MEASURING AFFECT WITH THE 2-DIMENSIONAL CIRCUMPLEX: CHOOSING THE RIGHT ROTATION

(Spine title: MEASURING AFFECT WITH THE 2-D CIRCUMPLEX)

(Thesis format: Monograph)

by

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Graduate Program
in
Psychology

A thesis submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Graduate Studies
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THE UNIVERSITY OF WESTERN ONTARIO
FACULTY OF GRADUATE STUDIES

CERTIFICATE OF EXAMINATION

Supervisor	Examiners
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Supervisory Committee	______________________
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entitled:

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Doctor of Philosophy

Date 2 June 2004

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Chair of the Thesis Examination Board

ABSTRACT

The behavior of employees at work is a function of both thoughts and feelings. Although considerable research has been devoted to understanding the cognitive aspects of work experiences, considerably less has been devoted to understanding the emotional aspects. Correspondingly, there is still a great deal of uncertainty concerning how to best conceptualize and measure emotions in the workplace. The purpose of this research was to resolve a controversy concerning how to best represent emotional experiences using a 2-dimensional affect circumplex. The affect circumplex has been conceptualized in terms of Valence and Arousal axes but also in terms of Positive and Negative Activation (PA and NA) axes. Although any orientation of the axes is possible, these two approaches represent the most popular orientations of the axes underlying the circumplex. Unfortunately, it is impossible to determine the most appropriate rotation using traditional 2-mode factor analysis. With this type of analysis, both the Valence and Arousal and PA and NA solutions are mathematically valid ways of representing the affect circumplex and both fit the data equally well. The current investigation used 3-mode parallel factor (PARAFAC) analysis to empirically determine axes underlying the circumplex. With this approach, different rotations of the factor axes account for different proportions of the variance in the data and the algorithm converges upon the *single* best-fitting set of axes.

Two studies were conducted in which participants watched a series of emotion-evoking film clips and recorded their emotional reactions after each of the film clips. In Study 1, 85 female participants recorded their affective state using 24 emotional adjectives on 12 occasions. Although any rotation of the axes was possible, PARAFAC analyses revealed that the best-fitting axes for 2-dimensional affective space were Valence and

Arousal. To determine the extent to which a 2-dimensional model of affective space was appropriate, I also explored the viability of solutions with more than 2 dimensions. This exploratory investigation suggested that more than 2 factors were required to account for the range of emotional experiences elicited by the film clips. In Study 2, 349 female participants recorded their affective state using 32 emotional adjectives on 25 occasions. Consistent with Study 1, the best fitting axes for the 2-dimensional affective space were Valence and Arousal. Further exploration of higher-dimensional solutions in Study 2, suggested by Study 1, revealed that three factors were needed to describe the affective experiences elicited in this study, although solutions with more than three factors were also interpretable. Most importantly, this 3-factor solution (arousal, positive valence, negative valence) provided evidence for the separation of positive and negative emotions. This finding is consistent with biological evidence suggesting different brain areas are responsible for arousal, positive affect, and negative affect. These results also illustrate the importance of using multi-mode methodologies to investigate affective experiences. An important implication of these findings to the workplace is that the popular 2-dimensional conceptualization of affect, based on PA and NA, is not appropriate. The consequences of using this inappropriate conceptualization of affect for developing theories to understand employee behavior are discussed.

Keywords: affect, affect circumplex, valence, arousal, positive affect, negative affect, positive activation, negative activation, PA, NA.

ACKNOWLEDGEMENTS

The journey toward obtaining a Ph.D. can both exciting and somewhat intimidating. I was fortunate that the quest for my Ph.D. was guided by my advisor John Meyer. Without his continuous encouragement and advice this project would not have been possible. Over the course of this journey he has taught me how to be a rigorous researcher and a teacher with a strong sense of humanity. I am deeply indebted to him for his support.

Every project can be improved by advice of experts and I was fortunate that this project benefited from the insights of Natalie Allen, Russell Cropanzano, Joerg Dietz, Richard Goffin, and Rod Martin. As well, I would like to thank Richard Harshman, not only for serving my defence committees, but also for providing me with many hours of instruction concerning 3-mode factor analysis. My dissertation was greatly improved through the thoughtful comments of these individuals.

The day to day hassles associated with my dissertation was substantially lessened by the data entry assistance I received from Sarah Irwin and John Orwin. Their assistance with data wrangling kept me sane. Finally, I would like to thank my family and friends who have helped me thorough out the Ph.D. process – obtaining my degree would not have been possible without your support.

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LIST OF ABBREVIATIONS, SYMBOLS, NOMENCLATURE

ALS	Alternating Least Squares
NA	Negative Activation
NV	Negative Valence
OCB	Organizational Citizenship Behaviour
PARAFAC	Parallel Factor analysis
PA	Positive Activation
PV	Positive Valence
SVD	Singular Value Decomposition

CHAPTER 1: AFFECT -- THE NEW APPROACH TO UNDERSTANDING EMPLOYEE BEHAVIOR

Emotions play an important role in our lives. In fact, many of the most important events in our lives are quite possibly designated as such because of their emotional intensity. The emotions we experience affect how we respond to situations as well as how we process information and make decisions. As a result, emotions can have a large impact on people's behavior in the workplace. Indeed, the way in which employees interact with supervisors, subordinates, peers, and clients is likely influenced by how they are feeling. Moreover, the extent to which people are able to perform effectively in certain types of jobs may even be determined by how well they are able to regulate their emotions. Consequently, after long neglect, emotions are currently receiving a substantial amount of attention in the organizational behavior and industrial/organizational psychology literatures (Brief, 2001; Weiss, 2002).

Some of the earliest attempts in the 20th century to study the determinants of employee performance focused on the behaviors required to perform certain tasks. Indeed, the first quarter of the century focused on the behaviors associated with optimal employee performance and how to elicited them (Latham & Budworth, 2004). This approach was epitomized by the work of Fredrick Taylor who conducted studies to determine the optimal way to physically design and perform any job (Taylor, 1911). He argued that a large portion of employees' wages should be based on the extent to which they obtained a specified goal using the optimal behaviors he identified (Taylor, 1911; Latham & Budworth, 2004). This focus on behaviors can also be seen in the more contemporary Behavioral Management approach which views employee behavior as a function of its consequences (Luthans & Kreitner, 1975, 1985; Stajkovic & Luthans, 2003).

A focus on the relation between employees' internal states and productivity did not occur until the second quarter of the 20th century. During this period, research was based on the premise that positive attitudes about one's work would have a positive effect on job performance (Latham & Budworth, 2004). This period also marked some of the first investigations into the relation between employees' affective states and job performance (e.g., Fisher & Hanna; 1931, Hersey, 1932; Hoppock; 1935). Unfortunately, the study of affective states was eventually subsumed into the study of job satisfaction which was usually assessed by primarily cognitive measures, a trend which has continued for the most part to the present day (Brief & Weiss, 2002). Although studying employees from a cognitive perspective has been quite fruitful, this research has been criticized on the grounds that it neglects the powerful influence of emotions and conceptualizes employees as little more than "cognitive stick figures" that respond to every situation in a perfectly rational way (Brief, 2001).

A theme emerging from the last decade of research is that a complete understanding of employee behavior cannot be gained without taking *emotions* into account. This rediscovery of workplace emotions is particularly well illustrated in the comprehensive Affective Events Theory (Weiss & Cropanzano, 1996). Moreover, with each passing year there is considerably more research devoted to understanding the role of affect at work. Indeed, Weiss (2002) noted that the rediscovery of workplace emotions has produced special issues of *Organizational Behavior and Human Decision Processes*, *Journal of Organizational Behavior*, *Leadership*

Quarterly, *Human Resource Management Review* and edited volumes (e.g., Lord, Klimoski, & Kanfer, 2002; Payne & Cooper, 2001). As well, a group of researchers from the Academy of Management recently created a forum for emotion researchers called EMONET that has resulted in numerous papers and several conferences dedicated solely to the study of emotions in the workplace. This shift toward the study of emotions in the organization is so profound that Barsade, Brief, and Spataro (2003) called it a new "paradigm," in the true Kuhnian scientific revolution sense of the word, for the study of organizational behaviour.

Indeed, the increased focus on emotions in the workplace has stimulated research in a number of areas. Most notably this research has investigated: the affective nature of job satisfaction (Connolly & Viswesvaran, 2000; Fisher, 2002; Judge & Larsen, 2002; Weiss, 2002), the link between affect and job performance (Cropanzano & Wright, 2000; Wright, Cropanzano, Denney, & Moline, 2002; Wright & Staw, 1999), the link between affect and turnover intentions (George & Jones, 1996; Shaw, 1999), the link between affect and OCBs (Kemery, Bedeian, & Zacur, 1996; Lee & Allen, 2002; Spector & Fox, 2002), reactions to organizational change (Mossholder, Settoon, Armenakis, & Harris, 2002; Paterson & Cary, 2002; Vince & Broussine, 1996), affective processes in teams (Jordan, Ashkanasy, Haertel, & Hooper, 2002; Pirola-Merlo, Haertel, Mann, & Hirst, 2002; Wolff, Pescosolido, Druskat, 2002), as well as emotional labor (Holman, Chissick, & Totterdell, 2002; Zapf, 2002) and regulatory focus (Brockner & Higgins, 2002) at work. Moreover, interesting research is emerging that examines the nature of leadership and the role of emotions in the emergence of leaders, employee perceptions of them, and the processes by which leaders are able to motivate their employees (Humphrey, 2002; Newcombe & Ashkanasy, 2002; Pescosolido, 2002). The preponderance and diversity of recent research on affect makes it easy to see why Barsade et al. (2003) termed it a new paradigm!

Given the rate at which research is being conducted on affective experiences in the workplace, it is tempting to assume that there is consensus on how to best conceptualize and measure emotional experiences. Unfortunately, this is not the case. Indeed, for purposes of illustration, consider two recent studies cited in the previous paragraph that conceptualized emotions quite differently. Mossholder et al. (2000) conceptualized affect based on the assumption that emotions consist of a valence component (ranging from positive to negative) and an arousal component (ranging from low to high). In contrast, Lee and Allen's (2002) measures were based on the assumption that emotions consists of a positive activation (PA) component and an negative activation (NA) component. Recognizing the uncertainty of how emotions should be conceptualized, Lee and Allen also examined their data in terms of specific emotions -- an indication that the question of how to best conceptualize emotions is far from clear.

Complicating the issue even further is the fact that many researchers appear to be unaware of (or choose to ignore) the fact there is still disagreement in the basic psychological literature concerning the structure of affect (c.f., Russell & Carroll, 1999a; Watson & Tellegen, 1999a). Currently, the most popular conceptualization of affect is the PA and NA approach. Indeed, this approach is so wide-spread that it was used by Connolly and Viswesvaran (2000) in their meta-analysis of affect and job satisfaction. The validity of a conceptualization of affect should not, however, be confused with its popularity.

Before establishing a large base of literature on the role of affect in the workplace, it is *critical* that the structure of affective experiences be determined. Otherwise, if it is later discovered that the “popular” conceptualization of affective experiences does not correspond with the “true” nature of affect, findings based on the “popular” conceptualization might be little more than statistical artefacts and the implications of those findings correspondingly limited. Furthermore, because it is quite common to choose a measurement approach based on *precedent,* it is imperative that a valid and universally accepted conceptualization of emotion is established in the near future.

In order to establish a basis for conceptualizing and measuring affective experiences in the workplace, it is necessary to examine the basic psychological literature on the nature of emotions. Therefore, in Chapter 2, I introduce the affect circumplex model currently favoured by psychologists and describe two popular versions of the model. Following this, in Chapter 3, I describe how neither physiological nor psychological research has been able to determine which circumplex model is most appropriate. In Chapter 4 I outline why psychologists using traditional 2-mode factor analysis have been unable to resolve which circumplex model is most appropriate. More importantly, I also illustrate in this chapter how a type of 3-mode factor analysis overcomes the limitations of 2-mode factor analysis, and how it can be used to determine the most appropriate circumplex model. In Chapter 5 I report the results of two short studies used to pretest stimuli and materials to be used in my primary studies. In Chapters 6 and 7 I report the results of two 3-mode factor analytic studies used to identify the best circumplex model. Finally, in Chapter 8, I return to an applied perspective and discuss how my findings have implications for both measure and theory development in Industrial and Organizational Psychology.

CHAPTER 2: THE NATURE OF AFFECTIVE EXPERIENCES

The study of emotions is complicated and, consequently, there are different approaches to conceptualizing affective experiences. For example, affective experiences can be studied in terms of *basic emotions,* or in terms of the *dimensions* underlying all emotional experiences. Although the two approaches initially appear quite different they are actually quite compatible and describe dimensions/emotions that can be similar in nature. The main difference between the two approaches is the rationale for determining the number of dimensions/emotions. The basic emotion approach is based on a desire to explain specific emotions in terms of their evolutionary significance whereas the dimensional approach is based on a desire to describe the subjective experience of emotions.

Basic Emotion Approach

The basic emotion approach to conceptualizing affective experiences is founded on the premise that there is a set of core emotions from which the breadth of human emotional experience is derived (Weiss, 2002). This approach has its roots in the writings of Darwin who looked for similarities between emotional reactions of humans and animals (LeDoux, 1996). He proposed that for all animals (including humans and "lower" creatures) there was a set of innate (i.e., inherited and not learned) expressive actions that contributed to evolutionary success. Critical to this view is the concept of modularity. Evolutionary psychologists view the brain not as an all-purpose computer, but as a set of evolutionarily-created programs designed to respond to specific situations (Weiss, 2002). These programs (or modules) are the foundation for the categories of basic emotions such as fear, sadness, or anger. Ortony and Turner (1990) argued against the existence of basic emotions based on the fact that there was great variability in the number of basic emotions proposed by different researchers. Moreover, they even went so far as to suggest that progress in the field was being impeded by the persistence of basic emotion theory. However, after reviewing the biological basis for basic emotions, LeDoux (1996), suggested that, although there is variability in estimates of the number of basic emotions, the approach has substantial value beyond that suggested by Ortony and Turner.

Dimensional Approach

The dimensional approach to conceptualizing affective experiences is based on the assumption that emotions result from fluctuations in a few underlying dimensions of experience. Essentially, supporters of the dimensional approach argue that affect is largely non-specific and that some emotions (e.g., fear and anger) are very similar to each other in nature (Gray & Watson, 2001). That is, fear and anger can be considered similar to each other because they can both be described as unpleasant and arousing. In contrast, fear and excitement can be considered as quite different because, although they are both characterized by a high degree of arousal, they differ in terms of the pleasantness associated with each emotion. In these examples, each emotion can be thought of as a combination of two underlying dimensions of experience (pleasantness and arousal)[1].

The sources of evidence used in the dimensional approach are typically the results of factor-analytic studies of self-ratings of emotion, or analyses of perceived differences between emotions. Similar to the basic emotion approach, estimates of the number of

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[1] These examples are based on the pleasantness and arousal dimensions; however, a different set of dimensions could also have been used.

underlying dimensions have varied. In recent years though, estimates have generally converged toward a quite robust 2-dimensional model of affective experiences (Gray & Watson, 2001).

Basic Emotions vs. Dimensions: Not So Different

Despite the issues still to be resolved, both the basic emotion and dimension approaches are important and provide different types of information about a person's affective state. Furthermore, although the dimensional view and the basic emotion view may initially appear quite different, they can, in some cases, be quite similar. Consider, for example, the way in which the basic emotion approach differs from the dimension approach with respect to the production of affective states. The dimensional approach typically views an affective state as resulting from the combined influence of the underlying affective building blocks (dimensions). For example, anger can be thought of as resulting from the combination of two underlying dimensions of affective experience (valence and arousal). That is a high level of arousal combines with a high level of unpleasantness (negative valence) to create anger. This combining of affective building blocks to produce an emotional state contrasts with the typical basic emotion approach of using a different emotional label for each state (see LeDoux, 1996). However, some basic emotions researchers (e.g., Plutchik, 1980) suggest that the basic emotions "blend" to create less basic emotions similar to the way dimensions combine to create specific emotion. For example, according to Plutchik (1980) two basic emotions, fear and surprise, might combine to produce a state of alarm. Thus, the distinction between basic emotions and dimensions is not as clear as it might initially seem.

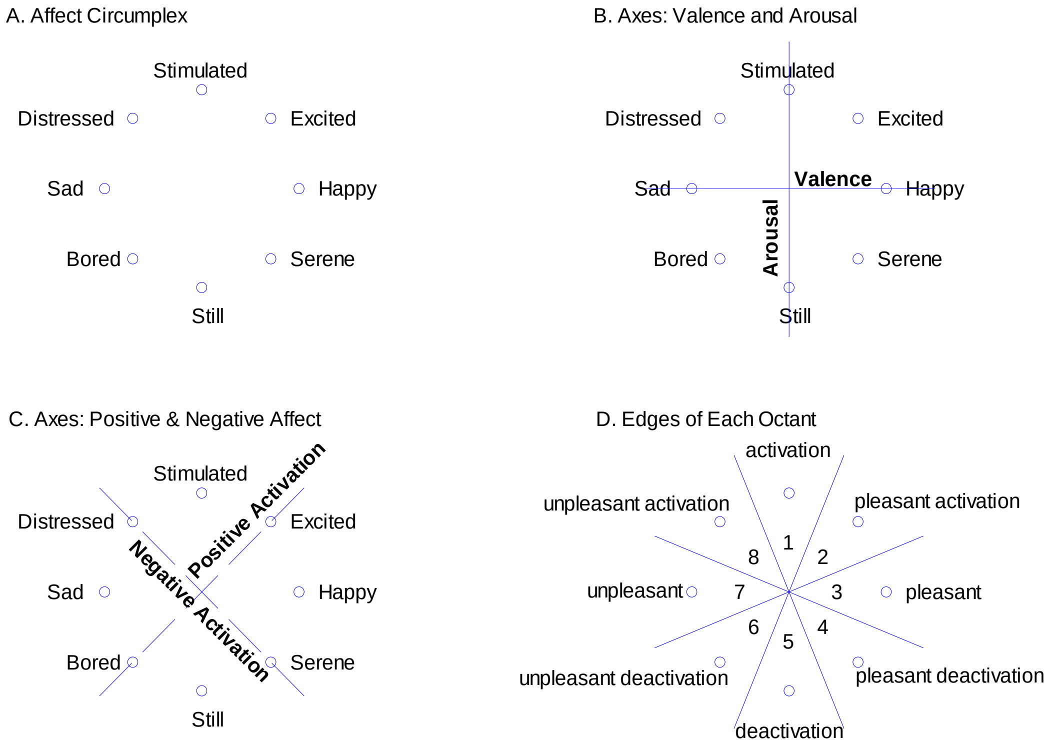
Conceptualizing Affect in the Current Investigation

The approach to representing affective experiences used most often in industrial and organizational psychology is a 2-dimensional approach (Weiss, 2002) and, consequently, this approach is used for the current investigation. Although this investigation was inspired by questions about affective experiences at work, it will be conducted in a lab context due to the methodological considerations to be discussed in Chapter 4. The 2-dimensional approach has been used widely, however, and therefore investigations of its structure should be generalizable. Indeed, the 2-dimensional approach to examining affective experiences has been used in variety of non-work contexts such as the study of weight loss (Landers, Arent, & Lutz, 2004), the relation between menstruation and women's mood (Reilly & Kremer, 2001), the effect of oral contraceptives on mood (Oinonen & Mazmanian, 2001), the relation between mood and locus of control (Henson & Chang, 1998), and the relation between affect and alcohol use (Randall, 1995). The number of diverse contexts in which the 2-dimensional conceptualization of affective experiences has been used suggests that the structure of affective experiences is similar across situations. Therefore, the question of how to best represent workplace emotions appears to be synonymous with how to best represent emotional experiences in general.

The 2-Dimensional Affect Circumplex

Within the dimensional view of affective experiences, the 2-dimensional affect circumplex model is most prevalent (Larsen, Diener, & Lucas, 2002). In this model, emotions are arranged in a circular pattern in 2-dimensional space as seen in Figure 1A. This circular configuration of points is produced by the factor analysis of self-rated

Figure 1
2-Dimensional Affect Circumplex Models



Note: Labels for 1D are based on Larsen and Diener (1992)

emotions. Each emotion can be described in terms of two underlying dimensions or axes (i.e., its position can be described as an *x,y* pair). There is, however, considerable debate over the most appropriate axes to describe the circumplex. Some authors have suggested the best way to conceptualize the circumplex is in terms of Valence and Arousal axes (i.e., V&A, see Figure 1B; e.g., Russell, 1980) whereas others suggest that the Positive and Negative Activation[2] axes are most appropriate (i.e., PA and NA, see Figure 1C ; e.g., Watson & Tellegen, 1985). The difference between the PA and NA and Valence and

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[2] The 'PA' and 'NA' labels have been used in the literature to refer to Positive and Negative 'Affect' as well as 'Activation.' The distinction is an important one. For example, Positive 'Affect' has sometimes been used to refer to any type of positive emotion but also to describe the Positive Activation axis illustrated in Figure 1C. In this manuscript, PA and NA will be used to refer to the axes in Figure 1C whereas the terms 'positive affect' and 'negative affect' will be used to describe generally positive or negative emotional states.

Arousal approaches is that the axes are rotated approximately 45 degrees. When the axes for the two models are combined into a single illustration, the end points of the axes form the *center* of eight octants. The *edges* of these octants are illustrated in Figure 1D and labeled using the terms suggested by Larsen and Diener (1992).

Valence & Arousal

The valence and arousal model of affect is based on the premise that valence and arousal are the fundamental dimensions of affect (see Figure 1B). In terms of the octants, the valence axis is the axis that links octants 3 (pleasant) and 7 (unpleasant) whereas the arousal axis is the axis that links octants 1 (activation) and 5 (deactivation; see Figure 1B and 1D). A high positive loading on the arousal axis suggests a state characterized by a high degree of arousal that is described by adjectives such as surprised or stimulated (when the valence loading is zero). In contrast, a high negative loading on this axis suggests a state characterized by a low degree of arousal (neither positive nor negative) that is described by adjectives such as still or quiet (when the valence loading is zero). A high positive loading on the valence axis suggests a state characterized by a moderate degree of arousal that is very positive and described by adjectives such as happy or pleased (when the arousal loading is zero). In contrast, a high negative loading on this axis suggests a state characterized by a moderate degree of arousal that is very negative and described by such adjectives as sad or unhappy (when the arousal loading is zero). Thus, an emotion such as distress has a high negative valence loading and a high positive arousal loading (octant 8 -- unpleasant activation), whereas an emotion such as depressed has a high negative valence loading and a low negative arousal loading (octant 6 --

unpleasant deactivation).

Positive Activation and Negative Activation (PA and NA) Model of Affect

The positive and negative activation model of affect is based on the premise that there are separate positive and negative activation systems that combine to produce emotional experiences. In terms of the circumplex described above, the negative activation axis is the axis that links octants 8 (unpleasant activation) and 4 (pleasant deactivation) whereas the positive activation axis is the axis that links octants 2 (pleasant activation) and 6 (unpleasant deactivation; see Figure 1C and 1D). A high positive loading on the positive activation axis suggests a state characterized by a high degree of arousal that is positively valenced and described by adjectives such as elated or excited (when the NA loading is zero). In contrast, a high negative loading on this axis suggests a state characterized by a low degree of arousal that is negatively valenced and described by such adjectives as sluggish or drowsy (when the NA loading is zero). A high positive loading on the negative activation axis suggests a state characterized by a high degree of arousal that is negatively valenced and described by adjectives such as distressed or fearful (when the PA loading is zero). In contrast, a high negative loading on this axis suggests a state characterized by a low degree of arousal that is positively valenced and described by adjectives such as calm or relaxed (when the PA loading is zero). Thus, an emotion such as distress (octant 8 -- unpleasant activation) has a high NA loading and a zero PA loading whereas an emotion such as depressed (octant 6 -- unpleasant deactivation) has a low negative loading on PA and a zero loading on NA.

Determining the Appropriate Axes for 2-Dimensional Space

The debate over the best way to conceptualize affect is often incorrectly framed as determining which one of two competing models (Valence and Arousal vs. PA and NA) is correct. Framing the debate in this way oversimplifies the problem. Both the Valence and Arousal model and the PA and NA model are attempts to describe the structure of emotions using factor analysis. As I will discuss in Chapter 4, both models are the result of the particular *rotation strategy* used by each camp to try to orient the 2-dimensional axes in the most meaningful position. In fact, *any* orientation of the axes is viable because all orientations of the axes fit the data equally well with traditional 2-mode factor analysis (Larsen & Diener, 1992). Indeed, the most appropriate axes for describing 2-dimensional affective space might not correspond to either the Valence and Arousal or PA and NA rotations. Thus, the purpose of the current investigation is best described, not as a test of competing models, but rather as an attempt to determine the "correct" orientation of the axes of 2-dimensional affective space.

The issue of which orientation of the axes is "correct" is based on the idea that every orientation of the axes can be considered an attempt to mathematically describe ratings of emotions (to be discussed in detail in Chapter 4). With traditional factor analysis, every orientation of the axes in a 2-factor solution is valid and all orientations fit the data equally well. Consequently, the concept of a "correct" rotation does not usually arise. This does not mean, however, that the differences between the rotations are trivial. Indeed, although it is possible to generate any number of axes to describe the 2-dimensional affect circumplex, each set of axes will produce a different pattern of relations with external criteria (e.g., job performance). In theory, only one set of axes will correspond with the actual experience of emotion -- this set of axes is considered the "correct" rotation.

Despite the fact that any rotation of the circumplex axes is viable, researchers tend to prefer the valence and arousal or PA and NA approaches, possibly because they are produced by the two most commonly used rotation strategies (i.e., no rotation and varimax rotation). In the next chapter (Chapter 3) I will review the research that is typically used to support each of these popular axis orientations (i.e., Valence and Arousal and PA and NA). Following this I will review the mathematical issues associated with establishing a "correct" rotation in Chapter 4.

CHAPTER 3: RELEVANT RESEARCH BEHIND THE ROTATION DEBATE

The debate concerning the most appropriate way to conceptualize affective experiences is complex and has been based on a number of issues that I will review in this chapter. First, I will discuss the research concerning how many dimensions are required to represent affective experiences. Second, I will review the research leading to the two most popular conceptualization of the 2-dimensional affect circumplex. Last, I will review the extent to which findings from affective neuroscience provide support for the different representations of the 2-dimensional affect circumplex.

Number of Dimensions.

A variety of multidimensional conceptualizations of affective experiences have been proposed over the years that vary both in terms of the number of dimensions as well as the interpretation of those dimensions (e.g., Bradburn, 1969; Burke, Brief, George, Roberson, & Webster, 1989; Nowlis, 1965; Schimmack & Grob, 2000; Schlosberg, 1954; Thayer, 1967). Initial factor analytic investigations of self-rated affect revealed between 5 and 11 factors that correspond more with basic emotions (e.g., Nowlis, 1965) than fundamental dimensions of affect (Watson & Tellegen, 1985). More recently, the consensus is that affective space is best described by between two and four factors (Lazarus, 1991). The two-dimensional circumplex model of affect currently receives the most use and dominates the field (Larsen et al., 2002). However, a recent review of the affect literature suggested that popularity of the two dimensional circumplex is somewhat regional in nature. More specifically, Schimmack and Grob (2000) suggested that, although the two dimensional model of affect is popular with North American researchers (e.g., Lange, 1995; Larsen & Diener, 1992; Russell, Weis, & Mendelsohn, 1989; Thayer, 1989; Watson & Clark, 1997), many non-North American researchers prefer a three dimensional model of emotion (e.g., Matthews, Jones, & Chamberlain, 1990; Sjoberg, Svensson, & Persson, 1979; Steyer, Schwenkmezger, Notz, & Eid, 1994).

Interestingly, some proponents of the two-dimensional circumplex are also considering higher dimensional conceptualizations of affective space (e.g., Watson & Clark, 1992, Watson & Clark, 1994). These researchers are attempting to recover factors that correspond to the specific emotions recovered in early factor analysis research. The difference between this new research and the older work is that specific emotions are now being conceptualized as part of a hierarchical model (e.g., Watson & Clark, 1992). Second-order factor analysis of the specific emotion factors is used to produce the broad positive and negative activation factors from the circumplex model (e.g., Tellegen, Watson, & Clark, 1999a; Tellegen, Watson, & Clark, 1999b). Nonetheless, two factors are recovered[3] from self-rating of affect with the most consistency (Diener & Iran-Nejad, 1986), and this is likely the reason for the current popularity of the 2-dimensional model.

Interpretation of the Dimensions from the 2-Factor Solution

The debate concerning how to best interpret the dimensions underlying affective space is a long one that is rife with confusion. A careful examination of the literature reveals that most of the literature has been devoted to trying to understand Bradburn's (1969) finding that ratings of positive emotions did not correlate highly with ratings of negative emotions. Indeed, the majority of the literature has dealt with trying to understand the "independence" of positive and negative emotions more than specifically demonstrating the superiority of one 2-dimensional model (rotation) over the other. The

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[3] The solution selected by each researcher as most appropriate using various criteria.

confusion appears to have has occurred mainly out of subtleties in the language used by the researchers.

Indeed, considerable misunderstanding has resulted from the fact that researchers have had different conceptualizations of what the terms ‘positive affect’ and ‘negative affect’ mean (for a complete discussion of this issue see Feldman Barrett & Russell, 1998). Some researchers (e.g., Watson & Clark, 1985; Watson et al., 1988) have interpreted positive and negative affect as being highly activated emotions (i.e., Positive and Negative Activation; represented by octants 2 [pleasant activation] and 8 [unpleasant activation] in Figure 1), whereas others (e.g., Russell, 1980, Russell & Feldman Barrett, 1998) have interpreted these terms as referring to moderately-activated emotion (represented by octants 3 [pleasant] and 7 [unpleasant] in Figure 1). Consequently, research suggesting that positive and negative affect were independent of each other was interpreted as being at odds with other research suggesting that valence was a primary dimension of affective experience. Thus, although the only difference between the two models reviewed in Chapter 2 is the rotation of the axes, the research has not always been clearly focused around this point.

Russell’s (1980) article established the current dominance of the affect circumplex and emphasized that it was important to include emotions in the low arousal regions of the circumplex. Russell argued that the circumplex is the best way to represent emotions on the basis of the factor analysis of self-ratings as well as multidimensional scaling research, which examined emotional words and faces, that also revealed a circumplex structure. Even at this early stage, Russell noted that “one interesting property of a circumplex is that, since rotation of the axes leaves the circular configuration of the variables intact, rotation is considered arbitrary" (p. 1171). Interestingly though, Russell (1980) actually obtained five factors (using the eigenvalue equal to, or greater than, one criterion) in his landmark article but opted for a more parsimonious solution with two factors (although second-order factor analysis of the 5-factors also resulted in the circumplex structure).

