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Affective Science Perspectives on Cancer Control: Strategically Crafting a Mutually Beneficial Research Agenda

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Abstract

Cancer control research involves the conduct of basic and applied behavioral and social sciences to reduce cancer incidence, morbidity, and mortality and improve quality of life. Given the importance of behavior in cancer control, fundamental research is necessary to identify psychological mechanisms underlying cancer risk, prevention, and management behaviors. Cancer prevention, diagnosis, and treatment are often emotionally laden. As such, affective science research to elucidate questions related to the basic phenomenological nature of emotion, stress, and mood is necessary to understand how cancer control can be hindered or facilitated by emotional experiences. To date, the intersection of basic affective science research and cancer control remains largely unexplored. The goal of this article is to outline key questions in the cancer control research domain that provide an ecologically valid context for new affective science discoveries. We also provide examples of ways in which basic affective discoveries could inform future cancer prevention and control research. These examples are not meant to be exhaustive or prescriptive but instead are offered to generate creative thought about the promise of a cancer research context for answering basic affective science questions. Together, these examples provide a compelling argument for fostering collaborations between affective and cancer control scientists.

Keywords

affective science, cancer control, emotion

Despite great scientific investment in cancer research, cancer remains a leading cause of mortality in the United States and other developed countries, accounting for approximately 25% of all deaths in the United States (American Cancer Society, 2014). Human behavior plays a central and well-established role in cancer risk and prevention and in the management of cancer outcomes (Klein, Bloch, et al., 2014). Accordingly, *cancer control science* involves conducting basic and applied research in the behavioral, social, and population sciences. The goal of cancer control science is to create or enhance interventions, independently or in combination with biomedical approaches, to reduce cancer risk, incidence, morbidity, and mortality, and to improve quality of life. Some examples of critical questions in cancer control relevant to behavioral or psychological science include the following: Why do individuals engage in behaviors that increase the risk of cancer, and what intervention designs can most effectively reduce those behaviors? Why do individuals undergo cancer screening when it is not medically indicated, and how can we improve adherence to screening recommendations? How can shared decision making be facilitated in the context of cancer treatment or transitions to end-of-life care?

The answers to some of these questions can be found in *affective science*, or the scientific study of discrete

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emotions (e.g., fear, anger, happiness), as well as states such as stress and positive and negative moods. Historically, cancer has been considered a disease "feared beyond all others," (Holland, 2003, p. 253) involving a range of affectively laden issues, such as symptom and pain management; reactions such as anxiety, sadness, and anger; social and familial concerns; and existential questions about life and death (Holland, 2003). Moreover, cancer risk and preventive recommendations involve exceptional uncertainty and ambiguity (e.g., Niederdeppe & Levy, 2007), which create highly affective psychological states (Bar-Anan, Wilson, & Gilbert, 2009; Han, Moser, & Klein, 2006). Media depictions of cancer further exemplify negative affect and uncertainty (Gottlieb, 2001; Niederdeppe, Fowler, Goldstein, & Pribble, 2010), potentially contributing to inaccurate beliefs about risk and mortality that are disproportionally driven by affect (Jensen, Scherr, Brown, Jones, & Christy, 2013; Klein, Ferrer, Graff, Kaufman, & Han, 2014). Thus, cancer prevention and control science can derive particular benefit from research on fundamental affective processes. Before critical questions in cancer control science can be answered, it is necessary to fill gaps in fundamental knowledge about affective processes, particularly when basic research considers cancer applications in its study design (i.e., use-inspired basic research; Stokes, 2005).

Important and unanswered fundamental questions about the nature of affective phenomena range from the basic to the complex and include the following exemplars: What neural processes generate and regulate emotions, and is the subjective experience of generation versus regulation really driven by different processes? How do complex emotional states (e.g., anger and sadness experienced in concert) influence decision making under uncertainty? What are the psychological and neural processes by which emotions are communicated, perceived, and shared? Questions like these address the fundamental nature of affective processes and form the foundation of *affective science*.

To date, the potential synergy between basic affective science and cancer control remains largely unexplored. Psychological scientists who focus on basic questions often discount cancer as a content area that is too applied to examine their research questions or mistakenly believe that cancer control research involves only cancer patients. However, the breadth of cancer control also encompasses risk and prevention behaviors in normal and healthy populations across the life span. Thus, hypotheses about the fundamental nature of affective states—in healthy individuals, cancer patients, and those surviving and thriving for decades after cancer treatment—are directly relevant to cancer control science.

The goal of this article is to sample key questions in the cancer control research domain to demonstrate its potential as a contextually rich and fertile incubator for new affective science discoveries (see Table 1). Several examples exist that depict which basic affective discoveries could inform future cancer prevention and control research. The examples, highlighted below, are not meant to be exhaustive or prescriptive. Rather, they are offered to generate examples of collaborative opportunities for affective science. The article is organized around general categories of cancer research: (a) cancer risk and prevention; (b) cancer detection; and (c) cancer treatment, survivorship, and palliative care. Each of these sections briefly describes the cancer control problem and then presents related affective science research questions, organized by general categories of affective science topics or areas of inquiry. We then provide examples of basic affective science questions that are relevant to all domains of cancer prevention and control research.

Primary Prevention

Key cancer control problems relevant to affective science

Preventing cancer before it occurs is of central importance to cancer control. In the United States and other economically developed countries, a substantial proportion of cancers could be prevented through behavior modification (American Cancer Society, 2014), an observation that has contributed to a national focus on changing behaviors that increase cancer risk (Eheman et al., 2012). Empirically supported risk factors for various types of cancer include behaviors such as smoking, poor energy balance (i.e., consuming more calories than are expended through physical activity), alcohol consumption, and unprotected sun exposure and artificial tanning (see Klein, Bloch, et al., 2014). An additional behavioral risk factor for cervical cancer is nonadherence to human papillomavirus vaccination recommendations (FUTURE II Study Group, 2007). Affective states, such as stress or negative affect, directly influence many of these cancer risk behaviors (e.g., Canetti, Bachar, & Berry, 2002; Fell, Robinson, Mao, Woolf, & Fisher, 2014; Kelly, Masterman, & Young, 2011; Loxton, Dawe, & Cahill, 2011; Ostafin & Brooks, 2011; Perkins et al., 2008; Ziarnowski, Brewer, & Weber, 2009).

