# A Dynamic Model of Failure to Maximize Utility in the Chronic Consumer Choice to Consume Foods High in Added Sugars

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## Motivation

- Sweetened carbonated soft-drinks (sCSDs, "soda") are the #1 source of added sugars in U.S. diet, while Sugar-sweetened Beverages (SSBs) comprise 46% of added sugars in U.S. diet.
- Added sugars/SSBs/sCSDs are associated with weight gain, diabetes, CVD, metabolic syndrome, hypertension, cancers, and ageing.
- sCSDs: ubiquitous, culturally accepted (iconographic), decades of sophisticated marketing
- Caloric intake of sCSDs triple in U.S. in < 25 years, as adult obesity doubles & child/teen obesity triples.

Commonly proposed excise tax and consumer-information policy strategies seem inadequate:

*"…substantial price changes are needed to improve these outcomes significantly."*

(Powell and Chaloupka: 2009; similarly: Sturm, et al.: 2010; Just & Payne: 2009; Maio, et al.: 2007)

*"…seeming paradox – increased information, observable information effects, yet disappointing public health outcomes?"*

*"…consumer difficulty in assimilating and using information in…more complex ways[?]"*

(Guthrie and Smallwood: 2003; similarly, Mancino & Kinsey: 2008)

- Did 200M Americans *decide* to become overweight, obese, and risk serious health problems? If so, why spend $40 - $100B/yr in the weight loss industry?
- Are U.S. consumers routinely rational and utility maximizing (**RUM**) in their eating habits? If not, why would they react to policy change in an RUM way? If not, can we anticipate and model this break from neoclassical assumptions?

## A Theoretic Model of Time-Inconsistent Food Choice

**(Utility | eat q)$_{max}$ = u[enjoy q now] + u[later health effects of q | health state and health drivers]**

**(Utility | q)$_{max\ (t\to\infty)}$ = $u_t[q\ ] + u_{t++}[h(H_s(q,x))]$**

**(Utility | q)$_{max}$ = $u[q\ ] + u[h(H_s(q,x))]$**

= "now" term + "later" term

**Exp[Utility | q]$_{max}$ = $u[q] + Exp\{u[h(H_s(q,x))]\}$**

$\stackrel{?}{=}$ "now" term + "later" term

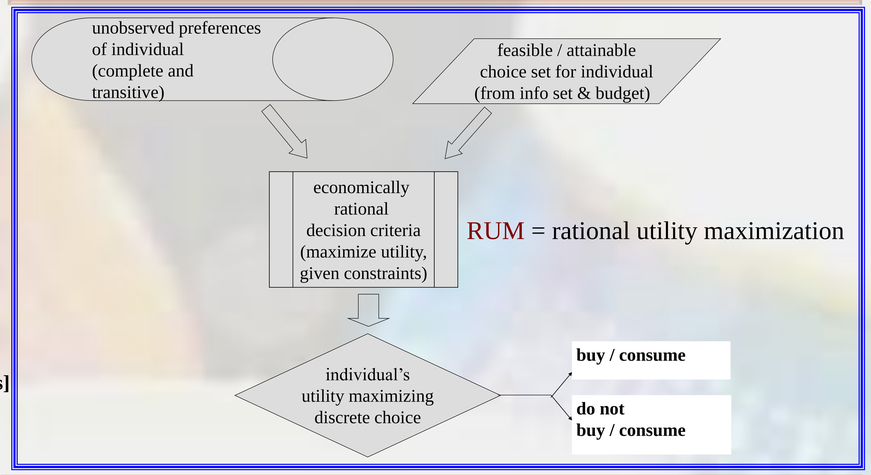
**Exp[Utility | q]$_{max}$ $\stackrel{?}{=}$ $u[q] + k \cdot u[h(H_s(q,x))]$**

**q = food item**
**t = time subscript (dropped; 't++' is all future)**
**h = true biological health effect from eating q**
**$H_s$ = health stock or state**
**x = all other factors affecting $H_s$**
***k* = multiplier, simplifying expectation of nutritional effect of eating q**

