When Health Policy and Empirical Evidence Collide: The Case of Cigarette Package Warning Labels and Economic Consumer Surplus

Anna V. Song, PhD, Paul Brown, PhD, and Stanton A. Glantz, PhD

In its graphic warning label regulations on cigarette packages, the Food and Drug Administration severely discounts the benefits of reduced smoking because of the lost "pleasure" smokers experience when they stop smoking; this is quantified as lost "consumer surplus." Consumer surplus is grounded in rational choice theory. However, empirical evidence from psychological cognitive science and behavioral economics demonstrates that the assumptions of rational choice are inconsistent with complex multidimensional decisions, particularly smoking. Rational choice does not account for the roles of emotions, misperceptions, optimistic bias, regret, and cognitive inefficiency that are germane to smoking, particularly because most smokers begin smoking in their youth. Continued application of a consumer surplus discount will undermine sensible policies to reduce tobacco use and other policies to promote public health. (*Am J Public Health.* 2014;104:e42–e51. doi:10.2105/AJPH.2013.301737)

The 2009 Family Smoking Prevention and Tobacco Control Act (HR 1256, 2009) required the United States Food and Drug Administration (FDA) to issue a regulation requiring cigarette companies to place large graphic warnings on all cigarette packages. As part of the process of issuing this regulation, the FDA conducted a cost–benefit analysis of the graphic warning label regulation.[1] In its analysis, the FDA estimated the benefits of graphic warning labels, including reduced tobacco-induced illness and premature death, then cut the estimated benefits of these warning labels in half to account for the cost of lost "pleasure" smokers incurred as a result of quitting (and lost pleasure would-be smokers would never experience) because of the new warning labels. The FDA quantified the cost of this lost pleasure using the economic concept of "consumer surplus," which is the difference between what a utility maximizing individual would be willing to pay and the actual price.[2–6]

Because of the extent that smokers are willing to pay more for cigarettes than their monetary cost, this willingness to pay more is an indication that smokers obtain a surplus benefit of smoking beyond the cost of the cigarettes. The FDA justified applying a large discount to the estimated health benefits of the warning labels, stating,

> The concept of consumer surplus is a basic tool of welfare economics. . . . In an analysis of benefits based on willingness-to-pay, we cannot reject this tool and still fulfill our obligation to conduct a full and an objective economic analysis.[1(p36714)]

Consumer surplus based on willingness to pay is a well-established concept in classical economics and is grounded in rational choice theory, a normative model of human decision-making.[7] Rational choice theory represents human decision-making at its most logical, when decisions are the result of careful cost–benefit analysis, with people choosing the option that maximizes the utility of the choice after subtracting perceived costs.[8–10]

When applied to smoking, this theory posits that smokers (and potential smokers) smoke because they computed that the current and future benefits of the pleasures of smoking outweigh the present value of future financial, social, and medical costs of smoking.[11–13] These benefits may include both the physiologic responses and emotional or social advantages (either real or imagined) that smoking provides.

By contrast, a large body of empirical evidence from cognitive behavioral sciences demonstrates that smokers (and would-be smokers) smoke because they are addicted and overestimate their ability to quit in the future.[14] Rational choice theory (and the adjustments that have been proposed to deal with addictive behaviors) assumes stable preferences, foresight, knowledge, and adequate cognitive abilities to make the decision to start or continue smoking. Conversely, empirical evidence demonstrates that these assumptions are seriously violated by smoking behavior that almost always begins during adolescence[15(p179)] and continues in adulthood through addictive consumption. In addition, there is no empirical literature that suggests adults who start smoking engage in deliberate decision-making processes in which they evaluate risks against benefits. The empirical literature suggests the opposite; even adults, who presumably are better equipped to consider the risks and benefits of smoking, do not anticipate regret or understand addiction.[16–18]

Applying a significant loss in (real or potential) consumer surplus when measuring the value of antismoking initiatives has important implications for policy, including reducing the benefits of proposed health regulations. This reduction in the estimated benefits of the policy results in weakened regulations that are harder to defend when challenged in court.[19,20] In using consumer surplus, a measure grounded in rational choice theory, to estimate a theoretical "cost" of not smoking,[1(p36772),4] the FDA is ignoring the strong empirical evidence against the validity of applying rational choice to smoking decisions, leading the FDA to seriously overestimate the costs of reducing smoking, and in turn, underestimate the net benefits.

RATIONAL CHOICE AND RATIONAL ADDICTION

Rational choice theory has been an important and useful tool in understanding large-scale

market trends or population-level consumption of many products.[8,21] The assumption of rationality also works very well for many individual behaviors, particularly simple situations in which costs and benefits can be easily represented as a numerical metric, such as money. For example, rational choice can be used to explain an individual consumer's purchasing behavior in situations like buying earthquake insurance for one's home. The costs are calculable (e.g., cost of insurance vs costs of earthquake damage given the probability of an earthquake), and the benefits are known (e.g., insurance coverage). The potential consequences associated with behavioral choices are limited to 4 potential outcomes: insurance coverage with an occurrence of an earthquake, insurance coverage without an earthquake, no coverage with an earthquake, and no coverage and no earthquake. When the situations involve very clear cut, money-based utilities, descriptions of decision-making processes and subsequent behaviors based on rational choice reasonably approximate actual human behavior. In these cases, consumer surplus calculations, which are based on the nature of the demand curve, are appropriate.

However, in other situations, including smoking, the application of rational choice theory (including the calculation of consumer surplus) is problematic because empirical data have consistently shown that the decision-making process behind smoking decisions significantly deviates from the assumptions that underlie rational choice theory.[22,23] Rational choice theory assumes that the human decision-maker is *Homo economicus*, a human with stable preferences, accurate foresight, adequate knowledge, and cognitive efficiency[24] who consistently acts to maximize pleasure and benefits.[8,21,24–26] By contrast, in some situations, including smoking, human decision preferences are unstable, foresight is flawed, knowledge is imperfect, and cognitive abilities are limited.[9,24,27]

This realization has led researchers to look for alternatives to standard rational choice to understand decision-making. For instance, the field of "evonomics" is predicated on the assumption that economic behavior follows evolutionary principles and that the rational choice assumption of a self-interested *Homo economicus* is contrary to the realities of complex *Homo sapiens* who evolved within a complex physical and social environment.[28–30] In cases where the decision and the consequences of behaviors are multidimensional, rational choice theory often fails to accurately characterize individual decisions.[24]

Economists have attempted to adapt rational choice to predict and describe human behavior by relaxing some of the core underlying assumptions,[3] including introducing factors such as bounded rationality,[21] hyperbolic discounting,[31] differences in risk taking,[32] and reduced expectations of future earnings.[33] Examples of assumption relaxation to deal with addiction include intertemporal decision-making,[11,34–36] "projection bias" models in which future preferences are assumed to be similar to current preferences,[37,38] or current preferences superseding future considerations.[39] In particular, in the rational addiction model by Becker and Murphy,[11] consumption decisions were based on past consumption and predictions about future consumption and future costs. Chaloupka[40] tested the rational addiction model against actual smoking behavior and showed that the predictions from the rational addiction model provided a reasonable fit to observed behavior. Others expanded the model to demonstrate that in the short term (over a few months), mature adults exhibited forward-looking behavior as it pertained to 1 dimension of cost–benefit measurement (monetary price).[3]

Alamar and Glantz,[41] however, showed that it was possible to fit the rational addiction model to a synthetic data set that was generated from a model that had no forward-looking behavior at all. This result meant that the empirical test of the rational addiction model for smoking[40] provided necessary, but not sufficient, evidence that the rational addiction model accurately embodied smoking behavior.