Despite the knowledge that affective processes contribute to cancer risk behaviors, little is known about the role of affect in the context of self-regulation of cancer risk behaviors (Diefenbach et al., 2008) or in decisions to engage in preventive behaviors (Conner & Norman, 1996). Cancer prevention interventions have targeted emotions such as fear and worry to some extent (e.g., Cho & Salmon, 2006; S. Hall, French, & Marteau, 2009), and it is believed that affect and emotion hold a key to crafting

Table 1. Cancer Control Targets and Relevant Basic Affective Science Questions

Cancer Control Category	Key Cancer Control Target	Relevant Basic Affective Science Questions
Primary cancer prevention	Cancer risk and prevention behaviors (e.g., physical activity, eating, tanning, alcohol use, tobacco use, human papillomavirus vaccination)	How do individuals use affective feelings as information to evaluate cancer-related behaviors? When is this most likely to occur and for whom?
	Self-regulation of behaviors associated with cancer risk (e.g., tobacco use, non-homeostatic eating, alcohol use)	What are the neural underpinnings of emotion regulation? What resources are necessary to mitigate the experience of negative affect? How do emotion and emotion regulatory processes unfold over time? When are negative affective experiences motivating and beneficial to an individual? When is positive affect detrimental?
	Physical inactivity and sedentary behavior	How are positive and negative affect related, at the experiential, physiologic, and neural levels of analysis?
	Poor or non-homeostatic eating	How does neural processing of affect relate to and interact with other psychological processes, such as sensory perception and cognition?
	Health communication receptiveness	How does affect contribute or relate to other psychological constructs (e.g., self and social constructs)?
Cancer detection	Adherence to cancer screening recommendations and reduction of overscreening	How does emotion influence high-stakes health decision making? How do complex emotional states influence risk perception and decisions under uncertainty? Are individuals correctly able to identify future affective responses to health outcomes? What mechanisms underlie accurate affective forecasting?
	Diagnosis	How do experts' affective states influence their decision making? Does emotion influence decision-related perceptions (e.g., visual search) differentially for experts?
	Symptom identification and diagnostic seeking	How are external sensory inputs and bodily sensations related to affect? Is it possible to distinguish a physical bodily sensation and an affective response?
Cancer treatment, survivorship, and palliative care	Treatment decisions (including clinical trial decision making and end-of-life transitions)	How are emotions communicated, perceived, and shared? What are the mechanisms and decisional consequences of emotional "contagions"? How does affective forecasting influence high-stakes decision making?
	Symptom management	How are "affective" and "cognitive" processes implemented in the brain, and what underlying mechanisms do they share? How does affect contribute to the experience of pain and other bodily sensations?
	Psychological adjustment and well-being	How are empathic responses formed under stress (e.g., cancer diagnosis, poor prognostic information)? What happens to empathic relationships when stressful experiences are resolved? How do individuals regulate the emotions of a close other? What is a beneficial trajectory of coping for both individuals with cancer and their caregivers, and how can it be facilitated? What shape does normal and impaired development of emotion regulatory capacity take?
	Biobehavioral processes potentially involved in tumor progression or metastasis	Do emotions have unique and specific biological signatures? How can we map and understand heterogeneity in processes associated with emotional responding?

persuasive health communications (e.g., National Research Council, 2012). However, affect is often targeted imprecisely, using common sense rather than principled, scientifically motivated frameworks. As such, it is critical that we develop a better understanding of affective underpinnings of the behaviors that modulate cancer risk.

Examining key questions of basic affective science within a cancer context

Affect as information. Individuals often use affect as information to help guide decisions, particularly when they are unaware of the real causes of affective changes (e.g., Clore, Gasper, & Garvin, 2001; Schwarz, 2011). Thus, it is likely that decisions to engage in cancer risk or prevention behaviors are influenced at least in part by affect. Individuals may use affect about a cancer-related behavior as information about whether the behavior is good or bad, rather than systematically considering its potential to increase or reduce cancer risk (Lawton, Conner, & McEachan, 2009). Thus, behaviors known to influence the risk of cancer are a fertile ground for examining basic questions about the nature of affect and how affect facilitates behavioral decisions relevant to cancer prevention: How do individuals use affective feelings as information to evaluate cancer-related behaviors? When is this most likely to occur, and for whom? For example, relatively low public awareness of human papillomavirus as a risk factor for cancer and the availability of vaccination as a preventive measure (Marlow, Zimet, McCaffery, Ostini, & Waller, 2013) render this a fruitful domain for affective scientists to examine the temporal dynamics of how affect is used as information to guide decisions in a novel and ecologically valid context.

Emotion regulation. Cancer risk and prevention behaviors are also a relevant context for research aimed at developing a better understanding of emotion regulatory processes. Social support (Beckes & Coan, 2011), cognitive reappraisal (or changing the way one thinks about a situation to alter an emotional response; Poldrack, Wagner, Ochsner, & Gross, 2008), automatic emotion regulation (Mauss, Bunge, & Gross, 2007), and instrumental emotion regulation (Tamir, Mitchell, & Gross, 2008) have been identified as effective means of directly or indirectly regulating negative emotion. Much remains to be learned about emotion regulation, including the resources needed to mitigate the experience of or overtly regulate negative affect, and the temporal dynamics of emotional responding (as discussed in Barrett, Wilson-Mendhenhall, & Barsalou, 2014).

