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# Memory and Obesity: Theory and Empirical Evidence

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*July 2018*

EGC Report No: 2018/07

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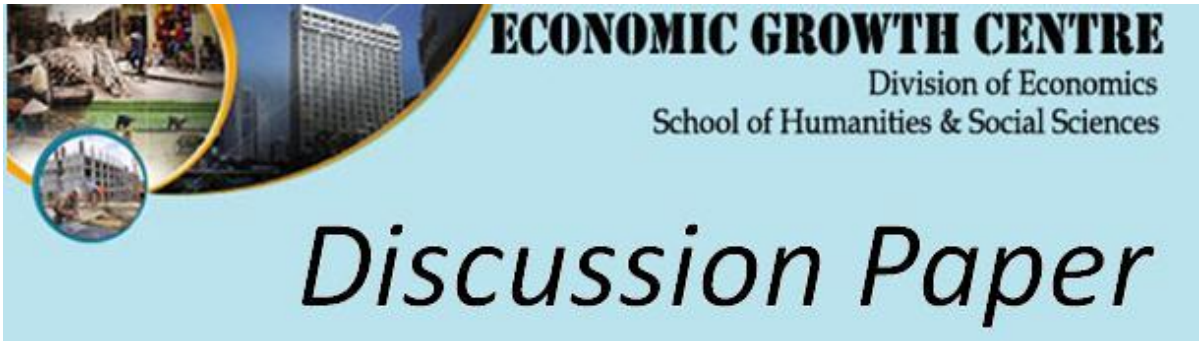

# Memory and Obesity: Theory and Empirical Evidence[1]

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**Abstract:** The prevalence of overweight and obesity is a rapidly growing threat to human health worldwide. Based on the theory of memory utility, we explore the effect of memory capacity on overweight and weight control by building a theoretical model and conducting related empirical research by a double-hurdle model. The result shows that better memory capacity can lead to higher probability of overweight and obesity, while it may also help to the overweight individuals to lose weight. The different effects of memory results from the balance of memory utility from food consumption and memory disutility from obesity.

**Keywords:** memory capacity; memory utility; memory disutility; overweight and obesity

**JEL Classifications**: Q18, D15, I12

## 1 Introduction

The prevalence of overweight and obesity is a rapidly growing threat to human health worldwide. According to the data from World Health Organization, the rate of overweight for adults above 18 is 39% worldwide, and the obesity rate was 13% in 2016, which was almost tripled from 1975. Overweight and obesity has not only become a public health threat but also caused a substantial economic burden and welfare loss (Wang et al., 2007; Katsaiti, 2012). Therefore, the obesity issue has received much attention from both the academia and policy makers.

To analyze the cause of overweight and obesity epidemic, the economics literature has paid ample attention to socio-economics factors, such as rising income, lower food price, the popularity of fast food, etc. (Chou et al., 2004; Lakdawalla and Philipson, 2009). However, we argue that memory, which is largely neglected in the economics literature, may play an important role in explaining body fatness. Previous studies have already confirmed the existence of memory utility, which posits that current utility depends not only on current consumption, but also on memory utility deriving from past consumption (Smith, 2009; Gilboa et al., 2016; Bao et al., 2018). According to the results of this literature, memory capacity is positively correlated with discount rates, thus better memory implies larger consumption amount in the early stage of life (Bao et al., 2018). Therefore, ignoring the heterogeneity in memory capacity could lead to substantial bias in understanding intertemporal consuming behavior, such as food consumption, which is largely considered the main determinant for body fatness.

Food consumption does not only provide necessary energy for human body, but is also a source of pleasure or feeling of satisfaction (Coveney, 2006; Mela, 2006). Abundant medical literatures

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have confirmed the existence of the hedonic feelings of palatable food consumption triggered by stimulating the brain opioid system (Giuliano & Cottone, 2015; Nathan & Bullmore, 2009). From this aspect, pleasure of palatable food enjoyed today may generate long-lasting positive memory utility for the future, which is then added to future utility. Therefore, an individual who maximizes his total utility during the lifetime will naturally consume more food at present. Better memory capacity should be associated with higher degree of memory utility and hence larger premium for consuming food today (Bao et al., 2018), consequently, better memory capacity may be associated with larger weight gain in the current period due to more food consumption.