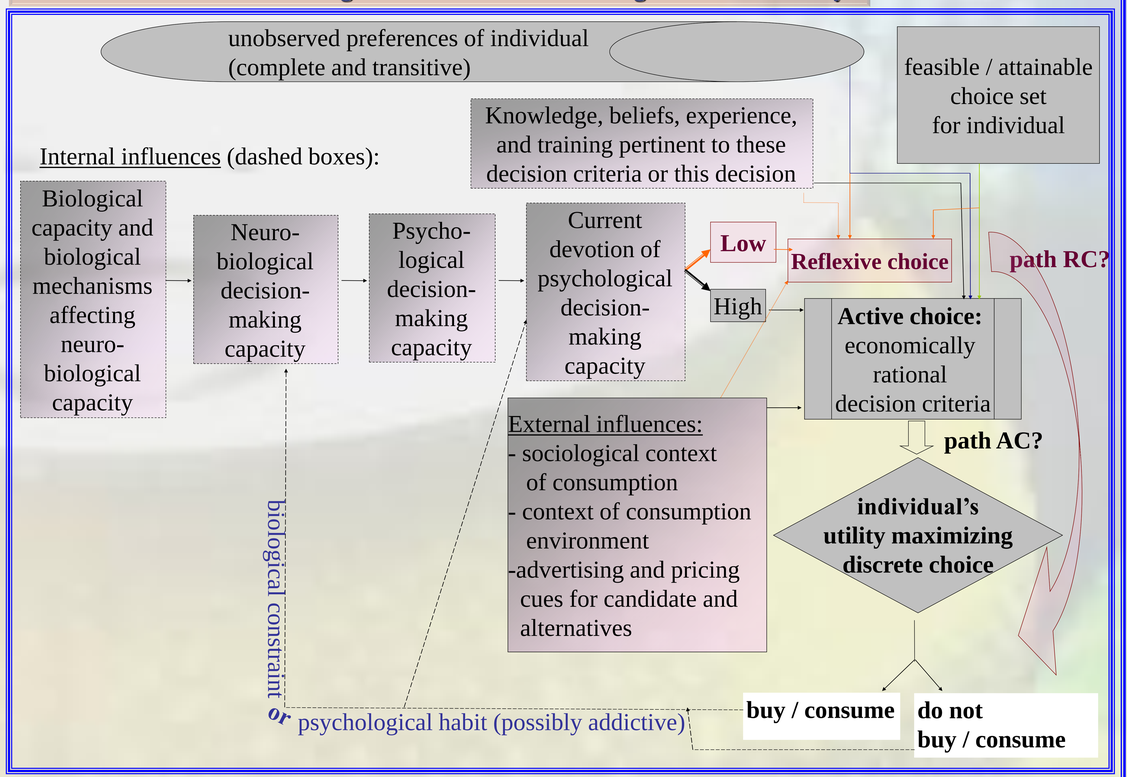
***Q.E.D.*: The final (green) equation demonstrates how an individual's ill-informed assessment of *k* in deciding whether to eat q can lead to an *inequality* between Exp[Utility | q]$_{max}$ and (Utility | q)$_{max}$. The value of *k* effects the expected utility of consuming q, but not the *realized utility* assumed in the first symbolic equation. Behavior divergent from utility maximization *must* follow if the right hand side in the green equation is less than the right hand side in the first symbolic equation. The "correctness" of the last term in green is a function of nutrition awareness and its application in decision making in accordance with biological facts specific to the individual decision maker, because for a daily food, the consumption utility, u[q], is well-known.**

## Research Objective: Model potential failures in rational utility-maximizing behavior for habitual consumption of high-added-sugar foods, informed by related economic and non-economic literatures.

## Basic Economic Flow-Chart Model of Decision to Purchase/Consume:




## A Flow-Chart Model Allowing RUM or non-RUM Eating Decision Pathways




## Quasi-exogenous Literature

| | |
|---|---|
| behavioral economics | **Kahneman** & Tversky; O'Donoghue & Rabin; D. Ariely; G. Gigerenzer; B. Wansink; D. Just |
| decision theory | **Kahneman** & Tversky; D. Ellsberg; G. Loewenstein |
| psychology | **H. Simon**; **Kahneman** & Tversky; R. Baumeister |
| consumer psychology | G. Loewenstein |
| social psychology | B. Verplanken; S. Faes |
| medicine/nutrition | V. Malik; G. Bray; F. Hu; B. Popkin; R. Johnson; Vartanian, Schwartz, & Brownell; Lustig, Schmidt & Brindis; Avena, Rada & Hoebel |

## Quasi-exogenous Literature Offers:

theories, mechanisms, clinical evidence for how and why consumer (eating) behavior breaks "rules of rationality":

- quick (useful/naïve) decision-making rules (***heuristics***)
- heuristics help develop habits
- emotion and visceral states
- influence from decision/consumption environment

## References


Abdullah, A., Wolfe, R., Stoelwinder, J. U., de Courten, M., Stevenson, C., Walls, H. L., et al. (2011). The number of years lived with obesity and the risk of all-cause and cause-specific mortality. *International Journal of Epidemiology*, *40*(4), 985-996.