If the prominence of the circumplex model of affect was established by Russell (1980), it was cemented by Watson and Tellegen (1985). In their influential article, Watson and Tellegen reviewed a wide array of studies and firmly emphasized that affective space across all studies reviewed was best described by "two dominant dimensions, not one or three" (1985, p. 233). Furthermore, they demonstrated how the circumplex structure could be represented by two varimax rotated factors – positive and negative activation.

Despite the fact that both of the major advocates of the affect circumplex noted the difference between the two models was rotational, an abundance of further research was stimulated by these articles. Indeed, Green, Goldman, and Salovey (1993) described the ensuing flurry of factor analysis research as a "cottage industry" bent on demonstrating that positive and negative affect were independent across a variety of contexts. This wave of research resulted in the identification of various factors that could influence the "independence"[4] of positive and negative affect.

First and foremost, the importance of the particular adjectives used to represent affective space was determined. Watson (1988) administered a survey of mood adjectives and constructed a variety of different PA and NA scales using subsets of the adjectives

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[4] 'Independence' is used in a very colloquial way in the affect research, and only occasionally corresponds to the mathematical definition of orthogonality (i.e., the sum of the dot-product for two basis vectors (axes) equals zero).

that corresponded to measures previously used in the literature. He found that the correlation between the *scale scores* was influenced by the adjectives used. This finding was undoubtedly a major impetus for the subsequent development of the PANAS (Positive and Negative Affectivity Schedule) which established a common set of emotional markers for researchers (Watson et al., 1988). Somewhat problematically, in an attempt to provide only "pure" markers of positive affect (octants 2 [pleasant activation] through 4 [pleasant deactivation], see Figure 1) and negative affect (octants 6 [unpleasant deactivation] through 8 [unpleasant activation], see Figure 1), Watson et al. chose only adjectives that were high in arousal and represented the ends of the axes they used to define the circumplex (i.e., only adjectives from octants 2 [pleasant activation] and 8 [unpleasant activation] were included in the scale, see Figure 1). Thus the PANAS does a good job of measuring high positive and negative *activation*, but because it does not cover the full range of positive and negative affect it is a poor representation of the affect circumplex (Russell & Carroll, 1999a).

Fortunately, an expanded version of the PANAS was later developed (the PANAS-X; Watson & Clark, 1994) that included low arousal adjectives. This new measure provided the researchers with the ability to assess *general positive and negative activation* (using the original PANAS adjectives), as well as eleven more specific emotions – thus, it is a sort of hybrid measure that encompassed both the dimensional and basic emotion approaches. The measure uses 60 adjectives which can be broken down into subsets to create the different scales. For example, researchers are directed to use a 20-adjective subset to create the PA and NA scales, and an 8-item subset to create a *joviality* scale. Although the authors unfortunately suggest measuring PA and NA using the original PANAS adjectives (a 20-item subset), rigorous researchers can, of course, deviate from the authors' suggestions and use all 60 PANAS-X items to assess emotions from the entire circumplex.

An additional finding that came from the abundance of affect research was that the time frame over which affective experiences were measured is important. Warr, Barter, and Brownbridge (1983) suggested that Bradburn's (1969) surprising finding that positive and negative self-rated affect were independent could reflect the independence of positive and negative life events over the time period for which affect was rated. They hypothesized that when participants were asked to report affect over a specified time period, ratings might reflect the independence of positive and negative *events* more than *emotions*. Warr et al.'s data were consistent with their hypothesis, and revealed that the number of positive and negative events in peoples' lives were independent.

Subsequently, Diener and Emmons (1984) found that the length of the time period over which affect was measured was important. More specifically, they found that positive and negative affect were highly negatively related when studied in momentary affect, but relatively independent when subjects were studied over longer periods. This finding is consistent with Warr et al.'s (1983) research which concluded that when subjects report how they have felt over long periods of time the ratings reflect the independence of events rather than emotions. Logically, these two findings are very compelling. The frequency of positive and negative events in a person's life must be distinguished from the structure of affective experiences at one moment in time (i.e., an instant in time). Thus, the structure of affective experience is best studied by examining momentary affective reactions.

The debate over which conceptualization of affective space is correct has continued to receive substantial attention. Indeed, 1999 was a banner year for publications examining the issue (e.g, Green & Salovey, 1999; Russell & Carroll, 1999a; Russell & Carroll, 1999b; Russell & Feldman Barrett, 1999; Tellegen, Watson, & Clark, 1999a; Tellegen, Watson, & Clark, 1999b; Watson, Wiese, Vaidya, & Tellegen, 1999; Yik, Russell, & Barrett, 1999). The articles published during this period did a great deal to sort out some of the major sources of confusion (e.g., the language issues discussed previously) between the two approaches to describing the structure of affective space. Indeed, a consensus between the two camps emerged in a final set of articles which demonstrated that there is substantial agreement about the *approximate* structure of the circumplex, and that the remaining disputes are about the rotation of affective space axes rather than the structure of affective space (c.f., Russell & Carroll, 1999b; Watson & Tellegen, 1999).

Findings from Affective Neuroscience

An important question relevant to choosing the correct circumplex model is the extent to which it is consistent with the biology of emotion. A model of self-rated affect should ideally reflect activation of the brain areas responsible for emotional experiences. Unfortunately, we currently do not know how the *experience* of emotion relates to the *biology* of emotion. Although it is likely that the two overlap substantially, this is not necessarily the case. Green, Salovey, and Truax (1999) suggested the analogy of room temperature to illustrate fluctuations along the *Valence* dimension to illustrate this point. The air temperature of a room results in the *experience* of feeling warm or cold. However, the temperature could be the result of two different types of mechanisms. One possibility is that the air in the room is provided by a single ventilation system that infuses air at a specific temperature (the valence approach). Alternatively, the room could have two ventilation systems; one that provides hot air and one that provides cold air. The air from these two systems combines to create a single room temperature (the positive and negative affect approach). Regardless of how the temperature in the room is produced, however, it varies along a single dimension ranging from hot to cold (Valence). Thus, knowledge of biology alone is insufficient to determine the most appropriate way to describe emotional experiences. Nonetheless, an understanding of the biology of emotion does provide a more comprehensive view of the circumplex debate.

Emotional experiences are produced by an underlying biology that is extremely complex and it is only in the last decade that substantial progress has been made toward identifying the brain structures associated with emotion. Affective neuroscience researchers, like researchers of self-rated emotion, have been concerned with the question of whether there are separate systems for positive and negative affective experiences. Currently, data from lesion, neuroimaging (fMRI), and electrophysiological studies provide converging support for the finding that the anterior cortex plays a critical role in the valence of emotional experience (Canli, Desmond, Zhao, Glover, & Gabrieli, 1998; Davidson, 2001; Davidson, 1993; Davidson & Irwin, 1999). More specifically, the valence of emotional experiences is related to the asymmetrical activation of the prefrontal cortex (PFC) across the left and right hemispheres. That is, positive affective experiences are related to greater relative activation of the left PFC whereas negative affective experiences are related to the greater relative activation of the right PFC.

Interestingly, support for the lateralization of valence has also been provided in the post-mortem examination of patients with major depressive disorder. The muted positive affect associated with depression was associated with the atrophy of the neurons in the left PFC. More specifically, examination of the left PFC in these patients revealed a 12-15% reduction in cortical thickness and a 22-37% reduction in the density of large neurons (Davidson, 1998; Davidson, Pizzagalli, Nitschke, & Putnam, 2002; Rajkowska, 2000). However, despite the considerable evidence that the brain areas responsible for positive and negative emotions are distinguishable, there is substantial overlap in the neural pathways of both systems (Lane et al., 1997). Rather than regarding these systems as independent, a better view is to regard them as distinguishable components of a larger emotional system (Lane et al., 1997).

Although the PFC has been implicated in the valence of emotion, it has been suggested that an alternate area of the brain is responsible for the arousal associated with emotions (Heller, 1993; Heller, Nitschke, & Lindsay, 1997; Heller & Nitschke, 1997). Heller and her colleagues have suggested that the parietal temporal region of the right-hemisphere is responsible for the arousal associated with emotional experiences. Support for this separation of arousal from the valence of affective experience was recently provided in a study examining emotional reactions to films using a methodology similar to Schachter and Singer (1962). Mezzacappa, Katkin, and Palmer (1999) randomly assigned participants to receive an epinephrine or saline injection prior to viewing a series of films. They found that participants who received the epinephrine injection rated pure arousal film clips (i.e., non-valenced) as more intense than participants who did not receive the injection. In contrast, ratings of film clips designed to elicit positive and negative emotions were not influenced by this arousal manipulation.

Thus, three areas of the neo-cortex have been identified as relevant to the experience of emotion. Valence and Arousal researchers (e.g., Russell & Feldman Barrett, 1999) focus on all three areas and suggest that experience of valence is based on the relative activation of the left and right PFC, whereas the experience of arousal is based on activation of the rear-right parietal area. In contrast, PA and NA researchers (e.g., Watson et al., 1999) focus only on the pre-frontal areas of the cortex, and use the fact that it is an *asymmetrical* activation of the PFC that produces positive and negative emotions as evidence for the notion that PA and NA are independent.

Summary

Factor analysis of self-rated emotions produces a 2-dimensional circumplex representation of emotional experiences. Although researchers generally agree that a 2-dimensional circumplex model of emotional experiences is appropriate, there is considerably less agreement concerning the most appropriate axes to represent the circumplex. All orientations of the axes fit the circumplex equally well[5], however, the two most popular approaches to conceptualizing the circumplex axes are the Valence and Arousal axes and the Positive and Negative Activation axes. Factor analysis will produce both of these two circumplex axes depending upon the rotation strategy (i.e., unrotated or varimax) chosen by the researcher. A substantial amount of self-rating based research has been devoted to determining the most appropriate orientation of the 2-dimensional circumplex axes; however, this research has thus far been inconclusive. Similarly, although the biology of underlying emotions is beginning to be understood, and a number of critical brain areas identified, the evidence is not yet sufficient to determine if a

[5] Using 2-mode factor analysis

particular set of axes is most appropriate. In the next chapter I will discuss how 3-mode factor analysis can be used to provide a powerful new source of evidence in support of once rotation over another.

CHAPTER 4: A STATISTICAL PROBLEM AND SOLUTION

A Statistical Problem

A methodology used extensively in the research reviewed previously is exploratory factor analysis. This type of analysis is a powerful technique for extracting systematic sources of variation from a set of variables. In most cases, a large set of variables can be represented as the combination of a few factors/dimensions. There are a number of approaches to conducting a factor analysis, however, and the "factor analysis" label is a generic term that refers to an entire family of methods.

Two frequently used methods of factor analysis are Principle Components Analysis and Common Factor Analysis. Both types of analyses create factors based on the relationships among a set of variables. However, the two approaches differ with respect to the variance that is modeled. More specifically, scores on a variable can be conceptualized as being determined by (a) the factors that are *common* to all measured variables, (b) the specific variance that is *unique* to each variable, and (c) random error (Bobko, 1992). Principal Components Analysis does not distinguish between common and unique variance. In contrast, Common Factor Analysis distinguishes between common and unique variance, and produces factor that are based on only common variance. Although the theoretical difference between the two approaches is emphasized by some researchers (e.g., Pedhazur & Schmelkin, 1991), others have concluded that, in practice, both approaches lead to quite similar results (e.g., Cliff, 1987; Nunnally, 1978; Stevens, 1992; Velicer & Jackson, 1990). The following discussion of 2- and 3-mode factor analysis refers to principal components analysis[6]; however, I will be using the more general term "factor analysis" to be consistent with the terminology typically used by 3-mode factor analysis researchers.

A notable issue with factor analysis is that the process of identifying the factors extracted is somewhat subjective. With traditional factor analysis (i.e., 2-mode factor analysis of a correlation or covariance matrix), the researcher must make subjective decisions concerning how to generate interpretable dimensions from the extracted factors (i.e., selecting a method for rotating the factors). The factors first extracted in traditional (i.e., 2-mode) factor analysis are referred to as the *initial factor solution*. These factors are independent (orthogonal) and uncorrelated, and can be conceptualized as a set of axes for 2-dimensional space (for a 2-factor solution). The axes used to define the space are the basis for naming the factors. To increase interpretability though, the axes can be rotated. Two general rotation strategies can be used: orthogonal or oblique. Orthogonal rotation strategies (e.g., varimax) maintain the independence of the factors, whereas oblique rotation strategies allow the initially orthogonal factors to correlate in order to increase interpretability. Both rotation algorithms work from the initial orthogonal solution, and therefore the percentage of variance accounted for by the two factor solution does not change. The geometric configuration of the points in a factor analysis is not affected, however, by the rotation method -- only the axes used to define those points are affected. That is, regardless of the rotation used, the points in the analysis (i.e., emotional adjectives) maintain their circumplex configuration. All 2-dimensional rotations of the axes are valid alternative ways of representing the correlation (or

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[6] Common Factor Analysis has not yet been developed for direct-fit 3-mode factor analysis.

covariance) matrix used in 2-mode analysis.

Most importantly, 2-mode factor analysis rotation strategies do not necessarily provide a “correct” rotation, as discussed previously in Chapter 3. Both orthogonal and oblique strategies are examples of *extrinsic* rotation strategies. The rotation is not determined entirely by the data, but also *by a rule set by the researcher*. In the unrotated solution (which typically produces the Valence and Arousal solution), the rule used for *extraction* is that each successive factor accounts for as much unique variance as possible. In contrast, with the varimax rotation (which typically produces the Positive and Negative Activation solution) the objective is to rotate the axes to achieve simple structure[7]. The rationale behind varimax rotation is that maximizing the variance for each factor will create a parsimonious rotation in which each item tends to load high (either positively or negatively) on one factor and close to zero on the others[8]. Thus, the rotated solutions obtained in traditional factor analysis are more a reflection of the extrinsic rule (i.e., rotation strategy) used by the researcher than inherent properties of the data.

The reason 2-mode factor analysis solutions have an “indeterminate rotation” can be understood using a simply analogy. Conceptually, finding a solution with traditional 2-mode factor analysis is similar to finding a solution to an equation such as $5x+27y=17$ for which there are an infinite number of x and y values (in the set of real numbers) that satisfy the equation. Consequently, empirical support for the superiority of one affect circumplex model over another cannot be provided using 2-mode factor analysis. In fact,

[7] Strictly speaking, varimax obtains a structure that is similar, but not identical, to ‘simple structure’ as described by Thurston (1947). However, varimax is described as creating ‘simple structure’ in this manuscript for the sake of consistency with previous affect research.

[8] More specifically, with the varimax rotation strategy, the factors are rotated to so that the variance of the squared loadings for each factor is maximized.

Russell and Carroll (1999) state that determining the correct rotation for the affect circumplex is a “problem [which] seems to defy empirical solution” (p. 5)

A Solution to the Rotation Problem -- 3-Mode Factor Analysis

Fortunately, the problem of which rotation for the circumplex is correct is not a problem without a solution. Three-mode factor analysis is a sophisticated statistical procedure that can provide empirical evidence for the pre-eminence of one rotation. Surprisingly, this form of analysis has not yet been applied to the affective space problem -- quite possibly because of the technical complexities associated with 3-mode analysis, or because it has not yet been included in any of the standard statistical packages.

With 3-mode factor analysis the “correct” rotation can be determined using only the properties of the data -- an *intrinsic* approach. Cattell (1944) first suggested this approach, calling it the *proportional profiles* method. At a basic level, the principle of proportional profiles specifies that underlying dimensions can be determined by finding the rotation that best fits many nonequivalent samples. This approach is based on the principle of constructive replication – for a factor structure to be valid it must, for a given dimensionality, fit multiple data sets. Cattell encountered difficulties in implementing his proportional profiles factor analysis, but the development of 3-mode factor analysis by Tucker (1963) set the stage for Harshman (1970) to implement the proportional profiles logic in his 3-mode PARAFAC (parallel factor analysis) model.

PARAFAC’s Unique Factor Solution

Although 3-mode factor analyses can possess the same rotational indeterminacy as 2-mode analyses, PARAFAC is special instance of 3-mode factor analysis in which there is a single best fitting solution[9]. Because only 3-mode PARAFAC analysis is used in the current investigation all subsequently references to 3-mode analysis refer specifically to 3-mode PARAFAC analysis. In 3-mode PARAFAC analysis, there is a Participants *x* Variables matrix at Occasion 1, a second Participant *x* Variables matrix at Occasion 2, a third Participants *x* Variables at Occasion 3, and so on. For a given dimensionality, the PARAFAC solution is the one that best fits the Participants *x* Variables matrix across all measurement times (i.e., the Participants *x* Variables *x* Occasions data cube). Thus, because the rotation is determined by intrinsic properties of the data, and not by external criteria specified by the researcher (such as simple structure), the rotation is said to represent the "true" underlying structure of the data. Recall the analogy that determining the correct rotation using 2-mode factor analysis is conceptually similar to solving $5x+27y=17$ for which there are an infinite number of x and y values that "fit" the equation equally well. Three-mode PARAFAC analysis is conceptually equivalent to introducing a second equation, $7x-3y=12$, that must also be satisfied by values for x and y. There are an infinite number of x-y pairs that could satisfy the equation $5x+27y=17$, however, there is only one x-y pair that will satisfy the set of equations $5x+27y=17$ and $7x-3y=12$. The addition of the second equation is equivalent to adding the third mode in a 3-mode factor analysis (analogy from Harshman and Lundy, 1984a). Consequently, with 3-mode PARAFAC analysis there is a unique factor solution that is based on intrinsic properties of the data.

9 The uniqueness of the PARAFAC solution occurs because the Tucker core is set to a 3-dimensional identify matrix.

Indirect vs. Direct Factor Analysis

Although many researchers are not aware of it, a 2-mode factor analysis can be conducted directly or indirectly. With the indirect method (illustrated in Figure 2) the factor analysis is based on the *correlation matrix*. More specifically, each variable in the original Participants *x* Variables data matrix (called X) is standardized (M=0, SD=1)[10] to create a "processed data matrix" (called XP). The XP matrix and the transpose of the XP matrix are then multiplied to create a correlation matrix which is subsequently subjected to the principle components analysis. The results of the principle components analysis can then be used to create factor scores for each individual by multiplying the XP matrix by the inverse of the factor loadings (also illustrated in Figure 2).

The direct method of principal components analysis (illustrated in Figure 3) is based on analyzing the *actual data* rather than a correlation matrix that is based on the data. More specifically, the original data matrix X is processed to create a centered and scaled version called XP. The singular value decomposition method is used to break the XP matrix down into three matrices (U, S, and V) which, when multiplied together, will perfectly recreate XP. The U matrix contains the "factor scores" whereas the S and V matrices are multiplied together to create the factor loadings[11]. If a researcher determined that a 3-factor solution was most appropriate then the factor scores and loadings would simply be the first three columns of these two matrices. With appropriate centering and scaling, the results of direct factor analysis are identical to the results of an indirect factor analysis. The ability to conduct a factor analysis directly is what makes 3-

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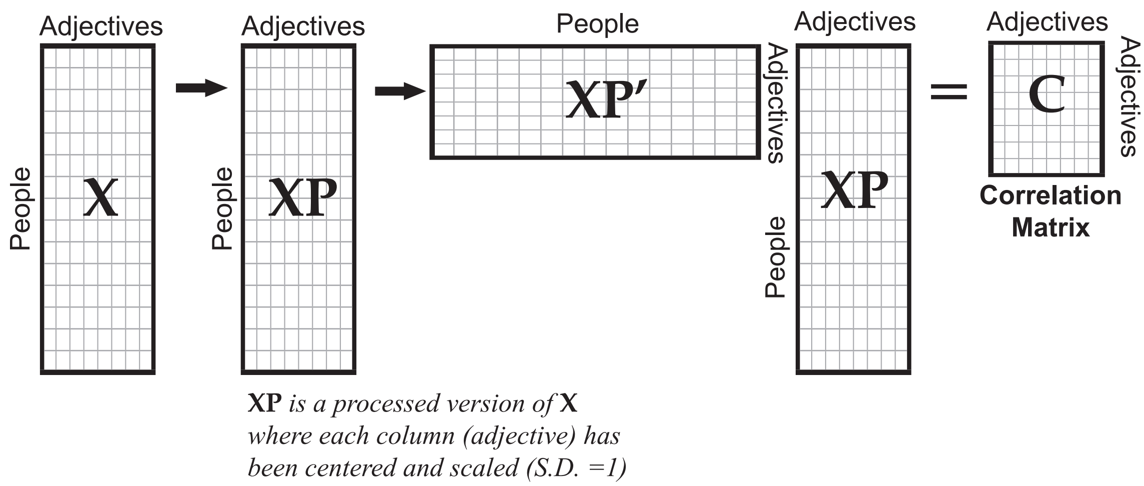
[10] If a covariance matrix is desired for analysis then each adjective is only centered and not scaled

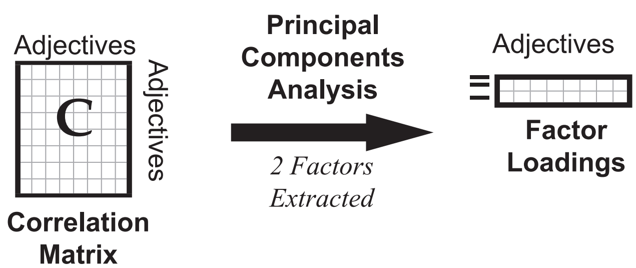
[11] The U matrix is a structure matrix. The S matrix is a diagonal matrix which contains the size of each factor.

Figure 2
Conceptual illustration of indirect 2-mode factor analysis

Step 1: Pre-processing the data and calculating the correlation matrix



Step 2: Calculating factor loadings based on the correlation matrix



Step 3: Calculating factor scores by dividing processed data matrix by factor loadings

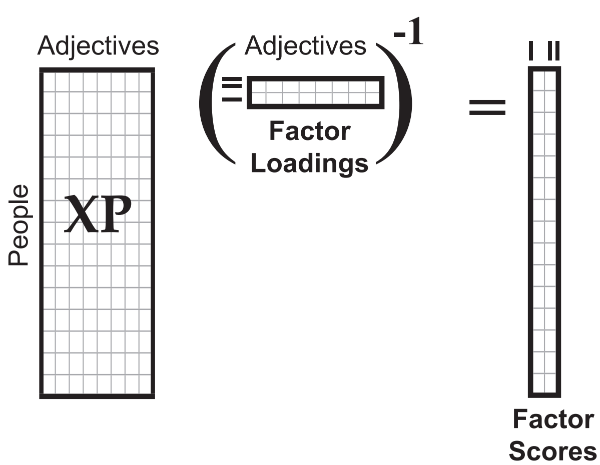
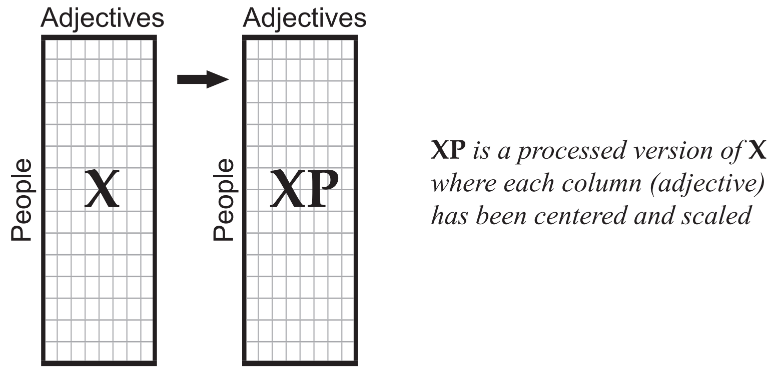
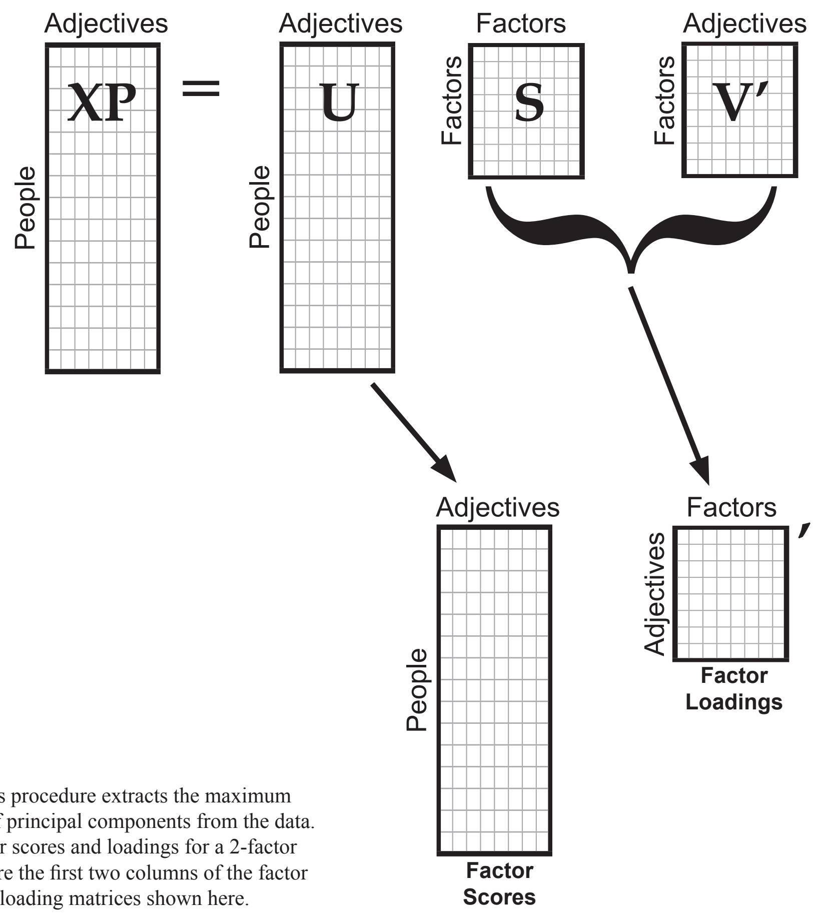


Figure 3
Conceptual illustration of direct 2-mode factor analysis

Step 1: Pre-processing the data



Step 2: Singular Value Decomposition (SVD) based on pre-processed data matrix



Note: This procedure extracts the maximum number of principal components from the data. The factor scores and loadings for a 2-factor solution are the first two columns of the factor score and loading matrices shown here.

mode factor analysis possible.

The advantage of having a third mode is illustrated by examining the mathematical representation of the two approaches to factor analysis. In a traditional 2-mode factor analysis the contribution of each factor is expressed as a bilinear product of the ***a*** loadings (also known as component scores) and the ***b*** loadings. Consider these loadings interpreted as Valence and Arousal for a single participant's endorsement of the emotional adjective *excited*.

$$x_{ij} = a_{i1}b_{j1} + a_{i2}b_{j2} + \text{error}$$

x_{ij}	$a_{i1}b_{j1}$	$a_{i2}b_{j2}$
Participant ***j***'s endorsement of adjective *i (excited)*	amount of arousal in participant i * amount of arousal variance measured by "excited" *FACTOR 1*	amount of pleasantness in participant i * amount of pleasantness variance measured by "excited" *FACTOR 2*

For Factor 1, the ***a*** loadings indicate the amount of arousal being experienced by the participant, whereas the ***b*** loadings indicate the extent to which *excited* is affected by arousal. The product of the ***a*** and ***b*** loadings represents the part of the rating (x_{ij}) that is associated with arousal. Similarly, for Factor 2, the ***a*** loadings represent the amount of pleasantness being experienced by the participant, whereas the ***b*** loadings indicate the extent to which excited is affected by pleasantness. The product of the ***a*** and ***b*** loadings represents the part of the rating (x_{ij}) that is associated with pleasantness. The sum of the Factor 1 and Factor 2 products is the extent to which a two-factor representation of the data can account for participant ***j***'s endorsement of excited. Note that a similar interpretation could be created to describe how PA and NA combined to account for participant ***j***'s endorsement of excited.

Of course participants rate more than a single adjective; therefore, matrix algebra is often a more effective method for describing how the factors can model the structure of the data matrix. A visual depiction of the matrix algebra is presented in Figure 4.1, which illustrates how the factor score matrix is multiplied with the factor loading matrix to create a model of the data. The way in which the two matrices are multiplied is moderated by a "core" matrix that is an identity matrix (zeros except for ones along the diagonal)[12]. The "1" in the upper left of this core matrix indicates that the adjective loadings for Factor 1 should be multiplied by the factor scores for Factor 1. This produces a matrix of the same dimensions as XP that contains all the variance that can be modeled by Factor 1. Similarly, the "1" in the lower right of this core matrix indicates that the Adjective Loadings for Factor 2 should be multiplied by the Factor Scores for Factor 2. This produces a matrix of the same dimensions as XP that contains all the variance that can be modeled by Factor 2. When these two matrices are added together they create XP(hat), the best estimate of XP that can be made based on two factors.

In a 3-mode factor analysis the contribution of each factor is expressed as a trilinear combination of the ***a*** loadings, the ***b*** loadings, and the ***c*** loadings. Consider these loadings interpreted as Valence and Arousal for a single participant's endorsement of the emotional adjective *excited* at time ***k*** (see below). An important aspect of this factor model is that participant loadings (mode ***a***) are now interpreted as the sensitivity of a person to a factor, whereas in 2-mode analysis factor participant loadings (component scores) are interpreted as the level of a person on that factor.

$$x_{ijk} = a_{i1}b_{j1}c_{k1} + a_{i2}b_{j2}c_{k2} + \text{error}$$

x_{ijk}	=	$a_{i1}b_{j1}c_{k1}$	+	$a_{i2}b_{j2}c_{k2}$	+	error
Participant i's endorsement of adjective j *(excited)* at time *k*		arousal sensitivity of participant i * amount of arousal variation measured by "excited" * amount of arousal at time k *FACTOR 1*		pleasantness sensitivity of participant i * amount of pleasantness variation measured by "excited" * amount of pleasantness at time k *FACTOR 2*		

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[12] Since this matrix is always the identity matrix in 2-mode analysis it is usually omitted. It is included here, however, to provide a bridge to understanding 3-mode analysis.