It is largely assumed that bodily sensations related to the regulation of glucose metabolism result in subjective affective states, such as stress or negative mood in response to hunger (e.g., Craig, 2002;; for a review, see Barrett & Bliss-Moreau, 2009). This implies that cancer-related behaviors such as smoking, alcohol consumption, and overeating may be strategies for regulating negative affect related to disruptions of the body's homeostasis. Indeed, several leading frameworks for understanding food intake and tobacco use infer that changes in diet can be in response to stress (see Canetti et al., 2002). Nicotine, in particular, may change neural circuitry and ability to adapt to negative emotional stimuli (Cinciripini et al., 2006; Gray & Critchley, 2007; Watkins, Koob, & Markou, 2000), suggesting that smoking to regulate affect may be self-perpetuating. A more comprehensive understanding of neural mechanisms underlying emotion regulation will shed light on why people choose maladaptive strategies and will suggest routes for encouraging more effective strategies for regulating homeostasis and metabolism. To the extent that links between glucose metabolism and stress or negative affect are influenced by social support and social threat (Dickerson, Gable, Irwin, Aziz, & Kemeny, 2009), this research also suggests ways that social regulation of affect can indirectly be leveraged in interventions to reduce the need for these other maladaptive strategies. Thus, cancer prevention is an ideal context to examine the following questions: What are the neural underpinnings of emotion regulation? What resources are necessary to mitigate the experience of negative affect? How do emotion and emotion regulatory processes unfold over time?

Positive versus negative affect: Benefits, detriments, and associations. Affective science has demonstrated that there are conditions under which negative affect is motivating versus maladaptive. In fact, in certain situations individuals actually seek out negative affective experiences, such as in the instance when anger is perceived as a motivation to right a transgression (e.g., B. Q. Ford & Tamir, 2012; Tamir & Ford, 2012). In a cancer context, it is crucial to avoid the folk belief that all negative emotion is harmful and to better understand when stress and other negative affective experiences motivate healthy behaviors. Nuances in positive affect and context may be important—positive affect could be maladaptive when it stems from unrealistic expectations about cancer risk or ability to perform a cancer preventive behavior. As such, emotion regulatory *goals* are just as important in the cancer prevention context as are emotion regulatory *strategies*. Thus, cancer prevention is an ideal context to examine the following questions: When are negative affective experiences motivating and beneficial to an individual? When is positive affect detrimental?

The decades-old question of whether positive and negative affect are opposites (e.g., see Barrett & Bliss-Moreau, 2009; Norris, Golan, Berntson, & Cacioppo, 2010) is also highly relevant to cancer-related behavioral decisions. Exercise, for example, can evoke physical discomfort and negative affective reactions while concurrently evoking positive affect attributable to feelings of empowerment or activation of reward processes (Ekkekakis, 2009; E. E. Hall, Ekkekakis, & Petruzzello, 2002; Magnan, Kwan, & Bryan, 2013; Williams, 2008). Thus, a critical question in this context is, how are positive and negative affect related, at the experiential, physiologic, and neural levels of analysis? Progress toward resolving the great valence debate will offer insight into overcoming discomfort associated with exercise-related cancer preventive behaviors or the pleasures associated with cancer risk behaviors, such as smoking or consumption of highly palatable but unhealthy foods.

Affective, sensory, and perceptual processes. Similarly, the question about the relation between affective and sensory processing can be studied within a cancer context. For example, individuals who are more sensitive to the bitter tasting compound 6-*n*-propylthiouracil (i.e., supertasters; Hayes, Bartoshuk, Kidd, & Duffy, 2008) also experience more intense negative emotional responses to unpleasant or aversive stimuli (Macht & Mueller, 2007; see also Macht, 2008; Macht, Haupt, & Salewsky, 2004; Macht, Roth, & Ellgring, 2002; Macht & Simons, 2000), suggesting that those who experience more negative affect and stress may also be predisposed to eat fewer green vegetables (which have higher concentrations of 6-*n*-propylthiouracil) and are more likely to be hedonic eaters. Studies designed to identify individual differences in other affectively laden sensory contexts, such as tobacco use, could shed light on individual differences associated with propensity toward cancer risk behaviors. Thus, cancer prevention is a context in which to ask, how does neural processing of affect relate to, and interact with, other psychological processes such as sensory perception and cognition?

Affect and self-identity. Affirming one's sense of self-integrity increases receptiveness to health communications (Harris & Napper, 2005), and affect can enhance or disrupt the process, leading to unintended resistance to such communications (Ferrer, Shmueli, Bergman, Harris, & Klein, 2012). Basic research to disentangle the psychological underpinnings of affect and self is necessary to better understand this interaction and develop health messages that are better matched to affective context. Emotional appeals have also been leveraged to change cancer risk behavior, which often involve presenting information linking risky behaviors to cancer threat in an attempt to target fear or worry (e.g., Cho & Salmon, 2006; S. Hall et al., 2009). Such emotional appeals have varying success in engaging the target emotion and motivating behavior change, depending on context and circumstances (see Peters, Ruiter, & Kok, 2013; van't Reit & Ruiter, 2011). Similarly, worry is inconsistently associated with protective health behaviors depending on its intensity (e.g., Janis, 1967) and also interacts with more deliberative health cognitions, such as risk perception (e.g., Ferrer, Portnoy, & Klein, 2013; Klein, Zajac, & Monin, 2009). Thus, addressing the following affective science question can help inform effective cancer interventions: How does affect contribute or relate to other psychological constructs (e.g., self or social constructs)?

Cancer Detection

Key cancer control problems relevant to affective science

Detection of cancer (also called secondary prevention) is crucial for cancer control because identifying cancer early can lead to better treatment outcomes and improved survival. Correct identification of symptoms and appropriate diagnostic-seeking behaviors play an important role in cancer detection. However, adherence to screening recommendations is suboptimal (Centers for Disease Control, 2012). Moreover, maximal benefit of appropriate screening is realized only with the clinical follow-up of abnormal results, which remains a challenge to facilitate (Zapka, Taplin, Price, Cranos, & Yabroff, 2010).