On the other hand, over consumption of food could contribute to body fatness (Appelhans et al., 2011). Being overweight and obese is not only associated with increased risk of health problems such as cardiovascular disease, hypertension, Type II diabetes, etc (Wang et al., 2007), but also connected to negative self-perceptions and social stigma in daily life (Katsaiti, 2012; Forste & Moore, 2012). For example, it is proven that overweight and obesity have a negative impact on possibility of employment, wages and promotion in the labor market due to discrimination (Lindeboom et al., 2010). Therefore, the weight effect of food consumption enjoyed today can also generate negative memory utility (memory disutility). Memory here serve as utility lose for consuming food at present, and better memory implies larger utility loss. Consequently, considering the disutility of being obese, a consumer with higher memory capacity tends to avoid being obese by reducing food consumption to reach the optimal weight. That is, better memory capacity could help to lose weight for overweight and obese individuals. In summary, with the involvement of memory utility from food consumption and memory disutility from obesity, memory capacity may have two different impacts on weight gain depending on the stages of being overweight and obese.

Although several medical literatures have found higher memory capacity is associated with reduced food intake and increased weight loss for overweight individuals (Hege et al., 2013; Dassen et al., 2018), the economics literature has explored the effect of memory on overweight and obesity in a limited way. Actually, heterogeneous memory capacity of individuals is largely neglected in the economic analysis. Therefore, the present paper firstly establishes a theoretical model for analyzing the roles of memory in weight gain, then with data from China, we empirically investigate the effect of memory capacity on overweight and obesity using the double-hurdle model. Our findings confirm that memory capacity is indeed correlated with weight gain, which depends on the balance of memory utility from food consumption and memory disutility from obesity.

Our paper is related to behavioral economic studies on overweight and obecity. There has been consensus among economists that the economic analysis of obesity is complicated, and it is better to assess it by combining the traditional economic models with insights from psychology and behavioral economics (Gundersen et al., 2012, Huang et al., 2012, McCluskey and Asiseh, 2012, Smith, 2012). Oliveira et al., (2016) find that higher risk tolerance is associated with larger probability of obesity among low income African Americans. A recent study by Lien and Zheng (2018) shows that college students eat less healthily in the exam period due to depletion of self-control because of the heavy workload for exam preparation. The key difference between this paper and those studies is that we focus on memory utility, a behavioral factor that has not been studied in the previous literature.

The remainder of this paper is organized as follows. Section 2 presents the theoretical framework; Section 3 introduces the data and the empirical model specification; Section 4 show the empirical results. Finally, the paper is discussed and concluded in Section 5.

## 2 Theoretical Model

The utility derived from consumption could be remembered, and this is defined as memory utility (Bao, Dai and Yu, 2018; Gilboa, Postlewaite, and Samuelson 2016). Given a budget constraint, a consumer with better memory tends to consume more in the early stage of his/her life, and shows higher discounting rate (Bao, Dai and Yu, 2018). The concept of memory utility could be applied to food consumption as well. We assume the utility of food consumption is

$$\bar{U} = U(F_0) + M(F_0, m) \quad (1)$$

where $U(F_0)$ is the direct utility derived from food consumption $F_0$; we can obtain pleasure feelings from eating and marginal utility is diminishing (Mela, 2006), thus $\partial U(F_0)/\partial F_0 > 0$ and $\partial U^2(F_0)/\partial F_0^2 < 0$. Food consumption could lead to memory utility $M(F_0, m)$ and $m$ measures the memory capacity.