An important limitation of the economic literature that attempted to modify the rational model to apply it to smoking behavior was that this literature almost exclusively dealt with addicted adult consumers. By contrast, the mean age of smoking initiation is 15.9 years, with 88.2% of smokers starting smoking at ages younger than 18 years, and 65.1% smoking daily by then[15(p179)]; this is well before they reach the age of reason.[42]

ISSUES OF DIMENSIONALITY OF DETERMINANTS OF CHOICE

The underlying foundation of rational choice is that people are motivated to maximize utility. Maximization requires that choices be ordered so that if choice A is preferred over B, and B over C, then A must always be preferred over C. This mathematical ordering is only possible if the scale is 1-dimensional (i.e., it is not possible to order a 2-dimensional—or higher—vector space[43]). From a behavioral point of view, this means that the determinants of the behavior have to be (or be close to) 1-dimensional, so that the preference ordering is invariant across context. That is, if A is preferred over B in 1 situation, this ranking should hold regardless of how the situation is presented.

These assumptions are easily upheld if units of analyses are limited to 1 dimension, such as money, or when the different measurements of behavior are highly correlated, so that when measured by multiple factors, the behavior is essentially 1 dimensional. (From a statistical point of view, this would mean that the measures of behavior exhibit 1 highly dominant principal component.) However, based on the evidence discussed in the following, this situation likely does not hold for smoking behavior. The monetary cost of cigarettes measures 1 dimension of the effects of tobacco use, whereas the morbidity effects, mortality, and social consequences represent other orthogonal dimensions.

The classic example of how dimensionality issues affect decision-making is a long-standing cognitive phenomenon called preference reversal.[44–46] Given the option of a low-risk, high probability of a small gains scenario versus a high-risk, low probability of a high gains scenario, people prefer the low-risk scenario. However, when asked to assign a monetary value to each scenario, people value the high-risk scenario more than the low-risk scenario. If a person was an expected (monetary) value decision-maker, the problem would be reduced to a single dimension, and transitivity would be maintained. The preference inconsistency arises from the fact that risk represents a second independent dimension, which includes emotions, thereby precluding multiplying the

probabilities times the money value and adding things up. The presence of a second dimension precludes a transitive ordering of all the possibilities[43] and gives rise to the observed preference reversal.[45,46]

The preference reversal phenomenon has been empirically demonstrated in health-related research as well.[47] Given the choice between a health-related item (e.g., preventive treatment to avoid cancer) and a leisure commodity (e.g., 1-day vacation in Bermuda), people valued health items higher than commodities when the dimension of evaluation was life expectancy measured in days. However, when the person was asked to place a monetary value on the health item and the commodity, the commodity was valued higher than the health item. In this case, the 2 independent dimensions are health status and the leisure commodity. Thus, in a multidimensional behavior, such as smoking, where it is impossible to order all possible outcomes, the utility optimization that lies at the core of idea of consumer surplus cannot be computed.

EMPIRICAL EVIDENCE OF UNSTABLE SMOKING-RELATED PREFERENCES

Smoking-related preferences do not remain stable over time.[3] If preferences were stable, smokers would continue to choose behaviors that support their smoking. Moreover, smokers would not feel regret in the future because their decisions are based on preferences that are stable (and they base their decisions using foresight about the future).

However, many smokers engage in self-control devices to undermine their own decision to keep smoking, such as by announcing intentions to quit or making pacts to quit in groups with other smokers.[48–50] By publicly announcing their decisions to quit or making pacts with other smokers to quit as a group, smokers are attempting to add an additional obstacle to continued smoking (i.e., self-induced social pressure). Smokers who engage in self-control devices are self-sabotaging their own decision to smoke by making it harder to smoke without incurring others' negative opinions for failing to quit. Moreover, as discussed in the following, most smokers report feeling regret over their decisions to smoke.[16,17,51]

In addition to smokers' self-sabotaging behavior, the empirical literature suggests that people are "cognitive misers" who have limited cognitive resources and employ cognitive short cuts, called heuristics, to help them make decisions.[52] In particular, people tend to base decisions on information that is readily accessible, vivid, or familiar to them (availability heuristic).[52,53] In the case of smoking, there are at least 2 other factors that explain why preferences are unstable: framing effects and emotions.

Framing Effects

The earliest empirical evidence to contradict rational choice theory came from the studies by Kahneman and Tversky,[9,10] who illustrated framing effects on decision-making[44,54,55] and demonstrated that people's preferences (and thus choices) varied according to how information was presented, even when the substance of the information remained constant. They found that people were more likely to accept risk when results were presented as potential losses than when results were presented as potential gains.[55] In their classic experiment, participants were told to imagine they were given $1000, but had to choose between (A) a 50% chance of gaining another $1000, or (B) a 100% chance of gaining $500. Alternatively, other participants were told they were given $2000, but had to choose between (C) a 50% chance of losing $1000, or (D) a 100% chance of losing $500. Options A and C yielded the same result (50% probability of having $2000, 50% probability of having $1000), while options B and D yielded the same outcome (100% probability of having $1500). However, most people chose B over A, but C over D, which demonstrated that people tended to accept uncertainty to avoid losses.

This principle, which is embodied in prospect theory, was also reported in the willingness-to-pay literature, which observed that people valued potential benefits differently depending on whether they were giving something up or keeping something they already had.[56,57] People were willing to pay far less to keep what they possess, but demanded significantly more if they were to be compensated for losing the good[56–60] (also called "willingness to accept"). For example, law students were asked how much they much money they would want if they were selling their textbooks, which included their notes and underlining. These same law students were asked how much they would pay to get the same textbook back if they lost it and wanted to retrieve it. In this example, law students demanded more money to sell their textbook (willingness to accept), compared with paying to retrieve (keep) the same textbook.[61] Despite efforts to explain this disparity by varying the type of item or good in question,[58,62] the difference between values measured in the willingness to pay and the willingness to accept scenarios demonstrated how consumer surplus was largely dependent on how the situation was framed, something that would not affect the decisions of a completely rational decision-maker.

Smoking situations can be framed in a variety of ways, including a loss frame (e.g., a potential smoker considering the loss of social standing if they do not smoke) to compensation for a lost right or benefit (e.g., the tobacco industry argument against smoke-free policies). It is unclear whether the FDA cost–benefit analysis considered preference variation caused by framing effects. Even so, analyses that are predicated on the assumption that preferences are stable are inappropriate in the context of tobacco control policy.

