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Effects of specific emotions on subjective judgment, driving performance, and perceived workload

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ABSTRACT

The aim of this paper was to explore effects of specific emotions on subjective judgment, driving performance, and perceived workload. The traditional driving behavior research has focused on *cognitive* aspects such as attention, judgment, and decision making. Psychological findings have indicated that *affective states* also play a critical role in a user's rational, functional, and intelligent behaviors. Most applied emotion research has concentrated on simple valence and arousal dimensions. However, recent findings have indicated that different emotions may have different impacts, even though they belong to the same valence or arousal. To identify more specific affective effects, seventy undergraduate participants drove in a vehicle simulator under three different road conditions, with one of the following induced affective states: anger, fear, happiness, or neutral. We measured their subjective judgment of driving confidence, risk perception, and safety level after affect induction; four types of driving errors: Lane Keeping, Traffic Rules, Aggressive Driving, and Collision while driving; and the electronic NASA-TLX after driving. Induced anger clearly showed negative effects on subjective safety level and led to degraded driving performance compared to neutral and fear. Happiness also showed degraded driving performance compared to neutral and fear. Fear did not have any significant effect on subjective judgment, driving performance, or perceived workload. Results suggest that we may need to take emotions and affect into account to construct a naturalistic and generic driving behavior model. To this end, a specific-affect approach is needed, beyond the sheer valence and arousal dimensions. Given that workload results are similar across affective states, examining affective effects may also require a different approach than just the perceived workload framework. The present work is expected to guide emotion detection research and help develop an emotion regulation model and adaptive interfaces for drivers.

1. Introduction

Psychologists now widely accept that it is impossible for people to think or perform an action without engaging their emotional system, at least unconsciously (Nass et al., 2005). A dynamic, complicated driving task presents such a context where emotions and affect can lead to enormous consequences. For instance, the road-rage phenomenon provides an example of the overt impact that emotions can have on driving safety. To date, a systematical approach to affect-related driving

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research has yet to be thoroughly investigated. The majority of driving behavior models has focused more on cognitive aspects of the drivers (e.g., Boer, Hildreth, & Goodrich, 1998; Endsley, 1995; Liu & Salvucci, 2001). They do not include affective elements as a *variable* to consider when modeling a driver. Rather, such factors seem to be labeled as noise or errors in the model. Overall, affect has been treated peripherally and sporadically. The objective of the present study is to examine roles and effects of specific affective states (i.e., anger, fear, and happiness, compared to neutral) on driving behavior in terms of both theory and practice.

2. Affective effects on cognitive tasks

2.1. Taxonomy: Emotions and affect

Affect describes several relevant constructs that are distinct, but frequently treated as interchangeable, including emotions, feelings, and moods (for a more thorough investigation of the terms, see Lottridge, Chignell, & Jovicic, 2011). However, researchers agree that affect is more typically used as a generic label including any other related terms (Forgas, 1995; Hudlicka, 2003; Lottridge et al., 2011; Mayer, 1986). Based on this notion, for the present paper, we will try to use 'affect' or 'affective state' as the most inclusive term as compared to other terms. Where appropriate, we will follow the traditional usage of terms in the specific research domain. Moreover, depending on the relationship between the source of the affect and the task requiring a response, integral affect (related to the task) and incidental affect (not related to the task) are differentiated (Bodenhausen, 1993). For the current experiment, we will focus on incidental affect (e.g., past emotional experience irrelevant to the current driving task).

One of the most common approaches to understanding the experience of emotions is the circumplex model, in which emotions are arranged in a circle around the intersection of two core dimensions of affect (Russell, 1980). The circumplex model maps emotions according to their *valence*, which indicates how negative or positive they are, and their *activation,* which indicates their level of arousal. This model has been useful as a basic taxonomy or classification system of mood states (Barrett, Mesquita, Ochsner, & Gross, 2007). However, throughout the current paper, we will show the important reasons why researchers need to go beyond the simple valence and arousal dimensions to conduct more accurate affect research.

2.2. General and specific affective effects on cognitive tasks

Considerable research has examined whether affect influences attentional tasks (Derryberry & Tucker, 1994; Fredrickson & Branigan, 2005; Olivers & Nieuwenhuis, 2006; Rowe, Hirsh, & Anderson, 2007) or judgment and decision making tasks (Arkes, Herren, & Isen, 1988; Conway & Giannopoulos, 1993; Isen & Geva, 1987; Wright & Bower, 1992) depending on valence. Those studies generally showed the mood-congruent effects (Constans & Mathews, 1993; Johnson & Tversky, 1983; Mayer, Gascke, Braverman, & Evans, 1992): participants in positive moods estimated positive events as more likely than participants in negative moods and those in positive moods showed better task performance.

Recent research, however, suggests that one should be cautious in generalizing these mood-congruent effects to all cases and shows specific affective effects in terms of domain or affect. For example, a study investigated the relationship between visual attention tasks and the mood of participants using the valence and arousal (low vs. high) dimensions (Jefferies, Smilek, Eich, & Enns, 2008). With complex results it was difficult to conclude that a positive mood or high arousal yields better performance. Research in judgment and decision making tasks also showed specified results. Students with increased anxiety for an *exam* showed an increase in risk perception only for the *exam*, but not for other tasks (Constans, 2001). *Happy* participants made faster lexical decisions to *happiness*-related words, but not to other positive words. (Niedenthal & Setterlund, 1994). Even within the same valence, different affective states influence judgments differently. Fearful people made pessimistic judgments about future events, whereas angry people made optimistic judgments (Gallagher & Clore, 1985; Lerner & Keltner, 2000). Clearly, these results are not compatible with the mood-congruent effects. Moreover, the difference in arousal does not provide an alternative explanation. Even though both anger and fear are associated with high arousal, they showed different risk taking tendencies (Mano, 1994). These findings highlight the possibility that task performance may not directly be linked to the simple valence or arousal dimension. Therefore, researchers need to specify connections between a task and each emotional state.

3. Affective effects on driving tasks

While the previous section emphasizes the specific affective effects on cognitive tasks, this section focuses on how the driving literature delineates specific affective effects on driving performance and safety.

3.1. Taxonomy: Driving-specific affect dimension

To conduct research on emotions and affect, researchers first need to assess what kind of emotions would be important in their domain. To date, applied affect researchers have mainly depended on the valence and arousal dimensions or basic emotions (e.g., Ekman, 1992; Plutchik, 1994). Since these basic models are well known and robust across cultures, an existing