Anand, P., Kunnumakara, A., Sundaram, C., Harikumar, K., Tharakan, S., Lai, O., et al. (2008). Cancer is a preventable disease that requires major lifestyle changes. *Pharmaceutical Research*, *25*(9), 2097-2116.

Avena, N. M., Rada, P., & Hoebel, B. G. (2008). Evidence for sugar addiction: Behavioral and neurochemical effects of intermittent, excessive sugar intake. *Neuroscience & Biobehavioral Reviews*, *32*(1), 20-39.

Baumeister, R. F. (2002). Ego depletion and self-control failure: An energy model of the self's executive function. *Self & Identity*, *1*(2), 129-136.

Baumeister, R. F. (2002). Yielding to temptation: Self-control failure, impulsive purchasing, and consumer behavior. *Journal of Consumer Research*, *28*(4), 670-676.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology*, *74*(5), 1252-1265.

Baumeister, R. F., Sparks, E. A., Stillman, T. F., & Vohs, K. D. (2008). Free will in consumer behavior: Self-control, ego depletion, and choice. *Journal of Consumer Psychology (Elsevier Science)*, *18*(1), 4-13.

Bayers, J. W. (2002). The Maillard hypothesis on aging: Time to focus on DNA. *Annals of the New York Academy of Sciences, 959* (Decreasing Healthy Life Span: Conventional Measures and Slowing the Innate Aging Process), 360-367.

Becker, G. S., Grossman, M., & Murphy, K. M. (1991). Rational addiction and the effect of price on consumption. *American Economic Review*, *81*(2), 237-241.

Bernheim, B. D., & Rangel, A. (2005). From neuroscience to public policy: A new economic view of addiction. *Swedish Economic Policy Review*, *12*, 99-144.

Bernheim, B. D., & Rangel, A. (2004). Addiction and cue-triggered decision processes. *The American Economic Review*, *94*(5), 1558-1590.

Blaylock, J. Smallwood, D., Kassel, K., Variyam, J., & Aldrich, L. (1999). Economics, food choices, and nutrition. *Food Policy*, *24*(2-3), 269-286.

Busby, J. C., Wells, H. F. & Vocke, G. *Possible implications for U.S. agriculture from adoption of select dietary guidelines*. Retrieved 8/11/2009, from http://www.ers.usda.gov/publications/err31/err31.pdf.

Camerer, C. F. (2007). Neuroeconomics: Using neuroscience to make economic predictions. *Economic Journal, 117*(519), C26-C42.

Cawley, J. (2004). An economic framework for understanding physical activity and eating behaviors. *American Journal of Preventive Medicine, 27*(3, Supplement), 117-125.

Chen, L., Appel, L. J., Loria, C., Lin, P., Champagne, C. M., Elmer, P. J., et al. (2009). Reduction in consumption of sugar-sweetened beverages is associated with weight loss: The PREMIER trial. *American Journal of Clinical Nutrition*, *89*(5), 1299-1306.

Cohen, D., & Farley, T. (2008). *Eating as an automatic behavior*. Santa Monica, CA: RAND Corporation.

Constantinides, G. M. (1990). Habit formation: A resolution of the equity premium puzzle. *The Journal of Political Economy*, *98*(3), pp. 519-543.

Cutler, D. M., Glaeser, E. L., & Shapiro, J. M. (2003). Why have Americans become more obese? *Journal of Economic Perspectives*, 93-118.

Davide, D. (2009). A rational eating model of binges, diets and obesity. *Journal of Health Economics*, *28*(4), 799-804.

DiMegilio, D. P., & Matter, R. D. (2000). Liquid versus solid carbohydrate: Effects on food intake and body weight. *International Journal of Obesity & Related Metabolic Disorders*, *24*(6), 794.

Elliott, S. S., Keim, N. L., Stern, J. S., Teff, K., & Havel, P. J. (2002). Fructose, weight gain, and the insulin resistance syndrome. *American Journal of Clinical Nutrition, 76*(5), 911-922.

Fernández-Huerga, E. (2008). The economic behavior of human beings: The Institutional/Post-Keynesian model. *Journal of Economic Issues (Association for Evolutionary Economics)*, *42*(3), 709-726.

