



Affective cognition: Exploring lay theories of emotion



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ABSTRACT

Humans skillfully reason about others' emotions, a phenomenon we term *affective cognition*. Despite its importance, few formal, quantitative theories have described the mechanisms supporting this phenomenon. We propose that affective cognition involves applying domain-general reasoning processes to domain-specific content knowledge. Observers' knowledge about emotions is represented in rich and coherent lay theories, which comprise consistent relationships between situations, emotions, and behaviors. Observers utilize this knowledge in deciphering social agents' behavior and signals (e.g., facial expressions), in a manner similar to rational inference in other domains. We construct a computational model of a lay theory of emotion, drawing on tools from Bayesian statistics, and test this model across four experiments in which observers drew inferences about others' emotions in a simple gambling paradigm. This work makes two main contributions. First, the model accurately captures observers' flexible but consistent reasoning about the ways that events and others' emotional responses to those events relate to each other. Second, our work models the problem of *emotional cue integration*—reasoning about others' emotion from multiple emotional cues—as rational inference via Bayes' rule, and we show that this model tightly tracks human observers' empirical judgments. Our results reveal a deep structural relationship between affective cognition and other forms of inference, and suggest wide-ranging applications to basic psychological theory and psychiatry.

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1. Introduction

It is easy to predict that people generally react positively to some events (winning the lottery) and negatively to others (losing their job). Conversely, one can infer, upon encountering a crying friend, that it is more likely he has just experienced a negative, not positive, event. These inferences are examples of reasoning about another's emotions: a vital and nearly ubiquitous human skill. This ability to reason about emotions supports countless social behaviors, from maintaining healthy relationships to scheming for political power. Although it is possible that some features of emotional life carries on with minimal influence from cognition, reasoning about others' emotions is clearly an aspect of cognition. We propose terming this phenomenon *affective cognition*—the collection of cognitive processes that involve *reasoning about emotion*.

For decades, scientists have examined how people manage to make complex and accurate attributions about others' psychological states (e.g., Gilbert, 1998; Tomasello, Carpenter, Call, Behne, & Moll, 2005; Zaki & Ochsner, 2011). Much of this work converges

on the idea that individuals have *lay theories* about how others react to the world around them (Flavell, 1999; Gopnik & Wellman, 1992; Heider, 1958; Leslie, Friedman, & German, 2004; Pinker, 1999). Lay theories—sometimes called intuitive theories or folk theories—comprise structured knowledge about the world (Gopnik & Meltzoff, 1997; Murphy & Medin, 1985; Wellman & Gelman, 1992). They provide an abstract framework for reasoning, and enable both explanations of past occurrences and predictions of future events. In that sense, lay theories are similar to scientific theories—both types of theories are coherent descriptions of how the world works. Just as a scientist uses a scientific theory to describe the world, a lay *observer* uses a lay theory to make sense of the world. For instance, people often conclude that if Sally was in another room and did not see Andy switch her ball from the basket to the box, then Sally would return to the room thinking that her ball was still in the basket: Sally holds a *false belief*, where her beliefs about the situation differs from reality (Baron-Cohen, Leslie, & Frith, 1985). In existing models, this understanding of others' internal states is understood as a *theory* that can be used flexibly and consistently to reason about other minds. In this paper, we propose a model of how people likewise reason about others' emotions using structured lay theories that allow complex inferences.

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Within the realm of social cognition, lay theories comprise knowledge about how people's behavior and mental states relate to each other, and allow observers to reason about invisible but important factors such as others' personalities and traits (Chiu, Hong, & Dweck, 1997; Heider, 1958; Jones & Nisbett, 1971; Ross, 1977; Ross & Nisbett, 1991), beliefs and attitudes (Kelley & Michela, 1980), and intentions (Jones & Davis, 1965; Kelley, 1973; Malle & Knobe, 1997). Crucially, lay theories allow social inference to be described by more general principles of reasoning. For example, Kelley (1973)'s Covariational Principle describes how observers use statistical co-variations in observed behavior to determine whether a person's behavior reflects a feature of that person (e.g., their preferences or personality) or a feature of the situation in which they find themselves. There are many similar instances of lay-theory based social cognition: Fig. 1 lists just several such examples, such as how lay theories of personality (e.g., Chiu et al., 1997), race (e.g., Jayaratne et al., 2006), and "theories of mind" (e.g., Gopnik & Wellman, 1992) inform judgments and inferences—not necessarily made consciously—about traits and mental states. Although lay theories in different domains contain vastly different *domain-specific* content knowledge, the same common principles of reasoning—for example, statistical co-variation, deduction, and induction—are *domain-general*, and can be applied to these lay theories to enable social cognitive capabilities such as inferences about traits or mental states.