Emotions and Preferences

In addition to framing effects, preferences fluctuate according to the emotional state of the person at the time the decision is made. When explaining what people currently perceive as bad choices made in the past, people point to the strong influence of emotional states at the time the decision was made as the cause of illogical actions. Emotions not only interfere with human abilities to engage in rational cost–benefit analyses but also change people's preferences by altering their perceptions, goals, and evaluations of options, and thus, behavior.[63–66]

Emotions play a large role in human decision-making because calculations that weigh costs and benefits are often complex and cognitively difficult. Emotions provide an alternative to cost–benefit analyses for shaping preferences, particularly when the decision is complex.[67,68]

Rather than engaging in challenging cognitive processes to identify preferences and use identified preferences to compute utilities

(as specified in rational choice theory), people rely on emotions related to objects and ideas to help them make faster, easier decisions about whether some behavior would be positive or negative to the decision-maker. For example, people are less likely to perceive risks for things and activities they like (and feel positive emotions toward), compared with things and events they dislike. The more they like something, the lower the perceived risk and higher the perceived benefit. The opposite is true for things people dislike. This reliance on emotions as cues to inform judgment is the affect heuristic,[68] which is a type of cognitive short cut that allows people to make decisions without engaging in time-consuming, cognitively burdensome cost–benefit calculations.

The affect heuristic plays a role in smoking-related decisions because smoking behavior is tied emotionally to smoking-related images. Positive emotions often follow repeated exposure to smoking advertisements.[15] Among adolescents, exposure to cigarette brands increase positive emotions associated with those brands, and consequently, increase preferences toward smoking.[69] Likewise, negative emotions elicited by graphic warning labels on cigarette packages reduce smokers' preferences to smoke and increase preferences to quit.[70] The effects of positive emotions from cigarette brand exposure and negative emotions from graphic warning labels work because people do not always make decisions based on stable preferences. Instead, preferences can change according to emotions, which are mutable.

Although the rational choice theorists may adjust consumer surplus calculations to account for small variations in preferences at the population level, as the empirical literature on framing and emotions shows, these changes can be significant even within individuals, thus violating an important tenant of rational choice theory, and therefore, the calculation of consumer surplus.

EMPIRICAL EVIDENCE OF FLAWED SMOKING-RELATED FORESIGHT

Rational choice theory assumes that people make accurate predictions about decision outcomes, including the effects of decisions on their future states. However, there is strong empirical evidence of smokers' optimism bias—that despite knowing the potential health risks of smoking, smokers believe they are less susceptible to health effects compared with the average smoker.[71–75] This trend is demonstrated in youths[73,74,76,77] as well as adults.[72,75] For example, in 1 study,[75] 61.2% of smokers estimated that the average smoker had 5 to 10 times the risk of lung cancer compared with nonsmokers. By contrast, 23.1% of adult smokers estimated they had 2 times the risk of lung cancer compared with nonsmokers, with an additional 31.8% estimating no elevated risk or slightly higher risk compared with nonsmokers. In reality, smokers have 25 times the lung cancer risk as nonsmokers.[78,79] The study also reported very weak or no relationship between the amount of cigarettes smoked and beliefs about personal smoking-related consequences. Moreover, a majority of smokers incorrectly believed that they could negate the effects of smoking by engaging in healthy behaviors, such as exercising.

Smoking-related decisions are particularly prone to violating the foresight assumption because risks and benefits tend to accrue at very different times. Although there is some evidence that adolescents recognize smoking's short-term health risks, most adolescents frame health risks as long term while framing benefits as short term.[77] These potential benefits are related to social norms and peer acceptance, which can be highly susceptible to tobacco industry marketing and promotion (creating a social benefit to smoking) and tobacco control measures (creating a social stigma toward smoking). Moreover, people tend to discount future consequences and heavily weight present-day consequences,[80] making future smoking-related risks less salient compared with immediate social and physical benefits despite the fact that future regret may counterbalance these short-term benefits.

Economists attempt to account for temporal changes in preferences by applying hyperbolic discounting. Behavioral sciences and psychology show that people who are characteristically impulsive, including smokers and drug addicts, more heavily discount future consequences.[81–85] In 1 study, participants were asked to choose between an immediate monetary reward (decreasing from $1000 to $1) versus $1000 delivered in the future (increasing from 1 week to 25 years). Smokers strongly favored immediate rewards compared with nonsmokers and ex-smokers, who were less likely to discount future rewards.[81] (As a result, some researchers have concluded that unhealthy behaviors resulting from hyperbolic or delayed discounting can be muted by targeted interventions,[85] including graphic warning labels.) Although the tendency to discount future events in favor of immediate rewards may be a relatively stable personality trait with smokers and nonsmokers using different discount rates, their degrees of discounting can vary in response to the social environment.[86] Taken together, these findings suggest that revising the rational choice model to provide a more accurate description of behavior is at best not straightforward, and in doing so, loses the relative simplicity that made rational addiction attractive to policymakers.

In addition to smokers' inaccurate estimates of their personal smoking-related risks, people have little ability to predict their emotional reactions to future events. Underlying rational choice theory is the idea that anticipated emotions drive behavior (i.e., emotions that accompany outcomes that will be experienced in the future). Despite the important role anticipated emotions play in decision-making, there is also strong evidence that people have little ability to predict their future emotional reactions to consequences of their decisions.[87,88] Specifically, people are prone to the impact bias, which is a tendency to overestimate the intensity of their future emotional reaction to current decisions. For example, people overestimate how sad they will feel months after a failed relationship or years after they are denied tenure.[89] The same goes for positive emotions; people overestimate how happy they will be after positive events, such as having their political candidate win an election.[90]

Predictions about the future are especially inaccurate when dealing with addictive substances such as nicotine.[49,51] Regret and remorse are indications that people did not accurately predict future consequences at the time they made a decision. These emotions are prevalent among smokers. When asked if they would make the same decision to start smoking, 85% of adult smokers respond "no."[51] Moreover, the more respondents smoked, the more likely they expressed regret about their decision to start smoking. This finding has been replicated across the globe, with approximately 90% of

smokers regretting their decisions to start smoking.[16,17] If smoking were the result of a rational decision-making process, people would have been able to accurately predict their future emotions. Instead, we have tens of millions of people in the United States and billions worldwide who smoke and regret doing so.

Moreover, the limited data on former smokers' emotions toward not smoking suggest that former smokers are happier after quitting.[91] Former smokers also report better quality of life and more positive emotions compared with continuing smokers.[92] Consumer surplus calculations ignore the evidence that most smokers regret their decisions to smoke and that former smokers report more happiness after quitting, although the level of regret may exceed any "forgone pleasure" and lead to a "consumer deficit."

At the very least, the data on regret demonstrates that smoking decisions are not consistent with rational choice theory's assumptions.

EMPIRICAL EVIDENCE OF IMPERFECT SMOKING-RELATED KNOWLEDGE

Rational choice theory also assumes that decision-makers have complete knowledge to inform their preferences and utility calculations. This assumption is particularly tenuous for decisions to start smoking, which typically happens during adolescence. Adolescents do not accurately understand the risks associated with smoking. Although youths "know" that smoking causes lung cancer, they demonstrate a lack of understanding of the magnitude of harm smoking causes.[71,76,77,93,94] For example, youths who smoke believe that smoking-related negative consequences are less likely to occur compared with youths who do not smoke.[76,77] Youths also underestimate the extent to which smoking can shorten one's lifespan.[93] Moreover, youths incorrectly believe that health risks can be mitigated by altering their smoking behaviors, like smoking light cigarettes instead of regular cigarettes.[95] The empirical literature strongly demonstrates that youths consistently misperceive the harmful and addictive nature of smoking.[15,94] Even describing adolescent smoking initiation as a "decision" may be inappropriate especially because it is questionable as to whether youths are capable of being "fully or adequately" informed decision-makers.[96]

