowment to the recipient, with the modal allocation being as high as 30% (Bolton, Katok & Zwick 1998).

Thus, the Dictator game is used as an illustration of the impact of social and moral demands over self-interested rationality. Different explanations have been proposed to explain the dictator's non-trivial allocation including a preference for fairness among the dictators (Forsythe et al 1994; Kahneman, Knetsch, Thaler 1986), altruism (Andreoni & Miller 2002), inequality aversion (Bolton & Ockenfels 2000; Fehr & Schmidt 1999) and a social concern for what other observers think (Hoffman, McCabe, Shachat & Smith 1994).

In addition to understanding the motivation behind the dictator's generous allocation, more recent research has sought to understand several moderating factors that influence the level of allocation in the dictator game. For instance, Hoffman, McCabe and Smith (1996), and, Bohnet and Frey (1999) found that allocation increased with social closeness, a sense of relationship between the dictator and the counterpart. Similarly, Aguiar, Brañas-Garza and Miller (2008) found that the allocation increased as moral distance decreased. In another vein, it has been found that allocation increased when an anonymous recipient was replaced by an established charity (Eckel & Grossman 1996) or a deserving/skillful participant (Ruffle 1998). Also, dictators increased allocation when they scored high on self-control (Martinsson, Myrseth & Wollbrant 2012); when they perceived the recipient's expectations to be higher (Heintz, Celse, Giardini & Max 2015); or when they thought the endowment was earned rather than unearned (Cherry, Frykblom & Shogren 2002). These studies are among a very large collection showing the sensitivity of the allocation level to outside influences. (See Engel 2011 for a summary.) In general, these effects generally look at the moderating influence of various forms of social norms. Less research has examined the qualities of the endowment that has to be divided between the dictator and the recipient. We examine one aspect of this level of analysis, namely the "*numerosity*" of the resource.

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To this end, we find that the form of the numerical value representing the quantity of the resource (e.g., $20 vs 2000 cents) systematically biases the decision-maker to perceive the quantity s/he is thinking of allocating as being "less than adequate" or "more than adequate". Such a biased perception about the quantity of the resource consequently influences the decision-maker's final allocation decision. We attribute this systematic bias to the "numerosity" of the resource.

1.1 Numerosity Bias

"Make six slices of the pizza, I can't eat eight."
("not so hungry" Yogi Berra)

As the classic pizza joke illustrates, we may perceive a resource, such as a pizza, to be greater in quantity if it is represented in terms of the more numerous eight slices than the less numerous six slices. This has been called the numerosity bias (Pelham, Sumarta & Myaskovsky 1994), because despite a difference in the expression of amount, the size of the resource (i.e., the pie) remains the same. The numerosity bias explains that individuals tend to over-infer quantity when it is represented with higher numeric values or bigger numbers (Pelham et al 1994).

Numerosity has been shown to affect judgments across consumer domains (Bagchi & Davis 2016) such as points in loyalty/reward programs (Bagchi & Li 2011; Nejad & Onay 2014), quality perceptions (Burson, Larrick & Lynch 2009) and pricing (Coulter, Choi & Monroe 2012; Coulter & Coulter 2010). Nejad and Onay (2014) found that loyalty/reward programs are perceived more positively by consumers if the rewards points are more numerous; for instance, 1000 rewards points cumulatively worth $10 are valued more by consumers than 100 reward points cumulatively worth $10. Burson et al. (2009) found that expanded (higher numerosity) scales led to greater discrimination between options than contracted (lower numerosity) scales; for instance, consumers will prefer product A more if it is represented as 20 points superior to product B on a 100-point scale when compared to the case where product A is represented as 1-point superior to product B on a 5-point scale. Numerosity is shown to bias consumers' perception of price as well — prices or discounts which are phonetically bigger (i.e., have more syllables in their pronunciation) will be perceived bigger; for instance, *three hundred seventy-eight* dollars may be perceived to be more than *three hundred eighty* dollars (Coulter et al 2012; Coulter & Coulter 2010). Thus, there is ample research on the impact of numerosity on judgments in terms of how numerosity can bias individuals' perceptions toward a product or brand.

Outside of this consumption context, few studies have examined effects of numerosity. One example is denominator neglect (a.k.a., ratio bias), in which individuals judge a low probability event to be more likely when represented as a large-numbered ratio, such as 30/100, than as a smaller-numbered but equivalent ratio, such as 3/10 (Kirkpatrick & Epstein 1992). We extend the numerosity bias research to another area, allocation behavior. Across four experiments, we show that numerical values representing the quantity of a resource systematically bias decision-makers' perception of the quantity to be less than, adequate, or more than adequate. As we will demonstrate, this bias affects decision makers' final allocations.