Figure 4
Estimating data using factor loadings

1. Conceptual representation of calculating an estimated data matrix

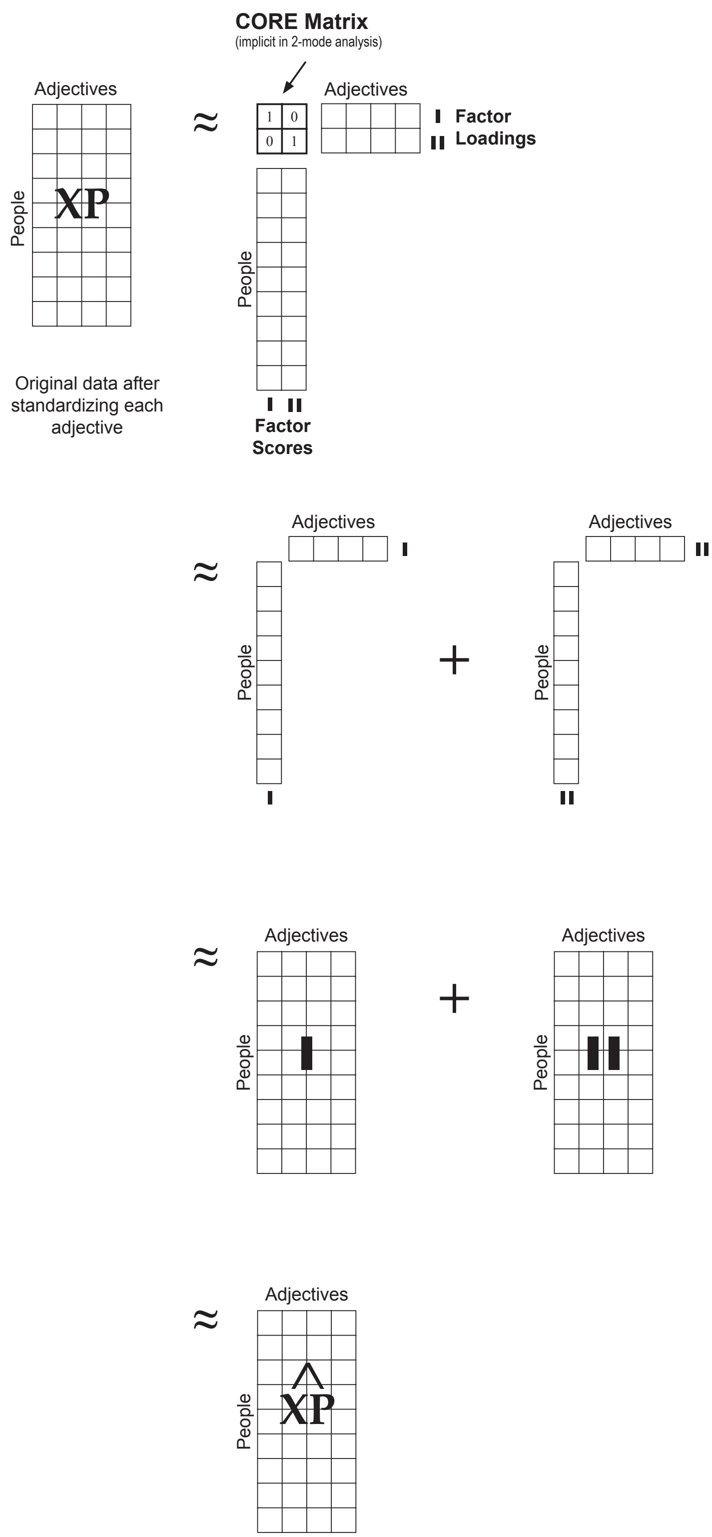
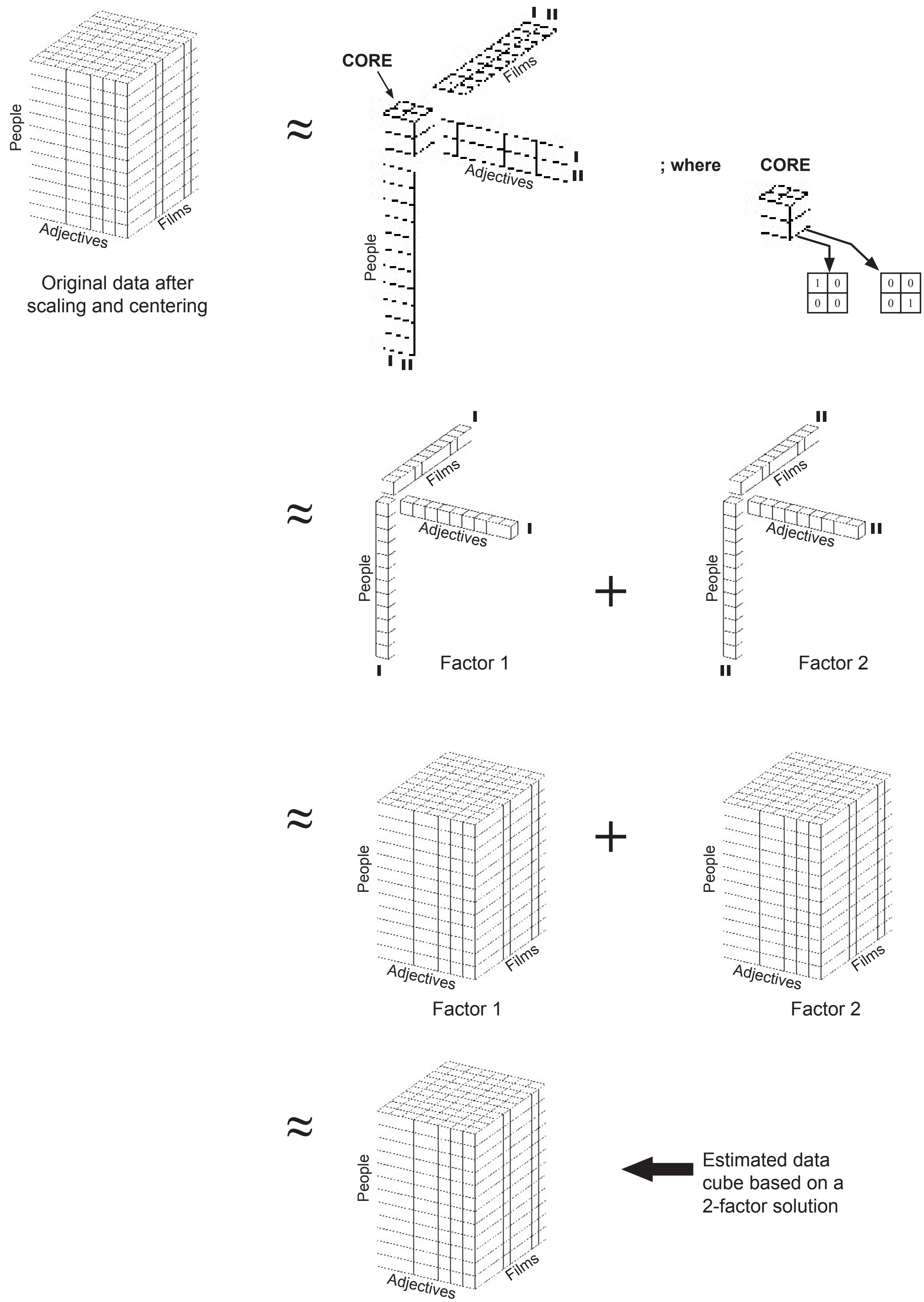


Figure 4 (continued)

2. Conceptual representation of calculating an estimated data cube



A visual depiction of the matrix algebra underlying 3-mode analysis is presented in Figure 4.2, which illustrates how the person-loading matrix is multiplied with both the adjective-loading matrix and the occasion-loading matrix for a two-factor solution. The way in which the three matrices are multiplied is determined by a 3-dimensional “core” that is all zeros except for ones along the superdiagonal (a diagonal in 3-space). The “1” in the upper left of this core indicates that the person loadings for Factor 1 should be multiplied with the adjective loadings for Factor 1 and the occasion loadings for Factor 1. If Factor 1 was the arousal factor this would create a data cube that contained all variation due to arousal. Inspection of the “1” in the lower right of the core indicates that the person loadings for Factor 2 should be multiplied with the adjective loadings for Factor 2 and the occasion loadings for Factor 2. If Factor 2 was the valence factor, this would create a data cube that contained all variation due to valence. Adding these two data cubes together creates an estimated data cube that models the variation from both factors. Figure 4.2 illustrates how this estimated data cube models *the actual ratings made by each individual at every occasion*.

Preprocessing: Centering and Scaling

As discussed above, because of the multiplicative nature of factor analysis, a formal mathematical requirement of both traditional 2-mode factor analysis and 3-mode factor analysis is ratio-scale data. Ratio-scale data are required because a common (and meaningful) zero-point is needed for multiplicative operations. Unfortunately, the self-rating-based data typically collected in psychology is not truly ratio scale because it lacks a consistent and meaningful zero-point. A common zero-point for all participants can be introduced, however, by centering the variables to be factor analyzed (i.e., setting the mean for a column of data to zero). Indeed, in traditional 2-mode factor analysis a zero-point is introduced by centering the data as part of creating a correlation matrix or covariance matrix. Unfortunately, when the zero-point is introduced by centering it is an arbitrary zero-point and, although the profile of loadings (i.e., how high or low variable loadings are on a factor relative to each other) can be interpreted, the absolute value of the loading is not interpretable. An important aspect of conducting factor analysis using the direct fit method (i.e., based on the data and not the correlation matrix) used in this investigation is that the *meaningfulness of the zero-point is not retained in modes that are centered* (Harshman and Lundy, 1984b). In the current study, because the data are centered across the film mode, the zero-point in this mode is arbitrary. The meaningfulness of the zero-point in the adjective and individual modes is retained because these modes are not centered. Consequently, inspection of the factor loadings in adjective-mode will all me to determine if the dimensions are bipolar or unipolar.

Nested factors: 2-mode vs. 3-mode analysis

Another important difference between 2- and 3-mode analyses is the fact that in a traditional 2-mode factor analysis the factors are *nested*. More specifically, the factors extracted in a 2-dimensional solution, prior to rotation, will be the first two factors in all factor solutions with more than two dimensions. An important aspect of 3-mode PARAFAC analysis is that the factors are not nested; rather, the most appropriate factors are extracted for a given dimensionality and the orientation of the axes is based on intrinsic properties of the data. Consequently, the factors in a 2-factor solution do not *necessarily* resemble the factors in a 3-factor solution.

PARAFAC's System Variation Requirement

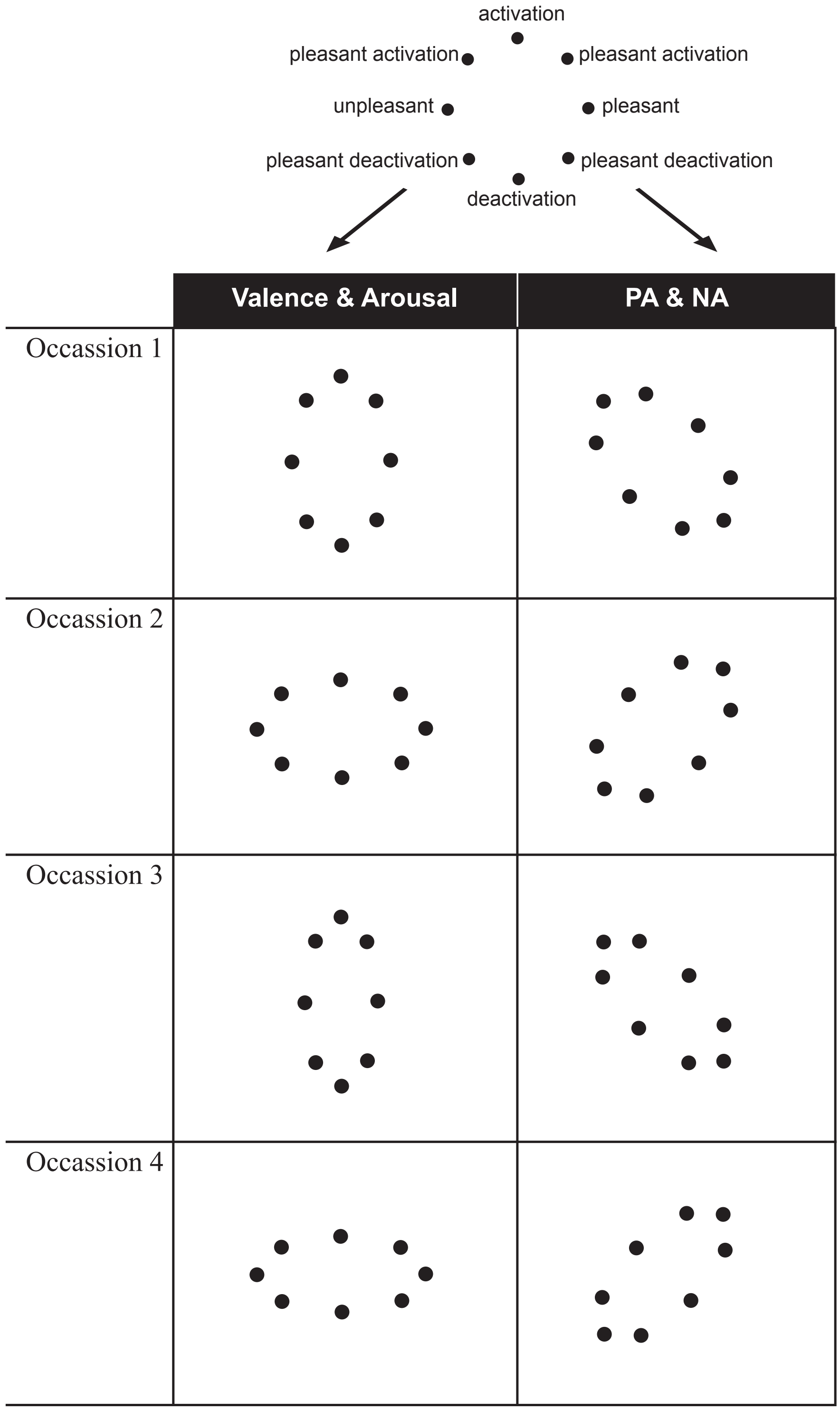
The use of 3-mode PARAFAC factor analysis requires separation of two theoretical models that are typically confounded in typical 2-mode analysis: the object-variation model and the system-variation model (Harshman, 1970). In the object variation model, changes in subjects' scores over time are the result of idiosyncratic variation in each subject. For example, during regular economic periods the price for a given stock (object) will go up or down for idiosyncratic reasons (example from Harshman, 1970). In the system-variation model, however, all stocks prices (objects) could be influenced by a common source of variation such as inflation or depression. A direct fit 3-mode PARAFAC analysis can only be done when there is system-variation. In psychology, however, most of the data collected are best conceptualized as reflecting object variation. Fortunately, the system-variation requirement can be satisfied by using experimental manipulations that alter the relative impact of the factors in a consistent way across all the subjects. Because all participants (objects) are influenced in a consistent way by the manipulations, the changes in a factor's influence across occasions can be represented by changes in a single "occasion weight" for that factor on each occasion. A factor's occasion weight for a given occasion describes how large an impact that factor had across all participants on that occasion. *One need not know in advance, or even guess, what the factors may be*. All that is needed is reasonable assurance that the manipulations will change the relative impact of whatever factors are present. In this project, participants were exposed to a variety of film stimuli to create the required system variation.

System Variation and the Intrinsic Axes of Affective Space

System variation is important for PARAFAC analyses because it is used to orient the axes. The circumplex configuration of emotional adjectives typically described (and illustrated at the top of Figure 5) is based on 2-mode analysis of ratings provided by individuals who are collectively experiencing a variety of affective states. In the current investigation, the affective states of the participants were manipulated (using film stimuli) over a number of occasions so that at each occasion a different mixture of emotions was elicited in participants. For a given occasion, however, all participants were likely to experience a very similar emotional state, so emotional variation across occasions was systematic and coordinated across all participants (system variation). Manipulating the emotional state of participants causes the variance contributed by the underlying dimensions of emotion to change; this causes the circumplex to contract and dilate at each occasion. If a dimension contributes less variance, the circumplex contracts along the direction of that dimension (i.e., it contracts because an axis contracts). Likewise, if a dimension contributes more variance, the circumplex expands in the direction of that dimension. Thus, the circumplex will only contract and dilate along the axes defining affective space and it is this stretching and contraction of the circumplex that PARAFAC uses to orient the axes.

For example, if a 2-mode factor analysis was conducted after participants viewed a single film clip (eliciting a common affective state) the circumplex would be stretched or contracted along the axes defining the space to reflect that affective state. If the participants then viewed a second film clip, and a 2-mode factor analysis was conducted once again, the circumplex would be stretched and/or contracted in a different way along

Figure 5
Illustration of how system variation is used to orient PARAFAC axes



Note: The rows illustrate how system variation causes the axes for 2-dimensional space to stretch and contract at each occasion.The Valence and Arousal column illustrates that pattern of stretching and contracting that would occur if the axes were Valence and Arousal. The PA and NA column illustrates the pattern of stretching and contracting that would occur if the axes were PA and NA.

the axes defining it to reflect the new common affective state. Most importantly, the change in the circumplex that occurs as a result of fluctuations in the relative amounts of the two dimensions from one occasion to the next are mathematically expressed by contracting or expanding the axes, hence it will occur along the directions of the axes defining affective space. Figure 5 illustrates how the configuration of adjectives might change from one occasion to the next for the Valence and Arousal axes as well as the PA and NA axes. Notably, it is impossible for any of the elliptical circumplex configurations in the Valance and Arousal column to occur if the axes underlying the space are PA and NA. Conversely, it is impossible for any of the elliptical circumplex configurations in the PA and NA column to occur if the Valence and Arousal axes underlie the space. The PARAFAC algorithm fits a set of axes that are aligned with the directions of contraction and dilation of the circumplex across all measurement occasions. When the axes of the model are optimally aligned with the direction of these stretches, the model can then adjust the occasion weights for the two factors in order to stretch or contract the fitted circumplex as needed to best fit the data on each occasion[13]. Consequently, there is a single best fitting axis orientation with PARAFAC analyses.

Because the orientation of axes with PARAFAC is based solely on the contraction and dilation of the circumplex, and not upon an external rotation criterion such as varimax, these axes are referred to as the *intrinsic* axes of the space. Note that the frequently employed varimax approach differs substantially from the approach used to

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13 The use of experimental manipulations to create variations in emotion, and then PARAFAC to discover the direction of these variations, makes this arguably an experimental study. First, the two competing theories of emotions are used to make competing theoretical predictions of the directions in which the circumplex would be stretched; then manipulations are imposed, and finally PARAFAC is used to determine the axis orientation and thus see which, if either, of the predictions can be supported experimentally.

orient the axes with PARAFAC. Roughly, the varimax algorithm orients the axes by rotating them to run through clusters of adjectives[14]. In the area of emotions, it is widely agreed that the configuration of adjectives in 2-dimensional affective space is more accurately described as a “circumplex” rather than as “clusters” of adjectives. For this reason, Larsen and Diener (1992) suggested that the varimax approach should not be used to orient the circumplex axes.

The illustration of the rationale behind PARAFAC in Figure 5 also highlights the conditions required for correct recovery of the axis orientations. First, the factors must change in relative importance somewhere in the set of occasions under analysis. If the circumplex is always a circle on each occasion, regardless of the film presented, then the rotation is indeterminate. However, showing a wide variety of different clips will almost certainly cause different relative contributions of the two dimensions to the affective state of the subjects immediately after the clip ends

The second assumption/requirement underlying PARAFAC is that the angle between the factors is consistent from one occasion to the next. That is, the directions in which the circumplex contracts or expands are roughly the same for all subjects, regardless of the movie being rated. In other words, the dimensions of emotion remain relatively consistent across different people and situations. This second assumption/condition would seem to be natural under both Valence and Arousal and PA and NA theories of the dimensions of emotion.

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[14] This is the usual result of the formal Varimax goal of maximizing the variance of squared factor loadings.

Assessing PARAFAC fit

The extent to which the PARAFAC algorithm fit the data is typically assessed using the proportion of explained variance. More specifically, for a given dimensionality, an estimated data cube is created (as illustrated in Figure 4.2) and the sum of squared deviations of each element from the mean of the estimated data cube is calculated (SSfit). Next, for the original data cube (post preprocessing), the sum of squared deviations of each element from the mean of the cube is calculated (SStotal). The proportion of explained variance is calculated using the formula SSfit / SStotal. The PARAFAC algorithm is solved, for the specified number of dimensions, using an iterative procedure that increases fit (proportion of explained variation) for each iteration of the analysis until a convergence criterion is reached.

When the proportion of explained variance for a 3-mode solution is reported, it is based on the extent to which the extracted factors recreate *each individual's ratings*. In contrast, when the proportion of explained variance for a 2-mode solution is typically reported, it is based on the extent to which the extracted factors are able to recreate the correlation matrix[15]. Thus, the 3-mode variance estimates, to be reported in the upcoming analyses, may appear low if they are interpreted as being equivalent to 2-mode variance estimates.

Overview of the Current Research

Previous investigations of the factor structure of 2-dimensional space examined different types of data. Some researchers have focused on the factor structure of within-

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[15] Figure 4.1 correctly implies, however, that it is possible to calculate the proportion of explained variance for a 2-mode factor analysis based on the extent to which the estimated data matrix reproduces the original data matrix (post preprocessing).

subject data measured over multiple occasions (e.g., Zevon & Tellegen, 1982), whereas other researchers examined the factor structure of cross-sectional data (by examining commonalities in the affective experiences of many individuals at the same moment in time). Regardless of the approach used, however, 2-mode factor analysis could not provide unequivocal empirical support for either model of affect because of the indeterminacy of rotation in 2-mode analysis.

The current investigation overcame limitations of previous research by using 3-mode Parallel Factor Analysis (PARAFAC) to estimate the appropriate axes of 2-dimensional affective space. In this investigation participants (Mode A) recorded their current affective state using a variety of emotional adjectives (Mode B) on a variety of occasions (Mode C). System-variation was created on each occasion by having participants view a short film clip selected to evoke an emotional response.

To provide the most accurate estimate for the orientation of the circumplex axes, the adjectives rated by participants, and the emotions evoked by the film clips they viewed, were selected to represent the circumplex. To do this, I conceptualized the circumplex in terms of eight octants; a procedure which is consistent with past research (e.g., Feldman Barrett & Fossum, 2001; Feldman, 1995a; Watson et al., 1999). Next, a number of adjectives were selected to represent each of the eight octants. Then, a number of film clips were created to elicit emotions from each of the eight octants. The two short pretest studies that were used to select the emotional adjectives and stimuli (i.e., film clips) are reported in Chapter 5. In the subsequent chapters (i.e., Chapters 6 and 7) I report the results of two investigations which estimated the appropriate axes for the circumplex.

CHAPTER 5: STIMULI SELECTION

Emotional Adjective Selection

The purpose of this investigation was to generate a list of adjectives that would both cover the complete range of the affect circumplex and be contained in the lexicon of undergraduate participants. The two-fold purpose of this study arose when an examination of the emotional adjectives typically used (e.g., Nowlis, 1965; Russell, 1980; Thayer, 1986; Watson, Clark, & Tellegen, 1988; Watson & Tellegen, 1985) revealed that many of the adjectives were relatively obscure English words (e.g., ennui). Therefore, I conducted this short study to screen for adjective familiarity. Ethics approval for this study (and this entire investigation) is presented in Appendix A.

Screening for Emotion Adjective Familiarity

To ensure a relatively comprehensive population of adjectives to sample from, I compiled a list of 302 emotion adjectives from the following articles: Daly, Lancee, & Polivy; 1983; Diener & Emmons, 1985; Gotlib & Meyer; 1986; Feldman, 1995a; Feldman, 1995b; Feldman Barrett & Russell, 1998; Larsen & Diener, 1992; Mayer & Gaschke, 1988; Meddis, 1972; Nowlis, 1965; Russell & Mehrabian, 1977; Russell; 1978; Russell, 1980; Russell & Feldman Barrett, 1999; Tellegen, et al., 1999b; Thayer, 1986; Watson, et al., 1999; Watson & Tellegen, 1985; Watson, et al., 1988. For the purposes of this investigation, I recruited 21 female students from an introductory psychology class, who participated in return for course credit. Each participant was presented with a complete list of these adjectives and asked to indicate the adjectives for which they did not know the meaning. To ensure a relatively high degree of understanding of the emotional adjectives selected for the main study, I discarded adjectives that were not understood by at least 80% or more of the participants. This resulted in 20 of the 302 adjectives being discarded.

Sorting Emotional Adjectives into Octants

After discarding adjectives that were typically not understood by participants, I split the remaining 282 adjectives into two groups: Octant-Identified and Octant-Unidentified. The octants used are depicted in Figure 1. Adjectives included in the Octant-Identified Group were identified by previous investigators as belonging to a specific octant in the circumplex (c.f., Feldman, 1995a; Feldman, 1995b; Larsen & Diener, 1992; Watson & Tellegen, 1985; Watson et al., 1999). All remaining adjectives were placed in the Octant-Unidentified Group.

Although adjectives included in the Octant-Identified Group were previously identified as belonging to a particular octant, there was occasionally disagreement about in which octant an adjective best belonged. For example, Russell (1980) suggested that *sleepy* belongs in octant 5 (deactivation), whereas Watson and Tellegen (1985) argued for octant 6 (unpleasant deactivation). Therefore, a list of the adjectives for each octant was created by including adjectives identified by any previous study as belonging to that octant[16]. Next, following previous research (e.g., Feldman, 1995b; Feldman Barrett, 1998) two adjectives were selected as markers for each octant by the consensus of four judges (one professor and three graduate students). The 16 emotional adjectives used to represent the circumplex were: (octant 1: stimulated, surprised), (octant 2: peppy, excited), (octant 3: cheerful, happy), (octant 4: calm, relaxed), (octant 5: still, quiet),

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[16] A consequence of this sorting procedure was that a single adjective could be in the list for two or more octants

(octant 6: drowsy, bored), (octant 7: sad, depressed), (octant 8: afraid, distressed). I included an additional eight adjectives because I was also interested in exploring the viability of solutions with more than two dimensions. The eight additional emotional adjectives, randomly selected from the unused adjectives, were: hostile, tense, satisfied, grouchy, angry, startled, gloomy, and uncomfortable.

Film Selection Pretesting

The purpose of this study was to pre-test a set of films that could be used to create the required system variation. More specifically, this study was used to obtain a set of film stimuli such that each film clip would elicit emotions from different locations in the circumplex. The decision to use film clips as emotion-eliciting stimuli was based on the fact that film stimuli are very effective, having been found to elicit both generalized physiological and cardiovascular responses (e.g., Fredickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000; Mezzacappa et al., 1999; Palomba, Sarlo, Angrilli, Mini, & Stegagno, 2000; Wiens, Mezzacappa, & Katkin, 2000). Additionally, the self-ratings of emotion obtained after participants view emotion-eliciting film clips have been related to neural activity in the frontal lobes (e.g., Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Tomarken, Davidson, & Henriques, 1990; Tomarken, Davidson, Wheeler, & Doss, 1992).

Participants

Forty-three undergraduate female students participated in the experiment in return for course credit. Gender was controlled for because of the growing body of research that suggests that the biology of emotion is different for men and women (e.g., George, Ketter, Parekh, Herscovitch, & Post, 1996). Women were specifically selected because film stimuli have been found to be more effective with women (Hagemann, Naumann, Maier, Becker, Lurken, & Bartussek, 1997; Westermann, Spies, Stahl, & Hesse, 1996).

Materials

Selecting film clips to elicit emotions within each of the eight octants is a difficult task. Fortunately, Gross and Levenson (1995) previously validated a set of films as emotional stimuli. These films were intended to target the emotions of surprise, amusement, sadness, anger, and fear. Russell and Feldman Barrett (1999, p. 808), hypothesized that these emotions were located on the circumplex in the areas labeled in this investigation as octants 1 (activation), 3 (pleasant), 7 (unpleasant), and 8 (unpleasant activation). Consequently, the Gross and Levenson film clips were expected to elicit emotions from these octants. Because these film clips provided only partial coverage of the affect circumplex, I screened additional films for clips to use as stimuli. I selected 30 films as likely containing the necessary emotion-evoking clips. After screening the films for emotional content I identified 5 of the 30 initially selected films as containing segments that would evoke emotions in the remaining octants.

Once the desired film segments were identified, the editing process began. In many cases, several segments from a single film were extracted and edited together to create a single “film clip” that was expected to evoke a desired emotion. For the Gross and Levenson (1995) films, the detailed frame by frame editing instructions provided by the authors were used to edit several segments from the same film together for each film clip. In contrast, for the film clips used for the first time in this study, I extracted segments from a variety of locations in the film and pieced these segments together to create a short story to evoke the desired emotion. All film clips were edited onto a single tape. Two tapes were created with different film orders. Each film clip on a tape was preceded by a screen identifying the film number but not the name of the film from which the clip was taken. At the end of each film clip, a screen was included to instruct participants to rate how they felt at that instant. A list of the film clips used is presented in Appendix B.

Procedure

Participants watched a series of film clips and then indicated how the film clips made them feel by rating their affective state using the emotional adjectives from the film pretest study. The task was presented to participants as a film validation study and required slightly less than one hour of participants' time. They were informed that films were sometimes used to manipulate how people feel and that the experimenters were interested in developing a standardized set of films. As well, they were told that some films might create relatively strong emotions in them, whereas others might have no effect. This cover story was expected to minimize demand characteristics associated with rating emotions following the films. The emotional state induced by the film clip was not expected to last very long; therefore, participants were instructed to rate how they felt at the *instant* each film ended. More importantly, ratings of momentary affect were used to ensure that the factors obtained reflected fundamental dimensions of the affect system. If participants had been asked to rate how they felt throughout the course of the film the factor structure of emotion ratings could reflect the *frequency* of certain types of affect in each clip, or the way emotional memories are organized. As well, to ensure accurate ratings, it was emphasized to participants that they should rate "how you feel and not how you believe other people would feel." In order to control for potential carry-over effects, two film orderings were used.

Results

To determine how well the series of films provided coverage of the circumplex, I averaged the ratings for the adjectives representing each octant and plotted the means. Recall that the rationale for eliciting emotions with the various film clips was to produce system variation such that the films clips would each influence the underlying emotion dimensions differently. Consequently, it was the *profile* of octant scores that mattered most. Each film clip was designed to have a different profile across the octants to create *variability in emotion ratings within octants across films*. The octant means are illustrated in Figure 6 with each octant labeled (1 to 8), and the distance of the line from the center of the graph indicates the mean rating (i.e., scale score) of the adjectives for that octant. Visual inspection of these plots revealed variability in emotion ratings within octants across films, suggesting that the film clips created the required system variation.