The idea that smokers, particularly adolescents who start to smoke, do not understand the risks of smoking was challenged by Viscusi,[97] who analyzed national survey data that concluded that smokers overestimated the risk of smoking. He suggested that smokers were making rational choices in smoking and that with better information more people would be smokers. The data Viscusi used, however, were collected in September 1985 by a private research firm, Audits & Surveys, Inc. (New York, New York), for several law firms retained by the tobacco companies (Arnold and Porter, Washington, DC; Jones, Day, Reavis & Pogue, Cleveland, OH; and Shook, Hardy & Bacon, Kansas City, MO) "in anticipation of litigation" against the tobacco companies.[98–100] In his 1997 deposition in the Mississippi's lawsuit against the major cigarette companies, Viscusi acknowledged that he knew the 1985 survey was commissioned by the law firms for the purpose of defending the tobacco companies in court.[101] Moreover, the basis for Viscusi's conclusion that smokers overestimated how dangerous smoking was rests on how respondents answered the single question, "Among 100 cigarette smokers, how many of them do you think will get lung cancer because they smoke? (If 'don't know,' PROBE 'Just your best guess will do.')."[97(p155)] People are notoriously bad at estimating such abstract low probability events. The fact that the survey company instructed interviewers to "probe" if the respondent did not know the answer makes the result even more unreliable.

By contrast, Schoenbaum[102] examined whether adult smokers recognized that smoking was likely to shorten their lives, and if so, whether they understood the magnitude of this effect by comparing people's expectations about their chances of reaching age 75 years to epidemiological predictions from life tables for never, former, current light, and current heavy smokers. He found that among men and women, the survival expectations of never, former, and current light smokers were close to actual survival probabilities. By contrast, among current heavy smokers, expectations of reaching age 75 years were nearly twice as high as actuarial predictions, indicating that heavy smokers significantly underestimated their risk of premature mortality. Despite the fact that the majority of people believe that smoking is dangerous and could cause death, smokers tend to doubt that they, personally, will die from smoking, even if they smoked for 30 or 40 years.[71]

Smokers also tend to underestimate the risk of addiction and overestimate their abilities to quit smoking[93,103] and widely hold self-exempting beliefs that prevent them from thinking about the risks of smoking. Smokers tend to be skeptical of smoking risks and believe that smoking-related diseases will be cured by the time they may contract these diseases.[104] Moreover, although smokers may be aware of particular risks, they may not understand or appreciate the knowledge enough to be considered an "aware" decision-maker.[96] The empirical evidence is strong that people, including adolescent initiators who are not yet addicted, do not have perfect knowledge regarding smoking.

EMPIRICAL EVIDENCE OF COGNITIVE LIMITATIONS IN SMOKING-RELATED DECISIONS

A major assumption of rational choice theory is that people are economically efficient decision-makers: the processes by which they make decisions is not only based on correct information, but the information about costs and benefits is weighed appropriately.[9,10,26] Empirical evidence that human decision-making sometimes deviates far from efficiency comes from 2 areas of research: neurologic work on the prefrontal cortex and emotions[105–107] and cognitive work on natural developmental processes.[108,109] These areas of empirical work are particularly relevant when considering initiation and continuation of an addictive behavior such as smoking.

Prefrontal Cortex and Emotions

Neuroscientists who focus on the role of the prefrontal cortex in decision-making have made important linkages between emotions and decision-making processes. Work on patients with brain damage to the prefrontal cortex shows impaired abilities to experience emotions. These patients are also unable to make decisions that maximize gains and minimize costs.[107] The same pattern of cognitive inefficiency exists among people who are addicted to drugs.[105]

Cognitive inefficiency among patients with prefrontal cortex damage and people with substance addictions, including tobacco use,[110] was demonstrated through the Iowa Gambling Task, in which research participants were presented with 4 decks of cards with varying levels and probabilities of payoffs. Participants were asked to select cards that either rewarded or punished (via sums of money) from the 4 decks. The decks were set up so that some decks produced modest rewards and punishments in the short term, but ultimately result in long-term gains. Other decks produced high rewards and punishments in the short term and ultimately result in long-term losses. Most people were able to resist decks that might have given them high rewards but also high punishments. These people tended to choose decks that provided smaller rewards, smaller punishments, and subsequently, long-term gains. However, some people, particularly people with prefrontal cortex damage or addicts, lacked the ability to resist the high reward or high punishment decks. Although they experienced huge losses when choosing from high-risk decks, they were unable to anticipate future outcomes and continued to follow the strategy of pursuing large rewards at the risk of large punishments and long-term losses.[105–107] This inability to anticipate future outcomes and pursue strategies that did not benefit them in the long run suggested that people with prefrontal cortex damage and substance addicts did not make decisions with the cognitive efficiency specified in rational choice theory. These 2 groups represented myopic decision-makers who did not appropriately value future consequences against current preferences.

Substance use, including smoking, also affects neurologic systems that control impulsivity and aid decision-making.[105,106,110] Cues to addictive substances may trigger the amygdala, which may modulate (or hijack) more "rational" neurologic systems.[105] It is possible that people are willing to smoke despite known health and financial costs, not because they are acting rationally and maximizing utility, but because the cues that remind them of their addiction bypass cognitive systems that control impulses and activate systems that are emotional and impulsive. This impulsivity and poor affective decision-making significantly increases youths' susceptibility to peer influence and smoking in the future.[110]

Bernheim and Rangel[111] developed an economic theory that sought to integrate these advances in cognitive neuroscience. Their model posited that people exist in 2 states—a hot state where decisions are not made based on rational behavior, and a cool state in which the usual assumptions of rational behavior apply. This model incorporated several elements that were more closely aligned with actual behaviors. First, it allowed for addictive behaviors to be mistakes where behaviors and preferences were not congruent (i.e., even addicts themselves characterized their behaviors as mistakes, even while consuming). Second, it recognized that addictive behaviors make people even more susceptible to environmental cues. As discussed previously, although people who exhibited trait-like impulsivity tended to seek short-term rewards over long-term consequences, this tendency could be affected by environmental cues[85] that could encourage or discourage impulsive behaviors that underlie unhealthy behaviors such as smoking. Third, the model accounted for the empirical finding that continued use of addictive substances changed neurologic pathways. These alterations affected people's ability to forecast future costs and benefits, making them particularly susceptible to external cues that overrode rational processes. To account for these lapses in rational thought, Bernheim and Rangel[111] included a stochastic component to represent the influence of memory and experiences, which are subjective, dependent upon situational context, and vary across time. Significantly, when Bernheim and Rangel[111] used this theory to conduct a welfare analysis of different addiction-related policies, they did not include the concept of consumer surplus.