Bao, Dai and Yu (2018) point out that better memory capacity could yield higher discounting rate, which leads to more consumption at the current stage. Intuitively, palatable food could offer good memory utility in the future so that consumers tend to consume more food at the current stage. That is, the optimal level of food consumption $F_0^*$ is increasing with $m$.

$$\partial F_0^*/\partial \mathrm{m} > 0. \quad (2)$$

Food is a basic need for human, and hunger from food scarcity yields very unpleasant experience and negative health consequence. However, in an affluent society with enough food, people are free from the threat of hunger, but overconsumption of food may lead to overweight and obesity, which has negative health and social consequences as well. Obesity is known to be linked to type II diabetes, heart diseases and other non-communicable diseases (Wang et al., 2007), and obese people are often discriminated in marriage and employment (Katsaiti, 2012; Oswald and Powdthavee, 2007). That is, over consumption could generate possible disutility from due to obesity. The probability of being obese could be assumed to be

$$P = P(\rho, F_0) \quad (3)$$

Where $\rho$ denotes the metabolic level. Clearly, a consumer with more food consumption is more likely to be obese, and high metabolic consumption level reduces the likelihood of obecity. That is, $\frac{\partial P}{\partial F_0} > 0$, while $\frac{\partial P}{\partial \rho} > 0$. Combined with Equation (2), we have

$$\frac{\partial P}{\partial m} = \frac{\partial P}{\partial F_0}\frac{\partial F_0}{\partial m} > 0 \quad (4)$$

**Proposition 1***: Better memory capacity could lead to more food consumption at the early stage of life due to higher memory utility in the future. While high food consumption is more likely to cause obesity in an affluent society. That is, a consumer with higher memory capacity is more likely to be obese.*

As aforementioned, obesity would cause disutility for consumers. Hence, a consumer's utility becomes

$$\bar{U} = U(F_0) + m[rU(F_0) - B(F_0)] \quad (5)$$

Where $M(F_0, m) = mrU(F_0)$, and $r$ is a parameter to measure the memory utility; and $B(F_0)$ is the disutility from obesity. It is an increasing convex function: $\frac{\partial B(F_0)}{\partial F_0} > 0$, and $.\frac{\partial B^2(F_0)}{\partial {F_0}^2} > 0$. That is, the disutility will increase in overconsumption of food over proportionately.

The first-order condition of Equation (5) for maximizing it yields

$$\frac{1}{m} = \frac{B'(F_0)}{U'(F_0)} - r \qquad (6)$$

Then

$$\partial(\frac{1}{m}) / \partial F_0 = \frac{B''(F_0)U'(F_0) - B'(F_0)U''(F_0)}{[U'(F_0)]^2} > 0 \qquad (7)$$

given that $B''(F_0) > 0;\ U'(F_0) > 0;\ B'(F_0) > 0; U''(F_0) < 0.$

Hence,

$\partial F_0 / \partial \mathrm{m} < 0$ (8).

**Propositon 2***: A consumer with higher memory capacity tends to avoid being obese by reducing food consumption to reach the optimal weight when he/she takes into account the memory disutility of being obese.*

Equation (8) seems contradictory to Equation (4). However they are telling different stories in different stage of being obesity. Equation (4) shows that a consumer who is not obese tends to be obese when he/she has a higher memory capacity due to possible more food consumption at the current stage. In contrast, Equation (8) indicates that a consumer who has been obese tends to reduce weight due to the memory disutility from obesity.

Empirically, this is a typical double-hurdle model. The first hurdle studies the probability of being obese (obesity participation decision), and the second studies what to do if obesity is observed (optimal weight decision). In the rest of the paper, we will test our hypotheses empirically.

## 3 Data and Methods

### 3.1 Data

The data were drawn from the China Health and Nutrition Survey (CHNS), which is a longitudinal and household-based study that began in 1989. There have been nine surveys to-date, of which the latest was in 2011. The CHNS includes around 4000-5000 households from eight or nine diverse provinces that vary substantially in geographical features, economic development, public resources and health indicators. A multistage cluster random sampling method was used to derive the original sample, and the related information was collected by questionnaire survey on the individual, household and community levels.

Our sample consists of 2882 adults aged 55 or above in 2006 survey with complete information needed for our empirical analysis. The CHNS collected data on memory capacity only for adults aged 55 and older in 1997, 2000, 2004, 2006 survey, because there was a systematic increase in the prevalence of memory decline for middle-aged and older people, whom should be payed

special attention to (Bassett and Folstein, 1993; Ponds et al., 1997). Also, with reducing metabolism and physical activity, middle-aged and older adults have higher risk of overweight and obesity compared with younger adults (Small et al., 2013; Chen et al., 2005), which makes it more meaningful to analyze the effect of memory on overweight and obesity among this group. In addition, memory tests were adjusted between each survey to better measure memory capacity, thus, the latest survey of 2006 was ultimately used for analysis.