I also empirically assessed the extent to which the film clips created system variation. Because the PARAFAC algorithm fits system variation, extracting two factors from a cube *with* system variation should result in a better fit (as indexed by the proportion of explained variation) than extracting two factors from a cube *without* system variation. Consequently, it is possible to determine the extent to which system variation is present in a data cube by comparing how well a 2-factor solution fits the cube in its original form relative to how well a 2-factor solution fits the cube when it has been scrambled to remove system variation.

The data collected in this study formed a 41 participant *x* 24 adjective *x* 11 occasion data cube. With respect to the original (unscrambled) version of the data cube, a

Figure 6
Plot of octant means for each film clip (pretest)

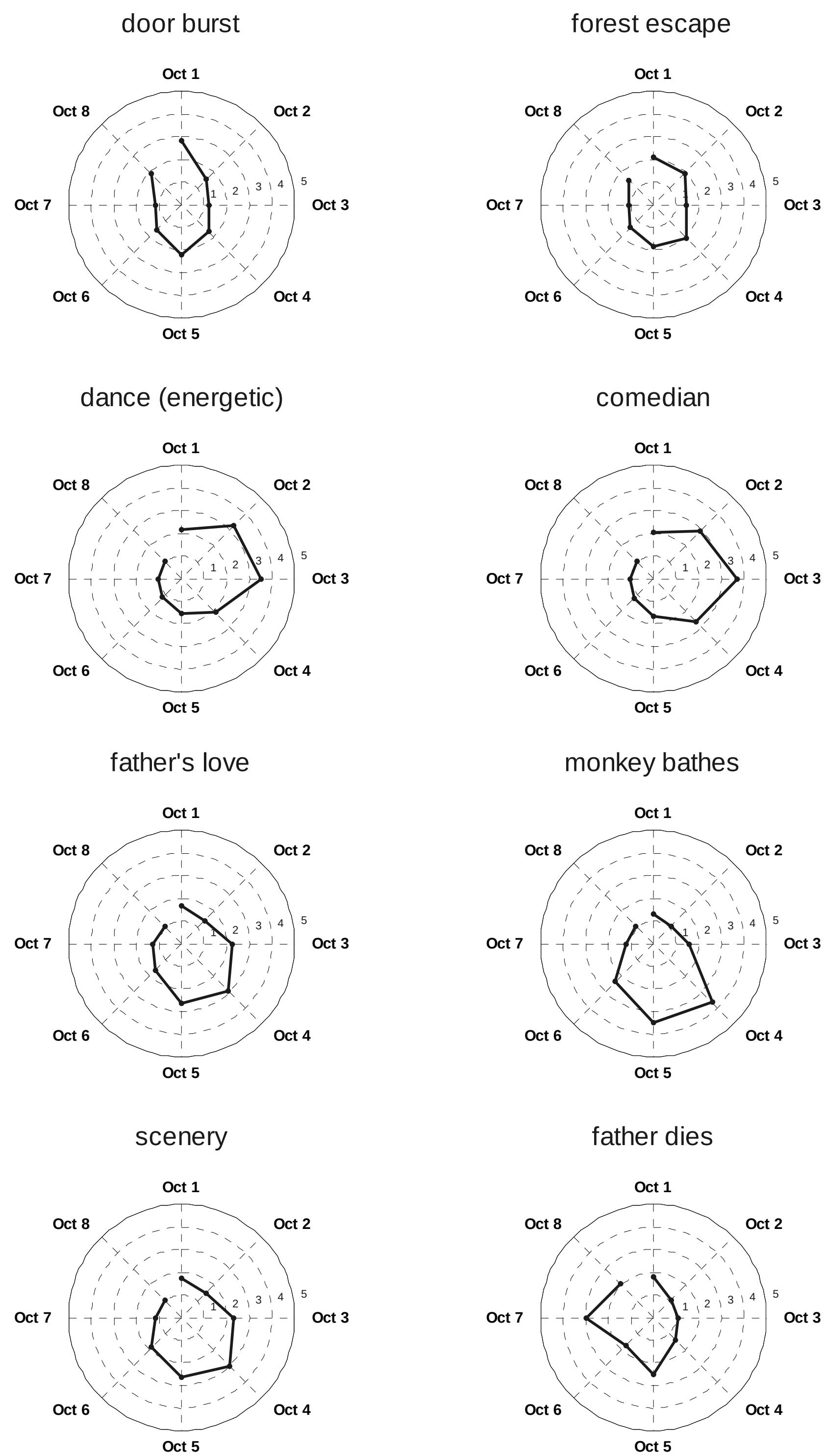
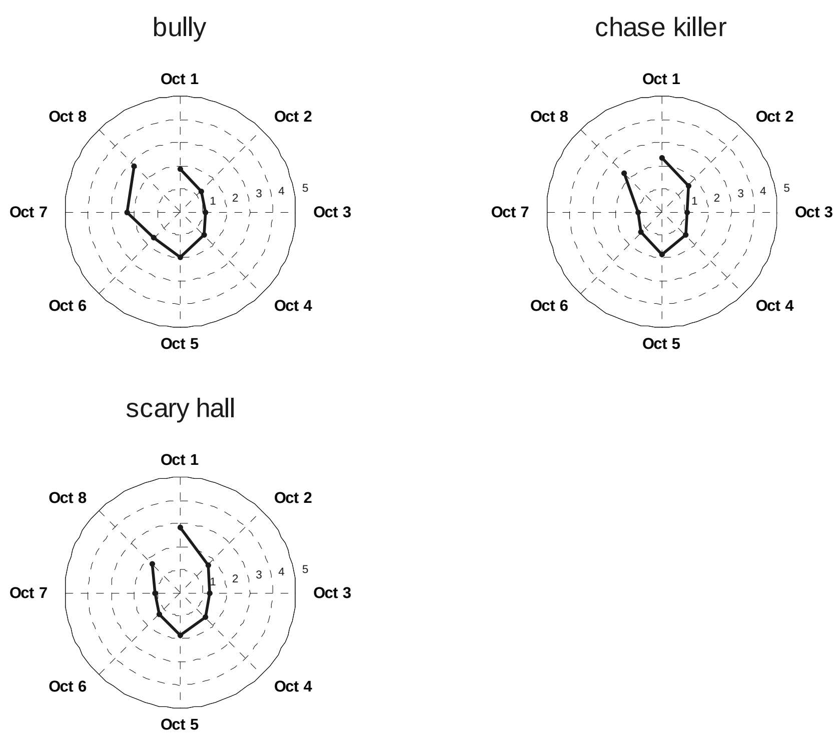


Figure 6 (continued)



2-factor solution explained 39.7% of the variation in participants' affect ratings[17]. To remove any system variation which many of been present in the original data cube, a scrambled version of this data cube was created by randomly ordering the data for each participant in the film mode. A total of 10 scrambled data cubes were created using this procedure. The percent of variance explained by a 2-factor solution for these scrambled data cubes ranged from 12.6% to 15.6%. The relatively large difference in explained variation between the original and scrambled data cubes suggests the films clips created the required system variation in participants' affect ratings.

Summary

The purpose of this study was to create and pretest the materials required to conduct a *participants x adjectives x occasions* 3-mode factor analysis. The first step was to create a list of 24 adjectives for participants to record their affective state following each film clip. A group of four subject matter experts selected 16 adjectives to represent the octants of the circumplex (two per octant) from a list of adjectives previously identified as belonging in the participants' lexicon. An additional eight adjectives were randomly selected from the list of unused adjectives to facilitate exploring the viability of factor structures with more than two dimensions. The second step was to generate a set of eleven film clips to elicit emotions from the circumplex for each occasion in the *participants x adjectives x occasions* data cube. Six of the film clips created were previously validated whereas five of the film clips created were specifically developed for this project. These emotional adjectives and film clips will be used in Study 1 (see Chapter 6) to estimate the intrinsic axes for 2-dimensional affective space.

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[17] This analysis was repeated ten times using different starting positions and each 2-factor solution explained 39.7% of the variation in participants' ratings.

CHAPTER 6: STUDY 1

The primary purpose of this study was to conduct a preliminary investigation of the appropriate axes for 2-dimensional affective space. A 3-mode data set was constructed using participants for Mode A, emotional adjectives for Mode B, and film stimuli for Mode C. Although I expected the best-fitting axes would be one of the popular 2-factor models (PA and NA vs. Valence and Arousal), *any rotation of the 2-dimensional affective space was possible*. A secondary purpose of this study was to explore the dimensionality of affective space to see if a 2-factor solution adequately accounted for variance in the self-rated affect data obtained.

Method

Participants

Eighty-five female undergraduate students (mean age = 21.4), from an introductory psychology class, participated in the experiment for course credit. As in pretesting, only female participants were selected because of research indicating emotion evoking film stimuli are more effective with women (Hagemann, et al., 1997; Westermann, et al., 1996); as well as the increasing evidence of sex differences in the biology of emotions (e.g., George, et al., 1996).

Procedure and Materials

The procedure and materials used in this study were similar to the ones used in the material pretesting session. Participants viewed a series of 11 film clips and rated their emotional state after each film clip. Six of the film clips were previously validated by Gross and Levenson (1995) whereas five of them were created for this investigation (details of the film clip development process are provided in Chapter 5). Prior to watching the first film, however, participants were provided with an "Initial Mood" rating form. The initial mood ratings ensured that participants were familiar with the rating task (and the specific adjectives) prior to rating their mood after the first film. The data formed an 85 participants *x* 24 adjectives *x* 12 occasions cube in which each of the participants contributed 288 data points for a total of 24,480 data points. Missing values constituted .0735% of the data cube. Study materials are presented in Appendix C.

PARAFAC code and additional programs

PARAFAC Code. PARAFAC has yet to be incorporated into any of the major statistical packages (e.g., BMDP, SAS, SPSS) and, although MatLab versions of the PARAFAC software exist (e.g., N-way Toolbox, Andersson & Bro, 2000), they do not possess the features required for the current investigation. Consequently, I created a PARAFAC program in MatLab 6.5, based on an alternating least squares approach to parameter estimation, which offers two advantages over existing software. First, following the suggestions of R.A. Harshman (personal communication, June 2003), convergence was based on changes in factor loadings rather than changes in the percent of modeled variation (used by the N-way Toolbox). Second, solutions could be constrained in any of the three modes to fix degenerate solutions, regardless of the centering procedure used[18]. As well, a line-search acceleration scheme was implemented to increase the speed of the program[19]. Missing values were estimated during each

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[18] A zero-correlation constraint is used to ensure the PARAFAC algorithm converges when there are individual differences in the correlations between factors (R.A. Harshman, personal communication, June 2003).

[19] This acceleration method uses the change in factor loadings, from one iteration to the next, as the basis

iteration of the alternating least squares (ALS) loop using imputation.

Preprocessing Code. Prior to analysis, the data were both fiber-centered and slab -scaled following the suggestions of Harshman & Lundy (1984b). Fiber-centering refers to setting the mean for each *column* of numbers (across a specified mode) in the data cube to zero (see Figure 7). In contrast, slab-scaling refers to setting the standard deviation for each *slice* (of a specified mode) of the data cube to a specific value (see Figure 8). In this investigation, to fulfill the ratio-scale data requirement of factor analysis, the mean for each adjective within each person (averaging across films) was set to zero (fiber-centering; see Figure 7). As well, to ensure that each individual's responses contributed equally to the solution, the data were adjusted so that the mean squared value of each person's ratings was scaled to within 1% of unity (slab scaling; see Figure 8). This preprocessing was done iteratively to ensure a zero-point, because the scaling operations in the second step disturb the centering used in the first step. These preprocessing operations converged in 3 iterations. After preprocessing, there was variance in all adjectives when the data cube was collapsed across participants and standard deviations calculated for each adjective across films (see Appendix D). That is, ratings on all adjectives were influenced to some degree by the film clip manipulations.

PARAFAC Analyses. PARAFAC analysis proceeds iteratively, with each iteration increasing fit, until a specified stopping point is reached. In this investigation, the PARAFAC analyses were set to stop (i.e., were considered to have converged) when

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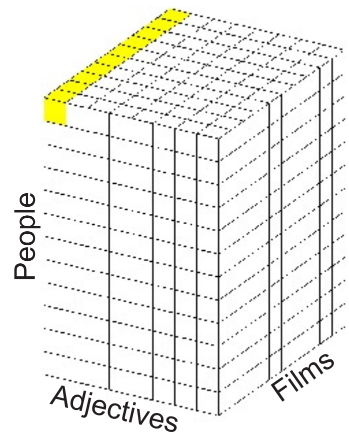
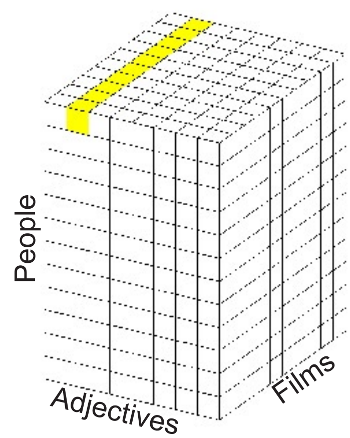
for estimating the value of factor loadings several iterations into the future. A test is then performed to determine if the estimated "future loadings" succeed in increasing the fit of the PARAFAC model. If the test indicates that fit would be increased by using the estimated "future loading", then the line-search algorithm uses these loadings as the basis for the next iteration. Otherwise, the program continues to the next iteration using the regular alternating least square approach. Because the line-search algorithm can slow down the already time-consuming PARAFAC calculations when it does not succeed in estimating future loadings, it was set to discontinue after 15 estimation failures. This acceleration code was based on Andersson and Bro (2000).

Figure 7
Illustration of fiber centering

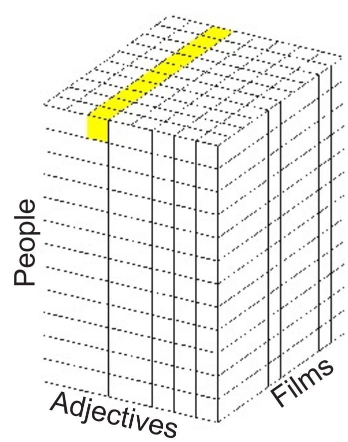
Fiber centering adjective 1
for participant 1



Fiber centering adjective 2
for participant 1

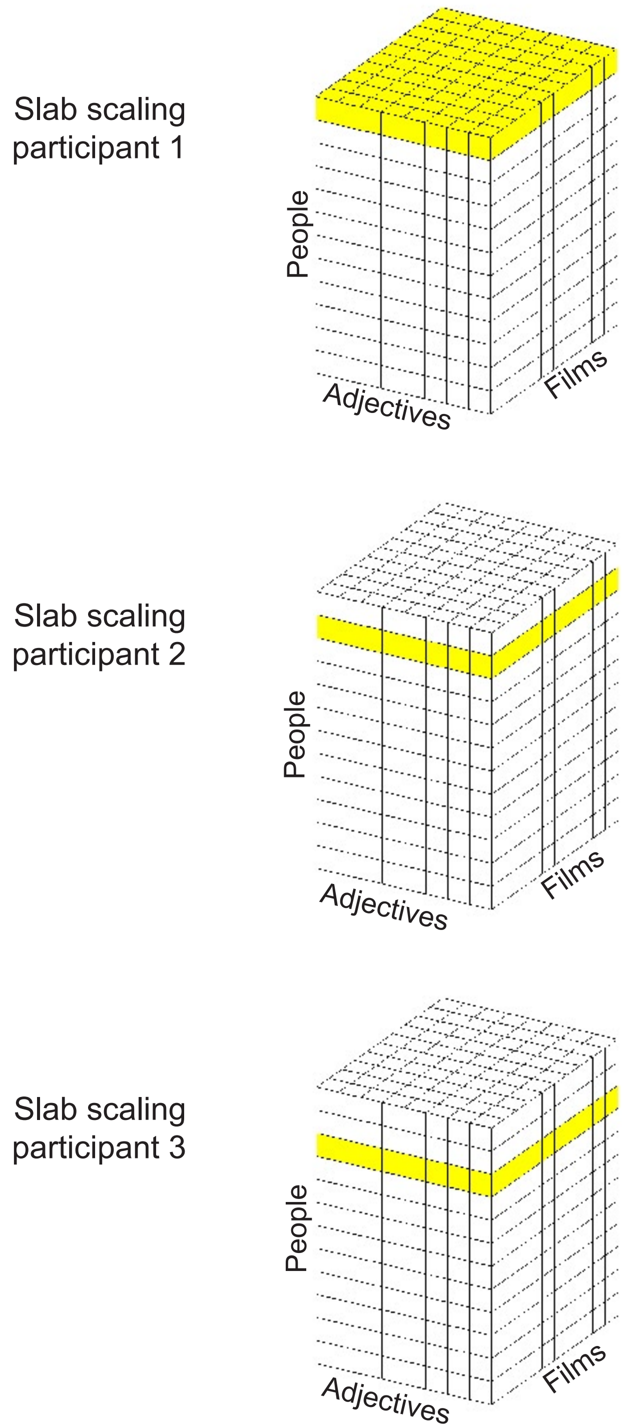


Fiber centering adjective 3
for participant 1



The adjectives for each participant were fiber centered across films. This figure illustrates, for a single participant, how the mean for each fiber (i.e. ratinging of a single adjective for a single person across multiple films) was set to zero.

Figure 8
Illustration of slab scaling



Each participant's ratings are scaled to have approximately the same mean-squared-error to ensure that all participants contribute equally to the factor solution.

factor loadings ceased to change substantially from one iteration to the next in the alternating least squares loop of the program. More specifically, the algorithm was set to consider the solution as converged when the change in factor loading in each mode did not exceed .00001 percent of the mean absolute factor loading for that mode[20].

Competing Solutions

The alternating least squares approach which is typically used to solve the PARAFAC algorithm can occasionally converge on a solution that is not an optimal fit for the data (i.e., it is a local fit optimum). To distinguish between the desired global optimum (the best fitting unique solution) and the various local optima, PARAFAC analyses are usually run a number of times at each dimensionality using different starting values[21]. Harshman and Lundy (1994) stated that if a PARAFAC solution is obtained and there is an equally likely (or more likely) solution than the current one, then the probability of five additional analyses (using random starting points) producing the same solution is less than five percent[22]. Therefore, prior to examining the viability of specific factor solutions, the extent to which competing solutions were present was assessed by using 10 random starting points for each dimensionality extracted.

Factor solutions with the same *structure* possess the same value on two diagnostic statistics (fit as measured by RSQ (r-squared) and core-consistency). Thus, when 3-dimensional scatter plots (run number *x* RSQ *x* core-consistency) are created, solutions

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[20] All analyses were conducted using a zero-correlation constraint applied to the person mode. This constraint is analogous to the orthogonality constraint on the person mode that is an implicit part of every initial unrotated 2-mode principal components analysis. The zero-correlation constraint MatLab routine was developed by R.A. Harshman.

[21] For each run, the starting position for each mode was a set of randomly generated factor loading matrices with orthogonal columns (i.e., a randomly generated loading matrix for each of the three modes).

[22] Harshman and Lundy (1994) indicate that this argument assumes competing solutions are independent of each other.

with the same factor *structure* appear as vertical columns. Factors within a vertical column correlate perfectly if a stringent convergence criterion is used. For example, if a 2-factor solution is extracted then factor 1 for a particular solution will correlate perfectly (r=1.0) with one factor from every other solution in the column. If there are two competing solutions, then there will be two vertical columns on the graph. The column which has the highest RSQ value contains the global optimum. Although there are *very slight* differences in fit for solutions within a column, all factor solutions within a column possess the same structure. In the plots used for this study, the single best-fitting factor solution (i.e., global optima), within the best-fitting column, is identified with a solid dot[23] (all other dots are outlines).

Extracting the Appropriate Number of Factors

Scree Plots with PARAFAC Analyses. A notable difference between 2- and 3-mode scree plots (Cattell, 1966; 1978) arises from the fact that the factors are not nested in 3-mode analyses. For example, in 2-mode analysis, where the factors are nested, the point on the scree plot corresponding to Factor 3 indicates the size of the third factor. In contrast, in 3-mode analysis, where the factors are *not* nested, the point on the scree plot corresponding to the 3-factor solution indicates the amount of variance that the *set of 3-factors* accounts for beyond the variance accounted for by *the set of 2-factors*. This occurs because in non-nested 3-mode analysis the factors from a 3-factor solution are not necessarily similar to the factors from a 2-factor solution. Thus, a regular 2-mode scree plot displays the variance attributable to *specific factors*, whereas, in 3-mode PARAFAC analyses, the plot variance corresponds to the *set of factors.*

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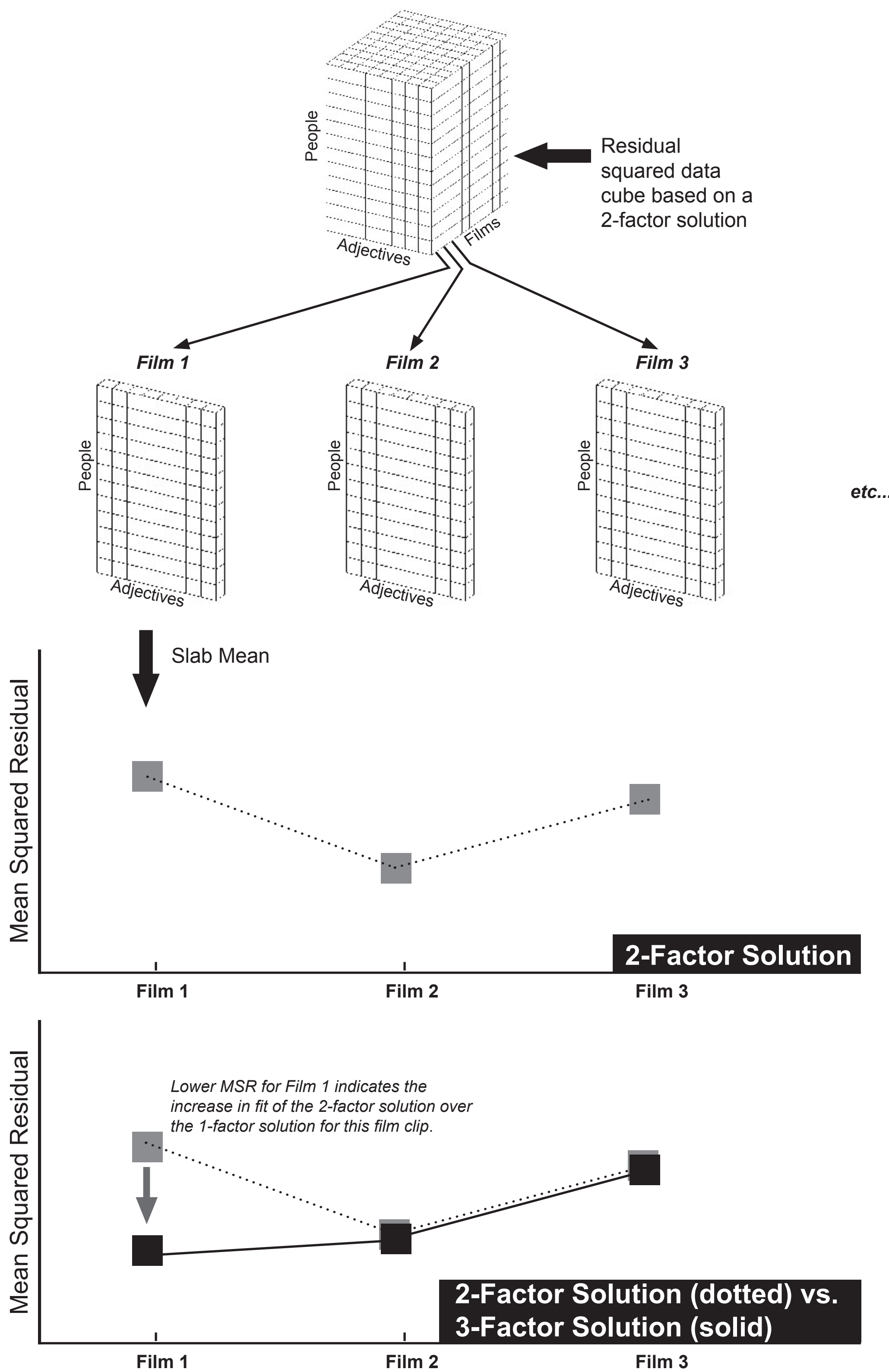
[23] There are extremely slight differences in fit for solutions within a single column

The rationale behind interpreting the two types of scree plots is very similar. Each additional factor extracted will contribute meaningful variance to the recreation of the original data cube – up to a point. After that point, however, the variance added by each additional factor will be minimal and reflect modeled error more than substantial underlying structural variation. The amount of error variance removed by “extra factors” should be roughly equivalent for each extra factor extracted. All ‘real’ factors should therefore occur before the elbow in the plot that indicates the beginning of a straight line. Interpretation of scree plots is somewhat subjective (Velicer, Eaton, & Fava, 2000), and consequently the decisions concerning how many factors were appropriate involved additional criteria. Specifically, decisions concerning the appropriate number of factors were based on a subjective assessment of the scree plot, interpretability of the loadings for each dimensionality, and the magnitude of the correlations between the factors for each dimensionality.

Residual Analysis. To obtain a better understanding of the additional variance contributed by each of the factor solutions in the scree plot, the mean squared residual (MSR) for each film clip was examined[24]. To calculate residuals, a predicted data cube was created by multiplying the factors obtained from each PARAFAC analysis (see Figure 4). This predicted data cube was then subtracted from the original data cube (post-processing) to create a residual cube. As illustrated in Figure 9, for each slab in this residual cube that corresponded to a film clip, I calculated the mean squared residual. A comparison of the MSR plot for a 3-factor solution and a 2-factor solution can be used to determine which film clips are better accounted for by going from a 2-factor solution to a

[24] Both the film and adjective modes were initially examined; however, the film mode residuals were more interpretable

Figure 9
Interpretting mean squared residuals (MSRs) for each film clip



3-factor solution. This procedure is very powerful when combined with a scree plot because it indicates the nature of the extra variance accounted for by each factor solution.

Results

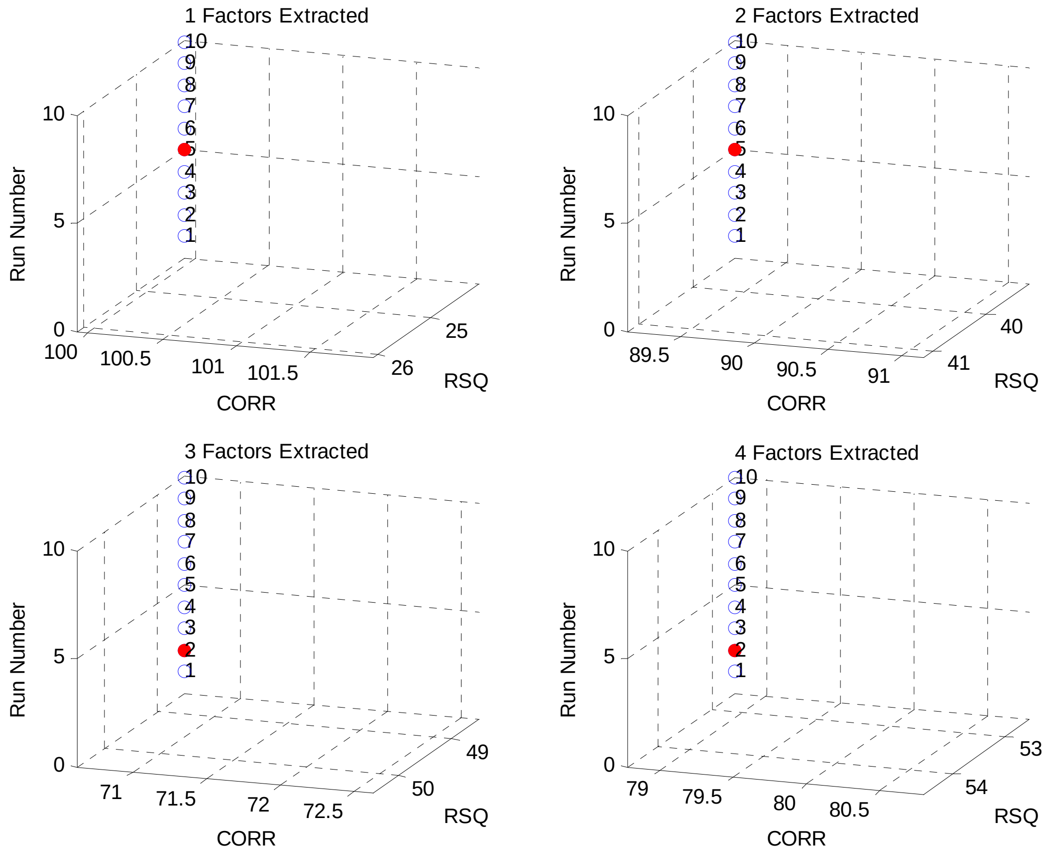
Competing Solutions

The presence of competing solutions was assessed using the *run number x RSQ x core-consistency* plots described previously. Inspection of the competing solution plots presented in Figure 10 revealed that there were not any competing solutions when two factors were extracted. Competing solutions did occur with some of the higher-dimensional solutions. In all cases only the global optimum (indicated by a solid dot) were interpreted.