Finke, Michael S., & Huston, Sandra J. (2003). Factors Affecting the Probability of Choosing a Risky Diet. *Journal of Family and Economic Issues*, *24*(3), 291-303.

Fulponi, L. (2009). *Policy initiatives concerning diet, health and nutrition*. Food Agriculture and Fisheries Working Papers, Report No. 14. OECD Publishing.

Gailliot, M. T., & Baumeister, R. F. (2007). The physiology of willpower: Linking blood glucose to self-control. *Personality & Social Psychology Review (Sage Publications Inc.), 11*(4), 303-327.

Gailliot, M. T., Baumeister, R. F., DeWall, C. N., Maner, J. K., Plant, E. A., Tice, D. M., et al. (2007). Self-control relies on glucose as a limited energy source: Willpower is more than a metaphor. *Journal of Personality and Social Psychology*, *92*(2), 325-336.

Galderisi, P., & Sabbis, N. (Eds.). (1998). *Decision, probability, and utility: Selected readings*. New York: Cambridge University Press.

Garg, N., Wansink, B., & Inman, J. J. (2007). The influence of incidental affect on consumers' food intake. *Journal of Marketing, 71*(1), 194-206.

Gigerenzer, G. (2001). Decision making: Nonrational theories. *International Encyclopedia of the Social and Behavioral Sciences*, 3304-3309, Elsevier Science.

Guthrie, J. F., & Variyam, J. N. (2007). *Nutrition information can it improve the diets of low-income households?* Economic Information Bulletin Number 29-6. USDA ERS.

Guthrie, J. F., & Smallwood, D. M. (2003). Evaluating the effects of the dietary guidelines for Americans on consumer behavior and health: Methodological challenges. *Journal of the American Dietetic Association*, *103*(12, Supplement), 42-49.

Huston, S. J., & Finke, M. S. (2003). Diet choice and the role of time preference. *Journal of Consumer Affairs*, *37*(1), 143.

Joh, V., Dwerk, C. S., & Walton, G. M. (2010). Ego Depletion – Is it all in your head? *Psychological Science*, *21*(11), 1686-1693.

Johnson, R. K., Appel, L. J., Brands, M., Howard, B. V., Lefevre, M., Lustig, R. H., et al. (2009). Dietary sugars intake and cardiovascular health: A scientific statement from the American Heart Association. *Circulation*, *120*(11), 1011-1020.

Johnson, R. K., & Yon, B. A. (2010). Weighing in on added sugars and health. *Journal of the American Dietetic Association, 110*(9), 1296-1299.

Jonas, E., Schulz-Hardt, S., Frey, D., & Thelen, N. (2001). Confirmation bias in sequential information search after preliminary decisions: An expansion of dissonance theoretical research on selective exposure to information. *Journal of Personality and Social Psychology*, *80*(4), 557-571.

Just, D. R., Mancino, L., & Wansink, B. (2007). Could behavioral economics help improve diet quality for nutrition assistance program participants? Economic Research Report No. ERR-43, USDA, ERS.

Just, D. R., & Payne, C. R. (2009). Obesity: Can behavioral economics help? *Annals of Behavioral Medicine*, *38*, 47-55.

Kahneman, D. (1991). Judgment and Decision Making: A personal view. *Psychological Science (Wiley-Blackwell)*, *2*(3), 142-145.

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *The American Economic Review*, *93*(5), 1449-1475.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263-291.

Kapteyn, A., & Wansbeek, T. (1982). Empirical evidence on preference formation. *Journal of Economic Psychology*, *2*(2), 137-154.

Kuhner, T. A., Shilovsky, O., & Werman, M. J. (2007). Long-term fructose intake reduces oxidative defense and alters mitochondrial performance in mice. *Nutrition Research*, *27*(7), 423-431.

Levine, A. S., Kotz, C. M., & Gosnell, B. A. (2003). Sugars and fats: The neurobiology of preference. *Journal of Nutrition*, *133*(3), 831S-834S.

Liu, B., Smith, T. A., Lee, J., & Hall, K. D. (2011). Measuring weight outcomes for obesity intervention strategies: The case of a sugar-sweetened beverage tax. *Economics & Human Biology*, *9*(4), 329-341.

Lindqvist, A., Baelemans, A., & Erlanson-Albertsson, C. (2008). Effects of sucrose, glucose and fructose on peripheral and central appetite signals. *Regulatory Peptides*, *150*(1-3), 26-32.

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes, 65*(3), 272-292.