The U.S. Preventive Services Task Force[1] (USPSTF) recommends detection of cancer risk through screening via the Papanicolaou (Pap) test (Moyer & USPSTF, 2012a), mammography (USPSTF, 2009), low-dose helical lung computed tomography (Moyer & USPSTF, 2014), fecal occult blood test, sigmoidoscopy, and colonoscopy (USPSTF, 2008). Decisions to postpone or forgo ineffective methods of screening are important areas of focus for cancer researchers. When evidence does not support the benefit for screening in a particular instance, engaging in such screening stresses the health care system and can contribute to negative individual-level outcomes like false positive test results and unnecessary biopsies. Prostate-specific antigen tests (Moyer & USPSTF, 2012b) and CA-125 assays and transvaginal ultrasound (USPSTF, 2004) do not have scientifically supported mortality benefit and are not recommended as effective means of screening for prostate and ovarian cancers, respectively. Screening recommendations are also age based (Moyer & USPSTF, 2012a; USPSTF, 2008, 2009). Complicating matters substantially, some screening recommendations are ambiguous for certain populations, and risk and benefit are associated with both the decision to screen as well as the decision not to screen. For example, the recent USPSTF recommendation on breast cancer screening before age 50 states that the decision to start regular biennial screening should be carefully considered by each woman in consultation with her health care practitioner. This recommendation arises from evidence of a decrease in mortality associated with mammography before age 50 and a substantial increase in false positives and unnecessary biopsies (USPSTF, 2009).

Screening decisions are inherently infused with cognitive affect. Fear or worry about cancer and the screening process has been linked to increased and decreased screening behaviors in different studies (Hay, McCaul, & Magnan, 2006; Jones, Devers, Kuzel, & Woolf, 2010; R. A. Smith, Cokkinides, Brooks, Saslow, & Brawley, 2010). Specific types of affect, such as culturally driven shame associated with cancer, are thought to contribute to disparities in screening rates (M. E. Ford, Vernon, Havstad, Thomas, & Davis, 2006; Jessop, Foti, Uribelarrea, & Chiasson, 2003; Kim, Lee, Lee, & Kim, 2004). Moreover, because of the nature of the screening procedures, colorectal cancer screening decisions are inherently related to and influenced by disgust and embarrassment (Kiviniemi, Jandorf, & Erwin, 2014; Reynolds, McCambridge, Bissett, & Consedine, 2014).

Examining key questions of basic affective science within a cancer context

Emotion and health decision making. Given the complexities associated with screening decisions, as well as the fact that screening decisions are made under considerable levels of ambiguity, the link between emotion and risk perception reflects a critical connection between affective science and cancer screening decisions. Although research has examined the influence of emotions on risk perceptions, much of this research has focused on perceptions or decisions in the financial domain (e.g., Lerner & Keltner, 2001; Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, Finucane, Peters, & MacGregor, 2004), and little is known about how emotions influence health care decision making (see Ferrer, Klein, Lerner, Reyna, & Keltner, in press). As previously described, mammography recommendations for women under age 50 state that women should work with their provider to make an individualized decision based on risks, benefits, and personal values and preferences. When these guidelines were initially communicated to the public by the media, one reaction was uncertainty and suspicion about recommendations (e.g., Weeks, Friedenberg, Southwell, & Slater, 2012; Woolf, 2010). This example highlights that the deliberation, establishment, implementation, and communication of clinical guidelines like cancer screening recommendations offer ecologically valid contexts to answer questions about how affective phenomena function under uncertainty, such as, How does emotion influence high-stakes health decision making? For example, emerging recommendations offer a platform to see how factors such as anxiety and suspicion unfold over time and how the trajectory of these responses influences an important screening decision.

Particularly little is known about whether complex emotional states (e.g., anger and fear experienced in concert) improve or diminish decision making under risk, in part because there is debate about whether such states should be understood as combinations of elemental emotions or whether they are unique states with their own profile of experiential, behavioral, and biological consequences. Different theoretical approaches to the nature of emotion (see Gross & Barrett, 2011)[2] make very different predictions about the mechanisms through which emotions will influence cancer screening decisions. Thus, fundamental knowledge about the nature of affective states can inform future efforts to identify specific patterns of screening decision making, contributing to research on questions such as, How do complex emotional states influence risk perception and decisions under uncertainty?

Moreover, little is known about ways emotion influences decision making among experts; research on emotion and decision making often examines how emotion influences everyday decisional processes in the general population. This line of questioning is directly related to medical provider decision-making processes and information that is attended to (or ignored) in medical encounters. Affect can influence problem solving in medical practice (Estrada, Isen, & Young, 1994), but additional research is necessary to more fully understand the complexity of how different affective states influence the wealth of decision-making processes among experts. Moreover, although research suggests that emotion influences attention and visual search (Cain, Dunsmoor, LaBar, & Mitroff, 2011; Phelps, Ling, & Carrasco, 2006), little is known about how emotion functions when experts perform visual search (e.g., radiologists who read mammography screenings to detect breast tumors). Cancer detection is an ideal context to examine questions about how affective factors interface with decisional processes among experts. For example, how do experts' affective states influence their decision making? Does emotion influence decision-related perceptions (e.g., visual search) differentially for experts?

Affective forecasting. Screening decisions also provide a context for developing a better understanding of affective forecasting—one's ability to identify the future affective consequences of a particular decision or event. Individuals are largely unable to accurately identify how they will feel in the future, a phenomenon that has been demonstrated with respect to life events (e.g., Wilson & Gilbert, 2003) and financial decisions (e.g., Laibson, 1997). However, little is known about whether individuals are correctly able to identify future affective responses to health decisions and outcomes. Screening decisions may be made in part by explicitly or implicitly predicting how one will feel in the future—about a cancer diagnosis or false positive screening result. Research suggests that there may be ways to improve detection decision making by helping individuals to anticipate or "pre-live" these affective reactions (e.g., Ferrer, Klein, Zajac, Land, & Ling, 2012; Shoda et al., 1998). However, the mechanisms underlying effects are unknown, and a better understanding of affective forecasting in this context could improve future intervention efforts. Thus, cancer detection is an ideal context to examine questions such as the following: Are individuals correctly able to identify future affective responses to health outcomes? What mechanisms underlie accurate affective forecasting?