Cognitive Development and Decision-Making

In addition to neurologic variation that leads to decision-making deficits, rational choice theory does not account for the fact that decision-making processes are prone to developmental changes. Adults tend to make decisions using schemas and gists (i.e., short cuts or vague representations of underlying meaning of information or trace information from memories), and cognitive short cuts or heuristics.[9,10,108] Youths tend to make decisions based on emotions and social influences,[112–114] particularly emotions associated with sensation seeking, the thrill of a new experience, and bonding with friends.[109,112] Although still imperfect in their decision-making abilities, most adults have more developed psychosocial skills to navigate decisions without relying on impulse or emotional states, compared with youths who tend to make riskier decisions because they lack the necessary psychosocial maturity to constrain their impulsivity.[115–117] The inability to constrain impulsivity also explains why youths tend to be more vulnerable to smoking initiation than adults; instead of a decision-making process consisting of a cost–benefit analysis based on forward-thinking hedonic predictions (which, as noted previously, even adults often do not exhibit in smoking-related decisions), youths often make risky decisions that heavily rely on emotions and social contexts.[109,112,115–117] This reliance on emotions and social context may also explain why youths are particularly susceptible to tobacco industry marketing and advertising.[15]

PROBLEMS OF MEASUREMENT AND QUANTIFICATION OF CONSUMER SURPLUS FOR SMOKING

As discussed previously, the FDA has been basing their regulatory rule-making for cigarette health warning labels (and, presumably, other regulations being developed) on a theory that is contradicted by a large body of empirical evidence. Although rational choice theory has advanced classical economic theory, there are major important flaws in applying it to multidimensional addictive behaviors, particularly those initiated in youths, such as smoking.

This issue is of more than passing concern because Office of Management and Budget (OMB) Circular A-4,[118] which lays out principles for regulatory cost–benefit analyses, lists specific cautions regarding the measurement of consumer surplus using revealed preferences. OMB notes that revealed preference methods are appropriate "[i]f the market participant is well informed and confronted with a real choice" and that "the goods and services affected by the regulation are traded in well-functioning competitive markets." Neither of these conditions applies to addictive substance use,

particularly smoking, when most people become addicted in their youth.

Even more to the point, OMB directs that

> the statistical and econometric models employed should be appropriate for the application and the resulting estimates should be robust in response to plausible changes in model specification and estimation technique.

This requirement is particularly relevant to tobacco regulation because Laux[42] demonstrated that peer group effects, which are generally overlooked in welfare analysis of tobacco regulations, make it impossible to identify the welfare consequences of regulating a product from observed demand curves. Citing these difficulties, Cutler et al.[119] declined to consider consumer surplus in their analysis of the economic effects of the Master Settlement Agreement that resolved litigation by many of the states against the major cigarette companies.

In response to public comment criticizing the FDA's use of Cutler's[13] theoretical suggestion that, for a completely rational person for whom the costs and benefits of reduced smoking are linear in the number of cigarettes given up, the consumer surplus equaled half the health benefits, the FDA presented additional theoretical arguments for using the 50% discount in its final warning label rule.[1,4] The FDA did not, however, present any robust empirical estimates of consumer surplus to support such a prediction. The FDA explicitly recognized the lack of empirical evidence in making this assumption, stating in the final rule, "FDA does not claim that 50 percent is the correct ratio . . . it may be near zero or near 100 percent."[1(p36774)]

CONCLUSIONS

Rational choice theory and its associated constructs (e.g., consumer surplus) are predicated on assumptions that behavior is guided in a very specific, circumscribed manner in which the decision-maker considers all information and makes a decision that is based on weighing benefits and risks without undue influence from others factors. These assumptions may be appropriate for certain kinds of behavior and situations: (1) situations in which the decision criterion is 1-dimensional, clear and observable (e.g., dollars); (2) when decisions are not cognitively too complex (e.g., confined to amount willing to pay and the emotional component is negligible); (3) when people have the cognitive capability to make decisions consistent with the utility calculations; and (4) when the decision environment drives people toward the optimal behavior or drives out suboptimal decisions (e.g., when there are active markets). None of these conditions exist in decisions to start or continue smoking.

The decision to start or continue smoking involves a substance (nicotine) that alters the brain and creates addiction that entails complex outcomes (e.g., costs and benefits are not captured within a 1-dimensional metric), where decision-makers may lack the cognitive capability to make rational complex decisions (e.g., children deciding whether to start smoking, thereby "creating" addicted adults), and where there is no "market" to drive out behaviors that are suboptimal in the long run. As a result, the application of rational choice theory and ad hoc estimates of consumer surplus are inappropriate.

The empirical evidence on smoking behavior shows that the fundamental assumptions underlying application of the concept of consumer surplus to smoking behavior are not supported by empirical evidence. Although these models account for lapses in rationality by incorporating stochastic or dynamic components to their mathematical models, the models still adhere to the basic rational choice premise.[25]

What is largely absent from the economic literature is the possibility that rational choice may not be an appropriate framework for addictive behaviors, particularly tobacco use. As McFadden[120] observed, a model based on rational expectations

> is vulnerable to behavioral rejection, because the solution of these programs involves levels of complexity and computation that fairly clearly exceed human cognitive capacity, because it is unrealistic to assume that historical experience and market information and discipline are sufficient to homogenize subjective expectations, particularly for rare events, and because the axiomatic foundations for utility jointly additively separable in time and uncertain outcomes are not persuasive.[120]

The increasing realization that the theoretical models used to estimate consumer surplus are likely misspecified, and therefore fail to reflect actual human smoking behavior, creates a challenge for economists, behavioral scientists, and others seeking to develop more appropriate models upon which to base public policy. It also creates an immediate need for the FDA and other regulatory agencies to either provide robust empirical evidence that their assumptions of consumer surplus are valid or to stop using these inaccurate estimates when determining public policy.

The evidence here suggests that the FDA's current estimates of 50% reductions in benefits are very unlikely to be substantiated empirically. The major deviations from the assumptions underlying these theoretical models makes it likely that consumer surplus is an inappropriate concept to apply to addictive behavior, thus contradicting the OMB's guidelines.

The FDA's current policy also serves to perpetuate health disparities among vulnerable groups. Although smoking prevalence is higher among disadvantaged groups who have a greater burden of tobacco-induced disease,[121-124] there are differences in preferences and attitudes toward smoking that would, if a literal application of the rational choice model were applied, suggest a higher value be placed on current smoking (and thus higher consumer surplus) among disadvantaged groups than the population as a whole.[125] This application of consumer surplus would have the effect of reducing the value of smoking prevention and cessation policies (including improved warning labels on tobacco products) in these groups, thereby increasing health disparities.

The inappropriate application of rational choice theory and consumer surplus to tobacco control policy is not merely of academic interest. By applying a large and unwarranted discount to the benefits of graphic warning labels, the FDA substantially understated the benefits of the warning labels, which made them harder to defend in court.[19,20] Considering that consumer surplus based on rational choice theory is not consistent with observed tobacco use behavior, the FDA should recognize that concepts based on the rational choice framework are not appropriate for cost–benefit analyses of scenarios involving addictive substances like tobacco and stop including consumer discounts in its analyses.

Continuing to apply a consumer surplus discount to the analysis of future regulations will, likewise, undermine sensible policies to reduce smoking and other tobacco use, and thus promote public health. ■

About the Authors

Anna Song is with Health Psychology, Psychological Sciences, University of California Merced, Merced. Paul Brown is with the Health Sciences Research Institute, University of California, Merced. Stanton A. Glantz is with the Center for Tobacco Control Research and Education and the Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco.

Correspondence should be sent to Stanton A. Glantz, Center for Tobacco Control Research and Education, University of California, San Francisco, 94143-1390 (e-mail: glantz@medicine.ucsf.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This article was accepted October 16, 2013.

Contributors

S. A. Glantz conceptualized the idea for the article. A. Song wrote the first draft. A. Song and S. A. Glantz further developed the draft of the article. P. Brown reviewed an advanced draft of the article, and suggested revisions and contributed additional material.

Acknowledgments

This work was supported in part by National Cancer Institute (grant CA-087472).