System Variation Manipulation Check

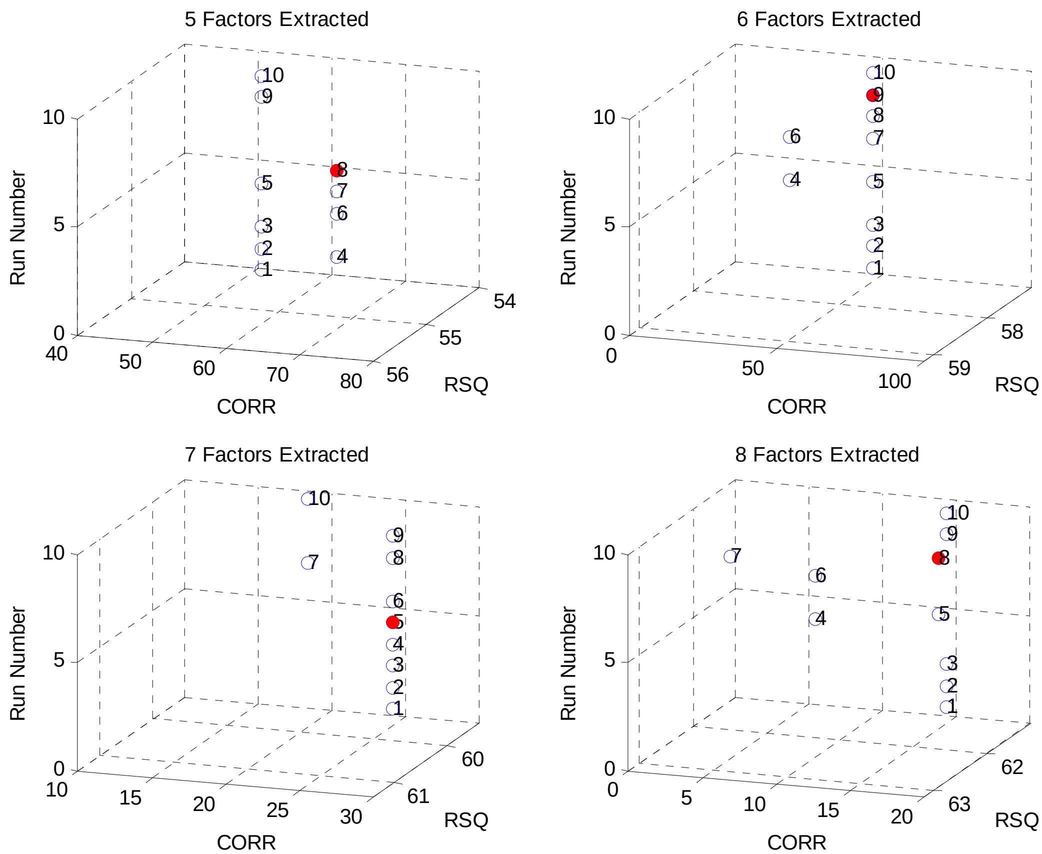
As described earlier, I examined the extent to which system variation had been created in the data cube by comparing how well a 2-factor solution fit the cube in its original form relative to how well a 2-factor solution fit the cube when it had been scrambled to remove system variation. With respect to the original (unscrambled) version of the data cube (85 participants *x* 24 adjectives *x* 12 occasions), a 2-factor solution explained 39.2% of the variation in participants' affect ratings (there were no competing solutions). To remove any system variation which many of been present in the original data cube, a scrambled version of this data cubes was created by randomly ordering the film clips for each participant. A total of 10 scrambled data cube were created using this procedure. The percent of variance explained by a 2-factor solution for these scrambled data cubes ranged from 9.1% to 10.7%. The relatively large difference in explained

Figure 10
Study 1: Plot of competing solutions for each dimensionality



Notes
RSQ indicates R^2 and CORR indicates core-consistency
The solid dot indicates the global fit optima

Figure 10 (continued)



Notes
RSQ indicates R^2 and CORR indicates core-consistency
The solid dot indicates the global fit optima

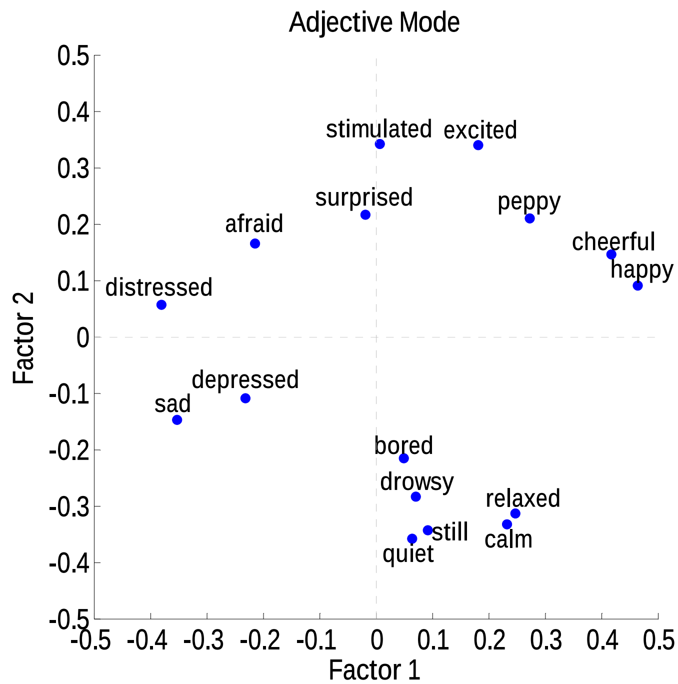
variation between the original and scrambled data cubes suggests the films clips created the required system variation in participants' affect ratings.

Two-Factor Solution

Initially the PARAFAC analyses were conducted using only the 16 adjectives identified a priori as belonging to a specific octant (i.e., the 16/24 adjectives set). The 2-factor solution accounted for 41.9 percent of the variance in self-ratings and the factors roughly corresponded to the Valence and Arousal dimensions (see Figure 11 and Table 1). Although this solution roughly approximated the Valence and Arousal factors, close inspection of Figure 11 revealed that the circumplex structure was somewhat compressed in the film mode (with some films forming a T-shape) due to the low variability in the arousal dimension (Factor 2).

Although adjectives 17 through 24 were included in the study only to explore the viability of solutions with more than two factors, the 2-dimensional PARAFAC extractions were run again with these adjectives to see if additional variability could be extracted along the arousal axis. Including the additional adjectives in the analysis succeeded in producing more arousal variance in the film mode (see Figure 12, Figure 13, and Table 2). The 2-factor solution with all 24 adjectives accounted for 39.2 percent of the variance in self-ratings which is slightly less than the variance accounted for by the 2-factor solution with 16 adjectives. The factors from this solution closely corresponded to the Valence and Arousal dimensions within the circumplex structure in both the adjective and film modes. Inspection of mean squared residuals (see Figure 14) illustrates how the 2-factor solution accounted for more variance in both high arousal film clips (e.g., energetic dance and comedian) and low arousal film clips (e.g., father dies and monkey

Figure 11
Study 1: Cross-plot of 2-factor loadings (16 adjectives)



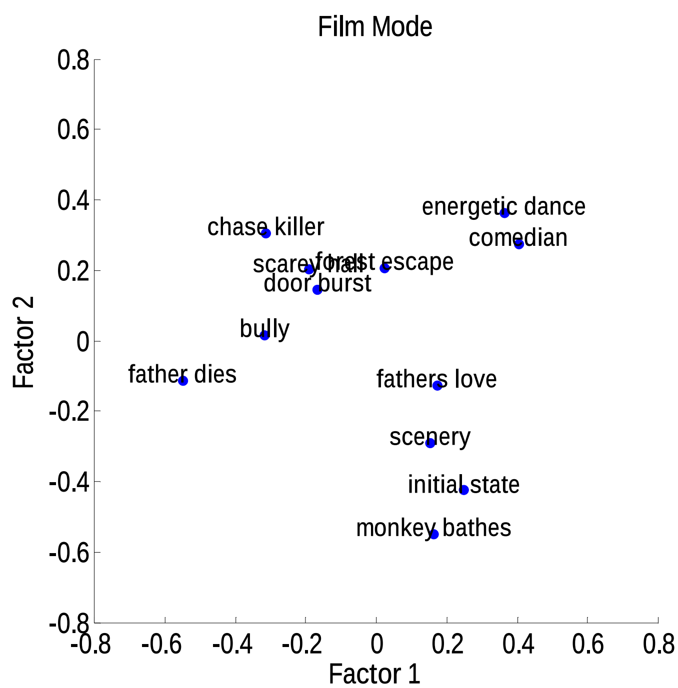


Figure 11 (continued)
Study 1: Cross-plot of 2-factor loadings (16 adjectives)

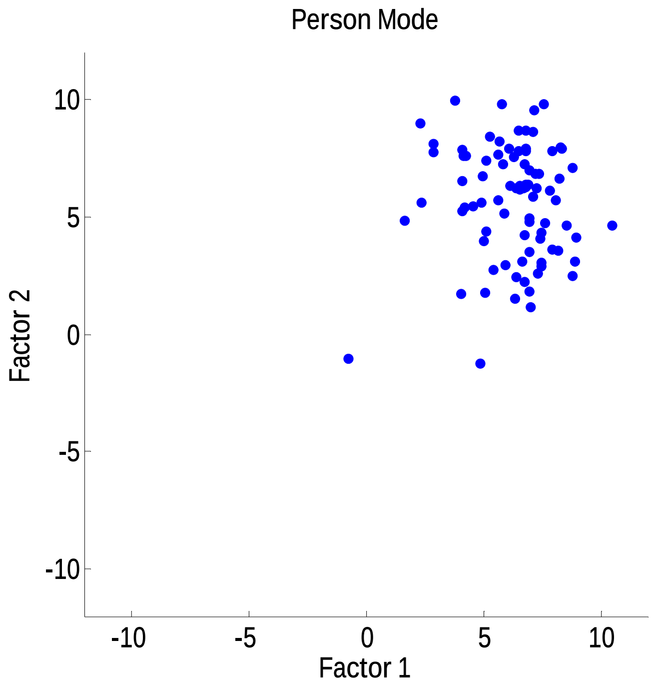


Table 1
Study 1: 2-Factor Solution (16 adjectives only)

Variance in ratings accounted for by the factors (%)

41.9%

Relative size of factors (% of explained variance)

54% 46%

Iterations to convergence

136

Individual Mode Factor Correlations

1.00	0.00
0.00	1.00

Adjective Mode Factor Correlations

1.00	-0.02
-0.02	1.00

Film Mode Factor Correlations

1.00	-0.06
-0.06	1.00

Figure 12
Study 1: Cross-plot of 2-factor loadings (24 adjectives)

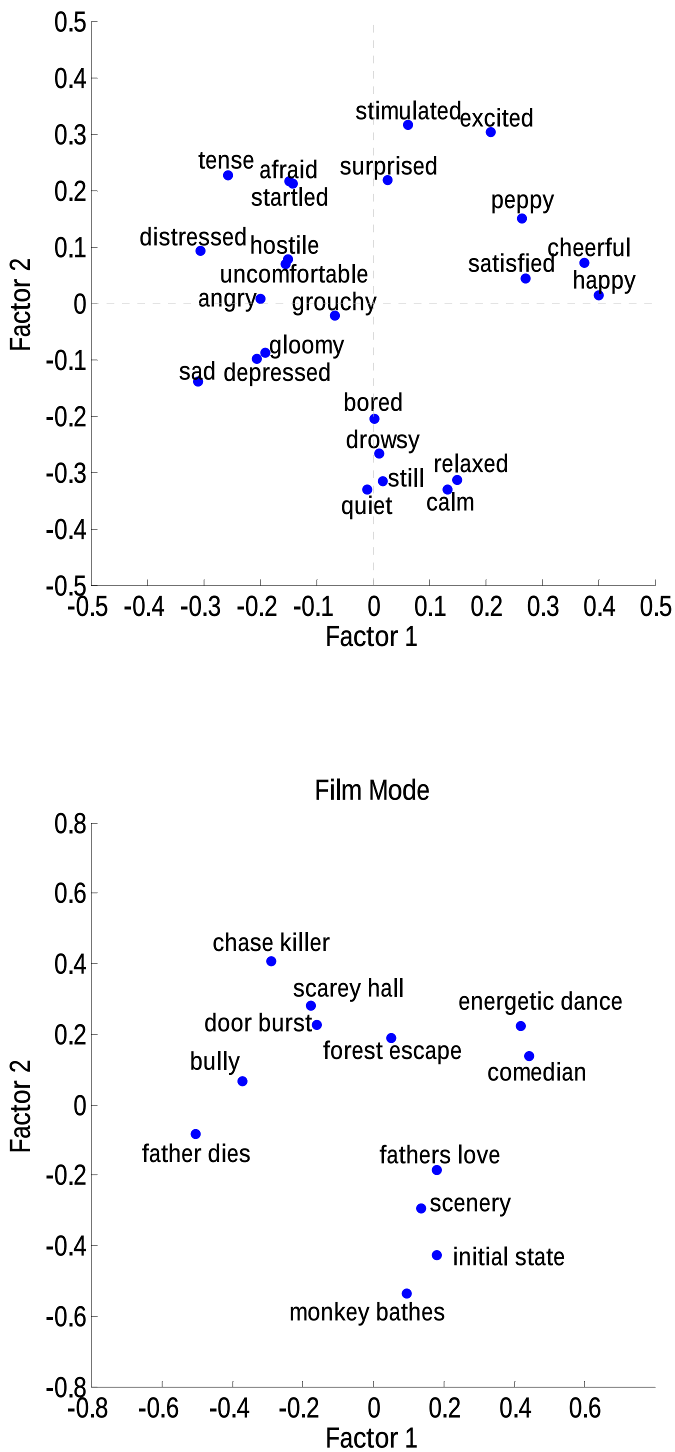


Figure 12 (continued)
Study 1: Cross-plot of 2-factor loadings (24 adjectives)

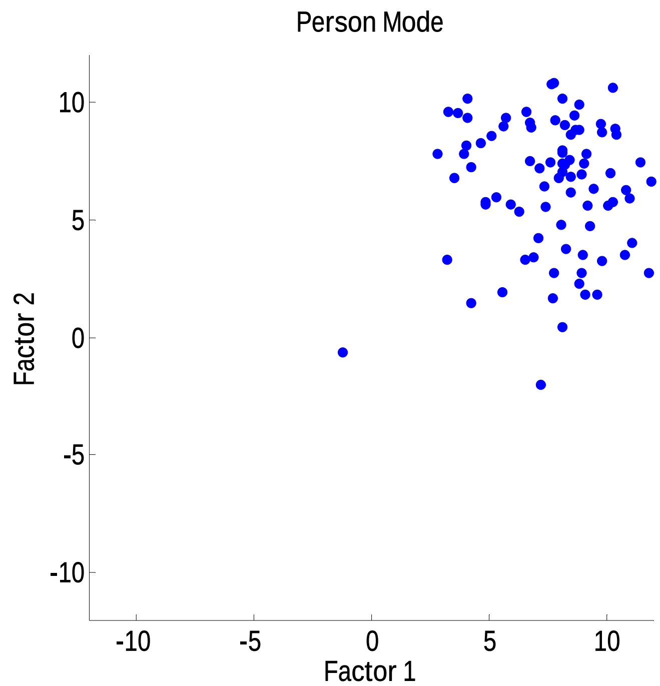
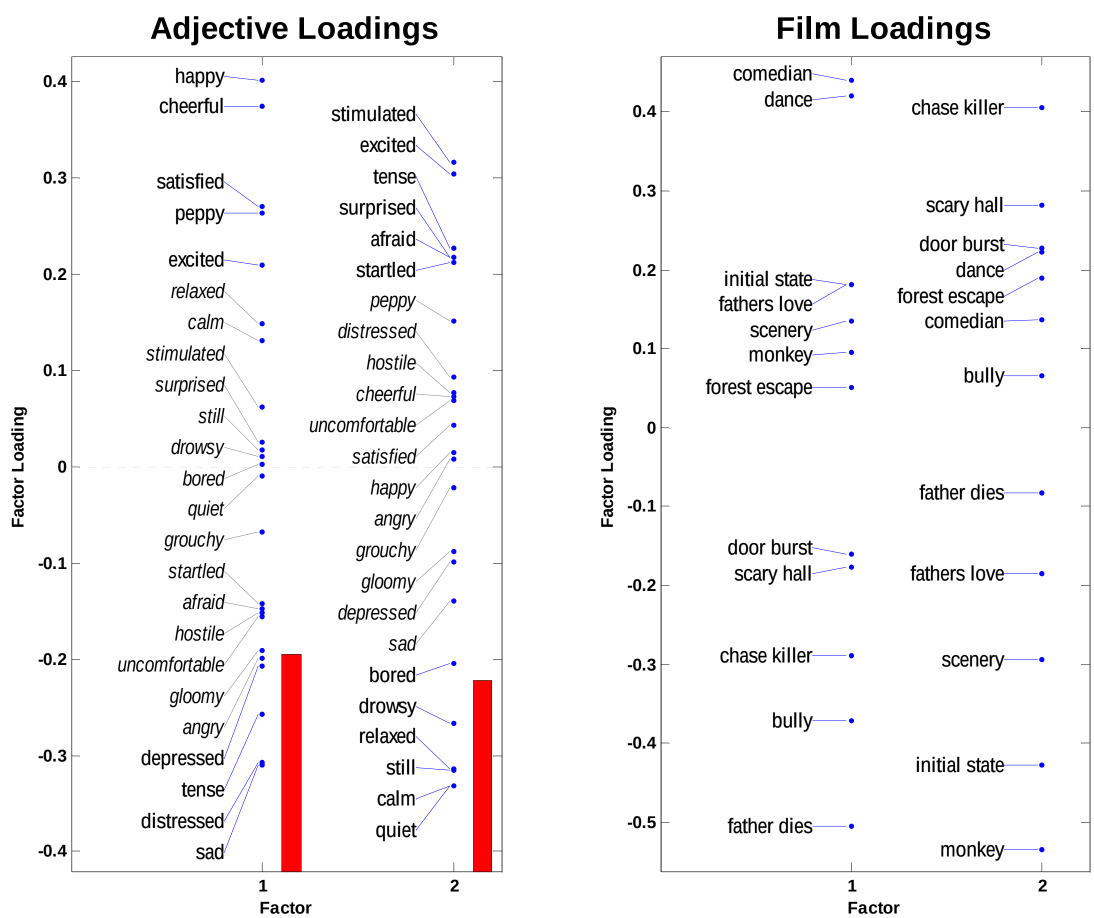


Figure 13
Study 1: One-way plot of 2-factor solution (24 adjectives)



Note: Vertical bars illustrate relative sizes of factors
A lighter italicized font is used for adjectives with factor loadings less than .20

Table 2
Study 1: 2-Factor Solution (24 Adjectives)

Variance in ratings accounted for by the factors (%)

39.2%

Relative size of factors (% of explained variance)

56% 44%

Iterations to convergence

336

Individual Mode Factor Correlations

1.00	0.00
0.00	1.00

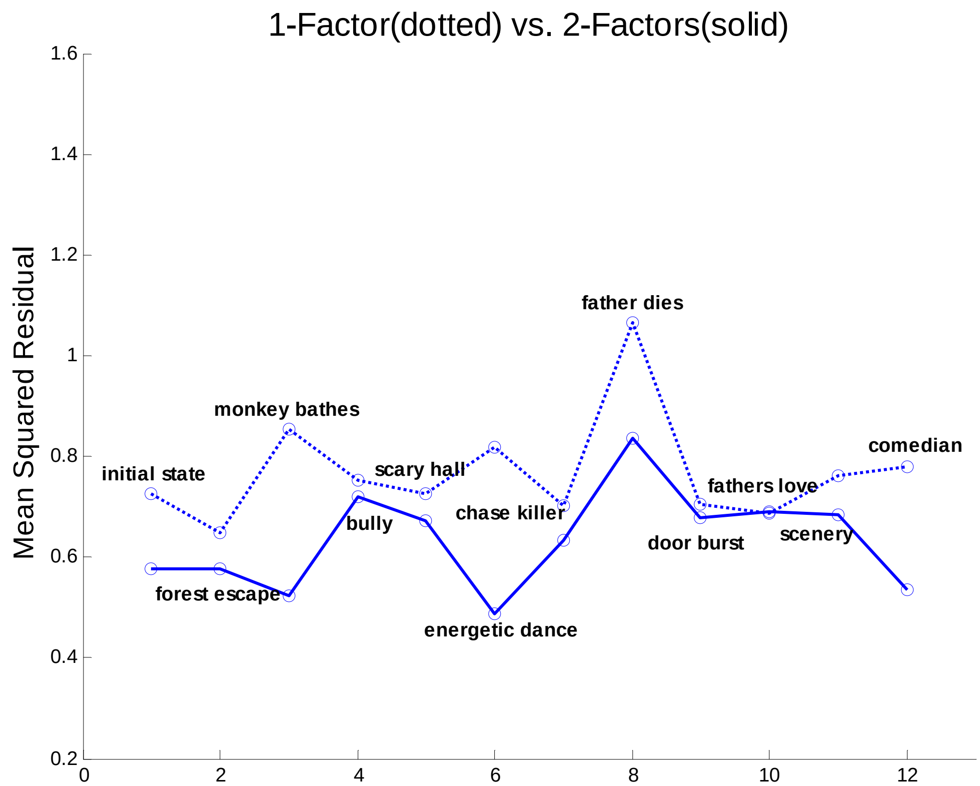
Adjective Mode Factor Correlations

1.00	0.01
0.01	1.00

Film Mode Factor Correlations

1.00	-0.23
-0.23	1.00

Figure 14
Study 1: Residual plot for 1- and 2-factor solutions



bathes) than the 1-factor solution. The low valence octants (both positive and negative) still appeared to be underrepresented in the adjective mode because none of the additional adjectives were from the low-arousal regions[25].

Exploring Higher Dimensions

An examination of the scree plot (see Figure 15) revealed a strong 3-factor solution; however, the scree elbow was somewhat ambiguous and, consequently, the 4- and 5-factor solutions also appeared feasible. All three factor solutions were examined in detail; however, the factor loadings for the 3-, 4- and 5- factor solutions were not as clean as the loadings for the 2-factor solution. Consequently, the interpretation I offer for these higher dimensional solutions is somewhat speculative.

Inspection of the loadings for the 3-factor solution (see Figure 16, Figure 17, and Table 3) suggested that the three factors were best interpreted as valence, arousal, and intensity. The adjective-mode correlations (Table 3) revealed that the arousal and intensity factors were somewhat similar (r=.56), however, the loading plots suggested that the factors were different in nature. The adjective-mode loadings for the intensity factor consisted of primarily positive emotions for the adjective-mode. However, in the film mode both positive and negative emotion-evoking film clips loaded highly on the positive end of this factor. Although some negative emotions in the adjective mode did load on the positive pole of the factor they did not define the factor to the same extent as the negative film clips did the film mode. Interestingly, with respect to the film mode, there also appeared to be a slight tendency for positive and negative film clips to be

[25] Regular 2-mode analysis rotation strategies, which depend upon the geometric configuration of the loadings, would be strongly influenced by the adjective “holes” in octants 4 and 6. This influence is minimized with PARAFAC analyses, however, because the orientation of the PARAFAC axes depends upon the contraction and dilatation of the factor space in the other modes.

Figure 15
Study 1: Scree plot

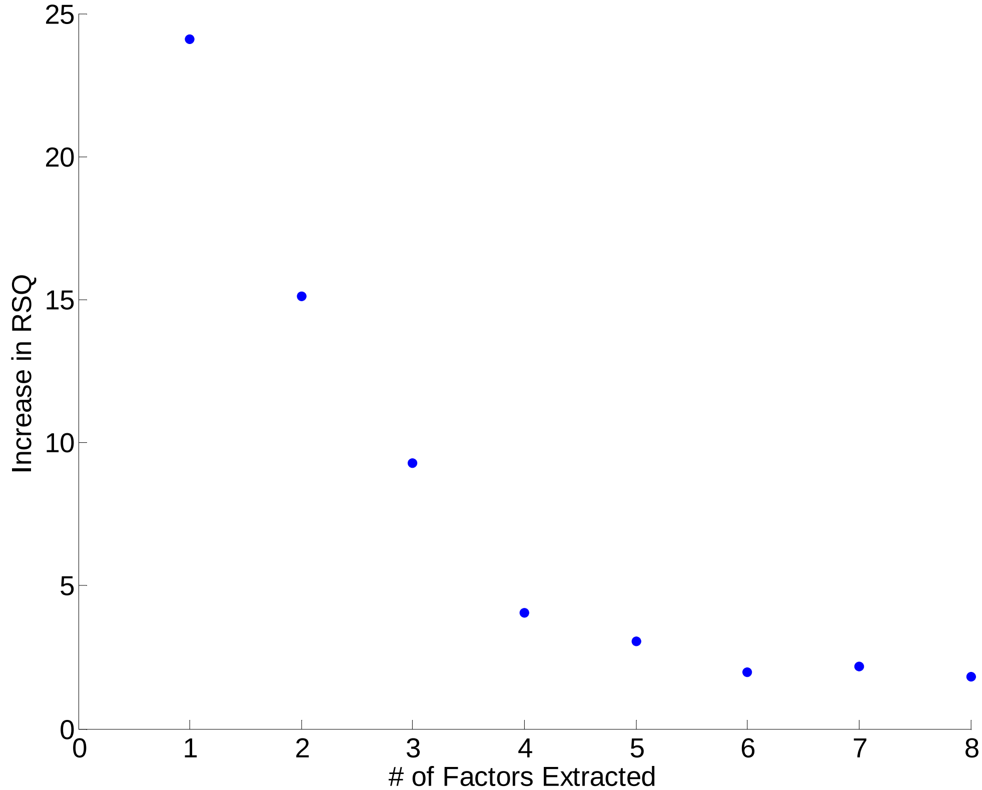
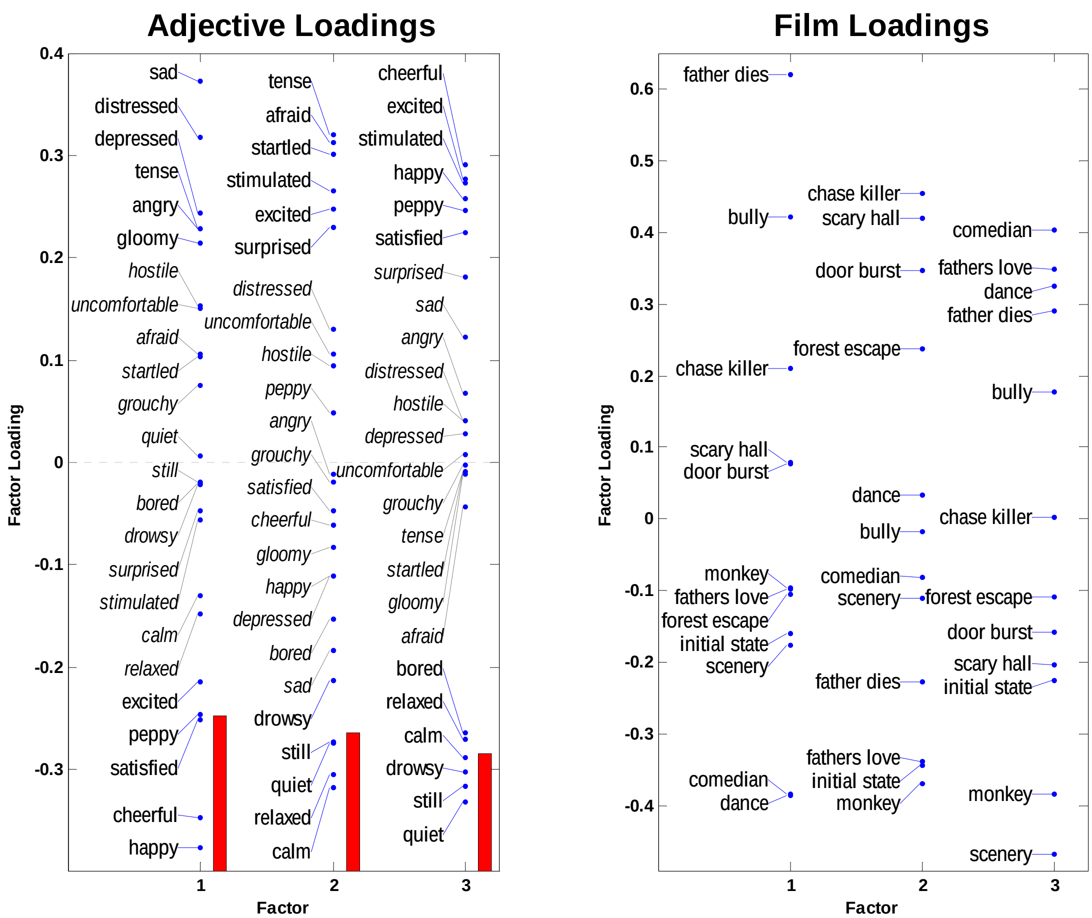


Figure 16
Study 1: One-way plot of 3-factor solution



Note: Vertical bars illustrate relative sizes of factors

A lighter italicized font is used for adjectives with factor loadings less than .20

Figure 17
Study 1: Residual plot for 2- and 3-factor solutions

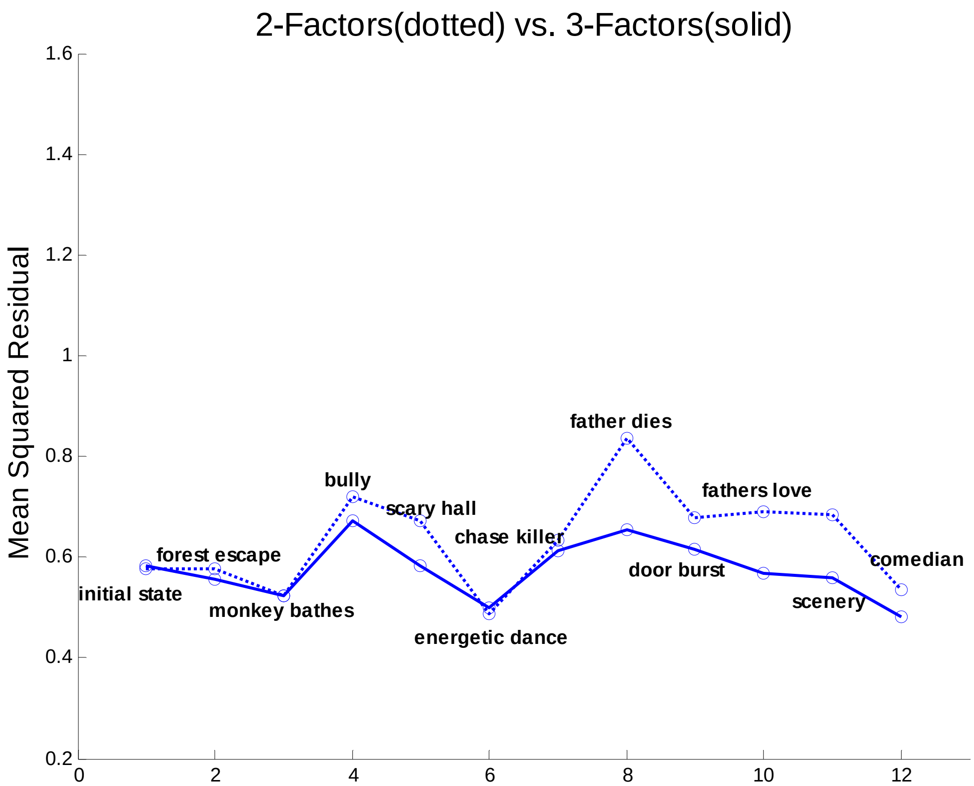


Table 3
Study 1: 3-Factor Solution

Variance in ratings accounted for by the factors (%)

48.5%

Relative size of factors (% of explained variance)

38% 33% 29%

Iterations to convergence

181

Individual Mode Factor Correlations

1.00	0.00	0.00
0.00	1.00	0.00
0.00	0.00	1.00

Adjective Mode Factor Correlations

1.00	-0.17	0.23
-0.17	1.00	0.56
0.23	0.56	1.00

Film Mode Factor Correlations

1.00	0.14	0.08
0.14	1.00	-0.10
0.08	-0.10	1.00

represented better on different factors. More specifically, the valence factor (factor 1) appeared to better account for films which elicited extremely negative emotions, and the intensity factor (factor 3) appeared to better account for films which elicited extremely positive emotions. Nonetheless, the loadings in the film mode strongly suggested that the third factor should be labeled intensity to account for the positive and negative film clips that loaded highly, and in the same direction, on this factor.