Affective feelings and physical symptoms. A final example of research at the intersection of affective science and cancer detection involves understanding the basic relationships between external and internal sensory inputs and affective experiences (for a review, see Arnold, 1960; Barrett & Bliss-Moreau, 2009). Is it possible to distinguish, in objective terms, a physical bodily sensation (e.g., tenderness or bloating), an affective response to the sensation (e.g., unpleasantness over the sensation), an emotional reaction to the symptom (e.g., fear the sensation indicates cancer), and a cognition (e.g., memories of previous experiences involving symptoms, perceptions about interpersonal conflict or work stress)? Whereas once physical symptoms, cognitions, emotions, and perceptions were thought to correspond to different processes that can be localized to different brain regions or networks, there is now an emerging consensus that they arise from the interaction of more domain-general brain networks (Barrett & Satpute, 2013; Lindquist & Barrett, 2012). Nonetheless, there is still a tremendous amount of work to be done to develop formal computational approaches to understanding how brain networks create mental states in real time (Park & Friston, 2013).

Cancer detection is an ideal context for examining such questions, given that it is affectively laden and involves experience and interpretation of pain and symptoms. While some symptoms of cancer are relatively unambiguous (e.g., breast lumps, depending on size and type), others are very common (e.g., bloating and abdominal pain in ovarian cancer; Fitch, Deane, Howell, & Gray, 2002). An individual's likelihood of seeing a provider about potential symptoms reflects a lower threshold for categorizing his or her bodily sensation as a sign of disease, rather than increased accuracy in such categorization (e.g., Noyes et al., 2001). Negative affect increases perception of bodily sensations and may play a role in facilitating interpretation of ambiguous sensations as indicative of illness (Gupta & Perez-Edgar, 2011). Insights from research on the role of affect in the interpretation of bodily sensations have implications for training individuals to more accurately identify symptoms and judge severity separate from the affective experience such symptoms may engender. Thus, cancer detection is an ideal context to examine the following basic questions: How are external sensory inputs and bodily sensations related to affect? Is it possible to distinguish a physical bodily sensation and an affective response?

Treatment, Survivorship, and Palliative Care

Key cancer control problems relevant to affective science

When cancer is first diagnosed, individuals are faced with single-event treatment decisions (e.g., lumpectomy or mastectomy in the case of breast cancer); those that involve maintenance or adherence (e.g., chemotherapy, radiation, hormone therapy); a combination of the two; or certain instances of watchful waiting. Because medical treatments involve side effects (e.g., Collins et al., 2011; Earle & Deevy, 2013; Monsuez, Charniot, Vignat, & Artigou, 2010) and can cause illness and other complications (e.g., Hurria et al., 2011; Vanneman & Dranoff, 2012), treatment decisions involve complex dimensions, weighing quality of life against longevity. These decisions evolve as a treatment is shown to be effective or ineffective, side effects and comorbid health conditions emerge, and cancer that had been successfully treated recurs. Cancer patients often face informed consent decisions associated with participation in early-phase clinical trials in which treatments are being evaluated for safety and/or efficacy, often with no direct benefit to participants (Jansen et al., 2011).

Decisions about treatment and clinical trial participation can be affectively charged (e.g., Mellon, Kershaw, Northouse, & Freeman-Gibb, 2007; Mullens, McCaul, Erickson, & Sandgren, 2004; Stanton & Snider, 1993). These decisions are made in the context of heightened threat sensitivity (and the emotional context of everyday life that progresses even in the context of disease). Some negative affective reactions can be paralyzing, leading to suboptimal treatment adherence (DiMatteo, Lepper, & Croghan, 2000) or low clinical trial enrollment rates (Leroy, Christophe, Penel, Clisant, & Antoine, 2011). However, some types of negative reactions are associated with positive outcomes, such as when fear of recurrence is linked to increased adherence to treatment and health surveillance (Friese et al., 2013). Advances in our fundamental knowledge of how affect and emotion influence decisions about treatment could inform efforts to improve decision support architectures and shared decision making in these domains.

Treatment decisions can be followed by—or paired with—decisions about palliative care, or treatment focused on symptom control and management. Different cancer treatments (i.e., surgery, chemotherapy, radiation therapy, targeted cancer therapies, biological therapies) are associated with different physical side effects, adverse events, and emotional and psychological sequelae, including lymphedema (Norman et al., 2009; Pyszel, Malyszczak, Pyszel, Andrzejak, & Szuba, 2006; Ridner, 2005), peripheral neuropathy (Delanian, Lefaix, & Pradat, 2012), nausea and vomiting (Grunberg et al., 2004), hot flashes and night sweats (Carpenter et al., 1998; Couzi, Helzlsouer, & Fetting, 1995), pain (Badr Naga, Al-atiyyat, & Kassab, 2013), fatigue (Horneber, Fischer, Dimeo, Rüffer, & Weis, 2012), sleep disturbance (Davidson, MacLean, Brundage, & Schulze, 2002), cognitive impairment (Ahles et al., 2002; Nelson & Suls, 2013; Wefel et al., 2010), and depression and anxiety (Ng, Boks, Zainal, & de Wit, 2011; Vahdaninia, Omidvari, & Montazeri, 2010). These side effects and consequences can linger—or arise for the first time—as "late effects," long after treatment exposure (Ewertz & Jensen, 2011; Treanor, Santin, Mills, & Donnelly, 2013).