S. A. Glantz is American Legacy Foundation Distinguished Professor in Tobacco Control.

We thank Frank Chaloupka, Kenneth Warner, Bonnie Halpern-Felsher, and Terry Pechacek for helpful comments on drafts of this article.

Note. The funding agency played no role in the selection of the research question, conduct of the research, or preparation of the article. The authors have no conflicts of interest to disclose.

Human Participant Protection

Human participant protection was not required because this study did not involve human participants.

References

1. US Food and Drug Administration. *Required warnings for cigarette packages and advertisements.* Final Rule (Docket No. FDA–2010–N–0568) Federal Registrar No. 120. Vol RIN 0910–AG41. Vol 76. Washington, DC: US Government Printing Office; 2011;150: 36628–36777.

2. Willig RD. Consumer's surplus without apology. *Am Econ Rev.* 1976;66(4):589–597.

3. Gruber J, Köszegi B. Is addiction "rational"? Theory and evidence. *Q J Econ.* 2001;116(4):1261–1303.

4. Gruber J. Government policy towards smoking: a view from economics. Available at: http://digitalcommons.law.yale.edu/yjhple/vol3/iss1/7. Accessed November 21, 2013.

5. Kirkden RD, Edwards JSS, Broom DM. A theoretical comparison of the consumer surplus and the elasticities of demand as measures of motivational strength. *Anim Behav.* 2003;65(1):157–178.

6. Cherukupalli R. A behavioral economics perspective on tobacco taxation. *Am J Public Health.* 2010;100(4):609–615.

7. Bell DE, Raiffa H, Tversky A. Descriptive, normative, and prescriptive interactions in decision making. In: Bell DE, Raiffa H, Tversky A *Decision Making: Descriptive, Normative, and Prescriptive Interactions.* New York, NY: Cambridge University Press; 1988:9–32.

8. Simon HA. Theories of decision-making in economics and behavioral science. *Am Econ Rev.* 1959;49(3):253–283.

9. Tversky A, Kahneman D. Rational choice and the framing of decisions. *J Bus.* 1986;59(4):S251–S278.

10. Tversky A, Kahneman D. The framing of decisions and the psychology of choice. *Science.* 1981;211(4481):453–458.

11. Becker GS, Murphy KM. A theory of rational addiction. *J Polit Econ.* 1988;96(4):675–700.

12. Weimer DL, Vining AR, Thomas RK. Cost–benefit analysis involving addictive goods: contingent valuation to estimate willingness-to-pay for smoking cessation. *Health Econ.* 2009;18(2):181–202.

13. Cutler DM. Are we finally winning the war on cancer? *J Econ Perspect.* 2008;22(4):3–26.

14. Hammar H, Carlsson F. Smokers' expectations to quit smoking. *Health Econ.* 2005;14(3):257–267.

15. US Department of Health and Human Services. *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General.* Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2012.

16. Fong GT, Hammond D, Laux FL, et al. The near-universal experience of regret among smokers in four countries: findings from the International Tobacco Control Policy Evaluation Survey. *Nicotine Tob Res.* 2004;6(suppl 3):S341–S351.

17. Lee WB, Fong GT, Zanna MP, Borland R, Omar M, Sirirassamee B. Regret and rationalization among smokers in Thailand and Malaysia: findings from the International Tobacco Control Southeast Asia Survey. *Health Psychol.* 2009;28(4):457–464.

18. Wilson N, Edwards R, Weerasekera D. High levels of smoker regret by ethnicity and socioeconomic status: national survey data. *N Z Med J.* 2009;122(1292):99–100.

19. Norman B. Court blocks FDA tobacco warning labels appeal. 2012. Available at: http://www.politico.com/story/2012/12/court-blocks-fda-tobacco-warning-labels-appeal-84656.html. Accessed February 16, 2013.

20. R.J. Reynolds Tobacco Co. v. United States FDA, 845 F. Supp. 2d 266, 270 (D.D.C., 2012), aff'd 696 F.3d 1205, 1219–20 (D.C. Cir. 2012) (2012).

21. Simon HA. A behavioral model of rational choice. *Q J Econ.* 1955;69(1):99–118.

22. Slovic P. *Smoking: Risk, Perception & Policy.* Thousand Oaks, CA: Sage Publications, Inc; 2001.

23. Flay BR. Understanding environmental, situational, and intrapersonal risk and protective factors for youth tobacco use: the theory of triadic influence. *Nicotine Tob Res.* 1999;1(suppl 2):S111–S114.

24. Henrich J, Boyd R, Bowles S, et al. In search of homo economicus: behavioral experiments in 15 small-scale societies. *Am Econ Rev.* 2001;91(2):73–78.

25. McFadden D. Rationality for economists? *J Risk Uncertain.* 1999;19(1–3):73–105.

26. McFadden D. Economic choices. *Am Econ Rev.* 2001;91(3):351–378.

27. Bell DE, Raiffa H, Tversky A. *Decision Making: Descriptive, Normative, and Prescriptive Interactions.* New York, NY: Cambridge University Press; 1988.

28. Wilson DS, Gowdy JM. Evolution as a general theoretical framework for economics and public policy. *J Econ Behav Organ.* 2013;90(suppl):S3–S10.

29. Gowdy JM, Dollimore DE, Wilson DS, Witt U. Economic cosmology and the evolutionary challenge. *J Econ Behav Organ.* 2013;90(suppl):S11–S20.

30. Wilson DS, Gowdy JM, Rosser JB Jr. Rethinking economics from an evolutionary perspective. *J Econ Behav Organ.* 2013;90(suppl):S1–S2.

31. Ainslie G, Haslam N. Hyperbolic discounting. In Loewenstein G, Elster J, eds. *Choice Over Time.* New York, NY: Russell Sage Foundation; 1992:57–92.

32. Cutler D, Kadiyala S. The return to biomedical research: treatment and behavioral effects. In: Topel R, Murphy S, eds. *Measuring the Gains From Medical Research.* Chicago, IL: University of Chicago Press; 2003:110–161.

33. Munasinghe L, Sicherman S. Why do dancers smoke? Smoking, time preference, and wage dynamics. *East Econ J.* 2006;32(4):595–616.

34. Orphanides A, Zervos D. Rational addiction with learning and regret. *J Polit Econ.* 1995;103(4):739–758.

35. Orphanides A, Zervos D. Myopia and addictive behaviour. *Econ J.* 1998;108(446):75–91.

36. Laibson D. A cue-theory of consumption. *Q J Econ.* 2001;116(1):81–119.

37. Loewenstein G, Prelec D. Anomalies in intertemporal choice: evidence and an interpretation. *Q J Econ.* 1992;107(2):573–597.

38. Loewenstein G, O'Donoghue T, Rabin M. Projection bias in predicting future utility. *Q J Econ.* 2003;118(4):1209–1248.

39. O'Donoghue T, Rabin M. Doing it now or later. *Am Econ Rev.* 1999;89(1):103–124.

40. Chaloupka F. Rational addictive behavior and cigarette smoking. *J Polit Econ.* 1991;99(4):722–742.

41. Alamar B, Glantz SA. Modeling addictive consumption as an infectious disease. *Contrib Econ Analysis Policy.* 2006;5(1):1–22.

42. Laux FL. Addiction as a market failure: using rational addiction results to justify tobacco regulation. *J Health Econ.* 2000;19(4):421–437.

