Effect of heaviness on the cognitive evaluation process

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Abstract

The aim of this study was to clarify how the sense of heaviness changes our cognition. According to recent studies in cognitive science, intelligent human behaviors ranging from perception to inference are not closed mental processes; rather, they are affected by body and action (Wilson, 2002; Gibbs, 2005; Proffitt, 2006). In previous studies, the sense of heaviness activated concepts metaphorically related to heaviness, and changed impressions accordingly. However, previous studies have not distinguished between subjective heaviness and physical weight. The purpose of this study was to clarify whether changes in impressions are due to subjective heaviness or physical weight. To examine this issue, a psychological experiment using a tasting task was conducted. The results confirmed that subjective heaviness influences evaluations of price and value.

Keywords: Embodied cognition; Size-weight illusion; Haptic priming.

Previous Studies

Embodied cognition literature

Research on embodied cognition suggests that mental activity is driven by physical body state, posture, and sensory-motor coordination. Perception can be modulated by bodily actions. For example, viewing visual stimuli between one's legs changes visual perception compared to when such stimuli are viewed normally (Higashiyama & Adachi, 2006; Higashiyama & Toga, 2011).

Bodily feedback from physical action can also change affective states and thoughts. Cacioppo, Priester, & Berntson (1993) suggested that arm extension gives rise to bodily feedback associated with avoiding negative stimuli, and arm flexion gives rise to bodily feedback associated with approaching positive stimuli. Friedman & Forster (2000, 2002) showed that arm extension and flexion bias participants toward different processing styles, which influences creative thinking. The authors manipulated the extent to which non-affective bodily feedback was associated with either positive or negative hedonic states, and then examined the effects of this feedback on cognitive processes related to creative insight. In the experimental social psychology literature, it has been suggested that tactile sensations influence consumer behavior and social attitudes. For example, Krishna & Morrin (2008) showed that the perception of bottle hardness affected the evaluation of natural water. Kay, Wheeler, Bargh, & Ross (2004) showed that the tactile sensation of hardness made participants appear more strict and stable, less emotional, and decreased negotiation flexibility. Embodied cognition research suggests that mental activity is driven by physical body state, posture, and sensory-motor coordination.

Heaviness and high-level cognition

This paper focuses on the sense of heaviness, because sense of heaviness is related to body state. For example, when we hold a heavy object, we feel heaviness, change our posture, and grow fatigued. These physical changes may alter cognition.

Seno, Abe, & Kiyokawa (2013) examined the effects of heaviness on visually-induced illusory self-motion perception, also know as "vection." They hypothesized that heavier items would inhibit vection because they make locomotion difficult. They found that wearing heavy clogs made locomotion difficult and inhibited vection, suggesting that cognition can alter vection strength. Bhalla & Proffitt (2008) examined perception under various physical conditions. They suggested that physical states affect people's judgments about whether they will be able to go up a slope or path. They showed that people estimate uphill distance and steepness as being longer and steeper when they are holding a heavy object and growing fatigued.

In haptic priming studies, "heavy" is used as a metaphor for "important" or "serious." For example, Jostmann, Lakens, & Schubert (2009) showed that our abstract concept of importance is affected by heaviness. They asked participants to judge importance in various situations while holding either a heavy or light clipboard. Results indicated heaviness makes people invest more cognitive effort when engaging in abstract thinking. Another study showed that curriculum vitae presented on heavier clipboards were judged to be more important than those presented on lighter clipboards (Ackerman, Nocera, & Bargh, 2010). These studies suggest that heaviness is associated with importance and seriousness. For example, we usually say "a heavy penalty," "heavy responsibility," and "put more weight on." It is thought that the sensory experience of heaviness activates these metaphorical concepts during haptic priming.

Hypothesis of this study

These previous studies have partially clarified the effects of heaviness on high-level cognition. Heaviness leads to longer and steeper estimates of distance and slope, respectively. Sense of heaviness can also change subjective impressions and social attitudes toward other people. Previous haptic priming research found that sensory input activates metaphorical concepts.