Another stream of relevant research concerns the money illusion, in which the face value of currency influences individuals' perceptions of its real value. Shafir, Diamond and Tversky (1997) showed how individuals do not account for inflation while making judgments about the utility they are getting from the money they are receiving. For instance, in one of their studies, people estimate that someone earning a 5% raise when there is a 4% inflation will be happier than someone earning a 2% raise when there is no inflation. Raghubir and Srivastava (2002) showed that individuals tend to spend more when the face value of foreign currency is a fraction of an equivalent amount in home currency (e.g., a US consumer in Jordan, where 0.7 Jordanian Dinar is equivalent to 1 US dollar, will overspend). Alternatively, individuals tend to spend less when the face value of foreign currency is a multiple of the equivalent amount in home currency (e.g., a US consumer in Malaysia, where 4 Malaysian Ringgits is equivalent to 1 US dollar, will underspend). Wertenbroch, Soman and Chattopadhyay (2007) introduce the idea that individuals use the face value of the difference between available budget and prices while making the purchase decision. For instance, US consumers are more likely to purchase a headphone in Singapore worth S$135 (equivalent to USD 100) when they have S$270 (equivalent to USD 200) left in their budget, than, the same headphone in Jordan worth JOD 70 (equivalent to USD 100) when they have JOD 140 (equivalent to USD 200) left in their budget. Our paper adds on to this research on the money illusion by showing how individuals' decision to allocate money to different entities can be influenced by the face value of money.

Initially, in order to document the impact of numerosity on allocation behavior, we manipulate the decision-maker's perception of quantity using different denominations for the resource – for example 10 dollars versus 1000 cents. Study 1 demonstrates the impact of numerosity on allocation using a hypothetical resource while Study 2 extends the finding to decisions with real money. To provide further insight into the manner in which numerosity drives allocation, we manipulate the decision-maker's focus by framing the decision as "giving to the other" versus "keeping for oneself", and, manipulate the decision-maker's relative attention by drawing attention to either the numerical value or the denomination (Study 3). Finally, we use a hypothetical currency to validate our process account and show that numerosity biases the decision-maker's perception of "adequacy" with respect to quantity of the allocated resource (Study 4).

1.2 Allocation Behavior: Experimental Setup

To investigate numerosity and allocation behavior, we use the standard dictator game, where an individual referred to as the "dictator" (i.e., decision-maker) is allotted an initial sum of money in the form of an initial endowment and is asked to allocate a portion of it to another individual. In the most commonly used version of the Dictator game, the other individual has no option but to accept the allocated amount (Forsythe et al., 1994).

As mentioned earlier, given our research question, we manipulate the decision-maker's perception of quantity of resources (which is money in this case) by describing the initial endowment using objectively equivalent amounts expressed in either dollars or cents. Essentially, we posit that when a decision-maker contemplates how much to allocate to the recipient in "cents", the numerosity bias will occur. By that we mean that a certain amount in cents such as 300 cents, will be perceived to be greater in quantity or more abundant than an objectively equivalent amount expressed as 3 dollars, as the numerical representation of 300 is much bigger than 3. Consequently, under this "Cents" condition, any amount in cents that the decision-maker is thinking about allocating to the other person (e.g., 300 cents) will be perceived to be greater than an objectively equivalent amount that a counterpart decision-maker may be thinking of giving in the "Dollar" condition (e.g., 3 dollars). Because the decision-maker tends to over-infer the amount when represented in cents, and thus perceives it to be more than adequate, s/he will adjust the contemplated allocation in cents to a lower value (for, e.g., 270 cents), when compared to an allocation decided by the counterpart decision-maker in dollars. Accordingly, as a result of the numerosity bias, we expect to see that the final allocation made to the recipient in the "Cents" condition will be lesser in absolute value when compared to the allocation made in the "Dollar" condition. We test this intuition in Study 1.

2 Study 1

2.1 Methods

One hundred and eight Mturk participants from the U. S. participated (69 females; M_{age} = 35.73 years) in a single factor between-subjects study. Participants engaged in a Dictator game where money was allocated in *dollars* versus *cents*. Participants were told to imagine that they were allotted an initial sum of \$10 (in the Dollar condition) or 1000¢ (in the Cents condition) for themselves and another participant in this experiment. They were told that they were randomly assigned to make the distribution decision and were asked to indicate the amount of money they would like to "give the other participant".[1] We used slider scales for the responses to avoid granularity issues. That is, since an amount in cents is more granular than an amount in dollars, we utilized a slider scale to ensure that those in the Dollar condition were able to allocate at the same level of granularity as those in the Cents condition — so, in the Dollar condition, the participant could allocate \$4.57, the same as a participant in the Cents condition could allocate 457 cents. Thus, the responses could be in steps of 0.01 dollars in the Dollar condition and 1 cent in the Cents condition. In each condition (cents or dollars) the sliders had just two labels, one on each side: 0 dollars (0 cents) and 10 dollars (1000 cents). As the decision maker navigated the scale, a number on the right of the scale displayed the corresponding amount (as per the position of a pointer on the slider scale). The displayed amount, in dollars for the Dollar condition and in cents for the Cents condition, depicted how much would be allocated to the recipient.