Loewenstein, G. (2000). Emotions in economic theory and economic behavior. *The American Economic Review*, *90*(2), 426-432.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin, 127*(2), 267-286.

Lustig, R. H., Schmidt, L. A., & Brindis, C. D. (2012). Public health: The toxic truth about sugar. *Nature*, *482*(7383), 27-29.

Luiter, M., & Nestler, E. J. (2009). Homeostatic and hedonic signals interact in the regulation of food intake. *Journal of Nutrition, 139*(3), 629-632.

Maio, G. R., Verplanken, B., Manstead, A. S. R., Stroebe, W., Abraham, C., Sheeran, P., et al. (2007). Social psychological factors in lifestyle change and their relevance to policy. *Social Issues and Policy Review*, *1*(1), 99-137.

Malik, V. S., Popkin, B. M., Bray, G. A., Despres, J., & Hu, F. B. (2010). Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation (Journal of the American Heart Association)*, *121*(11), 1356-1364.

Malik, V. S., Schulze, M. B., & Hu, F. B. (2006). Intake of sugar-sweetened beverages and weight gain: A systematic review. *American Journal of Clinical Nutrition*, *84*(2), 274-288.

Mancino, L., & Kinsey, J. (2008). *Is dietary knowledge enough? Hunger, stress, and other roadblocks to healthy eating*. Report No. 62, USDA, ERS.

Marriott, B. P., Olsho, L., Hadden, L., & Connor, P. (2010). Intake of added sugars and selected nutrients in the United States, National Health and Nutrition Examination Survey (NHANES) 2003-2006. *Critical Reviews in Food Science & Nutrition*, *50*(3), 228-258.

McCrory, M. A., Suen, V. M. M., & Roberts, S. B. (2002). Biobehavioral influences on energy intake and adult weight gain. *Journal of Nutrition, 132*(12), 3830S-3834S.

Nielsen, S. J., & Popkin, B. M. (2003). Patterns and trends in food portion sizes, 1977-1998. *JAMA: The Journal of the American Medical Association*, *289*(4), 450-453.

Nielson, S. J., & Popkin, B. M. (2004). Changes in beverage intake between 1977 and 2001. *American Journal of Preventive Medicine*, *27*(3), 205-210.

O'Donoghue, T., & Rabin, M. (1999). Doing it now or later. *The American Economic Review*, *89*(1), 103-124.

O'Donoghue, T., & Rabin, M. (2000). The economics of immediate gratification. *Journal of Behavioral Decision Making*, *13*(2), 233.

Ogden, C. L., Kit, B., Carroll, M., & Park, S. (2011). *Consumption of sugar drinks in the United States, 2005-2008*. NCHS Data Brief No. 71, USHHS, CDC, National Center for Health Statistics.

Peters, E. (2009). A perspective on eating behaviors from the field of judgment and decision making. *Annals of Behavioral Medicine, 38*, 81-87.

Popkin, B. M. (2010). Patterns of beverage use across the lifecycle. *Physiology & Behavior, 100*(1), 4-9.

Popkin, B. M., Zizza, C., & Siega-Riz, A. M. (2001). Who is leading the change? U.S. dietary quality comparison between 1965 and 1996. *American Journal of Preventive Medicine*, *25*(1), 1-8.

Powell, L. M., & Chaloupka, F. J. (2009). Food prices and obesity: Evidence and policy implications for taxes and subsidies. *Milbank Quarterly*, *87*(1), 229-257.

Read, D., & van Leeuwen, B. (1998). Predicting hunger: The effects of appetite and delay on choice. *Organizational Behavior and Human Decision Processes, 76*(2), 189-205.

Reiser, S. (1985). Effect of dietary sugars on metabolic risk factors associated with heart disease. *Nutr Health*, *3*(4), 203-216.

Saini, F., & Hunt, J. (2008). The prevention of lifestyle - Related chronic diseases: An economic framework. *OECD Health Working Paper*, *32*.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics*, *49*, 99-118.

Simon, H. A. (1959). Theories of decision-making in economics and behavioral science. *The American Economic Review*, *49*(3), 253-283.

Simon, H. A. (1978). Rationality as process and as product of thought. *The American Economic Review*, *68*(2), 1-16.

Smith, T. A., Lin, B., & Lee, J. (2010). *Taxing caloric sweetened beverages: Potential effects on beverage consumption, calorie intake, and obesity*. Report No. ERR-100, USDA, ERS.

Smith, T. G., & Tassioli, A. (2007). A theory of natural addiction. *Games and Economic Behavior*, *59*(2), 316-344.