However, it is not clear whether subjective impressions are influenced by subjective heaviness or physical weight. In this study, this issue was examined by addressing an estimation task. If the effects are due to the amount of the physical load, it may be considered that physical/implicit processes

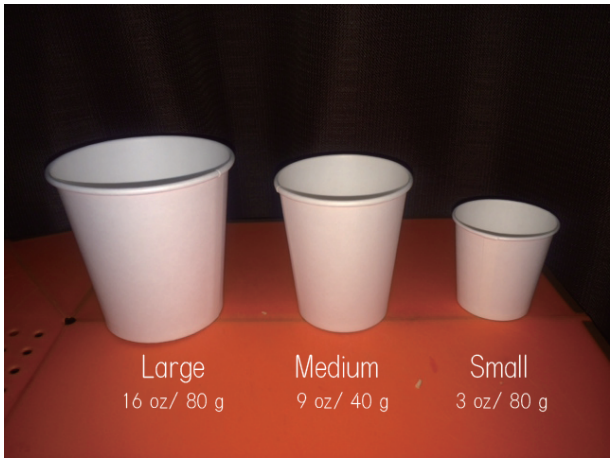

Figure 1: The three cups of water in the experiment

which are separate from the subjective view of the subject exert effects on the inference. Conversely, if they are due to the amount of the subjective load, it may be considered that the subjective view of the subject and explicit processes exert the effects on the inference.

As a means of examining these amounts of physical and subjective loads separately, the ”size-weight illusion” (Charpentier, 1891) was used in this study. This illusion is the phenomenon that, if the weights are the same, the larger object is sensed as being lighter. Utilizing this illusion, estimation tasks under conditions of being subject to different subjective loads while being subject to the same physical load were conducted to examine the effects of the physical and objective amount of the physical load.

Experiment

In this experiment, the effect of subjective heaviness on value judgment was examined using a water evaluation task. Participants drank water and evaluated its taste, value, and price. To examine the effect of differences in subjective heaviness, the size-weight illusion was used. Participants were asked to evaluate three cups of water. Two of the cups were the same physical weight, but their subjective heaviness differed due to the size-weight illusion. If subjective weight affects participants' evaluations, there will be a significant difference in evaluations between the cups of water.

Method

Participants

Twenty college students participated in the experiment. The IRB approval has been obtained.

Task

All participants were asked to drink three cups of water and evaluate them. The experimenter told participants: ”There are three cups of water here. These correspond to any of the following: tap water, natural water, and deep-sea water. Please drink and evaluate them.” Participants were not informed that in fact all cups contained the same natural water until after the experiment. The three cups of water differed in the size of the cup and the quantity of water (Figure 1). The small cup (3 oz) contained 80 g of water. The medium cup (9 oz) contained 40 g of water. The large cup (16 oz) contained 80 g of water. Participants were only told about the quantity of water in the medium cup. The large cup contained the same amount of water as the small cup, but because of the difference in cup size, it was expected that participants would think that the large cup was lighter than the small one.

Procedure

A two-factor within-subjects design was used in this experiment. The experiment was divided into three steps. First, participants evaluated the cups of water, before they actually drank, in order to test the effect of visual differences in cup size on participants' evaluation. Second, we verified that participants experienced the size-weight illusion. Third, the taste test was conducted. After that, the taste and value of the water were evaluated. In order to avoid the possibility that participants guessed the purpose of this experiment, we told them: ”To make these cups easy to distinguish, we prepared three sizes of cups.”

Pre-test evaluation Participants first evaluated the cups of water, before they actually drank from them, to test the effect of visual differences in cup size on evaluation. Participants were asked to evaluate how good tasting each cup of water looked, and how valuable each was, using a 101-point scale (100 = good, 0 = bad). Then, they were asked to estimate the price per 2 L of water.

Quantity estimation task After the evaluation task, participants were handed the medium cup. The experimenter told the participants that the medium cup contained 40 g of water. Participants were then asked to estimate the quantity of water in the other cups to determine whether participants experienced the size-weight illusion for the small and large cups. Smaller quantity estimations for the large, compared to the small, cup, indicate a size-weight illusion.

Post-test evaluation After the quantity estimation task, participants were asked to drink from the cups of water and evaluate the tastes. Participants were told to take a sip from each cup, and that they were not allowed to re-taste from any cup. They were not allowed to re-taste the water because this might change the weight of the cup and the quantity of water, which might affect their evaluations. Participants evaluated the water for taste and value. Finally, they decided the price per 2 L of water. If subjective heaviness affected evaluation, water in the small cup would be evaluated as better than the water in the large cup. The order that participants drank each cup of water was randomized to avoid order effects.