43. Cohen LW, Ehrlich G. *The Structure of the Real Number System.* Malabar, FL: RE Krieger Publishing Company; 1977.

44. Lichtenstein S, Slovic P. Reversals of preference between bids and choices in gambling decisions. *J Exp Psychol.* 1971;89(1):46–55.

45. Tversky A, Sattath S, Slovic P. Contingent weighting in judgment and choice. *Psychol Rev.* 1988;95(3):371–384.

46. Tversky A, Slovic P, Kahneman D. The causes of preference reversal. *Am Econ Rev.* 1990;80(1):204–217.

47. Chapman GB, Johnson EJ. Preference reversals in monetary and life expectancy evaluations. *Organ Behav Hum Decis Process.* 1995;62(3):300–317.

48. Prochaska JO, Crimi P, Lapsanski D, Martel L, Reid P. Self-change processes, self-efficacy and self-concept in relapse and maintenance of cessation of smoking. *Psychol Rep.* 1982;51(3):983–990.

49. DiClemente CC, Prochaska JO. Self-change and therapy change of smoking behavior: a comparison

of processes of change in cessation and maintenance. *Addict Behav.* 1982;7(2):133–142.

50. Christakis NA, Fowler JH. The collective dynamics of smoking in a large social network. *N Engl J Med.* 2008; 358(21):2249–2258.

51. Slovic P. Do adolescent smokers know the risks? *Duke Law J.* 1998;47(6):1133–1141.

52. Fiske ST. *Social Cognition: From Brains to Culture.* Thousand Oaks, CA: Sage Publications; 2013.

53. Tversky A, Kahneman D. Judgment under uncertainty: heuristics and biases. *Science.* 1974;185 (4157):1124–1131.

54. Lichtenstein S, Slovic P. Response-induced reversals of preference in gambling: an extended replication in Las Vegas. *J Exp Psychol.* 1973;101(1):16–20.

55. Kahneman D, Tversky A. Prospect theory: an analysis of decision under risk. *Econometrica.* 1979;47(2):263–292.

56. Knetsch JL, Sinden JA. Willingness to pay and compensation demanded: experimental evidence of an unexpected disparity in measures of value. *Q J Econ.* 1984;99(3):507–521.

57. Coursey DL, Hovis JL, Schulze WD. The disparity between willingness to accept and willingness to pay measures of value. *Q J Econ.* 1987;102(3):679–690.

58. Hanemann WM. Willingness to pay and willingness to accept: how much can they differ? *Am Econ Rev.* 1991;81(3):635–647.

59. Shogren JF, Shin SY, Hayes DJ, Kliebenstein JB. Resolving differences in willingness to pay and willingness to accept. *Am Econ Rev.* 1994;84(1):255–270.

60. Plott CR, Zeiler K. The willingness to pay-willingness to accept gap, the "endowment effect," subject misconceptions, and experimental procedures for eliciting valuations. *Am Econ Rev.* 2005;95(3):530–545.

61. Hoffman E, Spitzer ML. Willingness to pay vs. willingness to accept: legal and economic implications. *Wash Univ Law Q.* 1993;71(1):59–114.

62. Horowitz JK, McConnell KE. A review of WTA/WTP studies. *J Environ Econ Manage.* 2002;44(3):426–447.

63. Lerner JS, Keltner D. Fear, anger, and risk. *J Pers Soc Psychol.* 2001;81(1):146–159.

64. Lerner JS, Keltner D. Beyond valence: toward a model of emotion-specific influences on judgment and choice. *Cogn Emot.* 2000;14(4):473–493.

65. Loewenstein G, Lerner JS. The role of affect in decision making. In: Davidson RJ, Scherer KR, Hill Goldsmith H, eds. *Handbook of Affective Science.* New York, NY: Oxford University Press; 2003;619–642.

66. Loewenstein GF, Weber EU, Hsee CK, Welch N. Risk as feelings. *Psychol Bull.* 2001;127(2):267–286.

67. Slovic P, Finucane ML, Peters E, MacGregor DG. Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. *Risk Anal.* 2004;24 (2):311–322.

68. Slovic P, Finucane ML, Peters E, MacGregor DG. The affect heuristic. *Eur J Oper Res.* 2007;177(3):1333–1352.

69. Arnett JJ, Terhanian G. Adolescents' responses to cigarette advertisements: links between exposure, liking, and the appeal of smoking. *Tob Control.* 1998;7(2):129–133.

70. Hammond D, Fong GT, McDonald PW, Brown KS, Cameron R. Graphic Canadian cigarette warning labels and adverse outcomes: evidence from Canadian smokers. *Am J Public Health.* 2004;94(8):1442–1445.

71. Arnett JJ. Optimistic bias in adolescent and adult smokers and nonsmokers. *Addict Behav.* 2000;25(4):625–632.

72. Williams T, Clarke VA. Optimistic bias in beliefs about smoking. *Aust J Psychol.* 1997;49(2):106–112.

73. McCoy SB, Gibbons FX, Reis TJ, Gerrard M, Luus CAE, Wald Sufka A. Perceptions of smoking risk as a function of smoking status. *J Behav Med.* 1992;15 (5):469–488.

74. Chassin L, Presson CC, Rose JS, Sherman SJ. From adolescence to adulthood: age-related changes in beliefs about cigarette smoking in a Midwestern community sample. *Health Psychol.* 2001;20(5):377–386.

75. Weinstein ND, Marcus SE, Moser RP. Smokers' unrealistic optimism about their risk. *Tob Control.* 2005;14(1):55–59.

76. Halpern-Felsher BL, Biehl M, Kropp RY, Rubinstein ML. Perceived risks and benefits of smoking: differences among adolescents with different smoking experiences and intentions. *Prev Med.* 2004;39(3):559–567.

77. Song AV, Morrell HER, Cornell JL, et al. Perceptions of smoking-related risks and benefits as predictors of adolescent smoking initiation. *Am J Public Health.* 2009; 99(3):487–492.

78. Doll R, Hill AB. Smoking and carcinoma of the lung. *BMJ.* 1950;2(4682):739–748.

79. Doll R, Peto R, Boreham J, Sutherland I. Mortality from cancer in relation to smoking: 50 years observations on British doctors. *Br J Cancer.* 2005;92(3):426–429.

80. Hall PA, Fong GT. Temporal self-regulation theory: a model for individual health behavior. *Health Psychol Rev.* 2007;1(1):6–52.

81. Bickel WK, Odum AL, Madden GJ. Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology (Berl).* 1999;146 (4):447–454.

82. Reynolds B. A review of delay-discounting research with humans: relations to drug use and gambling. *Behav Pharmacol.* 2006;17(8):651–667.

83. Reynolds B, Richards JB, Horn K, Karraker K. Delay discounting and probability discounting as related to cigarette smoking status in adults. *Behav Processes.* 2004; 65(1):35–42.

84. Bickel WK, Marsch LA. Toward a behavioral economic understanding of drug dependence: delay discounting processes. *Addiction.* 2001;96(1):73–86.

85. Koffarnus MN, Jarmolowicz DP, Mueller ET, Bickel WK. Changing delay discounting in the light of the competing neurobehavioral decision systems theory: a review. *J Exp Anal Behav.* 2013;99(1):32–57.

86. Mitchell SH, Wilson VB. Differences in delay discounting between smokers and nonsmokers remain when both rewards are delayed. *Psychopharmacology (Berl).* 2012;219(2):549–562.