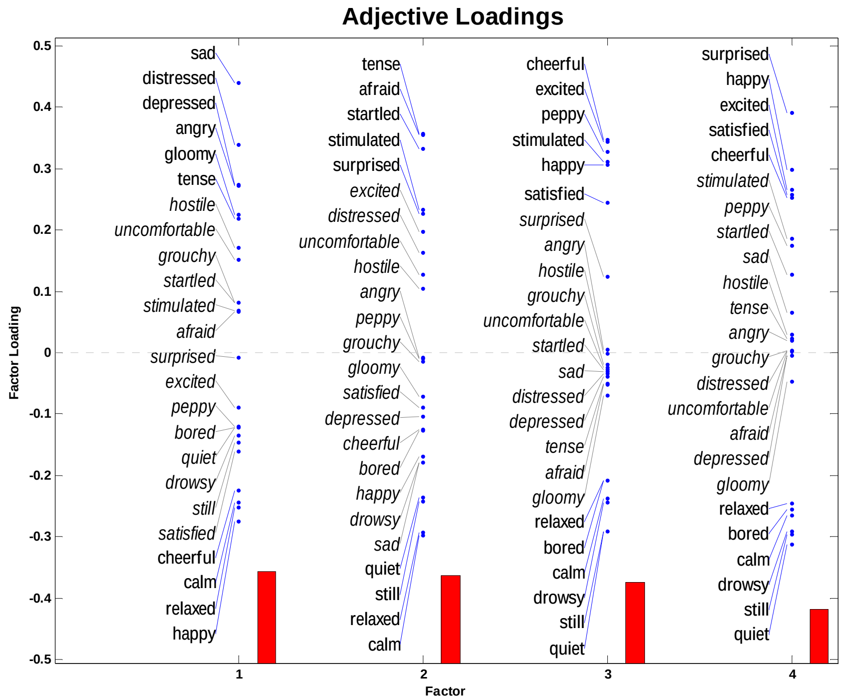
Extracting three factors allowed the solution to better account for intense negative emotions. Inspection of the 2- vs. 3-factor MSR plot (see Figure 17) revealed that the film clip with the greatest increase in explained variance was the intense film clip “father dies” indicating that the ratings of emotion obtained after this film clip were better explained by the 3-factor solution than by the 2-factor solution. Correspondingly, the “scenery” film clip, which anchored the non-intense end of the factor, was also better explained by the 3-factor solution than by the 2-factor solution.

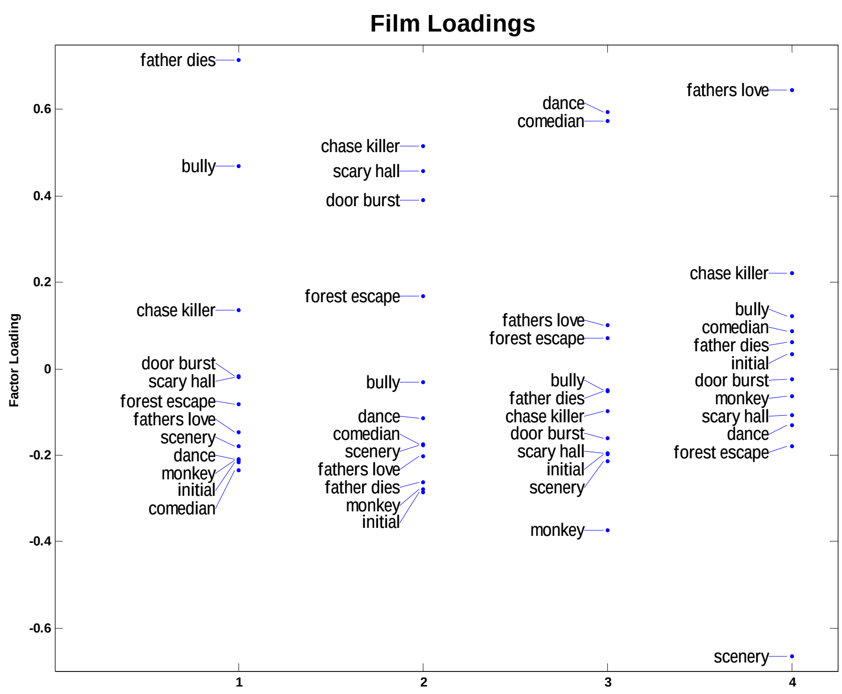
Inspection of the loadings for the 4-factor solution (see Figure 18 and Table 4) suggested that the four factors were best interpreted as valence, fear, happiness, and surprise[26]. Although the largest factor was primarily the valence factor, it was not evenly bipolar. That is, the loading for the most extreme negative emotion (sad) was .44 and was substantially greater in magnitude than the -.28 loading for the most extreme positive emotion (happy). This suggested that, although this factor represented valence, negative emotional experiences were better represented than positive emotional experiences. This

[26] The labels presented for some factors (i.e., fear, happiness, and surprise) suggest unipolar factors, but, inspection of the loadings plots in the adjective mode indicates that these factors are bipolar. To be consistent with the naming convention in affect research I labelled these factors based on the high arousal adjectives they were defined by. This naming convention is reflected in labels used by Watson et al. (1999) for the Positive Activation and Negative Activation factors that are both bipolar and labelled based on the high arousal end of the factors.

Figure 18

Study 1: One-way plot of 4-factor solution





Note: Vertical bars illustrate relative sizes of factors

A lighter italicized font is used for adjectives with factor loadings less than .20

Table 4
Study 1: 4-Factor Solution

Variance in ratings accounted for by the factors (%)

52.6%

Relative size of factors (% of explained variance)

29% 28% 26% 17%

Iterations to convergence

379

Individual Mode Factor Correlations

1.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00
0.00	0.00	1.00	0.00
0.00	0.00	0.00	1.00

Adjective Mode Factor Correlations

1.00	0.43	-0.08	0.10
0.43	1.00	0.35	0.51
-0.08	0.35	1.00	0.91
0.10	0.51	0.91	1.00

Film Mode Factor Correlations

1.00	0.09	-0.19	0.19
0.09	1.00	-0.17	0.00
-0.19	-0.17	1.00	0.18
0.19	0.00	0.18	1.00

finding is consistent with the fact that the majority of the variance associated with positive emotional experiences was absorbed by the happiness factor. An interesting aspect of this 4-factor solution is that the arousal factor from the 2-factor solution appears to have slowly changed into a fear factor as positive and negative experiences were better represented in separate factors. Although the happiness and surprise factors were highly correlated in the adjective-mode (r=.91, see Table 4) the correlation between these factors was substantially lower in the film-mode (r=.18). Names for factors must be based upon an inspection of the loadings in both modes. Therefore, although the happiness and surprise factors were extremely similar in the adjective-mode, because they were substantially different in the film-mode they were interpreted as different factors and named accordingly. Inspection of the 3- vs. 4-factor MSR plot (see Figure 19) revealed that extracting four factors (rather than three) allowed the solution to better account for film clips that were extremely positive in nature (i.e., energetic dance, father's love, and comedian) but they did not all load on a single factor. Specifically, the *father's love* film clip possessed a strong element of surprise which likely created the surprise factor (see film-mode loadings in Figure 18). The strong adjective-mode correlation of between this factor and the happiness factor suggests, however, that the surprise factor has a strong pleasantness component to it (i.e., a pleasant surprise).

Inspection of the loadings for the 5-factor solution (see Figure 20 and Table 5) suggested that the five factors were best interpreted as valence, fear, happiness, surprise, and anger). Similar to the 4-factor solution, although the largest factor in the 5-factor solution was primarily a valence factor, it was not evenly bipolar. The loading for the most extreme negative emotion (sad) was .49 and was substantially greater in magnitude

Figure 19
Study 1: Residual plot for 3- and 4-factor solutions

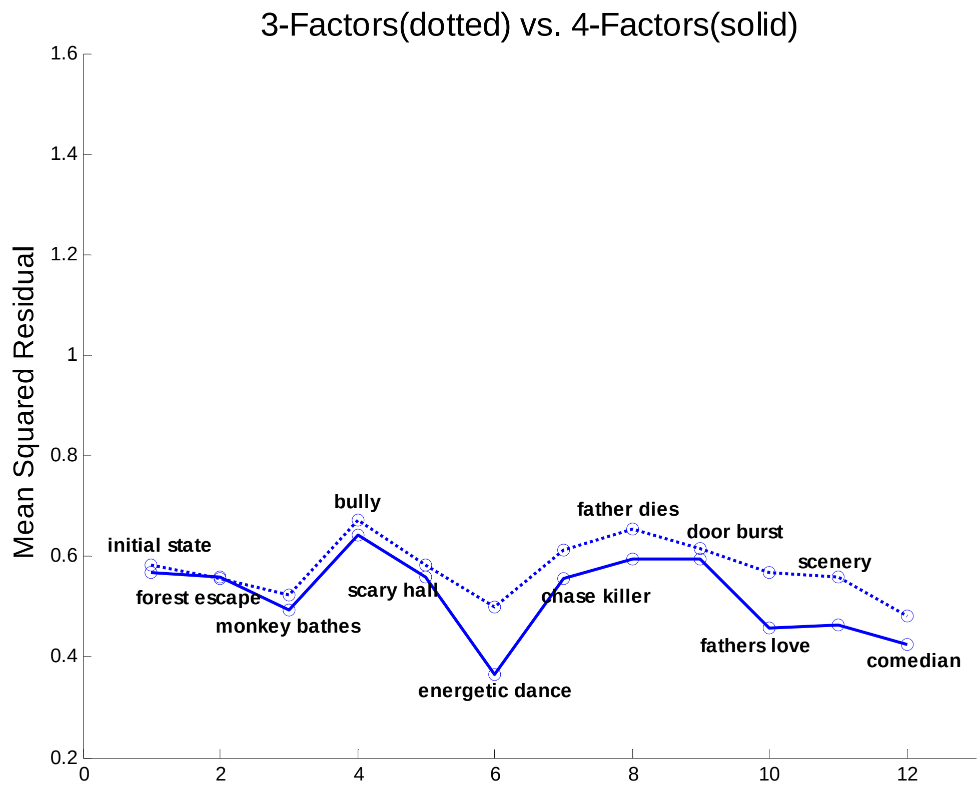
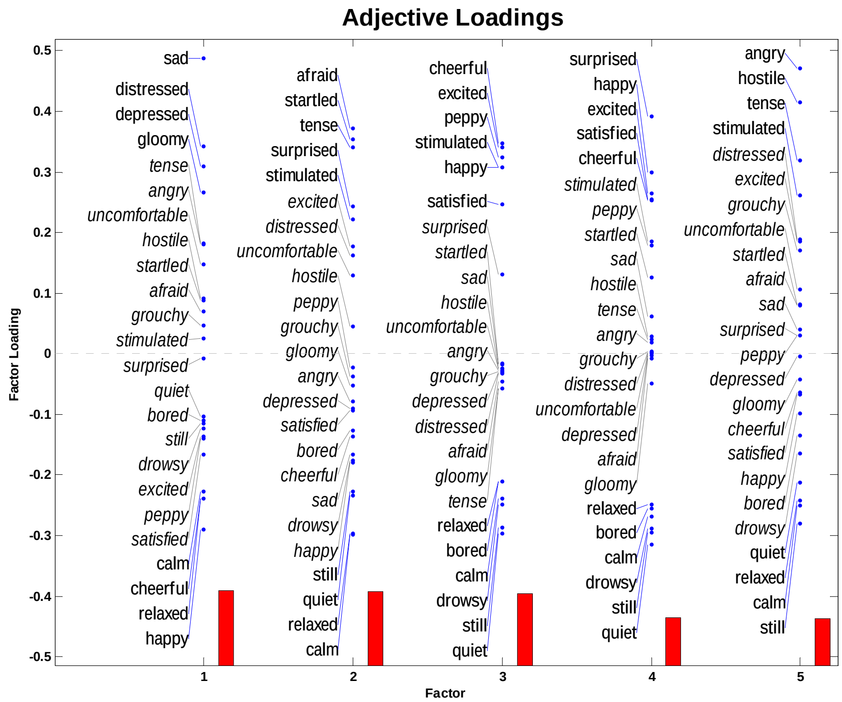
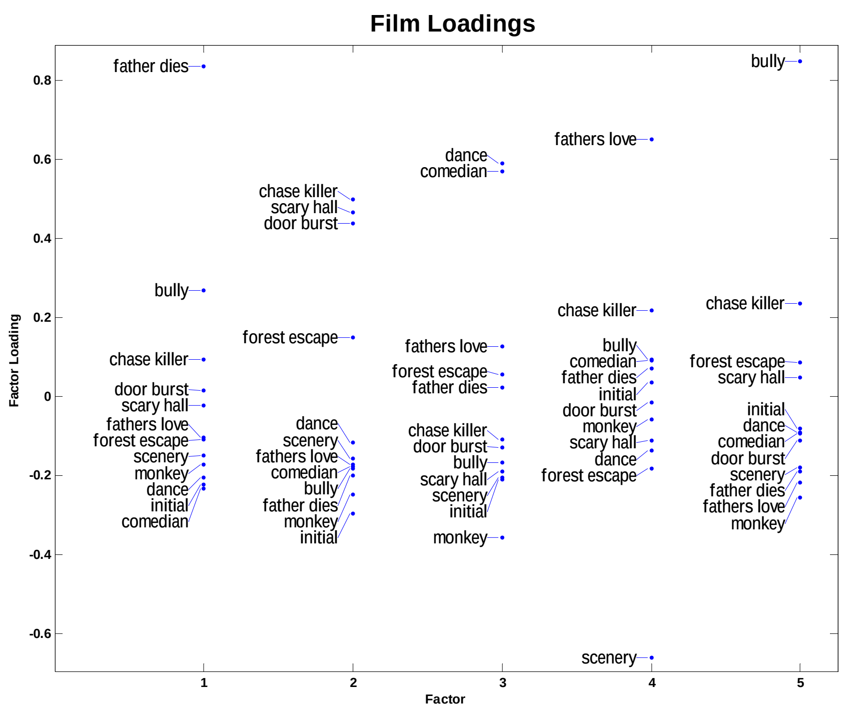


Figure 20
Study 1: One-way plot of 5-factor solution





Note: Vertical bars illustrate relative sizes of factors
A lighter italicized font is used for adjectives with factor loadings less than .20

Table 5
Study 1: 5-Factor Solution

Variance in ratings accounted for by the factors (%)

55.6%

Relative size of factors (% of explained variance)

24% 23% 23% 15% 15%

Iterations to convergence

564

Individual Mode Factor Correlations

1.00	0.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00	0.00
0.00	0.00	1.00	0.00	0.00
0.00	0.00	0.00	1.00	0.00
0.00	0.00	0.00	0.00	1.00

Adjective Mode Factor Correlations

1.00	0.37	-0.15	0.03	0.52
0.37	1.00	0.33	0.49	0.63
-0.15	0.33	1.00	0.92	0.35
0.03	0.49	0.92	1.00	0.45
0.52	0.63	0.35	0.45	1.00

Film Mode Factor Correlations

1.00	0.03	-0.17	-0.17	0.23
0.03	1.00	-0.17	0.01	0.17
-0.17	-0.17	1.00	-0.18	-0.15
-0.17	0.01	-0.18	1.00	-0.09
0.23	0.17	-0.15	-0.09	1.00

than the -.29 loading for the most extreme positive emotion (happy) -- indicating that negative emotional experiences were better represented than positive emotional experiences in this factor. Indeed, the 5-factor solution was nearly identical to the 4-factor solution (valence, fear, happiness, and surprise), except that anger separated from the valence factor to form its own factor. Inspection of the MSR plots for the 4- and 5-factor solutions (Figure 21) demonstrated that the addition of the anger factor noticeably reduced the residual variance for the anger-inducing film "Bully." The 6-factor solution (presented in Appendix E) was not viable because one of the factors appeared twice and the residual plot indicated only the slightest change from the 5- to 6-factor solution.

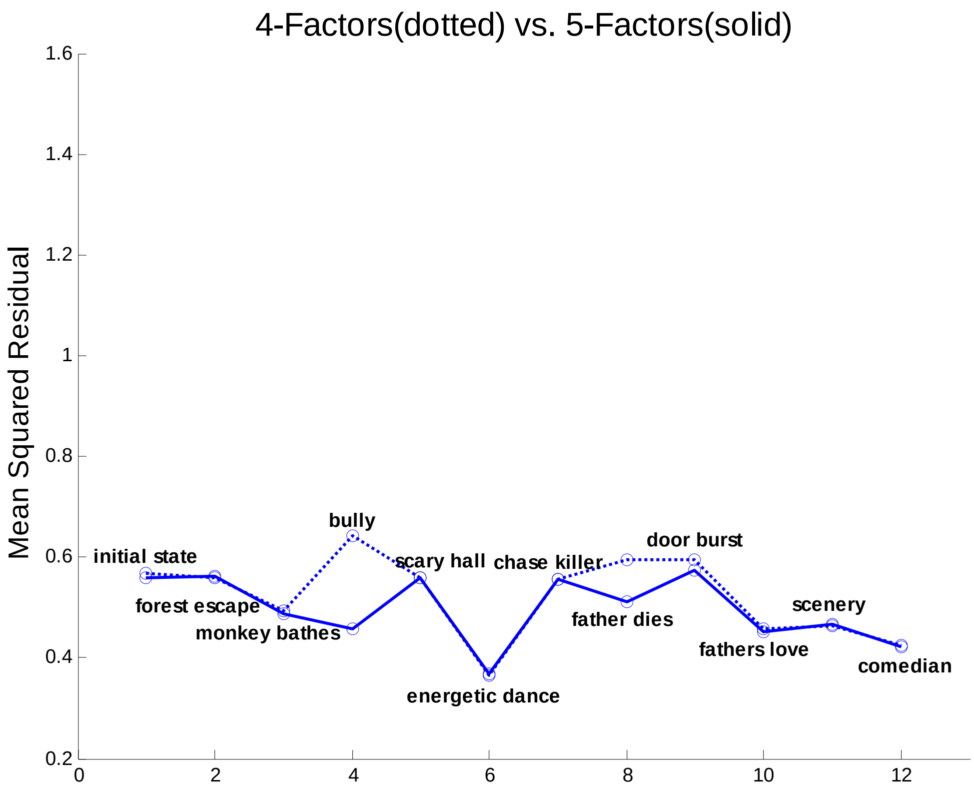
Discussion

2-Dimensional Affective Space

The 2-dimensional affect circumplex was investigated using both 16 and 24 adjectives. Analyses conducted using only 16 of the 24 adjectives (two per octant) produced a 2-factor solution in which the dimensions were best described as Valence and Arousal. Consequently, this finding supports the Valence and Arousal approach to defining the circumplex suggested by Russell (1980) and others (e.g., Felman Barrett & Russell, 1998; Feldman Barrett, 1998; Feldman, 1995; Green et al., 1999; Green & Salovey, 1999; Russell & Carroll, 1999a).

Inspection of the adjective-mode loadings revealed a clear circumplex structure; however, there were gaps in the circumplex in the positive low arousal and negative low arousal regions. In contrast, inspection of the film-mode loadings revealed a structure that, although reflecting the valence and arousal dimensions, was less circular in nature. More specifically, the loadings somewhat resembled a T-shape rather than a circumplex

Figure 21
Study 1: Residual plot for 4- and 5-factor solutions



because, for a subset of films (father dies, bully, door burst, scary hall, chase kill, forest escape, comedian, energetic dance), the variability in arousal appeared to be somewhat restricted. Consequently, I choose to re-analyze the 2-dimenional solution using the full set of 24 adjectives.

Consistent with the analyses conducted using only 16 adjectives, analyses conducted using the full set of 24 adjectives produced a 2-factor solution in which the dimensions were best described as Valence and Arousal. Inspection of the adjective-mode loadings revealed a clear circumplex structure; however, there were small gaps in the circumplex in both the positive and negative low arousal regions. Surprisingly, inspection of the film-mode loadings for the 24-adjective solution revealed a structure that more closely resembled a circumplex than the film-mode loadings from the 16-adjective solution. The inclusion of the additional adjectives increased the arousal variability in the film-mode loadings.

The relatively large difference in the film mode between the 16 and 24 adjective 2-factor solutions was not expected. Indeed, the use of 16 adjectives to express the circumplex is not without precedence (e.g., Feldman, 1995; Feldman Barrett & Fossum, 2001). Consequently, it was surprising that a poor circumplex structure was formed when the 16 adjective set was analyzed. It is possible, however, that the presence of the extra eight adjectives changed the way participants responded to the base 16 adjectives. For example, if a hypothetical female participant experiencing anger was asked to rate her mood using only four adjectives (happy, sad, distressed, and calm), then she might rate herself as a 5 on distressed. If, however, she was given five adjectives (happy, sad, distressed, calm, and anger) to express how she felt, then she might rate herself as a 5 on anger and 2 on distressed. Thus, participants' responses on any given adjective might also be influenced by the context provided by the other adjectives in the set. This explanation for the discrepancy between the two factor solutions is consistent with a growing body of research on survey context effects (Schwarz, 1999; Schwarz, Strack, & Mai, 1991; Strack, Martin & Schwarz, 1988; Tourangeau, Rasinski, & Bradburn, 1991).

The nature of survey context effects is well illustrated by a study that examined the relation between marital and life satisfaction (Schwarz 1999). The context in which the items were interpreted was manipulated by changing the order of the items. In the first context, participants read the life satisfaction item *before* the marital satisfaction item, whereas in the second context the order was reversed. When participants read the overall life satisfaction item first, the two items correlated highly (r=.67). When participants read the marital satisfaction item first, the two items correlated poorly (r=.32). This occurred because, when participants read the marital satisfaction item first, they interpreted the life satisfaction item as asking about satisfaction *aside from marriage* because they had just reported that information and did not want to be redundant.

Most relevant to my investigation, however, was a third context in which the participants were given a joint lead-in (establishing a *non-redundancy* norm), which told them that *two* questions would be asked about their well being -- one concerning their marriage and one concerning their life as a whole (Schwarz, 1999). In this context, the two items again correlated poorly (r=.18). This joint lead-in condition is very similar to the context of my study in which participants were ask to rate how they were feeling on the same 24 adjectives after each film. Participants may have become familiar enough with the set of adjectives that they invoked the norm of non-redundancy and did not express certain emotions on the 16 base adjectives that they were expressing on the extra eight adjectives. Thus, my results may have been influenced because ratings of a particular adjective may depend upon the context in which it is rated.

Exploring Higher Dimensions

The primary purpose of this investigation was to estimate the most appropriate axes for 2-dimensional affective space. The possibility that solutions with more than two factors would better represent the data was also explored. The conclusions of this exploratory analysis were limited, however, because both the adjectives used to measure emotional reactions and the film stimuli used to evoke those reactions were sampled from the 2-dimensional affect circumplex.

Nonetheless, a careful inspection of the scree plot, factor residuals, and factor loadings suggested that up to five factors were interpretable. Inspection of the loadings in the 5-factor solution indicated that the five factors most closely corresponded to valence, fear, happiness, surprise, and anger. Interestingly, the valence factor appeared somewhat more heavily weighted toward representing negative affective experiences when the adjective-mode loadings were inspected. Indeed, inspecting the set of factor solutions (i.e., solutions two through five) revealed that, as additional factors were extracted, the valence factor became increasingly negative in nature. Similarly, the arousal factor from the 2-factor solution became an increasingly pure fear factor as additional components were extracted. This suggests that the so called “arousal” factor may be based more upon fear arousal than generalized arousal as is frequently assumed.

Summary

The primary purpose of this investigation was to determine the appropriate axis for the 2-dimensional affect circumplex. Three-mode PARAFAC analysis revealed that Valence and Arousal were the most appropriate dimensions. However, investigating the 2-dimensional affect circumplex with 16 of the 24 adjectives produced slightly different loadings in the film mode than when the full set of 24 adjectives was used. This finding suggested that the way people reported their affective experiences on a specific emotional adjective may have been influenced by the other adjectives included in the set of adjectives used as emotional measures. Exploring higher-dimensional solutions revealed interpretable 3-, 4-, and 5-factor solutions that accounted for more variance than the 2-factor solution. However, a notable qualification with the higher dimensional solutions was that in many instances the factors were primarily defined by a single film-clip in the film mode. Together these findings suggest that although 2-factor solution provided a reasonable model of affective space, it did not completely account for the variance in emotions reported by participants.

CHAPTER 7: STUDY 2

In Study 1, Valence and Arousal were found to be the underlying dimensions for the 2-dimensional affect circumplex. This finding was qualified, however, by the fact that the films did not provide equal coverage of all octants in the circumplex. In particular, the positive and negative low arousal regions were not well represented. There were three purposes for this study. The first purpose was to provide a fair test of the best-fitting axes for the 2-dimensional affect circumplex using a more comprehensive coverage of the circumplex. The second purpose was to further investigate the adjective context effects observed in Study 1. The third purpose was to explore the viability of representing the affective experiences, as measured by affect circumplex adjectives, with more than two dimensions. This exploration of higher dimensions went beyond Study 1 because it was based on a more comprehensive sampling of affect circumplex emotions in both the adjective and film modes.

Inspection of the 2- and 3-factor solutions in Study 1 revealed that the Valence and Arousal factors were present in both solutions. This finding strongly suggested that Valence and Arousal are the fundamental components of affective experiences when conceptualized in terms of two dimensions. Therefore, the more complete coverage of the circumplex provided by the new film set was expected to result in a Valence and Arousal solution when two factors were extracted.

Hypothesis 1: The best-fitting axes for the 2-dimensional circumplex will be Valence and Arousal when a more comprehensive set of adjectives and film stimuli (both sampled from the circumplex) are used.

The findings from Study 1 suggested that the factor solution obtained by analyzing a set of adjectives may be influenced by rating context. More specifically, the structure of film-mode loadings differed depending upon whether the PARAFAC analysis used the entire 24-adjective set or a 16-adjective subset. Indeed, analyzing only the 16-adjective subset produced compressed loadings in the film mode compared to when the entire 24-adjective set was analyzed. An implication of this finding is that participants' decision to express their emotional state on a *particular* adjective may depend upon the set of adjectives it is nested within (i.e., a context effect).

The possibility that the rating of a particular adjective could be influenced by other adjectives in the set has important implications for the way affect is typically measured. For example, PA and NA are typically measured by either the 20-item PANAS or the 60-item PANAS-X. With respect to the PANAS-X, the PA and NA subscales are created by using a 20-item subset of the 60 adjectives. The findings from Study 1, coupled with the Schwarz (1999) research on context effects (discussed previously in Chapter 6), suggests that responses to the 20 PANAS adjectives may be different if they are nested within the larger set of 60 adjectives on the PANAS-X. If true, this suggests that important affective information may not be expressed on the 20-adjective subset that is used to form the PA and NA factors if they are nested in a set of 60 adjectives. More generally, and more importantly, this problem has implications for researchers who administer a large set of adjectives and create different measures of affect based on subsets of the adjectives rated. If the *underlying dimensions of affect* are influenced by the rating context, this suggests the construction of adjective scales using a subset of the adjectives rated could be problematic.

In this study, adjective context effects will be investigated by examining the impact of analyzing 16 adjectives which are either rated on their own or as a *subset* of a larger number of adjectives. Although the research by Schwartz and his colleagues (1999; Schwarz et al., 1991; Strack, et al.,1988; Tourangeau et al., 1991) on survey context effects was suggested as an explanation for the findings observed in Study 1, this investigation does not directly test the order effects which are a central part of their theories. Rather, the current study will examine the extent to which the common practice of creating affect scales from a subset of the adjectives rated is influenced by participants rating adjectives not included in the relevant scales. More specifically, I will examine the extent to which the factor structure of affect changes as a result of analyzing the entire set of the adjectives rated by participants compared a subset of those adjectives. As described above, a non-redundancy norm is possibly evoked when participants are provided with a large set of adjectives.

In Study 1, the context effect may have been diluted by the fact that the subset of 16 adjectives constituted a relatively large proportion of the 24 adjective set. In the present study, the list of additional adjectives will be expanded so that the 16-adjective subset is nested within a larger set of 32 adjectives. Participants are expected to endorse the set of 16 adjectives differently if they are presented as a complete set compared to when they are nested within a larger set of 32 adjectives. To test if the underlying dimensions of affect are influenced by context effects, the axes of a 2-factor solution from a 16 adjective *set* were compared to the axes of the 2-factor solution from the 16 of 32 adjectives *subset*.

Hypothesis 2: The Valence and Arousal axes obtained when participants rate their emotional state on a set of 16 adjectives might not be obtained when the same 16 adjectives are rated within a larger set of 32 adjectives because of the information lost by not including all adjectives in the analysis.

The results of Study 1 revealed that more than two interpretable factors could be extracted from participants' affect ratings. This was a surprising finding given the strong preference for the 2-factor solution among affect researchers (e.g., Russell, 1980; Russell & Carroll, 1999a; Watson et al., 1988; Watson & Tellegen, 1999). More specifically, the results of Study 1 suggested that, when a small number of factors are used to represent affect, three or more factors may be more appropriate. Thus, the 2-factor representation of affective experiences may not be as robust as some researchers imply (e.g., Gray & Watson, 2001).

Hypothesis 3: More than two factors will be required to represent the circumplex emotions elicited by the film clips.

Method

Participants

A total of 488 undergraduate female students (mean age = 20.2), from an introductory psychology course, who spoke English as a first language, participated for course credit.

Procedure

Similar to Study 1, participants rated their initial emotional state (occasion 1), and then watched a series of 24 film clips (occasions 2 through 25) and reported how they felt at the instant each film ended. Following the self-report measure at the end of the last film, participants reported their age and indicated if they were taking prescription drugs that might influence their mood. The self-report measures provided at the end of each film clip were not the same for all participants. Some participants reported how they felt using only 16 adjectives (16-Adjective Condition) whereas other participants reported how they felt using 32 adjectives (32-Adjective Condition). Participants were run in groups with each session lasting approximately two hours.