Soderberg Miller, L. M., Gibson, T. N., Applegate, E. A., & de Dios, J. (2011). Mechanisms underlying comprehension of health information in adulthood: The roles of prior knowledge and working memory capacity. *Journal of Health Psychology*, *16*(5), 794-806.

Stanhope, K. L., Bremer, A. A., Medici, V., Nakajima, K., Ito, Y., Nakano, T., et al. (2011). Consumption of fructose and high fructose corn syrup increase postprandial triglycerides, LDL-cholesterol, and apolipoprotein-B in young men and women. *Journal of Clinical Endocrinology & Metabolism*, *96*(10), E1596-E1605.

Sturm, R., Powell, L. M., Chriqui, J. F., & Chaloupka, F. J. (2010). Soda taxes, soft drink consumption, and children's body mass index. *Health Affairs*, *29*(5), 1052-1058.

Tordoff, M., & Alleva, A. (1990). Effect of drinking soda sweetened with aspartame or high-fructose corn syrup on food intake and body weight. *The American Journal of Clinical Nutrition*, *51*(6), 963-969.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124-1131.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, *211*(4481), 453-458.

Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *The Journal of Business*, *59*(4, Part 2: The Behavioral Foundations of Economic Theory), S251-S278.

U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans*, *2010*. 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010.

Variyam, J. N. Overweight children: Is parental nutrition knowledge a factor? *Food Review*, *24*(2), 18-22.

Variyam, J. N., & Golan, E. New health information is reshaping food choices. *Food Review*, *25*(1).

Variyam, J. N., Shim, Y., & Blaylock, J. (2001). Consumer misperceptions of diet quality. *Journal of Nutrition Education*, *33*(6), 314-321.

Vartanian, L. R., Schwartz, M. B., & Brownell, K. D. (2007). Effects of soft drink consumption on nutrition and health: A systematic review and meta-analysis. *Am J Public Health*, *97*(4), 667-675.

Verplanken, B. (2006). Beyond frequency: Habit as mental construct. *British Journal of Social Psychology*, *45*(3), 639-656.

Verplanken, B., Aarts, H., & Van Knippenberg, A. (1997). Habit, information acquisition, and the process of making travel mode choices. *European Journal of Social Psychology*, *27*(5), 539-560.

Verplanken, B., & Faes, S. (1999). Good intentions, bad habits, and effects of forming implementation intentions on healthy eating. *European Journal of Social Psychology*, *29*(5-6), 591-604.

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy & Marketing*, *25*(1), 90-103.

Vohs, K. D., & Baumeister, R. F. (2009). Addiction and free will. *Addiction Research & Theory*, *17*(3), 231-235.

Wang, G., Volkow, N. D., Poppas, N. R., Nemeni, N., Wong, C. T., Logan, J., et al. (2001). Brain dopamine and obesity. *Lancet*, *357*(9253), 354.

Wang, G., Volkow, N. D., Telang, F., Jayne, M., Ma, J., Rao, M., et al. (2004). Exposure to appetitive food stimuli markedly activates the human brain. *NeuroImage*, *21*(4), 1790-1797.

Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L., & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *The Lancet*, *378*(9793), 815-825.

Wansink, B. (2006). *Mindless Eating: Why We Eat More Than We Think*. New York, NY: Bantam Books.

Wansink, B., & Chandon, P. (2006). Can "low-fat" nutrition labels lead to obesity? *Journal of Marketing Research*, *43*(4), 605-617.

Wansink, B., Just, D. R., & Payne, C. R. (2009). Mindless eating and healthy heuristics for the irrational. *American Economic Review: Papers & Proceedings 2009*, *99*(2), 165-169.

Wansink, B., & Sobal, J. (2007). Mindless eating: The 200 daily food decisions we overlook. *Environment and Behavior*, *39*(1), 106-123.

Wansink, B. (1996). Can package size accelerate usage volume? *Journal of Marketing*, *60*(3), 1.

Wolf, A., Bray, G. A., & Popkin, B. M. (2008). A short history of beverages and how our body treats them. *Obesity Reviews*, *9*(2), 151-164.

Wolfe, R., & Dunsinger, M. L. Soft drinks and weight gain: How strong is the link? *Medscape J Med*, *10*(8), 189.

Zhen, C., Wohlgenant, M. K., Karns, S., & Kaufman, P. (2011). Habit formation and demand for sugar-sweetened beverages. *American Journal of Agricultural Economics*, *93*(1), 175-193.