2.2 Results

Results from a one-tailed t-test supported our intuition. Participants' allocation to the other individual was significantly lower in the Cents condition when compared to the allocation made in the Dollar condition ($M_{\text{allocation in cents}}$ = \$3.438 (SD = 1.904); $M_{\text{allocation in dollar}}$ = \$4.693 (SD = .573), $t(106) = -4.639$; $p_{one\text{-}tailed} < .001$).

2.3 Discussion

In Study 1, we found that the other individual's share was substantially (more than 10%) lower in the more numerous Cents condition when compared to that in the Dollar condition. These results suggest that the recipient can actually be better off if the decision-maker allocates resources represented in less numerous units, such as allocating money in dollars instead of cents, or, allocating time in hours instead of minutes, or, allocating commodities in gallons/pounds instead of cups/ounces.

The results of Study 1 were significant but were not incentive compatible, as participants responded to a hypothetical scenario and were asked to imagine making the allocation decision. Therefore, with the aim of replicating the core results obtained in Study 1, we administered Study 2 in the context of real money, where participants would receive a monetary payoff based on the allocation decision they made.

[1]As the Dictator game is essentially a one player decision task, each Mturk participant in both the conditions acts as the decision maker. There was actually no other individual or participant serving as the recipient.

3 Study 2

3.1 Methods

All members associated with The University of Iowa as faculty, students or staff were emailed a request to participate in the research study in return of monetary compensation. Eighty-six of the people who had registered showed up for the study (54 females; M_{age} = 39.53 years). Participants entered the main lounge of the lab. Each participant first got her/his picture taken in "room A". Then all participants entered "room C" where they were seated on individual work stations. Partitions were set up at the work station so that participants could not look at other individuals or computer screens during the study.

Participants did an unrelated task for ten minutes and then saw the following message "*As you might be aware, the study you are undertaking is taking place in different rooms right now. You are in room C (C220D PBB) and some other participants are in room D (S327 PBB) which is on the third floor of this building. Each participant in Room C has been randomly paired with another participant in room D for the next task*". On the next screen, participants saw a photograph of "another participant" and were told that they have been paired with this "other participant in room D". Please note that all participants were shown the same picture in order to keep the "other participant" uniform for all, a 22 years old Caucasian male who was a member of our research team and was unknown to our study participants.

On the very next screen participants were given the instructions for the allocation decision task. They were told, "*As you are aware, at the end of this session, you are being given an amount for participating in this study. In addition to this participation compensation, you are being allotted 10 dollars* (or 1000 cents for the cents condition) *for yourself and the other participant in room D whose picture you are currently seeing. In each experimental session, it is randomly decided whether participants in room C or in room D will make the distribution decision. In this particular session, it has been decided that participants in room C will make the distribution decision. Since you are in room C, you have been assigned the task of deciding the distribution. There is one-way anonymity in this task. This means that you can see the other participant's picture, but the other participant cannot see your name or picture - you are anonymous to him/her. Even though your picture is not being used in this session (as you are anonymous to the other participant in room B), your picture was taken at the beginning of the study to keep the process consistent for all participants irrespective of the room they are in. How much will you give the other participant in dollars* (in cents for the "cents" condition)". Participants provided their responses on a slider scale which was similar to the one used in Study 1.

At the end of the experimental session, participants walked into a separate room one by one and were paid $5 as their participation compensation plus an amount based on their allocation decision. So, for example, if a participant's response indicated that the participant had allocated $3 to the recipient (leaving $7 for herself), then the participant received $5 (participation fee) plus an additional $7, i.e., total of $12.

3.2 Results

Results from a one-tailed t-test replicated the results of Study 1. Participants' allocation to the other individual was again significantly lower in the Cents condition when compared to the allocation made in the Dollar condition ($M_{\text{allocation in cents}}$ = \$4.801 (SD = 1.75); $M_{\text{allocation in dollar}}$ = \$5.795 (SD = 2.06), $t(84) = -2.398$; $p_{one\text{-}tailed} = .01$).

3.3 Discussion

The results of Study 2 establish the validity of the phenomenon with actual money, where individuals' allocation decisions had an impact on their actual payoff.

