



Chimpanzees sometimes see fuller as better: Judgments of food quantities based on container size and fullness

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ARTICLE INFO

Article history:

Received 17 July 2013

Received in revised form 6 November 2013

Accepted 18 December 2013

Available online 27 December 2013

Keywords:

Quantity judgment

Context effects

Misperception

Chimpanzees

Pan troglodytes

ABSTRACT

The context in which food is presented can alter quantity judgments leading to sub-optimal choice behavior. Humans often over-estimate food quantity on the basis of how food is presented. Food appears larger if plated on smaller dishes than larger dishes and liquid volumes appear larger in taller cups than shorter cups. Moreover, smaller but fuller containers are preferred in comparison to larger, but less full containers with a truly larger quantity. Here, we assessed whether similar phenomena occur in chimpanzees. Four chimpanzees chose between two amounts of food presented in different sized containers, a large (2 oz.) and small (1 oz.) cup. When different quantities were presented in the same-sized cups or when the small cup contained the larger quantity, chimpanzees were highly accurate in choosing the larger food amount. However, when different-sized cups contained the same amount of food or the smaller cup contained the smaller amount of food (but looked relatively fuller), the chimpanzees often showed a bias to select the smaller but fuller cup. These findings contribute to our understanding of how quantity estimation and portion judgment is impacted by the surrounding context in which it is presented.

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1. Introduction

At your local bakery, you are given one of two options – a blueberry muffin overflowing its wrapper or a slightly larger muffin in an oversized wrapper. Expected Utility Theory predicts that one should choose the larger muffin as this alternative maximizes returns (Kahneman and Tversky, 1979; Kahneman et al., 1991). However, one might instead opt for the muffin that overflows its wrapper and thus appears to be bigger and better in comparison to the larger muffin. This is a clear example of how the context in which stimuli are presented directly affects choice behavior, sometimes leading to suboptimal outcomes in terms of maximization. Human decision-making research has shown that the framework of a decision often affects peoples' judgments, including classic framing effects and preference reversals as dictated by the availability of multiple options (e.g., Hsee, 1996, 1998; Kahneman and Tversky, 1979; Tversky and Kahneman, 1981). An interesting line of research extends these questions of human decision-making to other species to determine whether similar factors also affect the choice behavior of nonhuman species (e.g., framing effects: Lakshminarayanan et al., 2011; Marsh and Kacelnik, 2002) in ways that might lead to suboptimal choice behavior, and also whether

such phenomena do or do not match what is seen in humans when different species are given similar tests (e.g., Silberberg et al., 1998, 2013; Smith and Silberberg, 2010). Here, we investigated whether context effects impact food quantity judgments among chimpanzees (*Pan troglodytes*) to determine if they too may show suboptimal decision making as a function of the choice setting.

Contextual variables have affected food-quantity judgment and consumption behavior in a variety of human decision-making studies. Humans often over-estimate amounts of food on the basis of how that food is presented. For example, food presented on small plates appears to be a larger amount than the same food presented on large plates, directly affecting how much people eat and how subjectively full they feel (e.g., Van Ittersum and Wansink, 2012; Wansink, 2004, 2006). Glass size and shape also influence the visual perception of liquid volumes; taller cups are perceived as capable of holding more liquid than equal-capacity but shorter cups with larger diameters, influencing perception and pouring/consumption behavior in children (Piaget et al., 1960; Wansink and Van Ittersum, 2003) and adults (Chandon and Ordabayeva, 2009; Raghubir and Krishna, 1999; Wansink and Van Ittersum, 2005).

Another line of research has shown that humans value a smaller amount of food that appears to fill or even overflow its container more than a larger amount of food that does not fill its container. Hsee (1998) demonstrated a 'less-is-better' effect in which a less valuable option was considered to be worth more than an objectively more valuable option if it appeared to be more cohesive or fuller in comparison to its truly larger alternative. Human subjects

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were asked to report how much they were willing to pay for different amounts of ice cream. Despite the objective value of the ice cream (in terms of ounces), people used the ice cream's volume in relation to the cup to determine its monetary value. These results suggested that people might prefer an objectively lower-value option to an objectively higher-value option on the basis of their relation to certain contextual variables such as container size. In the current study, we investigated the 'less-is-better' effect among chimpanzees (*Pan troglodytes*) to determine whether they might also show biases to choose less food over more food when the context in which that food was presented varied such that the smaller quantity appeared to fill its container more than the larger quantity filled its container.

Chimpanzees have shown similar effects in which their food quantity judgments were directly influenced by presentation style. For example, Parrish and Beran (2013) presented chimpanzees with two different quantities of food on same or different sized plates. Chimpanzees were excellent at choosing the larger quantity of food when the foods were presented on identical plates (small plate versus small plate; large plate versus large plate). However, like humans (Van Ittersum and Wansink, 2012), chimpanzees sometimes preferred the smaller food quantity to the larger food quantity if the smaller quantity was presented on the smaller plate, thus appearing to be fuller or larger in that context than the truly larger food option. These results demonstrate that for chimpanzees, like for humans, context matters in food choice behavior, sometimes resulting in a preference reversal or sub-optimal decision-making in which subjects choose the smaller or less valuable option due to its contextual features.