### 3.2 Empirical Model

Individuals implicitly make "overweight/obesity decisions" in two steps. The first decision is whether or not to be overweight/obesity, referred to as the overweight participation decision. The second decision is the degree of overweight/obesity if one has already been overweight under the condition of utility maximization, referred to as the optimal weight decision. The two-step feature of overweight decision would impair the unbiased and consistency properties of ordinary least squares estimates (Amemiya, 1984). This article adopts a double-hurdle model to address the above problem. The double-hurdle model, with a Probit model to estimate participation equation and a truncated normal regression model to estimate amount equation, is specifically designed for two-step cases. As one of many extensions of the Tobit model, the double-hurdle model is more flexible than the Tobit model, because it allows for the two decisions to be determined by different sets of variables or be determined by the same sets of variables in different ways. Therefore, it has been widely applied in micro-econometrics to analyze a wide range of individual and household two-step behavior (Ye, 1993; Rickergilbert et al., 2011).

The double-hurdle model can be expressed as:

*Hurdle 1: Overweight Participation decision*

$$z_i^* = w_i\alpha + u_i \quad u_i \sim N(0,\ 1)$$

$$z_i = \begin{cases} 1 & if\ z_i^* > 0 \\ 0 & if\ z_i^* \le 0 \end{cases}$$

*Hurdle 2: Optimal weight decision*

$$y_i^* = x_i\beta + v_i \quad v_i \sim N(0,\ \sigma_i^2)$$

$$y_i = \begin{cases} x_i\beta + v_i & if\ z_i = 1\ and\ y_i^* > 0 \\ 0 & otherwise \end{cases}$$

Where $z_i$ is the observed variable describing the probability of overweight and $z_i^*$ is the corresponding latent variable in participation hurdle; if individuals are overweight, $z_i = 1$, otherwise, $z_i = 0$. $y_i$ is the observed dependent variable representing the degree of overweight for overweight individuals and $y_i^*$ is the corresponding latent variable. $z_i^*$ and $y_i^*$ can be modeled as linear functions of two sets of explanatory variables $w_i$ and $x_i$, respectively. $\alpha$ and $\beta$ are parameter vectors to be estimated. $u_i$ and $v_i$ are error terms that are assumed to be distributed as $(u_i\ v_i) \sim N(0,\ \sum)$, where $\sum = \begin{bmatrix} 1 & \rho\sigma_i \\ \rho\sigma_i & \sigma_i^2 \end{bmatrix}$. To observe positive degree of overweight $y_i$, both the participation hurdle and the amount hurdle must be pass.

Then the double-hurdle model is estimated by maximizing the following likelihood equation:

$$\mathrm{L} = \prod_{y_i=0}\left[1 - \Psi\left(w_i\alpha, \frac{x_i\beta}{\sigma_i}, \rho\right)\right]\prod_{y_i>0}\Phi\left[\frac{w_i\alpha + \rho/\sigma_i(y_i - x_i\beta)}{(1-\rho^2)^{1/2}}\right]\frac{1}{\sigma_i}\phi\left(\frac{y_i - x_i\beta}{\sigma_i}\right)$$

where $\Psi(\cdot)$ denotes the standard bivariate normal cumulative distribution function with

correlation $\rho$, $\Phi(\cdot)$ and $\phi(\cdot)$ are the univariate standard normal distribution and density functions, respectively. Parameters $\alpha$,$\beta$,$\sigma$ and $\rho$ can be estimated by maximizing the above likelihood function.

### 3.3 Definition of variables

#### 3.2.1 Definition of overweight

Body mass index (BMI), defined as weight (kg) divided by the square of height ($m^2$) is widely employed for classifying overweight in general. BMI at 24 with best sensitivity and specificity for identification of the risk factors, was recommended as the cut-off point for overweight in China (Cooperative Meta-Analysis Group of the Working Group on Obesity in China, 2002). Thus, the individuals with BMI<24 are considered to be not overweight in the participation equation, and (BMI-24) measure the degree of overweight in the optimal weight equation.