While building our intuition for Studies 1 and 2, we argued that owing to the numerosity bias, individuals tend to over-infer the amount they are thinking of allocating when it is represented with bigger numbers (i.e., in the cents denomination). Such a biased perception would in turn cause participants to adjust their contemplated allocation to the other person — in cents — to a lower value. Consequently, the final amount allocated by the decision-maker to the other individual was less in the Cents condition than in the Dollar condition (as observed from the results of Studies 1 & 2).

Please note that in Studies 1 and 2, the decision-maker was asked how much money from the initial endowment s/he would be willing to *give the other individual,* which means that the decision-maker's focus for allocation was on the other individual. If numerosity indeed works in the manner as delineated above, then the same reasoning should apply even when the decision-maker is alternatively asked how much money from the initial endowment she would *keep for herself* — in this manipulation, the decision-maker's focus for the allocation is now on herself. In this latter case as well, we predict that individuals will tend to over-infer an amount in cents – that is, any amount in cents that the decision maker is thinking of allocating to *herself* will be perceived to be greater than an objectively equivalent amount that a counterpart decision-maker may be thinking of in the Dollar condition. If our numerosity based reasoning is correct, such a bias should thus cause the decision-maker to adjust her contemplated allocation to *herself* – in cents – to a lower value. Consequently, the final amount allocated by the decision-maker to *herself* will be lower in the Cents condition when compared to the Dollar condition.

To summarize, in Studies 1 and 2 where the focus for allocation was on the other individual, we found that the decision-maker's allocation to the other individual was lower in the more numerous "Cents" condition. If numerosity is indeed driving such an effect, then in the case where the focus for allocation is on the decision-maker herself, we should see that decision-maker's allocation to herself should be lower in the more numerous "Cents" condition, and, *therefore* the other individual's share (which in this case is the initial endowment minus the decision maker's allocation to herself) should be higher in the "Cents" condition – note that the other individual's share serves as the dependent variable for the study. Study 3 investigates this "focus of allocation (other individual versus decision-maker herself)" x "numerosity (money allocated in dollars versus cents)" interaction.

Moreover, we had speculated that individuals pay attention to the numerical information (for example 300 versus 3) and thus perceive an amount of 300 cents that they may be thinking of allocating to be greater than 3 dollars. We are arguing that this attention/emphasis on numbers enhances the reliance on the numerosity bias, thereby driving the allocation effects. This reasoning can be tested by *manipulating the decision makers' attention* – if we make "**10**" ("**1000**") bold in the display of initial endowment of 10 dollars (1000 cents), then we encourage decision-makers to enhance their attention on numerical information. In this case, we expect to obtain the "focus of allocation" x "numerosity" interaction effect as predicted above. On the other hand, if we divert attention away from the number and make the "**dollars**" ("**cents**") bold, decision-makers will probably still attend to the number but now since more attention is paid to the denomination, they can see through the "numbers" game. There is probably still a sense of 1000 being more than 10 but this is tempered by the fact that the decision-makers are made more explicitly aware of the denomination. Thus, the "focus of allocation" x "numerosity" interaction effect should be diminished in this case. So, in essence, we predict a significant three way "focus of allocation" x "numerosity" x "attention on (numerical information versus denomination)" interaction. The results in the posited form and direction will provide support for our numerosity based reasoning driving allocation behavior. We check these predictions in Study 3.

With respect to the main effects of the three factors ("focus of allocation", "numerosity" , and, "attention on"), we predict only the main effect of "focus" – the other individual's share will be more when the decision maker's focus for allocation is on the other individual, and, the other individual's share will be less when decision maker's focus for allocation is on herself (hence allocating more to herself, which in turn, leaves less for the other individual).

4 Study 3

4.1 Methods

We conducted a 2(Focus of allocation: other individual versus decision-maker herself) X 2(Numerosity: money allocated in dollars versus cents) X 2(Attention on: numerical information versus denomination) between subjects study. Two hundred and forty-seven Mturk participants (103 females; M_{age} = 31.97 years) were randomly distributed across the cells. Participants were made to imagine that they were allotted an initial sum of $10 (in the Dollar condition) or 1000¢ (in the Cents condition) for themselves and another participant in the experiment. They were told that they were randomly assigned to make the distribution decision. In the "focus of allocation = other individual" condition (identical to Studies 1 and 2), participants were asked "*how much would you like to give the other participant"*. Alternatively, in the "focus of allocation = decision-maker herself" condition, participants were asked "*how much would you like to keep for yourself"* (the remainder was left for the other player). We encouraged half of the individuals to enhance their attention to the numerical information by making bold the numerical value in the initial endowment (**10** dollars or **1000** cents). For the remaining individuals, we diverted their attention away from the numerical information by making bold the denomination of the initial endowment (10 **dollars** or 1000 **cents**). Similar to Study 1, we used slider scales for participants' responses.