Similarly, Beran et al. (2008) and Boysen et al. (2001) reported that chimpanzees used cues other than the total amount of food in choice sets to guide decision-making. Despite a high accuracy in choosing the larger amount of food across most conditions, chimpanzees' choice behavior was influenced by the location of the largest single piece of food, leading to suboptimal decision-making if that item was not in the set with the overall larger amount of food. These results reflect sub-optimal decision-making in food quantity judgment tasks that are the result of the effects of individual food items on choice behavior, rather than the overall value of each quantity (also see Beran et al., 2009; Silberberg et al., 1998, for other sub-optimal choice biases in monkeys and apes). We attempted to extend these previous findings with chimpanzees into food quantity judgments like those made by humans who show choice biases based on the context in which food is presented.

The study of chimpanzee quantity judgment has a long-standing history in comparative psychology. Early studies demonstrated that chimpanzees were highly accurate in selecting the larger of two sets of food quantities and were sensitive to very small differences in quantity (Menzel, 1960, 1961; Menzel and Davenport, 1962; Menzel and Draper, 1965). More recent studies have confirmed and contributed to these findings; chimpanzees are proficient in choosing the larger amount of food across a range of conditions (e.g., Beran, 2001, 2004, 2012; Beran and Beran, 2004; Boysen and Berntson, 1995; Dooley and Gill, 1977; Hanus and Call, 2007; Rumbaugh et al., 1987). Furthermore, chimpanzees and other great apes also are proficient in conservation tasks (Piaget, 1965) in which they accurately judge quantities when they are spatially transformed into new arrangements (e.g., when liquids are poured into new container shapes and sizes, Muncer, 1983; Suda and Call, 2004, 2005; Woodruff et al., 1978). Thus, chimpanzees should easily navigate a task in which two food quantities are presented without any contextual effects that might bias how those quantities are perceived. But, what if the context in which the foods are presented is altered in such a way that it might produce perceptual illusions and choice biases like those seen with humans? Here, we manipulated the presentation of food quantities so that sometimes they

were presented within identical contexts whereas other times the context was such that the chimpanzees might have misrepresented the true quantities.

In the current study, chimpanzees chose between two amounts of food presented in different sized containers, a large cup (2 oz. in capacity) and a small cup (1 oz. in capacity). In baseline conditions, chimpanzees chose between the same-sized cups with different quantities in each cup. In test conditions, they chose between different-sized cups with either the same quantities or different quantities within them. Critical test trials were presented in which equal quantities were presented in the small and large cup such that the small cup appeared fuller, despite having the same quantity as the large cup. Additionally, we presented trials in which the small cup contained a smaller quantity than the large cup, but the small cup appeared subjectively fuller because the food took up more of its capacity. These were quantity comparisons that would rarely lead to errors when cup size was the same on a given trial, and so any errors would reflect that context matters in how chimpanzees perceived food amounts.

In Experiment 1, we tested how fullness of a container affected quantity judgments for a continuous food type (Jell-O). We varied the difficulty of the task across testing phases as we introduced objectively more difficult quantity discriminations in terms of the relative differences between the presented quantities. In Experiment 2, we extended this investigation to the perception of discrete food items (mini-marshmallows) to determine how the perception of overflow of containers might also contribute to misperceptions of quantity.

In critical test trials in which an equal or smaller amount of food was presented in the smaller but fuller cup, we predicted biases in which the chimpanzees would choose the small cup over the large cup more than they would make the same error when cup sizes were the same within a trial. Moreover, we predicted that the relative fullness of the small cup would impact choice behavior such that the fuller a small cup appeared, the more likely they would choose this cup in comparison to an equal or larger alternative presented in a large cup. Such misperceptions of quantity by chimpanzees would match the same misperceptions sometimes seen in humans and chimpanzees in similar tasks (e.g., Hsee, 1998; Parrish and Beran, 2013).

2. Experiment 1

2.1. Methods

2.1.1. Subjects

We tested four chimpanzees from Georgia State University's Language Research Center, including two males (Sherman, age 39; Mercury, age 26) and two females (Lana, age 42; Panzee, age 27). The chimpanzees were group housed but separated voluntarily into adjacent enclosures for testing. All chimpanzees worked for preferred foods, but received their normal diet of primate chow, fruits and vegetables and were never food or water deprived.

Three of the four chimpanzees, excluding Mercury, were language-trained via a lexigram system comprised of arbitrary symbols representing objects, food, people, places, and activities (Rumbaugh and Washburn, 2003). All chimpanzees had extensive experience in making quantity judgments in a variety of contexts and with a variety of stimuli, including quantities of food items (e.g., Beran, 2001, 2004, 2012; Beran and Beran, 2004; Rumbaugh et al., 1987).

2.1.2. Apparatus

Trials were presented via a rolling cart with a sliding tray (86 cm × 28 cm) and a set of retractable mini-blinds. The cart was

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