Also, waist circumference (WC), an important indicator for central obesity, is used for robustness test. 85cm for men and 80cm for women were recommended as the cut-off points for central obesity in China (Cooperative Meta-Analysis Group of the Working Group on Obesity in China, 2002), hence the observed data of men with WC≤85 and women with WC≤80 are considered at the corner in our model. Data of weight, height and WC were collected in CHNS by anthropometric measurements, which was conducted by trained local staff according to protocols of the WHO.

#### 3.2.2 Assessment of memory capacity

The key explanatory variable in both participation and amount equation is memory capacity. The psychology literature distinguishes three types of memory, namely, sensory, short-term, and long-term (Kassin, 2006). Short-term memory is the critical chain linking sensory memory and long-term memory and the bulk of the psychology literature focuses on it (Bao et al., 2018). Thus, experiment of short-term memory was conducted to capture individuals' memory capacity in this article.

Short-term memory tests are carried out in the China Health and Nutrition Survey as follows. Respondents are told in advance that they should repeat the words read by investigators as many as possible. The investigator firstly reads 10 words, including house, wood, cat, table, night, needle, steamed bread, door, bridge, bed, approximately two seconds per word in a plain tone. The respondent is asked to repeat the words after thinking within two minutes. The number of correct answers is recorded by investigator. Then, after one backward counting exercise (from 20 to 1) and five subtraction exercises, the respondent is asked to repeat the above words again within two-minute thinking, but the investigator is not allowed to read the words again. The number of correct answers is also recorded. The average correct number of two memory tests is defined as memory capacity, the value of which ranges from 0 to 10.

#### 3.2.3 Control variables

The variable $w_i$ in the overweight participation equation and $X_i$ in the optimal weight equation also include demographic, socio-economic and lifestyle variables that are supposed to influence body fatness according to previous studies (Lakdawalla & Philipson, 2009; Chou et al., 2004; Zeng & Zeng, 2018; Roemling and Qaim, 2012). Age, gender, education level and marital status are chosen as demographic characteristics for controlling differences among individuals.

Socio-economic variables include per capital annual household income. Lifestyle variables include activity level, current smoking and drinking alcohol. In addition, urban-rural district and region variables are also controlled for the effect of geographical differences. The statistic descriptions of these variables are given in Table 1.

Table 1 Summary statistics of variables used in the analysis

| Variable | Description | Mean | SD |
|---|---|---|---|
| BMI | body mass index ($kg/m^2$) | 23.244 | 3.557 |
| Share of overweight | individuals with BMI>24 | 0.396 | 0.489 |
| Memory capacity | getting better from 0 to 10 | 4.394 | 2.205 |
| Age | in years | 65.751 | 7.971 |
| Gender | male=0, female=1 | 0.533 | 0.499 |
| Education level | years of formal education | 5.168 | 4.623 |
| Marital status | married=1, otherwise=0 | 0. 793 | 0.405 |
| Activity level | moderate or above=1, otherwise=0 | 0 .359 | 0.480 |
| Current Smoking | Yes=1, No=0 | 0.253 | 0.435 |
| Drinking alcohol | Yes=1, No=0 | 0.260 | 0 .439 |
| Income | Yuan/year, in logarithmic scale | 8.557 | 1.121 |
| Urban-rural district | urban=0, Rural=1 | 0 .622 | 0 .485 |
| East region | East region=1, middle and west region=0 | 0.365 | 0.482 |

## 4 Results

Table 1 illustrates that the proportion of overweight in middle-aged and older adults is 39.59% in 2006. The average score of memory capacity is 4.394 (out of 10), which confirms a relative low level of memory capacity in middle-aged and older people (Bassett & Folstein, 1993; Ponds et al., 1997). Specifically, the score of memory capacity in overweight individuals (4.621) is significantly higher than that in non-overweight individuals (4.246) ($P<0.01$), however, the score in obese individuals (4.353) is significantly lower than that in overweight individuals ($P<0.05$). It indicates BMI change may be non-monotonic in memory capacity.