16-Adjective Condition. One-hundred and fourteen undergraduate female students participated in this condition (20 sessions). Data from two participants who failed to follow instructions were discarded. These eliminations resulted in a 112 (people) *x* 16 (adjectives) *x* 25 (occasions) data cube in which each participant contributed 400 data points for a total of 44, 800 data points. Missing values constituted 0.125% of the data cube. Participants were run in groups, with the group sizes ranging from 5 to 22 (*M*=13.0). The 16 emotional adjectives used to represent the circumplex in this condition were: (octant 1: stimulated, surprised), (octant 2: peppy, excited), (octant 3: cheerful, happy), (octant 4: calm, relaxed), (octant 5: still, quiet), (octant 6: drowsy, bored), (octant 7: sad, miserable), (octant 8: afraid, distressed).

32-Adjective Condition. Three-hundred and seventy-four undergraduate female students participated in this condition (43 sessions). Data from seven participants who failed to follow instructions were discarded. As well, data from an additional eighteen participants were discarded because the participants reported taking prescription (and in some cases non-prescription) drugs that would influence their emotional reactions (e.g., antidepressants). These eliminations resulted in a 349 (people) *x* 32 (adjectives) *x* 25 (occasions) data cube in which each participant contributed 800 data points for a total of 279, 200 data points. Missing values constituted 0.096% of the data cube. Participants were run in groups with the group sizes ranging from 5 to 26 (*M* =15.9). The data from the 32-Adjective Condition were used to explore the viability of solutions with more than two factors, and, consequently, more participants were required than in the 16-Adjective Condition (for which only the 2-factor solution was examined). The 32 emotional adjectives used to represent the circumplex in this condition were: (octant 1: stimulated, surprised, startled, aroused), (octant 2: peppy, excited, attentive, enthusiastic), (octant 3: cheerful, happy, satisfied, warmhearted), (octant 4: calm, relaxed, serene, tranquil), (octant 5: still, quiet, sleepy), (octant 6: drowsy, bored, gloomy, dull), (octant 7: sad, miserable, depressed, downhearted), (octant 8: afraid, distressed, angry, hostile, tense).

Materials

Film Clips. Twenty-four film clips were constructed specifically for this project using the procedure outlined in the Stimuli Selection section (see Chapter 5). More specifically, in addition to the 10 film clips from Study 1[27], an additional 14 film clips were created for Study 2. Five of the additional 14 film clips were created by following the extremely specific frame by frame editing instructions provided by Gross and Levenson (1995). Nine of the additional 14 film clips in Study 2 were developed

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[27] Eleven films clips were used in Study 1, however, the "True Lies" film clip was discarded for Study 2 because the participant debriefing sessions led me to believe it was not as effective at evoking excitement as I had intended.

specifically for this study. Thus, of the 24 clips used in Study 2, eleven of the film clips were previously validated by Gross and Levenson (1995) whereas 13 of them were created for this investigation (of which 4 were used previously in Study 1).

The additional nine film clips I developed specifically for Study 2 were created by screening a large number of films for emotion-evoking moments. Next, the film clips were created by editing together several segments from a single film to create a short story. The new film clips for this study provided a greater sampling of emotional stimuli from the entire circumplex, but, most notably, they provided denser coverage of the low arousal regions of the circumplex. A complete list of the film clips is presented in Appendix F. Octant means for the film stimuli are presented in Appendix G.

Adjectives. Study materials for the 16- and 32-Adjective Conditions are presented in Appendices H and I, respectively.

PARAFAC Analyses

Before conducting PARAFAC analyses the data cube was preprocessed (fiber centered and slab scaled) as in Study 1. After preprocessing, there was variance in all adjectives when the data cube was collapsed across participants and standard deviations calculated for each adjective across films (see Appendix J). That is, ratings on all adjectives were influenced to some degree by the film clip manipulation. The PARAFAC convergence criterion used in this study (.00001 percent of the mean absolute factor loading for each mode) was identical to the one used in Study 1.

Results and Discussion

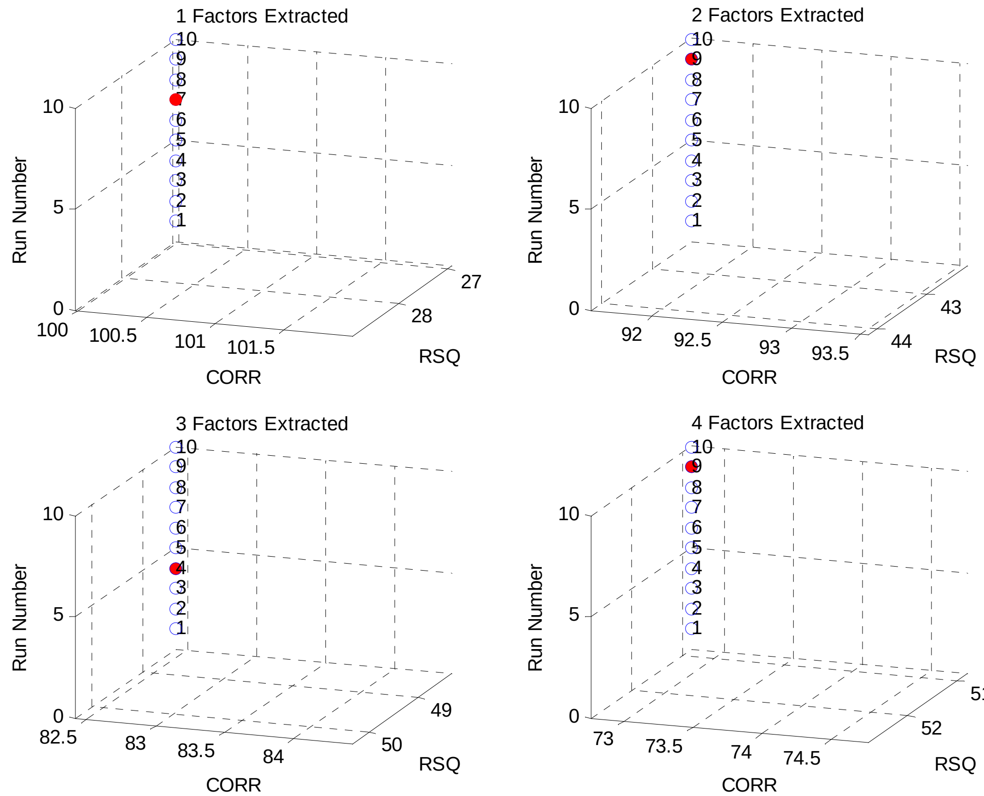
Competing Solutions

The extent to which competing solutions were present at a given dimensionality was assessed by using 10 random starting points for each PARAFAC analysis. The results of these analyses were plotted using the procedure outlined in Study 1 (see Chapter 6). Competing solutions did not occur for any of the analyses in which two factors were extracted. When exploratory analyses were conducted to examine factor solutions with more than two dimensions, some competing solutions did occur. In cases where there were competing solutions, these solutions are identified in Figure 22 by vertical columns of dots which are indexed by fit (RSQ) and core-consistency (CORR). Each vertical column of dots indicates a cluster of solutions (i.e., a fit optimum) with the same factor *structure*. The column which contains the single solid dot (all other dots are outlines) represents the cluster of solutions which possess a common *structure* that best fits the data. Although the structures of the solutions in a given column are essentially identical in terms of structure, there are extremely slight differences in fit. Thus, the solution with a solid dot is the best-fitting solution within the cluster of solutions with the best-fitting structure.

System Variation Manipulation Check

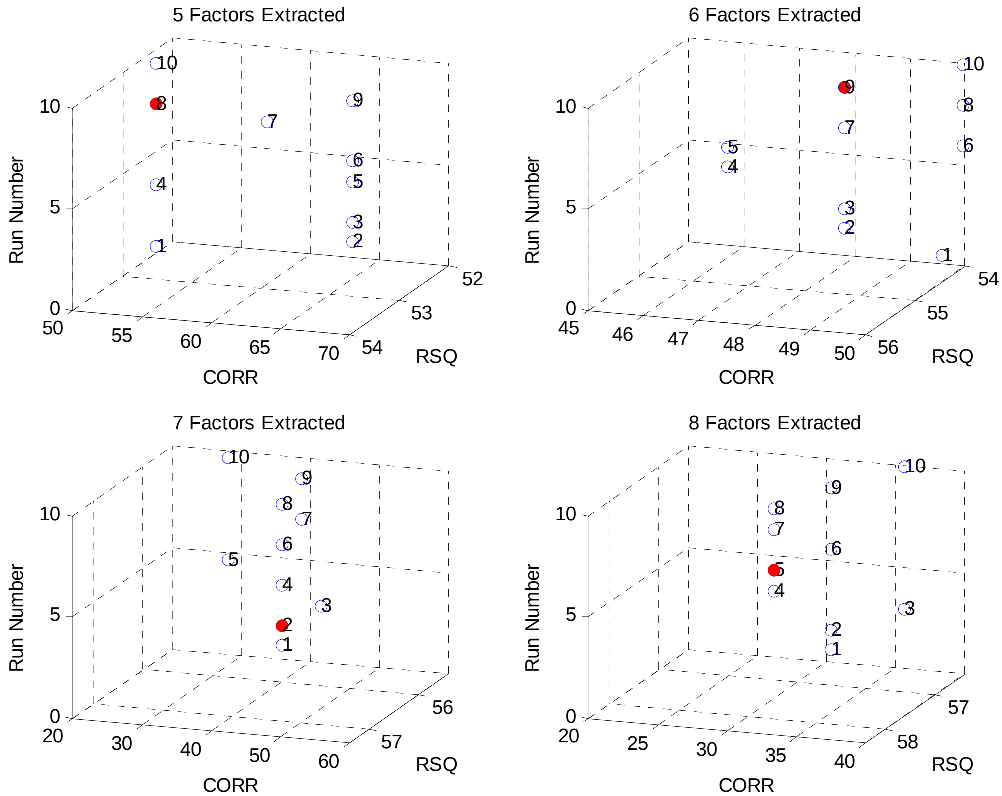
As in Study 1, I examined the extent to which system variation had been created in the data cube by comparing how well a 2-factor solution fit the cube in its original form relative to how well a 2-factor solution fit the cube when it had been scrambled to remove system variation. With respect to the original (unscrambled) version of the data cube, a 2-

Figure 22
Study 2: Plot of competing solutions



Notes
RSQ indicates R^2 and CORR indicates core-consistency
The solid dot indicates the global fit optima

Figure 22(continued)



Notes
RSQ indicates R^2 and CORR indicates core-consistency
The solid dot indicates the global fit optima

factor solution explained 42.2% of the variation in participants' affect ratings (there were no competing solutions). To remove any system variation which many of been present in the original data cube, a scrambled version of this data cube was created by randomly ordering the film clips for each participant. A total of 10 scrambled data cubes were created using this procedure. The percent of variance explained by a 2-factor solution for these scrambled data cubes ranged from 4.1% to 4.4%. The relatively large difference in explained variation between the original and scrambled data cubes suggests the films clips created the required system variation in participants' affect ratings.

Affect Circumplex

The unconstrained 2-factor PARAFAC solution for the 32-Adjective Condition accounted for 42.2 percent of the variability in the data cube. The first factor (which accounted for 55.1 percent of the explained variance) was slightly larger than the second factor (which accounted for 44.9 percent of the explained variance). The correlations between the factors in each mode are presented in Table 6. Inspection of the adjective- and film-mode factor loadings (see Figures 23 and 24) suggests that Factor 1 is best described as Valence whereas Factor 2 is best described as Arousal. The zero-point for the adjective mode is presented on the plots to facilitate interpreting the extent to which the factors are unipolar or bipolar[28]. Inspection of the factor loadings on this graph suggests that both factors are bipolar in nature. Because I centered across the film mode the zero-point for this mode cannot be interpreted and is therefore not displayed. The MSR plot for the film mode (see Figure 25) illustrates, however, that the 2-factor solution

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[28] Because the adjective mode was not centered, the magnitude of the loadings is meaningful in this mode. To facilitate interpretation of this mode, large loadings (i.e., above .20) were printed in bold whereas small loadings (i.e., below .20) were printed in non-bold italics.

Table 6
Study 2: 2-Factor Solution (32 Adjectives)

Variance in ratings accounted for by the factors (%)

42.2%

Relative size of factors (% of explained variance)

55% 45%

Iterations to convergence

136

Individual Mode Factor Correlations

1.00	0.00
0.00	1.00

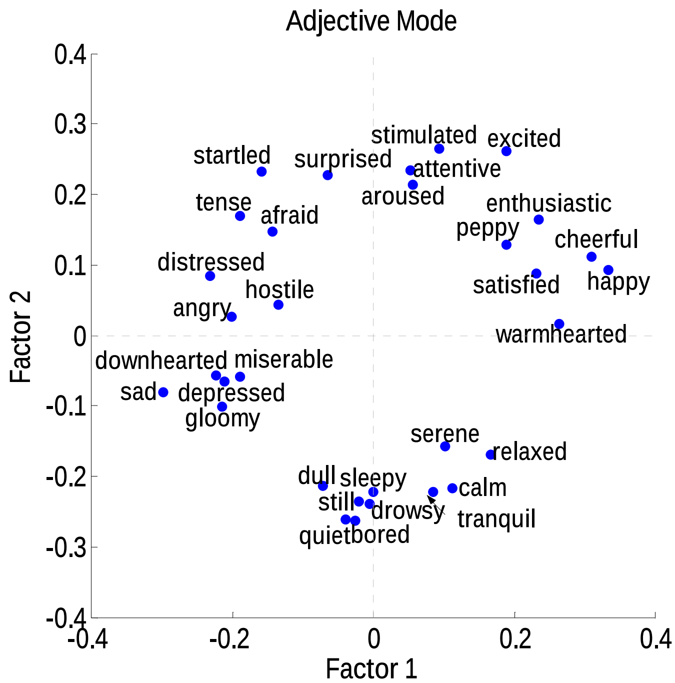
Adjective Mode Factor Correlations

1.00	0.15
0.15	1.00

Film Mode Factor Correlations

1.00	-0.34
-0.34	1.00

Figure 23
Study 2: Cross plot of 2-factor solution



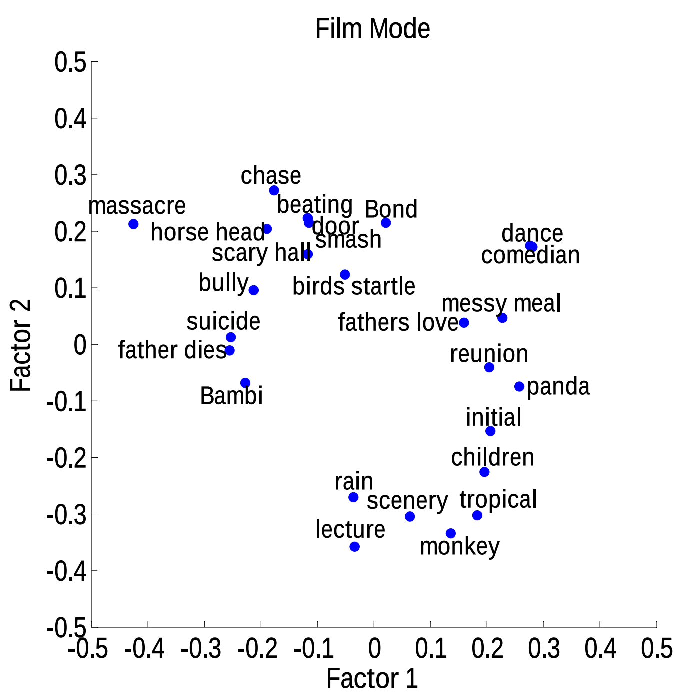


Figure 23(continued)

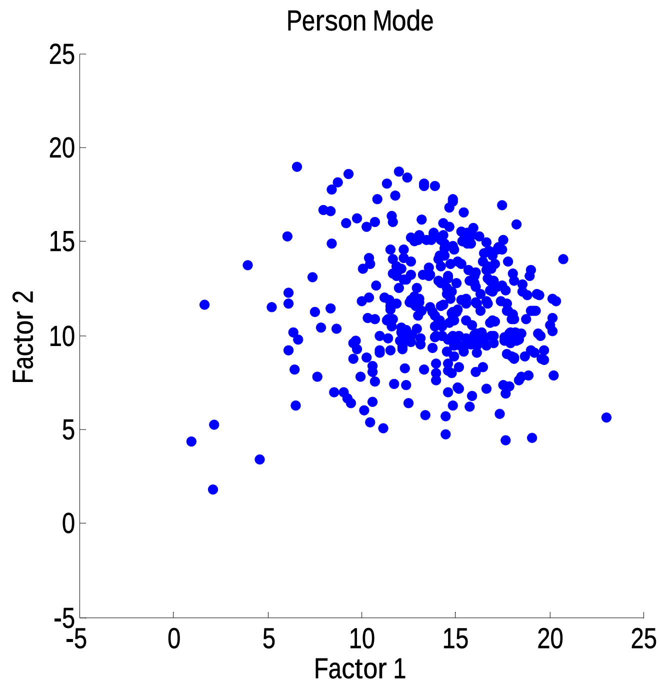
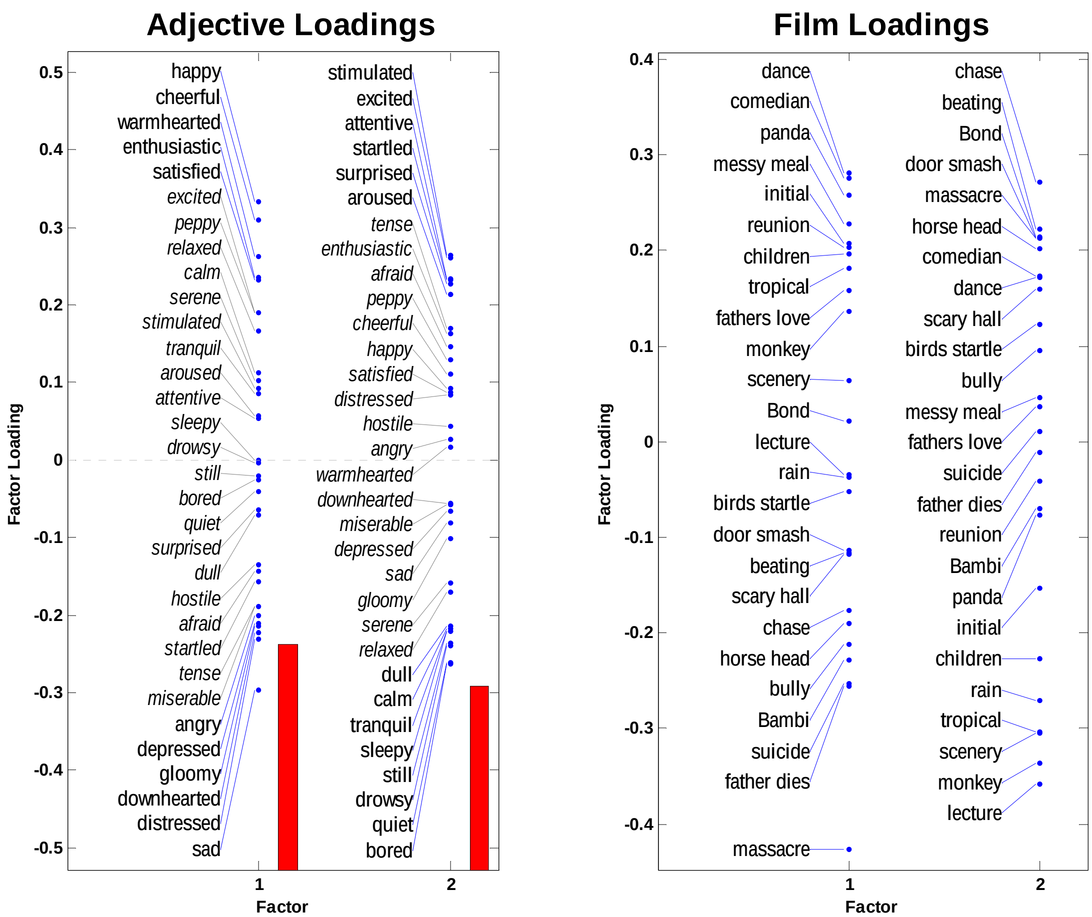
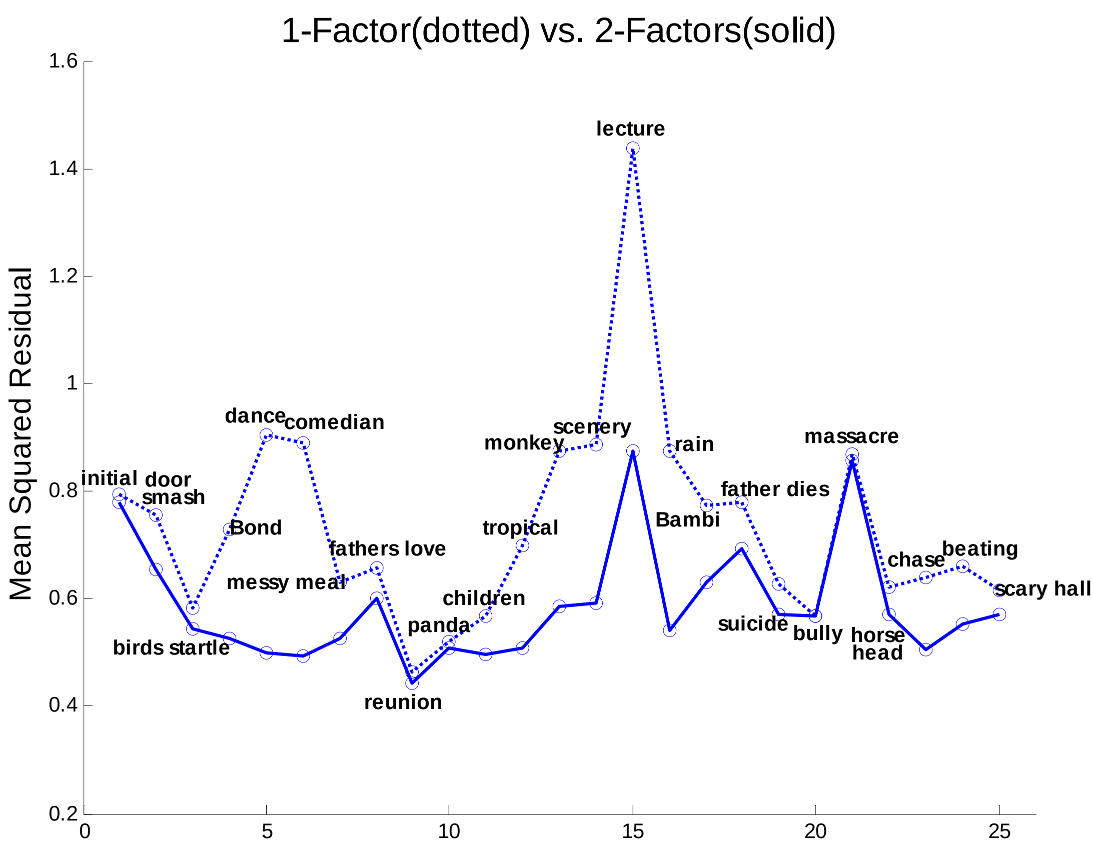


Figure 24
Study 2: One-way plot of 2-factor solution



Note: Vertical bars illustrate relative sizes of factors
A lighter italicized font is used for adjectives with factor loadings less than .20

Figure 25
Study 2: Residual plot of 1- and 2-factor solutions



accounted for more variance in both high arousal film clips (e.g., dance and comedian) and low arousal film clips (e.g., lecture and rain) than the 1-factor solution. Furthermore, the Valence and Arousal axes were also found when I examined data from participants for each of two film orderings separately.

The accuracy of the factor loadings estimated in any factor analysis depends on the people included in the analysis. Idiosyncratic properties of individuals (i.e., sample-specific variance) will influence the results obtained. Although this source of error in the data is usually just ignored, its influence can be estimated using bootstrapping to create confidence areas (or bubbles) for each adjective and film included in the analysis (Kiers, 2003).

The first step in the bootstrapping procedure was to create 1000 samples that emphasized individual-specific variation to different degrees. Random sampling with replacement was used to create a number of bootstrap samples (N=349 for each) based on the original sample (N=349). Sampling with replacement was used so that each participant's data were represented with different frequencies across the samples. For example, a given individual's data might be included once in the first bootstrap sample, three times in the second bootstrap sample, omitted from the third bootstrap sample, and so on. This procedure ensured that idiosyncratic variation was somewhat different for each bootstrap sample and simulated drawing the samples independently from an infinite population. Next, a PARAFAC analysis was conducted on each of the bootstrap samples to create 1000 sets of factors loadings. These loadings were used to create an empirical distribution of 2-factor loadings for each of the 32 adjectives. More specifically, for each of the 32 adjectives there were 1000 estimates of its loading on Factor 1 and 1000 estimates of its loading on Factor 2. A singular value decomposition (SVD) was used to obtain a set of independent axes for the loadings for each adjective. Loadings obtained from the singular value decomposition were used to construct 90% confidence bubbles for each of the adjectives[29]. A similar procedure was used to create confidence bubbles for each film clip.

If the Valence and Arousal solution obtained was substantially dependent upon idiosyncratic properties of the individuals included in the analysis, then the confidence bubbles would be very large. Indeed, if PA and NA were a viable 2-factor solution, disguised by the idiosyncratic variation, then the confidence bubbles would be sufficiently wide to permit the circumplex of adjectives to rotate 45 degrees to a PA and NA orientation. Inspection of the confidence bubbles for each adjective (see Figure 26) revealed, however, that the bubbles were sufficiently small to eliminate the possibility that PA and NA were viable axes for representing 2-dimensional affective space.

In summary, these data provide strong support for Hypothesis 1. PARAFAC analysis revealed that the best-fitting axes for 2-dimensional affective space were Valence and Arousal. Bootstrap analyses were used to create confidence bubbles which assessed the extent to which orientation of the axis was based on idiosyncratic properties of the participants. Inspection of the confidence bubbles revealed that the Valence and Arousal axes uncovered by PARAFAC were not dependent upon idiosyncratic properties of the participants examined; a finding that also implies that the PA and NA orientation

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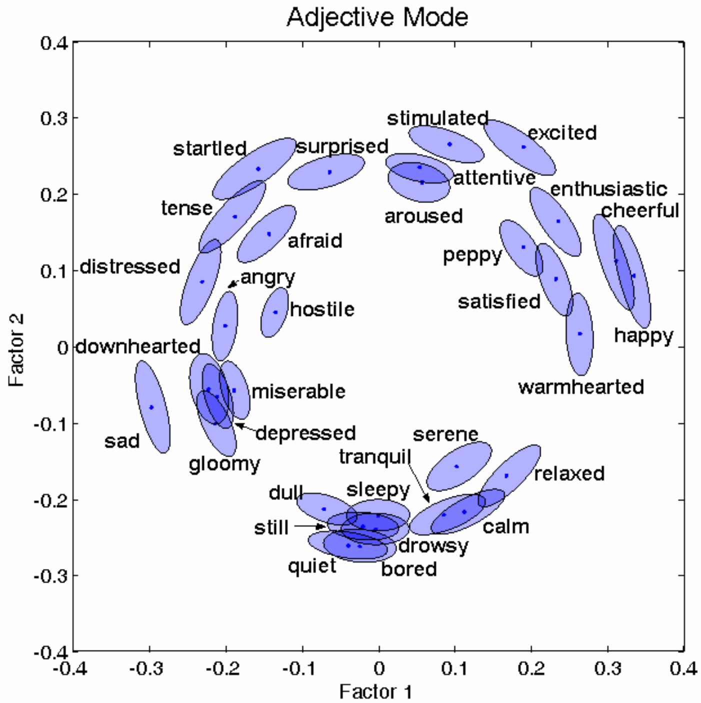
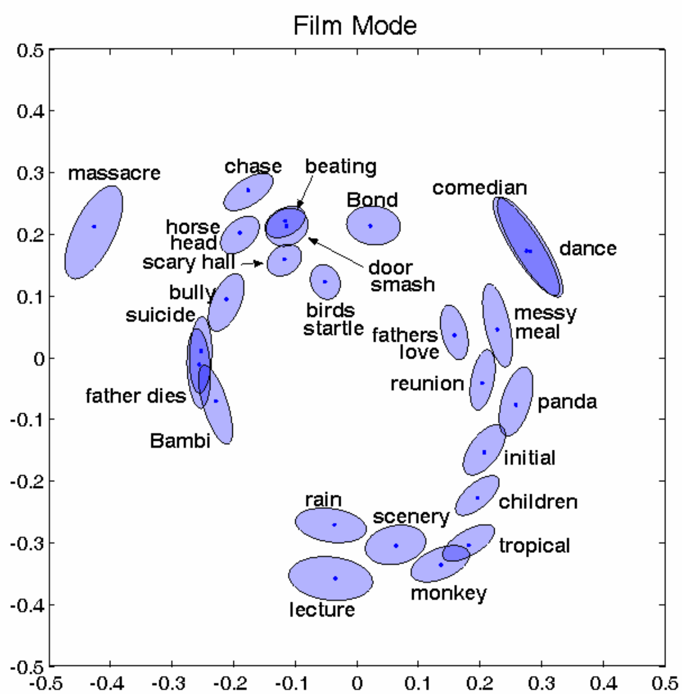
[29] For each cluster of points representing a single adjective, a SVD was used to extract two independent axes to describe the cluster. These axes were extracted by the SVD algorithm such that each axis accounted for as much independent variance as possible. Consequently, the two independent axes (90 degrees apart) formed a frame of reference for describing the set of points (for a particular adjective) such that the first axis was aligned with the direction of maximal variation and the second axis was aligned with the next largest source of independent variation. A 90% confidence interval was created along each axis. The 90% confidence bubble was created by drawing an oval based on these 90% confidence intervals.

Figure 26
90% Confidence plot for Study 2: 2-factor solution
(32 of 32 adjectives analyzed, 32 of 32 adjectives plotted)





of the circumplex axes is not viable.