Research has identified demographic factors and health cognitions (e.g., pre-cancer risk expectations) associated with adjustment to cancer, its treatment, and the side effects described above (e.g., Costanzo, Ryff, & Singer, 2009; Persoskie, Ferrer, Nelson, & Klein, 2014; Pudrovska, 2010). Strategies exist to promote quality of life and psychological adjustment in cancer; these include psychosocial (Fors et al., 2011; Ross, Boesen, Dalton, & Johansen, 2002), mindfulness (Piet, Würtzen, & Zachariae, 2012), and exercise (Brown et al., 2011; Brown et al., 2012; Ferrer, Huedo-Medina, et al., 2011) interventions. Because psychological adjustment has a strong affective component (e.g., Frederick & Loewenstein, 1999; Luhmann, Hofmann, Eid, & Lucas, 2012), a more fundamental understanding of affective processes may be critical to better inform interventions designed to promote adaptation to cancer.

Finally, it has been suggested that affect—depression, stress, and accompanying physiological changes—may influence the trajectory of cancer outcomes (Kiecolt-Glaser, Robles, Heffner, Loving, & Glaser, 2002; Spiegel & Giese-Davis, 2003). Evidence implicating stress in tumor progression is strongest in animal models, where extreme stressors (i.e., social isolation, physical stress) influence the biology of tumors, accelerating growth and metastasis (see Antoni et al., 2006; Cole & Sood, 2012). Among humans, affect has been linked to inflammatory processes known to be involved in tumor progression (e.g., Antoni et al., 2012; Sepah & Bower, 2009). However, equivocal findings have promoted skepticism about associations between affect and cancer outcomes in humans (e.g., Stefanek, Palmer, Thombs, & Coyne, 2009). It remains possible that the presence of cancer- or treatment-induced pro-inflammatory cytokines may induce depression, rather than the reverse (Sotelo, Musselman, & Nemeroff, 2014).

Examining key questions of basic affective science within a cancer context

Emotion, communication, and relationships. Research on emotional communication, shared emotional experiences, emotional contagion, empathy, and compassion are highly relevant to cancer treatment. Cancer treatment decisions are rather complex, because they are embedded in a social context; individuals with cancer have relatives, friends, and a team of providers who work with them in some capacity to arrive at decisions about whether and how to treat their cancer. Indeed, physicians are now encouraged to participate in shared decision making, where they partner with patients in facilitating an informed choice (Kon, 2010). Although we know that emotional experiences can be transmitted or shared (e.g., De Vignemont & Singer, 2006), much remains to be learned about mechanisms and consequences of this phenomenon in the context of complex social relationships or networks. Little is known about how an "emotional environment," composed of interactions among individuals contributing to a particular environment or decision, influences individual-level emotions, judgments, or decisions. Cancer treatment and survivorship is an ecologically valid context to examine basic questions, such as the following: How are emotions communicated, perceived, and shared? What are the mechanisms and decisional consequences of emotional "contagions?"

Research is also necessary to develop a more precise understanding of how empathic responses are formed (and under what circumstances this is likely to occur). Cancer survivorship is a context to develop ecologically valid studies about the formation of social bonds during heightened threat and to explore what happens to the relationship and the individuals as the stressful experience is somewhat resolved (e.g., transitioning to post-treatment, away from the close relationships with care providers but perhaps to a strengthened relationship with loved ones who were emotionally supportive during the treatment). It is important to note that the basic knowledge about affective experience and social bonds in survivorship has the potential to improve the survivorship experience. Note that individual-level emotions may also influence treatment trajectories; research has demonstrated that negative affect may predispose individuals to deficits in self-efficacy and illness outcome expectations as well as poorer adherence to treatment regimens, compared with positive affect (Schuettler & Kiviniemi, 2006), a possibility that deserves further exploration given that serious illness such as cancer may trigger negative affective reactions. Basic affective science questions that can be answered in the context of cancer treatment and survivorship include the following: How are empathic responses formed under stress (e.g., cancer diagnosis, poor prognostic information)? What happens to empathic relationships when stressful experiences are resolved?

Questions about the social dynamics of emotion regulation are also relevant to survivorship. While being in proximity to a close other can provide automatic regulation of negative affect (Beckes & Coan, 2011), it is also possible that individuals may be able to actively engage in efforts to regulate the negative emotions of a loved one. There is a dearth of research on explicit social emotion regulatory strategies, and a better understanding of the potential for such strategies is relevant to cancer treatment and survivorship, given that individuals with cancer may try to regulate the emotions of their loved ones—and vice versa. An understanding of shared resource building, coping, and resilience may help to answer important questions, such as when an individual is willing to take on personal emotional or instrumental cost in order to help a loved one with cancer cope. With a better understanding of social emotion regulation, cancer researchers could develop strategies to facilitate an adaptive trajectory of coping that adequately addresses emotions of both individuals with cancer and their caregivers. Key questions in this context include the following: How do individuals regulate the emotions of a close other? What is a beneficial trajectory of coping for both individuals with cancer and their caregivers, and how can it be facilitated? This type of basic research has the potential to inform more comprehensive psychosocial interventions to promote adjustment to cancer by providing augmenting content that can improve well-being at the relationship, rather than the individual, level. For example, emotion expression interventions for promoting adjustment to cancer (e.g., Stanton et al., 2000) could be combined with emotional disclosure intervention content (e.g., Robbins, Lopez, Weihs, & Mehl, 2014) to facilitate adjustment for both the cancer survivor and the caregiver.

Affective forecasting. Like cancer detection, cancer treatment decisions provide a context for studying the complex influence of affect and emotion on high-stakes decisions that involve uncertainty or affective forecasting demands. Cancer treatment decisions often involve choosing between treatment options, and although these choices involve examining evidence about potential efficacy, there are cancer situations for which the treatment choice is not clear and involves weighing risks and benefits in the context of uncertainty. Moreover, decisions about cancer treatments can involve attempts to predict how one will feel about future side effects (e.g., developing incontinence or impotence during treatment of prostate cancer or needing a colostomy bag for colorectal cancer treatment). As stated, affective forecasting (e.g., Laibson, 1997; Wilson & Gilbert, 2003) and the role of emotions in decision making under ambiguity (e.g., Lerner & Keltner, 2001; Loewenstein et al., 2001; Slovic et al., 2004) have been examined in other (largely financial) contexts, but little is known about these decisions in the context of a decision that has the very real potential to influence mortality outcomes (see Ferrer et al., in press). Thus, like cancer detection, cancer treatment and survivorship is an ecologically valid context to examine such questions as, How does affective forecasting influence high-stakes decision making?