Before the empirical estimation, as corner solution models, both Tobit model and double-hurdle model can be used to model individuals' overweight decision. The selection between two models can be determined by conducting a likelihood ratio test that compares the likelihood ratio statistic between Tobit and the double-hurdle model (Greene, 2010). The test suggests the difference (21.985) exceed the critical value of Chi-square distribution (19.675) at significance of 5%, thus the double hurdle model is preferable.

Table 2 presents the estimation results of double-hurdle model. The coefficient of memory capacity is 0.152 in the participation equation, which is statistically significant at the 5% level. This implies that higher memory capacity could increase the probability of overweight. Interestingly, when it comes to the optimal weight equation, the coefficient of memory capacity is -0.118, which is negative at the 10% significance level. It indicates better memory capacity decrease the degree of overweight once individuals have already been overweight. The empirical results are fully consistent with our hypothesis. An individual with higher memory capacity is more likely to be overweight, for better memory could lead to more food consumption due to higher memory utility from eating. However, considering the memory disutility from overweight,

better memory capacity helps to reduce weight for the overweight individual.

Table 2 Estimation results of double-hurdle model for memory influencing overweight

| Variable | Hurdle 1 Probability of overweight | | Hurdle 2 Degree of overweight | |
|---|---|---|---|---|
| | Coefficient | SE | Coefficient | SE |
| Memory capacity | 0.152** | 0.062 | -0.118* | 0.069 |
| Age | -0.051*** | 0.018 | -0.001 | 0.024 |
| Gender | 0.275 | 0.266 | 0.679** | 0.298 |
| Education level | 0.050 | 0.039 | 0.011 | 0.033 |
| Marital status | 0.217 | 0.257 | 0.183 | 0.390 |
| Activity level | -0.584** | 0.229 | -0.725** | 0.320 |
| Current Smoking | -0.014 | 0.273 | -0.882*** | 0.307 |
| Drinking alcohol | -0.106 | 0.236 | 0.453 | 0.294 |
| Income | 0.079 | 0.090 | 0.074 | 0.124 |
| Urban-rural district | -0.508** | 0.254 | -0.119 | 0.257 |
| East region | 0.910*** | 0.331 | 0.607** | 0.280 |
| _Cons | 26.956*** | 1.504 | 23.404*** | 1.842 |
| Sigma | 3.634 | 0.107 | | |
| Rho(ρ) | -0.089 | 0.181 | | |
| Log-likelihood | -4080.025 | | | |
| Number of Obs | 2882 | | | |

Note: "***", "**" and "*" denote significance at the 1%, 5% and 10% level, respectively. SE represents standard error.

In addition, a number of other variables also appear to affect individuals' probability and degree of overweight. For instance, the coefficient for age is negative and significantly different from zero in the regression for the probability of overweight but is not significant in the regression for the degree of overweight. Men and smoker have lower level of overweight than women and nonsmoker if they get overweight. Meanwhile, higher activity level helps reduce both the probability and degree of overweight. Geographical characteristics also play a role. Urban residents are more likely to get overweight than rural residents, but this may not cause a significant difference after they have already been overweight. Individuals in east region of China have a higher probability and level of overweight than middle and west regions. These results are mostly consistent with previous studies (Case & Menendez, 2009; Lakdawalla & Philipson, 2009; Roemling & Qaim, 2012).

To check the robustness of our results, we use the probability and the degree of central obesity, measured by waist circumference, as the dependent variable in double-hurdle model. Previous studies have already proved there is an upward trend in the prevalence of central obesity in China, which is thought to be more pathogenic than overall obesity (Du et al., 2013). Table 3 presents the estimation results. Memory capacity has a positive effect on the probability of central obesity, while the effect of memory capacity on the degree of central obesity is negative once individuals have already been central obese. These results are consistent with the results in table 2, showing good robustness of our research.