4.2 Results

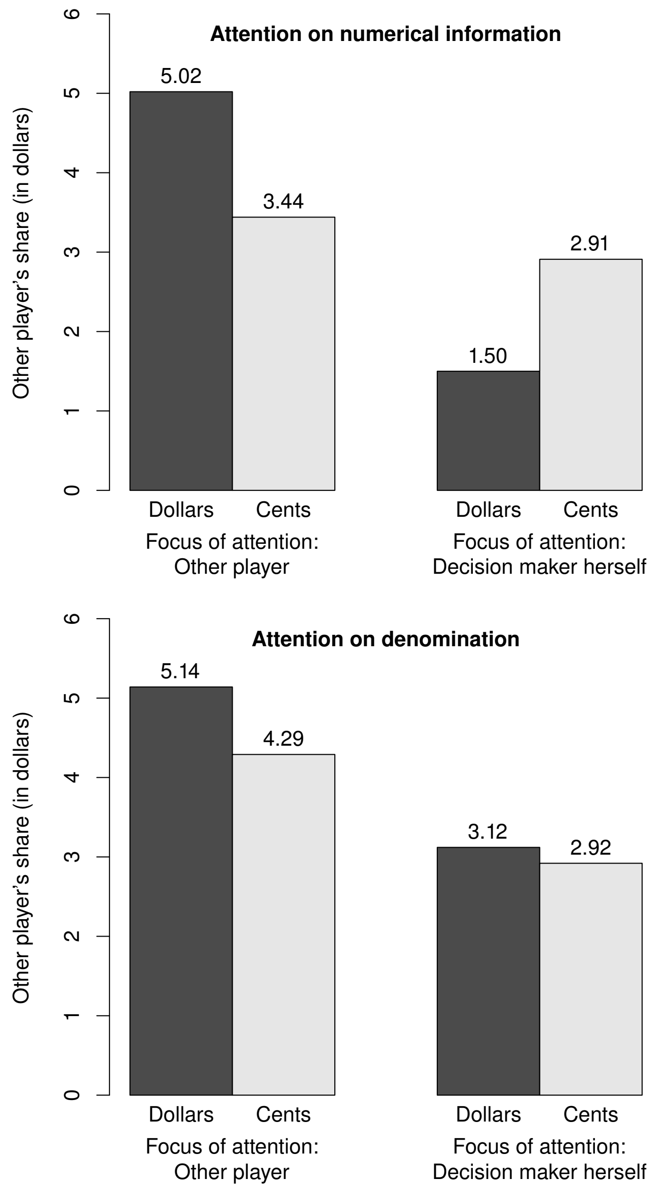
We ran a three-way ANOVA with the other individual's share as the dependent variable. Results revealed a significant main effect of "focus" as the other individual's share was higher when the decision-maker's focus for allocation was on the other individual as compared to the case where the decision-maker's focus for allocation was on herself ($M_{\text{focus of allocation = other individual}}$ = $4.452, $M_{\text{focus of allocation = decision-maker herself}}$ = $2.602; $F(1,239) = 31.308$; $p = .000$; $\eta_p{}^2 = .116$). The main effect of Attention on numerical information versus the denomination was almost significant ($M_{\text{numerical value in bold}}$ = $3.174, $M_{\text{denomination in bold}}$ = $3.881; $F(1,239) = 3.797$; $p = .053$; $\eta_p{}^2 = .016$). We found an insignificant main effect of dollars versus cents ($M_{\text{allocation in cents}}$ = $3.396, $M_{\text{allocation in dollars}}$ = $3.649; $F(1,239) = 0.843$; $p = .359$; $\eta_p{}^2 = .004$).

Central to the question at hand, the three-way interaction was almost significant and was in the predicted direction and form ($F(1,239) = 3.109$; $p = .079$; $\eta_p{}^2 = .013$). Under the "Attention on numerical information" condition, we found that the interaction of (focus of allocation) x (money allocated in dollar versus cents) was significant as predicted ($F(1,121) = 12.166$; $p = .001$; $\eta_p{}^2 = .091$). Follow-up analyses in this regard revealed that when the focus of allocation was on the other individual (identical to Studies 1 and 2), we replicated the results obtained in Studies 1 and 2, and, found that the other individual's share was *less* when the allocation was made in cents than when it was made in dollars ($M_{\text{allocation in cents}}$ = 3.436 (SD = 1.99), $M_{\text{allocation in dollars}}$ = 5.021 (SD = 3.19), $t(59) = -2.293$; $p_{one\text{-}tailed} = .011$). On the other hand, when the focus of allocation was on the decision-maker herself, we found that this was not the case; the other individual's share (calculated in this case by subtracting the decision maker's allocation to herself from the initial endowment) was more when the allocation was made in cents than when it was made in dollars ($M_{\text{allocation in cents}}$ = 2.911 (SD = 2.25), $M_{\text{allocation in dollars}}$ = 1.5 (SD = 2.04), $t(62) = 2.629$; $p_{one\text{-}tailed} = .006$).