87. Gilbert DT, Brown RP, Pinel EC, Wilson TD. The illusion of external agency. *J Pers Soc Psychol.* 2000; 79(5):690–700.

88. Wilson TD, Wheatley T, Meyers JM, Gilbert DT, Axsom D. Focalism: a source of durability bias in affective forecasting. *J Pers Soc Psychol.* 2000;78(5):821–836.

89. Wilson TD, Gilbert DT. Affective forecasting knowing what to want. *Curr Dir Psychol Sci.* 2005;14(3):131–134.

90. Wilson TD, Meyers J, Gilbert DT. "How happy was I, anyway?" A retrospective impact bias. *Soc Cogn.* 2003;21(6):421–446.

91. Shahab L, West R. Do ex-smokers report feeling happier following cessation? Evidence from a cross-sectional survey. *Nicotine Tob Res.* 2009;11(5):553–557.

92. Piper ME, Kenford S, Fiore MC, Baker TB. Smoking cessation and quality of life: changes in life satisfaction over 3 years following a quit attempt. *Ann Behav Med.* 2012;43(2):262–270.

93. Romer D, Jamieson P. Do adolescents appreciate the risks of smoking? Evidence from a national survey. *J Adolesc Health.* 2001;29(1):12–21.

94. *Ending the Tobacco Problem: A Blueprint for the Nation.* Washington, DC: The National Academies Press; 2007.

95. Kropp RY, Halpern-Felsher BL. Adolescents' beliefs about the risks involved in smoking "light" cigarettes. *Pediatrics.* 2004;114(4):e445–e451.

96. Chapman S, Liberman J. Ensuring smokers are adequately informed: reflections on consumer rights, manufacturer responsibilities, and policy implications. *Tob Control.* 2005;14(suppl 2):ii8–ii13.

97. Viscusi K. *Smoking: The Risky Decision.* New York, NY: Oxford University Press; 1992.

98. Audits & Surveys, Inc. A survey about smoking (prepared at the request of Arnold & Porter; Jones, Day, Reavis & Pogue; and Shook, Hardy & Bacon in anticipation of litigation). Sep. 1985. Bates no. 85758734/8746. Available at: http://legacy.library.ucsf.edu/tid/kke70e00. Accessed November 21, 2013.

99. Audits & Surveys, Inc. Study on smoking/health relationship. 1985. Bates no. 507737884. Available at: http://legacy.library.ucsf.edu/tid/qsh10d00. Accessed November 21, 2013.

100. Jones, Day, Reavis & Pogue. Re: General Tobacco/ Health. 1985. Bates no. 507737882. Available at: http://legacy.library.ucsf.edu/tid/cwx61d00. Accessed November 21, 2013.

101. Viscusi WK, Kusinitz CH. In Re: Mike Moore, Attorney General Ex Rel, State of Miss. Tobacco Litigation, Deposition of: W. Kip Viscusi, Ph.D. 1997. Bates no. 519547894/8022. Available at: http://legacy.library.ucsf.edu/tid/xvd56d00. Accessed November 21, 2013.

102. Schoenbaum M. Do smokers understand the mortality effects of smoking? Evidence from the Health and Retirement Survey. *Am J Public Health.* 1997;87(5):755–759.

103. Weinstein ND, Slovic P, Gibson G. Accuracy and optimism in smokers' beliefs about quitting. *Nicotine Tob Res.* 2004;6(suppl 3):S375–S380.

104. Oakes W, Chapman S, Borland R, Balmford J, Trotter L. "Bulletproof skeptics in life's jungle": which self-exempting beliefs about smoking most predict lack of progression towards quitting? *Prev Med.* 2004;39(4): 776–782.

105. Bechara A. Decision making, impulse control and loss of willpower to resist drugs: a neurocognitive perspective. *Nat Neurosci.* 2005;8(11):1458–1463.

106. Bechara A, Tranel D, Damasio H. Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain.* 2000;123 (Pt 11):2189–2202.

107. Damasio AR, Everitt B, Bishop D. The somatic marker hypothesis and the possible functions of the prefrontal cortex [and discussion]. *Philos Trans R Soc Lond B Biol Sci.* 1996;351(1346):1413–1420.

108. Reyna VF, Farley F. Risk and rationality in adolescent decision making: implications for theory, practice,

and public policy. *Psychol Sci Public Interest.* 2006;7(1):1–44.

109. Steinberg L. Risk taking in adolescence new perspectives from brain and behavioral science. *Curr Dir Psychol Sci.* 2007;16(2):55–59.

110. Xiao L, Bechara A, Cen S, et al. Affective decision-making deficits, linked to a dysfunctional ventromedial prefrontal cortex, revealed in 10th-grade Chinese adolescent smokers. *Nicotine Tob Res.* 2008;10(6):1085–1097.

111. Bernheim BD, Rangel A. Addiction and cue-triggered decision processes. *Am Econ Rev.* 2004;94(5):1558–1590.

112. Gardner M, Steinberg L. Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: an experimental study. *Dev Psychol.* 2005;41(4):625–635.

113. Brady SS, Song AV, Halpern-Felsher BL. Adolescents report both positive and negative consequences of experimentation with cigarette use. *Prev Med.* 2008;46(6):585–590.

114. Blanton H, Gibbons FX, Gerrard M, Conger KJ, Smith GE. Role of family and peers in the development of prototypes associated with substance use. *J Fam Psychol.* 1997;11(3):271–288.

115. Steinberg L, Graham S, O'Brien L, Woolard J, Cauffman E, Banich M. Age differences in future orientation and delay discounting. *Child Dev.* 2009;80(1):28–44.

116. Steinberg L, Albert D, Cauffman E, Banich M, Graham S, Woolard J. Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: evidence for a dual systems model. *Dev Psychol.* 2008;44(6):1764–1778.

117. Cauffman E, Steinberg L. (Im)maturity of judgment in adolescence: why adolescents may be less culpable than adults. *Behav Sci Law.* 2000;18(6):741–760.

118. Office of Management and Budget. *Circular A-4.* Washington, DC: Office of Management and Budget; 2003.

119. Cutler DM, Gruber J, Hartman RS, Landrum MB, Newhouse JP, Rosenthal MB. The economic impacts of the tobacco settlement. *J Policy Anal Manage.* 2002;21(1):1–19.

120. McFadden DL. The new science of pleasure. NBER. 2013. Available at: http://ssrn.com/abstract=2199763. Accessed November 21, 2013. Working paper no. w18687.

121. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci.* 2012;1248(1):107–123.

122. Fagan P, Moolchan ET, Lawrence D, Fernander A, Ponder PK. Identifying health disparities across the tobacco continuum. *Addiction.* 2007;102(suppl 2):5–29.

123. Sorensen G, Barbeau E, Hunt MK, Emmons K. Reducing social disparities in tobacco use: a social-contextual model for reducing tobacco use among blue-collar workers. *Am J Public Health.* 2004;94(2):230–239.

124. Fagan P, King G, Lawrence D, et al. Eliminating tobacco-related health disparities: directions for future research. *Am J Public Health.* 2004;94(2):211–217.

125. Peretti-Watel P, L'Haridon O, Seror V. Time preferences, socioeconomic status and smokers' behaviour, attitudes and risk awareness. *Eur J Public Health.* 2013;23(5)783–788.