Affective and cognitive processes. Basic questions about association between "affective" and "cognitive" processing can also be examined in the context of cancer treatment and survivorship. Cancer-related cognitive impairment may be influenced or exacerbated by affective challenges associated with cancer diagnosis and survivorship (e.g., Ahles et al., 2002; Wefel et al., 2010), although evidence for these effects are mixed and the mechanisms underlying them are poorly understood (see Ahles & Saykin, 2007; Jim et al., 2009). Affective science is relevant for understanding these cognitive impairments, given theoretical frameworks suggesting that "affect" and "cognition" may share neural processes (Barrett & Satpute, 2013; Lindquist & Barrett, 2012). Such frameworks also have the potential to provide insight into the experience of other treatment-related side effects, given that "cognitive" expectations and affective interpretations contribute to the subjective experience of pain and other physical symptoms (Atlas & Wager, 2012). In a related line of thinking, we know that affect influences memory for emotionally evocative events or events that are experienced concurrently while an individual is in an affective state regardless of the target of such a state (e.g., Okuda et al., 2004), but little is known about whether this is protective or destructive for memory, problem solving, and executive function (Barrett, Tugade, & Engle, 2004). Cancer treatment and survivorship are thus ideal contexts to answer questions, such as, How are "affective" and "cognitive" processes implemented in the brain, and what underlying mechanisms do they share?

Affect and bodily sensation. Evidence from cognitive neuroscience demonstrates that sensory input is not integrated into perceptual experiences with unidirectional processing; rather, sensory processes and cognitive processes (e.g., memory and expectation) synchronously contribute to the perception of the world and body (Damasio, 1989). More recently, affective neuroscience research has shown that affective processes play a role in expectations and perceptions of bodily sensations such as pain (e.g., Wager et al., 2004). For example, somewhat paradoxically, repeated exposure to painful stimuli can either increase or decrease sensitization to pain, depending on whether neural mechanisms related to habituation or sensitization are engaged (Jepma, Jones, & Wager, 2014). However, much remains to be learned about how affective processes contribute to engagement of these processes and how they contribute to the experience of other bodily sensations, such as fatigue. Key questions include, How does affect contribute to the experience of pain and other bodily sensations? Studies designed to generate a more fundamental understanding of how these processes relate to different types of pain and other physical symptoms (e.g., fatigue), and more precise identification of the neural mechanisms that contribute to engagement of these processes, may shed light on strategies to facilitate pain (and symptom) management among individuals being treated for cancer.

Emotion regulation. Another example of a line of affective science inquiry related to cancer concerns the normal and impaired development of emotion regulatory capacity and affective processing. Cancer and cancer treatments can influence neuropsychological processes among those diagnosed with cancer as children, and these effects are borne out over a lifetime, potentially disrupting normal functioning. Moreover, the side effects of cancer and cancer treatments often manifest (in children, adolescents, and adults) as late effects, years after treatment exposure. As such, these effects and their proposed biological and psychological mechanisms have the potential to shed light on how normal and impaired cognitive, affective, and sensory processing change over the life span. Relevant basic affective science questions include, What shape does normal and impaired development of emotion regulatory capacity take? In turn, understanding the role of affective experiences in late effects of cancer treatment has implications for ways in which these effects are addressed.

Affect and the autonomic nervous system. Finally, the century-old question about whether emotions have unique and specific patterns of nervous system activation has implications for research examining variability in tumor progression and metastasis trajectories. Although some theoretical frameworks involve a classification of emotions where each discrete emotion can be identified with a unique nervous system activation pattern (Gross & Barrett, 2011; e.g., Ekman, 1992; Ekman & Cordaro, 2011; Frijda, 1986), no such replicable patterns have been identified (cf. Barrett, 2006a, 2012; Barrett, Lindquist, et al., 2007; Lindquist et al., 2012). Instead, each emotion has varied activation, rather than a specific and unique pattern, even with the same methods and induction stimuli (cf. Barrett, 2013; Cacioppo et al., 2000). Mapping and understanding nervous system activation heterogeneity is critical for designing applied studies to elucidate potential links between emotion and cancer progression.

For example, negative affective states often involve strong beta-adrenergic sympathetic nervous system activity that, in nonhuman animal models, encourages cancer cell replication (Irwin & Cole, 2011; Reiche, Nunes, & Morimoto, 2004; Thaker et al., 2006). Stress-related sympathetic nervous system activity may also directly influence the microenvironment of tumors, enhancing metastasis and increasing mortality (Antoni et al., 2006; Cole & Sood, 2012). However, as stated, evidence for the influence of affective states on tumor progression and metastasis in humans is lacking (see Stefanek et al., 2009). This may be because humans have more variable affective and physiological responses than do nonhuman animals. Critical and unanswered basic questions include the following: Do emotions have unique and specific biological signatures? How can we map and understand heterogeneity in processes associated with emotional responding?

Basic Affective Science Questions Relevant Across Cancer Control Domains

Up to this point, we have attempted to provide a heuristic framework for basic affective science questions that could be addressed within specific domains of cancer control. However, there are other fundamental questions that could be examined in multiple domains, such as the following: (a) What are the distinctions between discrete emotions and general affect, and when are these distinctions important? (b) What is the difference between emotion and stress? and (c) How can we move toward an empirical science of affective experience through measurement advances?