Alternatively when individuals' attention was diverted away from the numerical information, i.e., under the "Attention on denomination" condition, the interaction of (focus of allocation) x (money allocated in dollar versus cents) was not significant ($F(1,118) = .413$; $p = .522$; $\eta_p^2 = .003$). Follow-up analyses revealed that, when the focus of allocation was on the other individual, the other individual's share was insignificantly different when the allocation was made in cents or in dollars ($M_{\text{allocation in cents}}$ = 4.286 (SD = 1.44), $M_{\text{allocation in dollars}}$ = 5.136 (SD = 3.84), $t(60) = -1.153$; $p_{one\text{-}tailed} = .127$). Also, when the focus of allocation was on the decision-maker herself, the other individual's share (calculated by subtracting the decision maker's allocation to herself from the initial endowment) was insignificantly different when the allocation was made in cents or in dollars ($M_{\text{allocation in cents}}$ = 2.914 (SD = 2.50), $M_{\text{allocation in dollars}}$ = 3.116 (SD = 2.87), $t(58) = -0.281$; $p_{one\text{-}tailed} = .39$).

The means are represented in Figure 1. These results provide support for our numerosity based reasoning driving the observed allocation behavior. Figure 1 reflects that the "focus of allocation" x "numerosity" effect is significant when attention is on numerical information (i.e., the numerical value is made bold), but it is insignificant when attention is on denomination (i.e., the denomination is made bold).

FIGURE 1: Results of Study 3.



4.3 Discussion of Study 3

From the pattern of data shown in Figure 1, it can be noted that, when the decision-maker's focus for allocation is on the other player, the other player's share is higher in the Cents condition when the denomination is made bold than when the numerical value is made bold. However, the other player's share in the Dollar condition does not seem to vary when the denomination or the numerical value is made bold. Alternatively, in the case where the decision-maker's focus for allocation was on herself, the other player's share was higher in the Dollar condition when the denomination is bolded than when the numerical value is bolded. However, the other player's share in the Cents condition does not seem to vary when the denomination or the numerical value were bolded. This is an interesting pattern of results and was not predicted. It opens an interesting avenue, as in, how framing the allocation task in different objectively equivalent frames (in this case the foci of allocation) can influence our core numerosity based results.

An important and final part of our process account that warrants investigation is whether numerosity biases the decision-maker's perception of "adequacy," with respect to the quantity of the allocated resource. While developing our process account for the impact of numerosity on allocation behavior, we posited that the bigger numerical values representing an amount in "cents" bias individuals to perceive the amount, they are thinking of giving to the other entity, as being larger, and thus more than adequate. Such a biased perception causes individuals to adjust their contemplated allocation in cents to a lower value. Consequently, in the case where the decision-maker's focus for allocation is on the other entity (i.e., "*how much will you give to the other person*"), the final allocation to the other entity is lower in the Cents condition than in the Dollar condition (as demonstrated previously). Thus, we did Study 4, to directly test our "perception of adequacy" based underlying mechanism for the demonstrated phenomenon.

If an individual decides on a final allocation denominated in dollars — $3 for example – then this same allocation should be perceived to be *more than adequate* when s/he sees the same amount expressed in cents (300¢) at a later time. Alternatively, if a certain participant decides on a final allocation in cents – let's say 300¢, then this very allocation should be perceived to be *less than adequate* when s/he sees the same amount expressed in dollars ($3 in this example) at a later time. The fact that an individual perceives the same amount of money to be more than adequate or alternatively less than adequate, when shown in a different denomination, would indicate that numerosity biases the decision maker's perception of "adequacy". We conducted Study 4 to test this prediction. We use a fabricated currency – Tekkas and Yokes – in place of the familiar dollars and cents used in previous studies. This procedure mimics real-world conditions where monetary units vary greatly across nationalities.

5 Study 4

One hundred and twenty-one Mturk participants participated (50 females; M_{age} = 34.24 years) in a 2(money initially allocated in: tekkas versus yokes) X 2(reference denomination: same versus different) study. Participants were initially given a cover story where they were asked to imagine that they were in Takaland where the currency was primarily expressed in the form of "Tekka" and "Yoke". All participants were told that 1 tekka equaled 1000 yokes. Then participants in the "money allocated in tekkas" condition ("money allocated in yokes" condition) were told that they were randomly chosen to be allotted an initial sum of 10 tekkas (10000 yokes) and had to decide the distribution between themselves and another player in this experiment. Similar to Studies 1 and 2, participants were asked how much they would like to "give the other player." Each participant's response (allocation decision) was stored as amount "p" by the software. After participants had made their allocation decision, they undertook a couple of buffer tasks.