Lay theories can be formalized using Bayesian statistics using *ideal observer models* (Geisler, 2003). This approach has been used successfully to model a wide range of phenomena in vision, memory, decision-making (Geisler, 1989; Liu, Knill, & Kersten, 1995; Shiffrin & Steyvers, 1997; Weiss, Simoncelli, & Adelson, 2002), and, more recently, social cognition (e.g., Baker, Saxe, & Tenenbaum, 2009). An ideal observer analysis describes the optimal conclusions an observer would make given (i) the observed evidence and (ii) the observer's assumptions about the world. Ideal observer models describe reasoning without making claims as to the mechanism or process by which human observers draw these conclusions (cf. Marr, 1982), and provide precise, quantitative hypotheses through which to explore human cognition.

We propose that affective cognition, too, can be understood as reasoning with a lay theory: that is, affective cognition comprises domain-general cognitive processes applied to domain-specific knowledge about emotions (Fig. 1). Domain-specific knowledge comprises the observers' lay theory of emotion, and includes, for example, beliefs about what emotions are, how they are caused, and how people behave in response to emotions. We propose that this complex knowledge can be captured in a causal model, and

that observers use domain-general reasoning and inference processes to draw conclusions from this knowledge, similar to those used in perception and other domains. We make these ideas precise below by constructing an ideal observer model of emotional reasoning: we describing the domain-specific knowledge in a statistical causal model, and the domain-general reasoning as an application of Bayesian inference.

1.1. *Attributing emotional reactions*

How does an observer infer that agents (the targets of affective cognition) who spill a cup of coffee, miss the bus, or fall off a bicycle, likely feel similar (negative) emotions? One problem that any model of affective cognition must deal with is the combinatorial explosion of outcomes and emotional states that people can experience. It would be both inefficient and impractical for observers to store or retrieve knowledge about the likely affective consequences of every possible situation. We hypothesize that people circumvent this complexity by evaluating situations based on a smaller number of "active psychological ingredients" those situations contain. For instance, many emotion-inducing situations share key common features (e.g., the attainment or nonattainment of goals) that consistently produce particular emotions (Barrett, Mesquita, Ochsner, & Gross, 2007; Ellsworth & Scherer, 2003). An individual in a situation can take advantage of this commonality by *appraising* the situation along a small number of relevant appraisal dimensions: that is, reducing a situation to a low-dimensional set of emotion-relevant features (Ortony, Clore, & Collins, 1988; Schachter & Singer, 1962; Scherer, Schorr, & Johnstone, 2001; Smith & Ellsworth, 1985; Smith & Lazarus, 1993).

We propose that observers similarly reduce others' experience to a small number of emotionally relevant features when engaging in affective cognition. The examples above—spilling coffee, missing the bus, and falling off a bicycle—could all be associated, for instance, with unexpectedly losing something (e.g. coffee, time, and health). Note that the features relevant to the person's actual emotions (identified by appraisal theories) may not be identical to the features used by the observer (which are part of the observer's lay theory). The latter is our focus when studying affective cognition. Thus, we will first elucidate the situation features relevant for attributing emotion to another person. We operationalize this in Experiment 1 by studying a simple family of scenarios—a gambling game—and considering a variety of features such as amount of money won, prediction error (the amount won relative to the expected value of the wheel), and distance from a better or worse outcome.

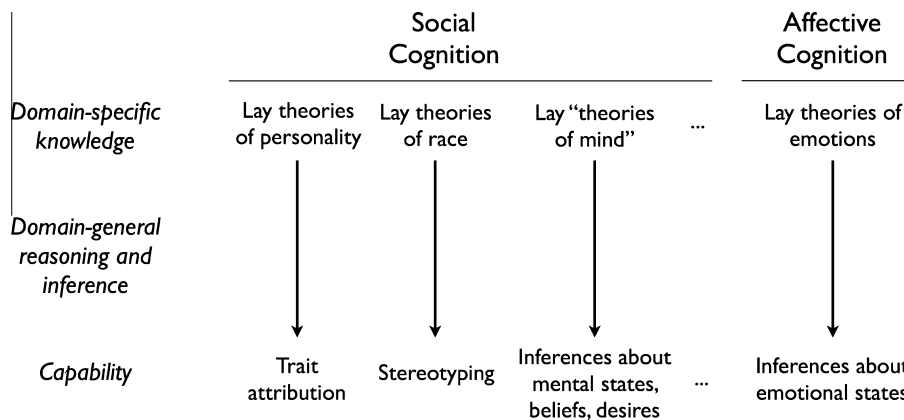


Fig. 1. Lay theories within social cognition comprise domain-specific knowledge about behavior and mental states. Inferences about traits and beliefs occur when observers apply domain-general reasoning processes to these lay theories. In an analogous fashion, we propose that affective cognition is domain-general reasoning over domain-specific knowledge in a lay theory of emotions.

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