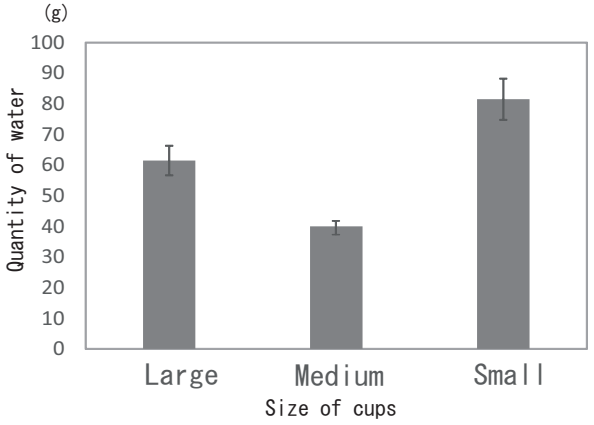

Figure 2: Means and standard errors the quantity estimation task

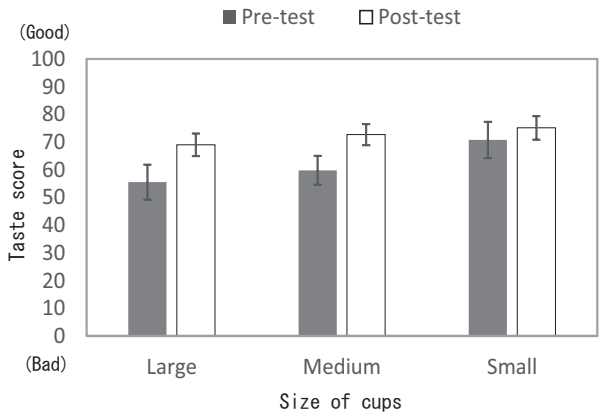

Figure 3: Means and standard errors of the taste evaluation task

Debriefing After the experiment, the researcher asked participants to describe the purpose of the experiment in order to determine if participants detected the aim of the experiment. Then, the experimenter explained the aim of the experiment to them.

Results

According to the answers in the debriefing session, no participants determined the aim of the experiment.First, to check whether participants experienced the size-weight illusion, quantity estimations were examined. Figure 2 shows the mean quantity estimates. A one-way ANOVA revealed a main effect of size ($F(2,38) = 31.773, p < .01, partial\eta^2 = .626$). Multiple comparisons with the Bonferroni method revealed a significant difference between each cup size (large-small: $p < .001$; large-medium:$p < .001$; small-medium: $p < .001$). The quantity of water in the small and large cups was physically the same, but participants thought that their quantities differed. This confirms that participants experienced a size-weight illusion.

Taste ratings Figure 3 shows the mean taste ratings. A two-way ANOVA revealed no significant interactions ($F(2,38) = .361, p = .695$), but did reveal a marginally significant main effect of pre- vs. post-test ($F(1,19) = 4.016, p = .060, partial\eta^2 = .174$), and a significant main effect of cup size ($F(2,38) = 3.356, p = .045, partial\eta^2 = .150$). A simple main effect test using the Bonferroni method revealed that there was a marginally significant difference between pre-test and post-test taste evaluation in the medium size cup condition ($p = .066$).

Value evaluation Figure 4 shows the mean value ratings. A two-way ANOVA revealed a marginally significant interaction ($F(2,38) = 3.251, p = .050, partial\eta^2 = .146$), and a significant main effect of pre- vs. post-test ($F(1,19) = 4.464, p = .048, partial\eta^2 = .190$). There was no significant

Figure 4: Means and standard errors of the value evaluation task

main effect of cup size ($F(2,38) = 1.261, p = .295, n.s.$). A simple main effect test with Bonferroni method revealed there were no significant differences in value evaluation during the pre-test ($F(2,18) = .372, p = .695, n.s.$). This result suggests that the visual differences between the cups did not affect participants' evaluations. In contrast, there was a significant difference in post-test value evaluations ($F(2,18) = 4.141, p = .033, \eta^2 = .315$). A simple main effect test revealed, with the Bonferroni method, that the large cup was rated significantly lower in value than the medium cup ($p = .041$). There was a marginally significant difference between large and small cups ($p = .080$).