After the buffer tasks, each participant was shown a **message** depending on the condition s/he was in. Half the participants were shown the message in terms of the same denomination in which they had made the allocation earlier. That is, participants who had allocated "p tekkas" in the first part of the study were told that another participant who had undertaken this same experiment earlier had given "p tekkas" to the other player. Similarly, participants who had allocated "p yokes" in the first part of the study were told the exact same message in yokes.

The other half of the participants were shown a similar message but the currency was converted to the other denomination from the one in which they had made the allocation earlier. That is, participants who had allocated "p tekkas" in the first part of the study were told that another participant who had undertaken this same experiment earlier had given "(p X 1000) yokes" to the other player. Similarly, participants who had allocated "p yokes" in the first part of the study were told that another participant who had undertaken this same experiment earlier had given "(p/1000) tekkas" to the other player.

Thus, we had four different conditions based on the denomination participants had used to make the allocation in the first part of the study, and, the denomination participants saw in the message later: tekkas-tekkas (reflecting consistent numerosity); yokes-yokes (also reflecting consistent numerosity); tekkas-yokes (reflecting low to high numerosity); yokes-tekkas (reflecting high to low numerosity).

After receiving the message, all participants were asked to indicate whether they felt the amount shown in the message was adequate or not on a seven-point scale ranging from strongly disagree to strongly agree.

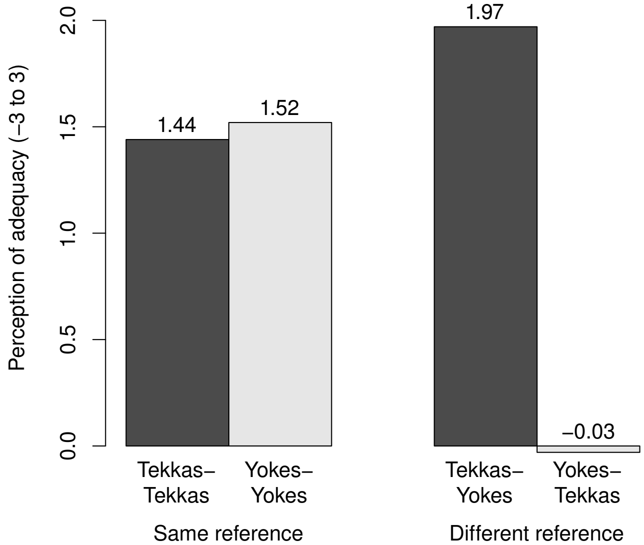
To illustrate an example, a participant in the (tekkas-yokes) condition who gave 3 tekkas to the other player in the first part of the study, was shown a message saying that "Another participant who undertook this study earlier had given 3000 yokes to the other player." Then s/he was asked, "Do you agree/disagree that this person has given an adequate amount to the other player?" on the seven-point scale.

5.1 Results

We first analyzed the amount each decision maker allocated to the other payer. One tailed t-test revealed that, in line with previous studies, decision makers allocated less money to the other player in the more numerous Yokes than in Tekkas ($M_{\text{allocation in yokes}}$ = 3.003 (SD = 2.316), $M_{\text{allocation in tekkas}}$ = 3.961 (SD = 2.871); $t(119)$= 2.042; $p_{one\text{-}tailed}$ = .022).

Participants' response on the seven point "adequateness" scale, where they express whether the amount shown in the message was adequate or not, was the dependent variable. We ran a two-way ANOVA and found the main effect of money initially allocated in "tekkas versus yokes" (M_{tekkas}= 1.69 (SD = 1.336), M_{yokes} = .72 (SD = 1.932); $F(1,117) = 11.319$; $p = .001$; $\eta_p^2 = .088$) to be significant, and, that of "reference denomination: same versus different" ($M_{\text{same denomination}}$ = 1.48 (SD = 1.765), $M_{\text{different denomination}}$ = 0.93(SD = 1.649); $F(1,117) = 3.210$; $p = .076$; $\eta_p^2 = .027$) to be almost significant.

FIGURE 2: Results of Study 4.



However, central to the question at hand, we are interested in the two-way interaction between "money initially allocated in tekkas versus yokes" and "reference denomination: same versus different". We found this two-way interaction to be significant ($F(1,117) = 13.280$; $p < .001$; $\eta_p{}^2 = .102$). Follow-up tests revealed clear support for our proposition. When participants were shown the message in the same denomination as the one they had used for making the allocation decision in the first part of the study, their responses on the adequateness scale did not differ significantly ($M_{\text{tekkas-tekkas}}$ = 1.44 (SD = 1.585), $M_{\text{yokes-yokes}}$ = 1.52 (SD = 1.745); $t(59) = -.187$; $p_{one\text{-}tailed} = .426$).