Table 3 Estimation results of double-hurdle model for memory influencing central obesity

| Variable | Hurdle 1 Probability of central obesity | | Hurdle 2 Degree of central obesity | |
|---|---|---|---|---|
| | Coefficient | SE | Coefficient | SE |
| Memory capacity | 0.077** | 0.037 | -0.456** | 0.197 |
| Age | -0.032*** | 0.011 | 0.178*** | 0.064 |
| Gender | 0.646*** | 0.199 | 1.727 | 1.062 |
| Education level | 0.050** | 0.023 | -0.050 | 0.105 |
| Marital status | 0.397** | 0.200 | -1.010 | 1.254 |
| Activity level | -0.208 | 0.194 | -2.071* | 1.088 |
| Current Smoking | -0.308 | 0.203 | -0.384 | 1.308 |
| Drinking alcohol | -0.309* | 0.178 | 1.827* | 1.098 |
| Income | 0.053 | 0.064 | 0.242 | 0.385 |
| Urban-rural district | -0.416** | 0.181 | 1.309 | 0.929 |
| East region | 0.322** | 0.161 | 2.005** | 0.843 |
| _Cons | 1.951* | 1. 056 | -8.570 | 5.889 |
| Sigma | 10.678 | 0.358 | | |
| Rho(ρ) | -0.526*** | 0.109 | | |
| Log-likelihood | -6351.525 | | | |
| Number of Obs | 2866 | | | |

Note: "***", "**" and "*" denote significance at the 1%, 5% and 10% level, respectively. SE represents standard error.

## 5 Discussion and Conclusions

Based on the theory of memory utility, which posits that the utility derived from current consumption could be remembered and then added to future utility (Smith, 2009; Gilboa et al., 2016; Bao et al., 2018), we explore the effect of memory capacity on weight fatness by building a theoretical model and then conducting the empirical research by a double-hurdle model. It is found that an individual with higher memory capacity is more likely to be obese, for better memory could lead to more food consumption at the current stage due to higher memory utility from eating in the future. On the contrary, an overweight individual with higher memory capacity tends to lose weight by reducing food consumption to achieve optimal weight when he/she take into account the memory disutility from overweight and obesity. Our study proposes a new perspective to understand the heterogeneities in overweight and obesity outcome in economic literature. Improving memory capacity helps to improve self-regulation in food consumption and increased weight loss for overweight individuals, hence, carrying out memory-training programs would be a promising strategy to support weight loss.

The current economics literature has paid much attention to the observed demographic variables (such as age, education, etc.) or socio-economics factors (such as rising income, lower food price, the popularity of fast food, etc) to analyze overweight and obesity epidemic, while heterogeneities in internal and unobserved factors such as memory capacity are neglected. Neglecting the heterogeneities in memory capacity may render it difficult to understand the difference in individuals' behavior, for memory capacity could influence human current decision-making and

related behavior with involvement of memory utility and disutility. For example, in this paper, rational consumers with heterogeneous memory capacity would make different decisions in current food consumption to maximize their total utility, which makes memory affect weight gain oppositely. Therefore, heterogeneity in memory should be paid more attention particularly in estimations of discounting behavior in economics literature.

Also, our conclusion that better memory helps the overweight individuals to lose weight is consistent with the results from medical experiments. They reveal that higher memory capacity is associated with reduced food intake and increased weight loss for overweight individuals (Hege et al., 2013; Dassen et al., 2018), while reduced working memory capacity is associated with overweight and obesity (Gunstad et al., 2007), and with increased food intake (Hofmann et al., 2008). The present paper reanalyzes the association between memory capacity and weight gain in economic perspective, which induces memory utility and memory disutility into utility function. Except for the above effect, our research also reveals that better memory may also increase the probability of overweight when memory utility form palatable food consumption dominants, which is also worthy of attention.

The present study has some limitations, for example, due to availability of the data, our sample is limited to adults aged 55 or above and assessment of memory capacity is relatively simple; these limitations could be improved in future research with better research design. Also, this is the first study in health economics to involve memory capacity, which could be extended to more fields in future research.

## Acknowledgements

This work was supported by the National Natural Science Foundation of China (71633005). This research used data from the China Health and Nutrition Survey (CHNS). The authors thank the National Institute of Nutrition and Food Safety, the China Center for Disease Control and Prevention, the Carolina Population Center and the University of North Carolina at Chapel Hill.

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