Distinctions among affect, stress, and emotion

Although a detailed discussion of the intersection of the fields of stress and emotion is beyond the scope of this article (see DeSteno, Gross, & Kubzansky, 2013; Ganzel, Morris, & Wethington, 2010; Lazarus, 2006; Lerner, Dahl, Hariri, & Taylor, 2007; Zautra, 2006), it is important to briefly examine the relevance of this distinction to cancer prevention and control research. Research on stress has focused largely on the association between a stressor (a situation where demands exceed coping ability) and biobehavioral responses (e.g., disruptions in homeostasis, hormonal disregulation, and negative health outcomes). Research on emotion has focused largely on brief experiences of discrete emotional states, neuropsychological underpinnings of such experiences, and behavioral consequences. Although the fields are disconnected and proceed somewhat in parallel, if differences between stress and emotion are related to definitions and scientific focus rather than real biological differences, then each field could benefit from capitalizing on existing scientific discoveries and theoretical and methodological advances of the other. Further, understanding the associations among various affective states may be important: For example, is increasing positive emotion the same as reducing stress? These types of questions can be addressed in an ecologically valid cancer context, given the proposed role of both stress and emotion in biobehavioral processes relevant to cancer prevention and control. For example, as described above, emotions are relevant to decisions and behaviors associated with risk and prevention, detection, treatment, survivorship, and palliative care. Stress has also been implicated in some such behaviors and moreover may play a role in cancer-related biobehavioral processes such as craving. Taken together, these cancer-relevant processes could provide an ideal space for examining the associations and distinctions between emotions and stress.

Similarly, the functional distinction between discrete emotions and more general affect (Barrett, 2012) has implications for how we understand the influence of affective states on cancer-related behaviors and decisions. Research on how discrete emotions systematically influence decisions has been undertaken in other domains (and, in particular, consumer decision making, social processing, and persuasion; e.g., DeSteno, Dasgupta, Bartlett, & Cajdric, 2004; DeSteno, Petty, Rucker, Wegener, & Braverman, 2004; Lerner, Gonzalez, Small, & Fischhoff, 2003; Lerner & Keltner, 2001) but has rarely been undertaken explicitly in a cancer domain (see Ferrer et al., in press). Understanding when and how discrete emotion versus general affect systematically influence different types of cancer-related behaviors can contribute to interventions to intervene on those behaviors (either by targeting and changing affective states or by identifying those at increased need for intervention on the basis of affective screening).

Measurement and coherence

Measurement issues have plagued affective science (e.g., Barrett, 2006b; Barrett & Russell, 1998; Larsen & Fredrickson, 1999; Quigley & Barrett, 2014; Quigley, Lindquist, & Barrett, 2013), and valid measures are essential to understand affective phenomena. Much remains unknown about the idiographic variation and heterogeneity in emotional and affective responding as it occurs in everyday life (Barrett, 2009). Also essentially unknown are the temporal trajectory of emotional experiences and related physiological markers and outcomes and the ways in which induced affect compares with naturally occurring affect in predicting behaviors. Still less is known about how to measure and operationalize group-level emotions. For example, existing epidemiological cohorts could generate fundamental knowledge about affective science, while contributing to efforts designed to understand affective trajectories of individuals with cancer, if affect could be assessed more precisely with shorter, validated measures. Following individuals and groups as they move from cancer prevention through detection, diagnosis, treatment, and survivorship may lend insight into the trajectory of affective experiences, how they function in the context of physiological responses, and how they differ depending on health and social support network. Moreover, cancer control efforts that leverage and connect large, population-level data sets would benefit from unconventional group-level operationalization of affect (e.g., affect assessed at the census level; social network analysis) to predict outcomes of individuals who live in an area.

Varied cancer decision-making contexts may also lend themselves to novel methods for studying in-the-moment emotion and real-world responses and for examining affect over time rather than in thin slices in a laboratory. For example, one could videotape people being consented and coding for emotional cues associated with outcomes and satisfaction with those outcomes (e.g., Albrecht et al., 2008) or could unobtrusively observe couples' conversations and code for emotional content that may be related to psychological adjustment to cancer (Robbins et al., 2014). Studying the brain directly is also important; integrating neural measures can provide valuable insights into human behavior in and outside a cancer context (e.g., Amodio, 2010), and cancer may be a context in which the brain could be imaged over time to identify structural and activation changes associated with emotion trajectories. Furthering the basic science of subjective experience through advances in measurement and technology is critical to advancing cancer prevention efforts.

Conclusion

Interdisciplinary efforts between cancer control and affective science will yield deeper insights into workings of the human mind within the context of health and disease. From this perspective, it is critical to build cross-disciplinary partnerships and collaborations to address questions like those identified in this article. We have before us a wealth of untapped opportunities. Affective scientists who focus on basic questions can be motivated to consider research possibilities in a cancer context, focusing on unique opportunities and advantages with more representative populations. Similarly, cancer control scientists can be motivated to collaborate with and to seek out affective scientists to inform cancer control efforts by applying rigorous affective science theory and methodology to applied cancer problems and questions. Interdisciplinary research is always filled with challenges, but challenge fuels discovery. The history of science teaches us that one must communicate across unfamiliar theories, vocabularies, and viewpoints to reach a novel context for discovery. For those of us who wonder about the basic mechanisms of affect and emotion or who strive to improve cancer control, such challenges can be an opportunity to speed scientific discovery in both fields and improve public health in the process.

Notes

1. The USPSTF is a government-appointed panel of experts who routinely review available evidence and make formal recommendations for medical procedures and screenings.
2. A classic basic emotion approach characterizes emotions as categories that are irreducible or basic at both the psychological and biological levels of analysis, with universal neural processes that are automatically triggered by the environment; a revision of this approach states that specific patterns of cognitive appraisals trigger these emotions and biological patterns. Psychological construction theories hypothesize that an emotion word names a category of highly variable instances of that emotion, and a given instance emerges as a complex construction of more basic, domain-general biological and psychological processes that are not specific to emotion per se (see, e.g., Averill, 2012; Barrett, 2013; Ekman & Cordaro, 2011; Ellsworth, 2013; Levenson, 2011; Lindquist, 2013; Mason & Capitanio, 2012; Panksepp & Watt, 2011).

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