In contrast, when participants were shown the message in a denomination different from the one they had used for making the allocation decision earlier, we find that those individuals who made the allocation decision earlier in yokes (more numerous representation) but were later shown the message in tekkas (less numerous representation), perceive the same objective amount in the message to be less adequate than those individuals who made the allocation decision earlier in tekkas but were later shown the message in yokes ($M_{\text{yokes-tekkas}} = -0.03$ (SD = 1.816), $M_{\text{tekkas-yokes}}$ =1.97 (SD = 0.944); $t(58) = 5.290$; $p_{one\text{-}tailed} < .001$).

Means are described in Figure 2. As shown in Figure 2, individuals' perception of adequacy does not differ when there was consistent numerosity (i.e., when the denomination in the message was the same as the one they had used for making the allocation decision in the first part of the study). However, as reflected in Figure 2, individuals' perception of adequacy was lower when numerosity went from high to low than from low to high.

These results indicate that an individual perceives the same amount of money to be less adequate or more adequate when the amount is shown in a different denomination varying in numerosity. Thus, the study lends direct support to our position that numerosity biases the decision maker's perception of "adequacy" which underlies the allocation decisions described in the earlier studies.

6 General Discussion

Previous research on the Dictator game has investigated the impact of several factors, including social distance (Bohnet & Frey 1999), moral distance (Aguiar, Branas-Garza & Miller 2008) and recipient's deservedness (Eckel & Grossman 1996), on the amount allocated to another entity. We contribute to this research by examining the qualities of the endowment that has to be divided between the dictator and the recipient. In this regard, we examine how the numerosity of the resource affects allocation decisions. We find that the numerical values representing quantity of the resource (e.g., 10 dollars versus 1000 cents) systematically change the allocation decision. We hypothesize, and defend, the explanation that the numerical values bias the decision-maker's perception of "adequacy" with respect to the quantity, consequently impacting the decision-maker's final allocation decision. We have argued that this bias is due to numerosity, which is the notion that individuals tend to over-estimate quantity when it is represented with bigger numbers. Thus, our work not only contributes to research studying determinants of allocation behavior but also adds to the numerosity bias literature which has garnered considerable research interest recently. As a result of the numerosity bias, across all our studies, we find that bigger numerical values – for example representing an amount in "cents" – can bias individuals to over-infer the amount, thus inducing them to allocate *less* to the entities they are *focusing* on.

Past research has often used dictator games to study charity behavior (e.g., Bekkers 2007; Engel & Grosman 1996). In the context of charitable giving, the Dictator is in the role of the benefactor and the recipient takes the role of the charity. Thus the present work, which demonstrates the impact of numerosity on allocation behavior in dictator games, can have implications for charity behavior as well. In this vein, our paper paves the way for further research on how numerosity affects pro-social behavior which is currently understudied (Bagchi & Davis 2016).

Due to the use of dictator framework, our results can be used to explain the high stakes dictator games conundrum (Novakova & Flegr 2007). It has been shown in the research pertaining to dictator games that individuals allocate less money when stakes are very high (Engel 2011). Researchers have asserted that this decrease in allocation with an increase in stakes is because individuals have a lower sense of fairness when the stakes are high. Our results suggest a more nuanced explanation for the lower allocation when the stakes are high. The studies (e.g., Novakova & Flegr 2007) showing this

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effect of stakes on allocation typically use the "give to the other person" paradigm (just like our Studies 1 and 2). These studies use the same denomination for different treatment groups and as a result, smaller stakes and allocations are represented by smaller numbers (e.g., $ 5) and bigger stakes are represented by bigger numbers (e.g., $ 5000). While this is a straightforward way of manipulating the magnitude of the stakes involved in dictator games (which the researchers were interested in), it confounds numerosity with size of stakes. For instance, if individuals decide to allocate thirty percent of the total money to the other person, then, thirty percent of a bigger stake can be over-estimated or over-inferred due to the numerosity bias. Based on the results we have shown in the current paper, one can argue that due to this misjudgment, individuals end up making a lower allocation to other people when the stakes are high (just as we see in the "Cents" condition of our Studies 1 and 2). One way to apply our work to this conundrum would be to control for numerosity while looking at the impact of varying stakes on allocation size.

We also feel it would be interesting to extend our approach to other dimensions that can vary on numerosity, such as time (minutes versus hours) or size (pounds versus ounces). Would a volunteer offer fewer minutes of support than hours, or a friend a smaller portion of a watermelon in ounces rather than pounds. If our research holds, it might be smart to ask your friend for an allocation of his/her delicious dessert as a quarter pound rather than 4 ounces.

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