Price decisions Figure 5 shows the mean water price estimates. A two-way ANOVA revealed a marginally significant interaction ($F(2,38) = 3.066, p = .058, partial\eta^2 = .139$), and a marginally significant main effect of cup size ($F(2,38) = 2.687, p = .08, partial\eta^2 = .124$). A simple main effect test revealed that there were no significant dif-

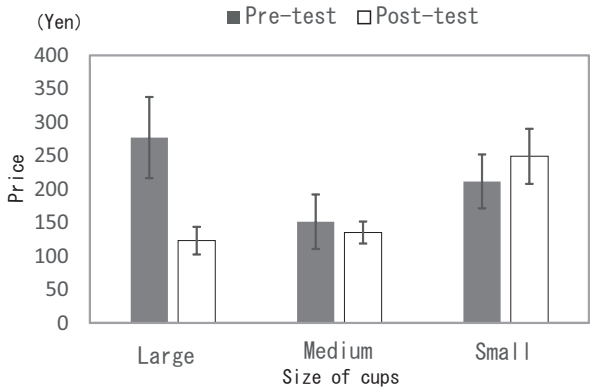

Figure 5: Means and standard errors of the price decision task

ferences in price judgments during the pre-test ($F(2,18) = 1.334, p = .288, n.s.$). This result suggests that the visual differences between cups did not affect participants' price decisions. In contrast, there was a significant difference in price judgments in the post-test condition ($F(2,18) = 3.760, p = .043, partial\eta^2 = .295$). A simple main effect test with the Bonferroni method revealed that the water in the small cup was given a significantly higher price than the water in the medium ($p = .046$) and large ($p = .036$) cups. The price of the water in the small cup was judged to be significantly higher in the post-test than in the pre-test.

Discussion

The results of this experiment support the hypothesis that subjective heaviness affects evaluations. There was a significant interaction and a main effect of pre- vs. post-test for value evaluations. The price and value of the water in the small cup were rated significantly higher than these of the large cup in the post-test evaluation. These results indicate that subjective heaviness information changed the evaluation of value.

In the quantity estimation task, participants estimated the weight of the small cup to be heavier than that of the large cup. Therefore, participants experienced the size-weight illusion. Participants subjectively thought that the water in the large size cup was lighter than that in the small size cup. There was a significant interaction and a main effect of pre- vs. post-test for value evaluations. The price and value of the water in the small cup was rated significantly higher than that of the large cup in the post-test evaluation. These results indicate that subjective heaviness information changed the evaluation of value. However, in the value evaluation, the water in the small cup was not significantly higher than that of the medium cup. It is possible that, because participants performed the value evaluation using a 101 scale, it was difficult to differentiate the rating of small the cup from that of medium cup, which had been already highly evaluated. On the other hand, in the price decision task, evaluation of the water in the small cup was evaluated as the most expensive. It is hypothesized that it is easy to differentiate the evaluation of each cup, because the price decision is open-ended. In contrast, there were no significant differences in taste evaluations, perhaps because the taste of water does not metaphorically relate to heaviness. We do not express the taste of water with abstract concept of heaviness.

Conclusions and future directions

This paper examined whether subjective heaviness affects evaluations of value and price judgments. Differences in subjective heaviness affected participants' evaluation of value, even though there was no difference in physical weight between the large and small cups. Subjective heaviness likely activated concepts metaphorically associated with value, as in haptic priming.

Future work should examine whether how heavy objects are carried affects cognition. Previous haptic priming studies differ in how participants carried objects. In Bhalla & Proffitt (1999), participants carried a heavy backpack on their backs, but in Ackerman et al. (2010), participants were handed a heavy clipboard.

Responsibility, pressure, and expectations are often associated with heaviness on one's back. For example, the phrase "carry life's burdens on one's shoulder" indicates a responsibility for someone's life. In contrast, acquirement, chance, and gain are associated with heaviness in the hands. For example, the phrase "to grab at the chance" means taking a favorable opportunity. Thus, experiencing weight in different body parts may activate different metaphorical concepts.

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