Adjective Context Effects

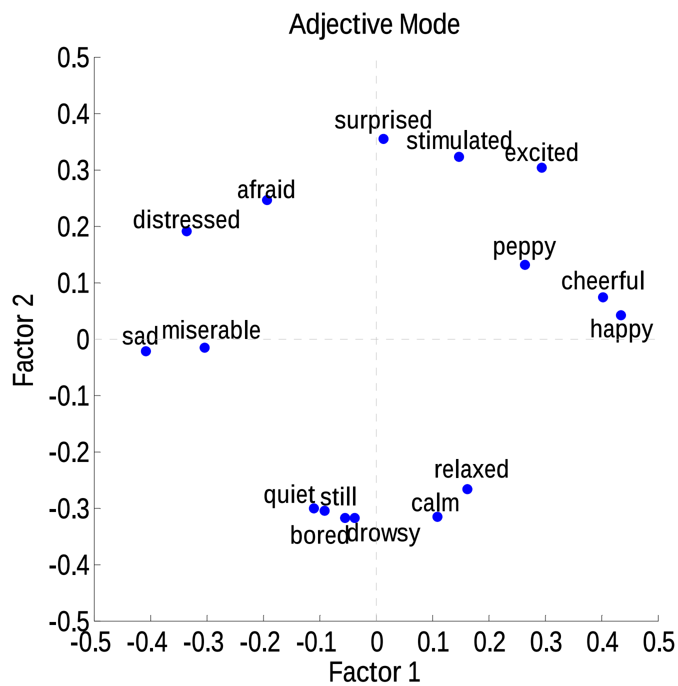
Adjective context effects were examined by comparing the results of two PARAFAC analyses. More specifically, the results of a factor analysis of data from the condition in which participants rated only 16 adjectives (16-Adjective Condition) was compared to the results of a factor analysis for the condition in which participants rated the same 16 adjectives nested in a larger set of 32 adjectives (32-Adjective Condition). The 2-factor PARAFAC solution for the 16 adjective data set accounted for 47.8 percent of the variability in the data cube. The first factor (which accounted for 53.7 percent of the explained variance) was somewhat larger than the second factor (which accounted for 46.3 percent of the explained variance). The correlations between the factors in each mode are presented in Table 7. Consistent with previous findings, the two factors reflected Valence and Arousal (see Figure 27). This solution did not manifest the compressed film-mode loadings associated with the 16 adjectives solution from Study 1.

The 2-factor PARAFAC solution for the 16/32 adjective data set accounted for 44.7 percent of the variability in the data cube. The first factor (which accounted for 56.8 percent of the explained variance) was larger than the second factor (which accounted for 43.2 percent of the explained variance). Somewhat surprisingly, the two factors from this solution were also Valence and Arousal (see Figure 28; correlations between the factors in each mode are presented in Table 7). Indeed, this factor solution, based on a 16 adjective subset of the 32 adjectives rated, did not manifest any of the problems associated with the 16/24 adjective solution from Study 1. Moreover, visual inspection of the loading plots for the two conditions revealed a high degree of similarity in both the

Table 7
Study 2: 2-Factor Solution (16 and 16/32 Adjectives)

	16 Adjectives	16 of 32 Adjectives
Variance in ratings accounted for by the factors (%)	47.8%	44.7%
Relative size of factors (% of explained variance)	54% 46%	53% 47%
Iterations to convergence	46	112
Individual Mode Factor Correlations		
	1.00 0.00	1.00 0.00
	0.00 1.00	0.00 1.00
Adjective Mode Factor Correlations		
	1.00 0.14	1.00 0.19
	0.14 1.00	0.19 1.00
Film Mode Factor Correlations		
	1.00 -0.32	1.00 -0.33
	-0.32 1.00	-0.33 1.00

Figure 27
Study 2: Cross-plot of 2-factor solution
(16 of 16 adjectives analyzed, 16 of 16 adjectives plotted)



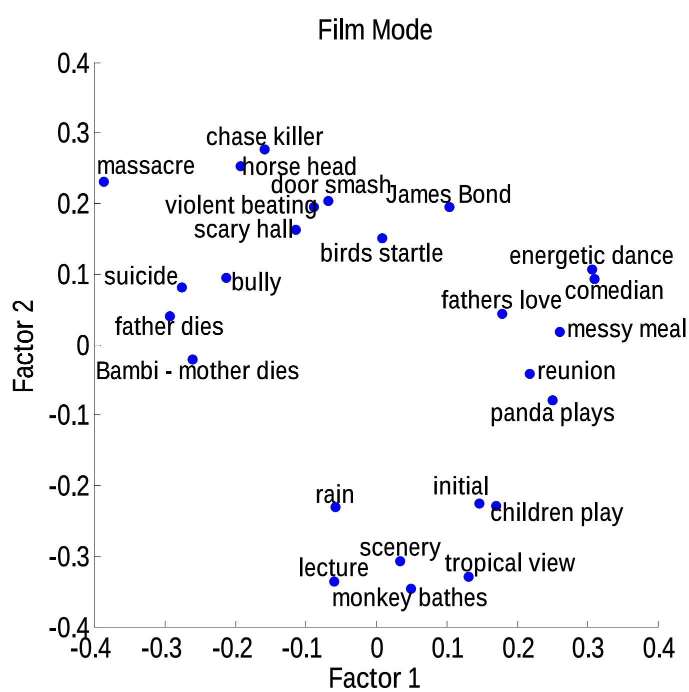
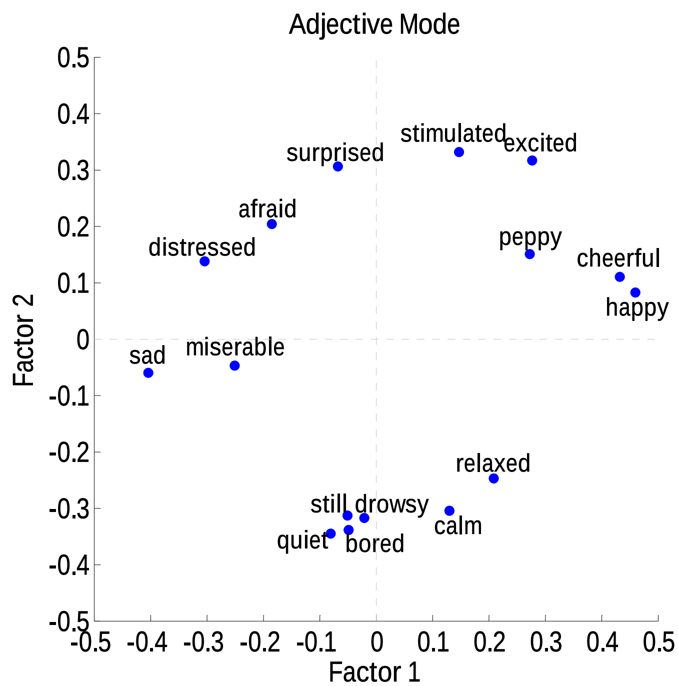
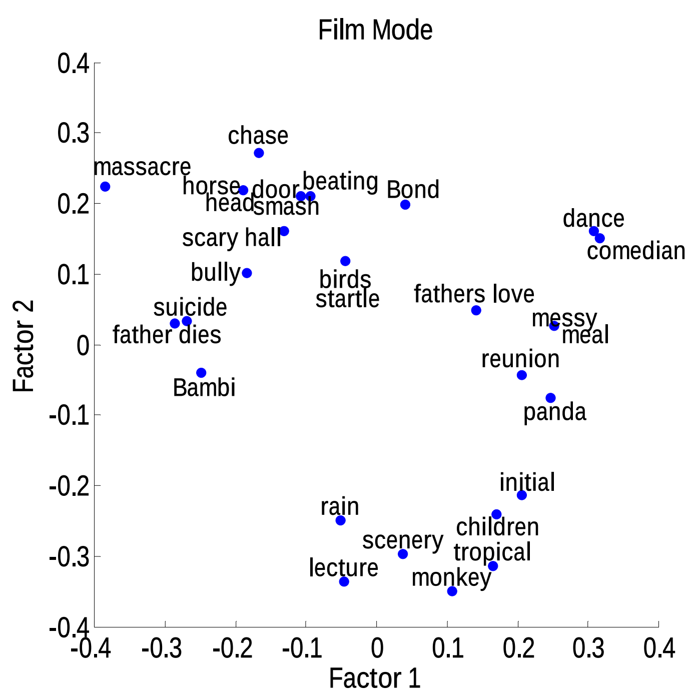


Figure 28
Study 2: Cross-plot of 2-factor solution
(16 of 32 adjectives analyzed, 16 of 32 adjectives plotted)





adjective and film modes. This similarity is reflected in the high correlations between the factors obtained in the two conditions (r=.99 and .99 for both the adjective and film modes; see Table 8) indicating that the problems associated with analyzing a subset of adjectives found in Study 1 did not occur in this study. Consequently, because the Valence and Arousal axes were found in both conditions, Hypothesis 2 was not supported[30].

Exploring Higher Dimensions

The viability of solutions with more than two factors was assessed using a scree plot (Cattell, 1966; 1978; see Figure 29). Inspection of the scree plot suggested that a 3-factor solution was appropriate. Nonetheless, the loadings for solutions with more than three dimensions were also examined.

Three-Factor Solution. Inspection of the loadings in the 3-factor solution (see Figure 30 and Table 9) indicated that the three factors most closely correspond to arousal, positive affect, and negative affect. However, the positive and negative affect factors extracted had less arousal than is typically associated with the PA and NA labels. More specifically, PA and NA labels are typically used to describe high arousal emotions (peppy, excited [PA]; distressed, afraid [NA]), whereas both factors in the current factor solution were defined at their poles by adjectives with less arousal (happy, cheerful [PA]; sad, downhearted [NA]). Indeed, the PA and NA factors found in the 3-factor solution

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[30] To further explore the reasons for the distorted film-mode circumplex in Study 1, I used a subset of the adjectives and films from the 32-adjectives condition in Study 2 to create a data set that reflected the specific films and adjectives in the 16-Adjective condition from Study 1. This data set was almost identical to the one used in Study 1, however the “True Lies” film clip was not included in Study 2 nor was the adjective “uncomfortable.” Analysis of this similar but larger data set (N=349 vs. N=85) revealed a clear circumplex structure in both the adjective- and film-modes suggesting the distorted film-mode circumplex from Study 1 occurred because of the small sample size in that study.

Table 8
Study 2: Correlations between 16 and 16/32 Factor Solutions

		16 Adjectives	
16 of 32 Adjectives	Adjective Mode	0.99	0.08
		0.25	0.99
	Film Mode	0.99	-0.40
		-0.25	0.99

Figure 29
Study 2: Scree plot

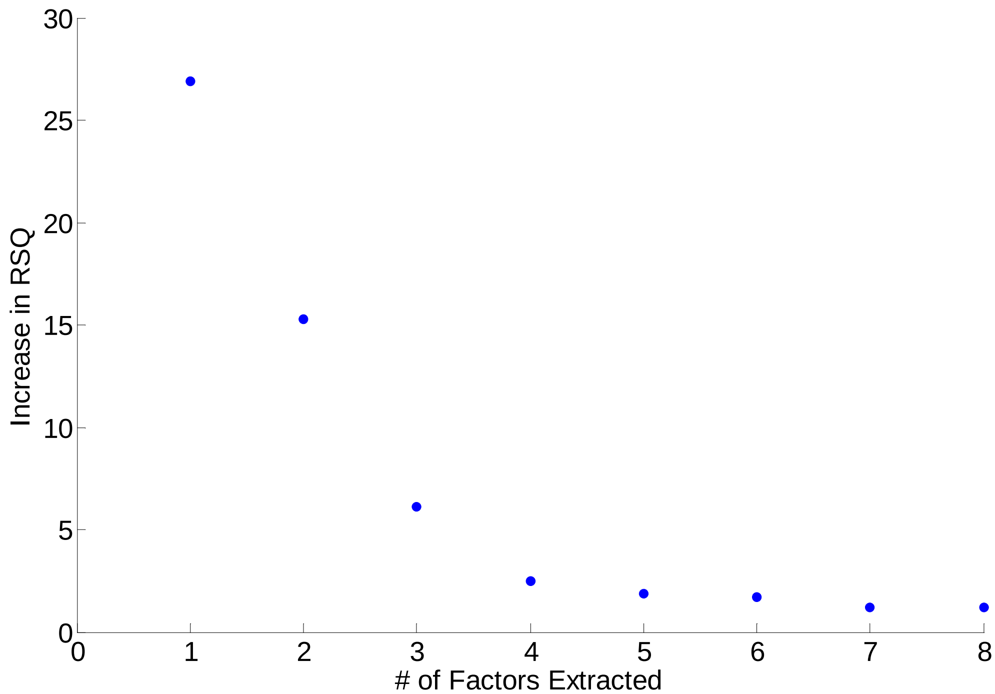
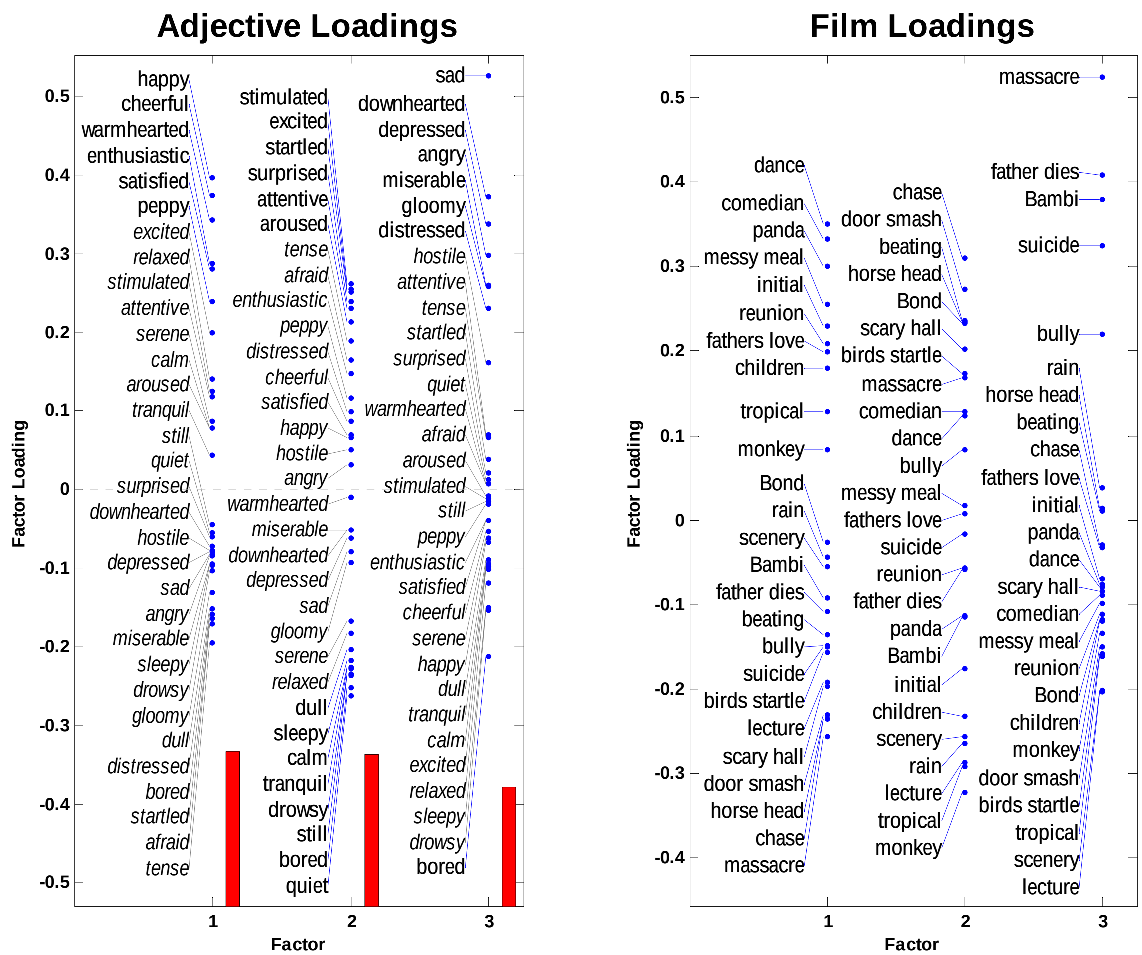


Figure 30
Study 2: One-way plot of 3-factor solution



Note: Vertical bars illustrate relative sizes of factors
A lighter italicized font is used for adjectives with factor loadings less than .20

Table 9
Study 2: 3-Factor Solution (32 Adjectives)

Variance in ratings accounted for by the factors (%)

48.3%

Relative size of factors (% of explained variance)

36% 36% 28%

Iterations to convergence

461

Individual Mode Factor Correlations

1.00	0.00	0.00
0.00	1.00	0.00
0.00	0.00	1.00

Adjective Mode Factor Correlations

1.00	0.24	-0.34
0.24	1.00	0.14
-0.34	0.14	1.00

Film Mode Factor Correlations

1.00	-0.35	-0.37
-0.35	1.00	0.14
-0.37	0.14	1.00

corresponded more closely to the positive and negative ends of the valence dimension from the 2-factor solution. Consequently, these factors will subsequently be referred to as PV (positive valence) and NV (negative valence). Correlations between the 2- and 3-factor solutions are presented in Figure 31. Residual plots for the 2- and 3-factor solutions are presented in Figure 32. Inspection of this figure reveals that the increase in fit obtained by extracting 3 factors appears to be the result of a better fit for the sadness-inducing film clips (father dies, Bambi's mother dies, and massacre). As well, when I examined data from participants for each of two film orderings the same 3-factor solution was found.

Beyond Three Factors. Although the scree plot suggested that solutions with more than three factors did not significantly increase the amount of modeled variance, these factors were also examined and are presented in Appendix K. These additional analyses revealed that up to six distinguishable factors could be extracted (happiness, sadness, arousal, boredom, surprise, and serenity); however, the 5-factor solution appeared most meaningful (arousal, happiness, anger, sadness, serenity). More specifically, anger formed its own factor in the 5-factor solution; however, when six factors were extracted, anger was reabsorbed into the arousal factor. The 6-factor solution did, however, make a clear distinction between being bored and surprised. This distinction resulted in anger being less clearly distinguishable; therefore, the 5-factor solution appeared to be more appropriate. Moreover, this 5-factor solution was very similar to the 5-factor solution from Study 1, with the exception that the surprise factor in Study 1 was replaced by a serenity factor in the current study. This does not appear to be a mere reversal of the same factor because both the surprise and serenity factors were found in the 6-factor solution

Figure 31
Adjective mode correlations between the 1-, 2-, and 3-factor solutions

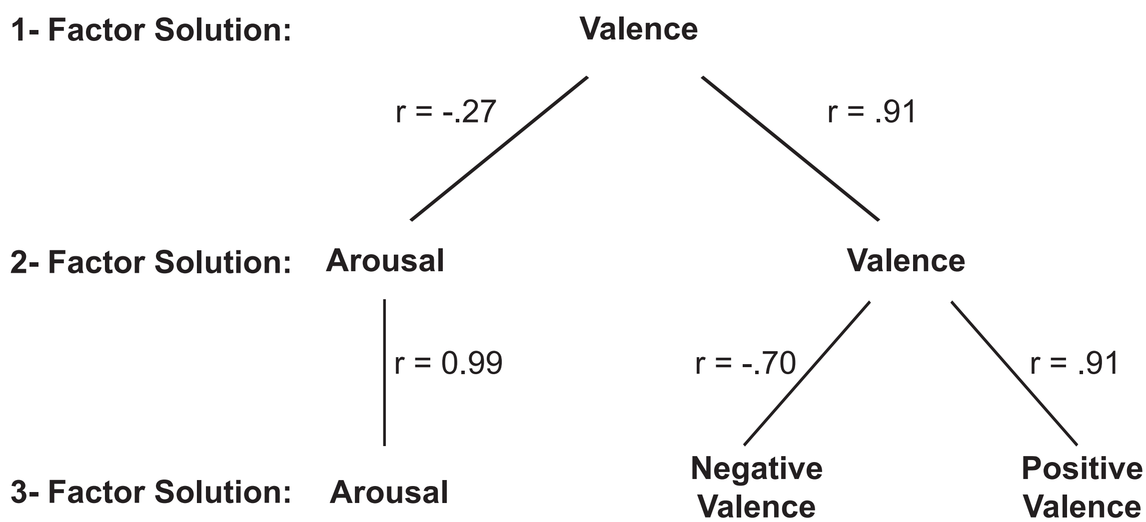
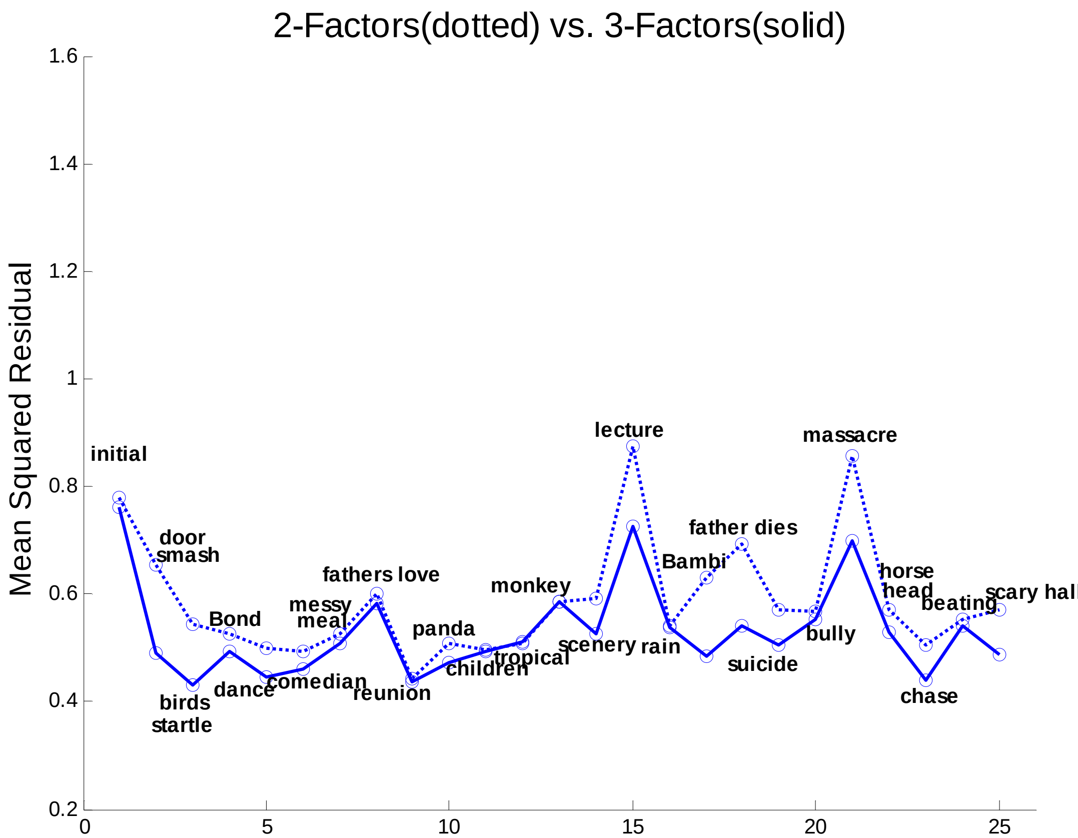


Figure 32
Study 2: Residual plot of 2- and 3-factor solutions



for Study 2. These findings suggest that there are potentially seven distinguishable factors (happiness, sadness, fear, anger, boredom, surprise, and serenity), although they could not all be extracted at the same time with these data. The failure to extract all seven factors at the same time may be the result of an insufficient number of films and adjectives representing these factors. This is not surprising, given the fact that the films and adjectives were selected to represent the affect circumplex rather than the complete range of possible emotions.

Furthermore, solutions with more than three factors were not robust with respect to the order of film stimuli. Although both film clip orderings produced the 4-factor solution, discussed above, the same was not true for the 5-factor solution. More specifically, anger emerged as a factor when the entire data set was analyzed, but not when the two film orderings were examined separately. Indeed, when the 5-factor solution was extracted for each of the two film orderings separately, the anger factor was not found in either solution. Similar problems occurred when the 6-factor solution was examined. In these analyses, the factors found in the different film orders corresponded even less with the factors found when the entire data set was examined. Interestingly though, anger did occur as a factor in both of the film orderings when 6-factors were extracted.

In summary, these data provide strong support for Hypothesis 3. The scree plot suggested that three factors, rather than two, were appropriate for representing affective space. Moreover, although three factors appear to account for the variance that is common to all emotional reactions, up to seven factors can be distinguished that allow for a more complete representation of emotional experiences. Nonetheless, these findings underscore that the 2-dimensional representation of affective space does not completely account for the variance in emotions identified as belonging to the affect circumplex. The implications for these findings are discussed in Chapter 8.

CHAPTER 8: GENERAL DISCUSSION

The behavior of individuals in the workplace is the result of both *thoughts* and *feelings*. A substantial amount of research has examined the cognitive basis for employee behavior (e.g., numerous motivation theories, justice theory, work attitudes, etc.). However, it is only recently that attention has shifted toward examining how emotions influence behavior at work. Emotions in the workplace are most often examined via self-ratings on a series of emotional adjectives. Factor analyses of these self-ratings have revealed a quite robust 2-dimensional model of affective experiences (Gray & Watson, 2001). The factor loadings for emotional adjectives are typically arranged in a circular pattern that has been described as an affect circumplex (Russell, 1980). Although there is consensus on the appropriateness of the circumplex model itself, there is substantial disagreement concerning how the circumplex should be interpreted (c.f., Russell & Carroll, 1999a; Russell & Carroll, 1999b; Watson & Tellegen, 1999). More specifically, some authors (e.g., Russell, 1980) have conceptualized the circumplex as being defined by a Valence axis, ranging from happy to unhappy, and an Arousal axis, ranging from stimulated to drowsy. In contrast, other authors (e.g., Watson, et al., 1988) have conceptualized the circumplex as being defined by a Positive Activation (PA) axis, ranging from high positive activation (e.g., excited) to low negative activation (e.g., lethargic), and a Negative Activation (NA) axis, ranging from high negative activation (e.g., afraid) to low positive activation (e.g., serene). These two approaches represent different rotations of the circumplex axis (differing by approximately 45 degrees), and considerable research has been devoted to determining which rotation is correct.

Unfortunately, the debate over which set of axes is most appropriate has been largely unresolved because of the rotational indeterminacy of the traditional 2-mode factor analytic technique typically used by affect researchers. Consequently, applied researchers have been left with little definitive evidence to guide them in their choice of emotion measures and are therefore unduly influenced by availability and popularity. The Positive and Negative Affectivity Schedule (PANAS: Watson et al., 1988) is the most popular measure of affect, having been cited over 1400 times as of January 2003 (Huelsman, Furr, & Nemanick, 2003). The prominence of the PANAS has resulted in the PA and NA approach becoming the unofficial standard for measuring affective experiences. Indeed, as mentioned previously, the PA and NA perspective was recently used in a comprehensive meta-analytic review of the relation between affect and job-related attitudes including job satisfaction, organizational commitment, turnover intentions, and the dimensions of job burnout (Thoresen et al., 2003). The authors of this meta-analysis acknowledged both perspectives for measuring affect, but decided to use the PA and NA approach because the vast majority of organizational studies have done so. Given the current dominance of the PA and NA approach, it is important to determine if these are indeed the appropriate axes to describe affective space.

In the current research, I used 3-mode PARAFAC analysis (Harshman & Lundy, 1984) to empirically determine the most appropriate rotation of the affect circumplex axes. With 3-mode PARAFAC analysis, the most appropriate orientation of a set of axes is determined by using both between and within-participant data to directly fit the factors extracted. The inclusion of additional measurement occasions (i.e., the within participant data) creates restrictions on the factor solution such that there is a single best fitting solution. Consequently, with 3-mode factor analysis, there is only one solution that fits that data and this solution is based on intrinsic properties of the data -- as opposed to a rule (i.e., rotational strategy) chosen by the researcher (e.g., varimax). This makes a 3-mode PARAFAC analyses an ideal approach for determining the most appropriate orientation of the 2-D affect circumplex axes.

2-D Affect Circumplex

In both Study 1 and Study 2, PARAFAC analyses revealed that the most appropriate axes for the 2-dimensional affect circumplex were Valence and Arousal. This finding provided especially strong support for the Valence and Arousal axes because any orientation of the axes could have occurred, depending on how patterns of adjective covariation changed over the film clips. Moreover, to ensure that idiosyncratic variation did not produce the Valence and Arousal orientation of the axes, a bootstrapping analysis was conducted in Study 2 to generate confidence bubbles for each adjective in the affect circumplex. If the PA and NA solution was feasible, and the Valence and Arousal solution was fit only because of idiosyncratic (i.e., sample specific) variation, then the confidence bubbles would have been sufficiently wide to allow the axes to be rotated to the PA and NA position. The resulting confidence bubbles were quite narrow, however, and therefore provided strong support for the Valence and Arousal orientation of the axes.

Despite the robustness of the orientation of the axes, not all octants in the affect circumplex were well defined in the factor loadings. Specifically, in both Study 1 and Study 2, the positive and negative low arousal regions (Octants 4 [pleasant deactivation] and 6 [unpleasant deactivation]) were poorly defined, with many of the adjectives having loadings that placed them adjacent to the intended octant. This finding is consistent with the results of research that examined the extent to which the 2-dimensional affect structure represents a true mathematical circumplex (Remington, Fabrigar & Visser, 2000). Remington et al. analyzed 46 published data sets and discovered that the adjectives identified a priori as belonging to Octants 4 (pleasant deactivation) and 6 (unpleasant deactivation) did not consistently load in the appropriate octant (although adjectives from other octants did load consistently in the appropriate octants). Thus, the difficulty associated with representing affect in the low arousal regions was common across many of the 46 studies examined by Remington et al. It is unclear, however, if the difficulties associated with representing low arousal octants represent a problem with the 2-dimensional circumplex model, or simply reflect the largely non-specific nature of low arousal experiences. As discussed previously (in Chapter 6), the traditional 2-mode rotation strategies, which depend upon the geometric configuration of the loadings, would be strongly influenced by the adjective "holes" in octants 4 (pleasant deactivation) and 6 (unpleasant deactivation). However, this influence is much smaller with PARAFAC analyses because the orientation of the PARAFAC axes depends upon the contraction and expansion of the factor space in the other modes. Thus, it is unlikely that the orientation of the Valence and Arousal axes obtained in this study would be substantially influenced by the paucity of adjectives in octants 4 (pleasant deactivation) and 6 (unpleasant deactivation).

Adjective Context Effects

In addition to determining the best orientation of the axes for the 2-dimensional affect circumplex, I also examined the potential impact of adjective context effects. The film loadings in Study 1 differed depending upon whether the entire set of adjectives was analyzed or just a subset. Surprisingly, when the subset of adjectives (all of which had been used previously to measure the circumplex) were analyzed, the factor loadings were somewhat compressed in the film mode such that the Arousal dimension was not well defined and, consequently, the circumplex was not well defined in this mode. When the entire set of adjectives was analyzed, however, the Arousal dimension was not compressed, and the circumplex was better defined. This finding from Study 1 suggested that the way an individual rates emotions on a specific emotional adjective may depend upon the set of adjectives it is nested within. This explanation of the Study 1 findings is consistent with research on survey context effects (e.g., Schwarz, 1999)

The extent to which the findings from Study 1 were the result of context effects was investigated in Study 2 by manipulating the context in which the adjectives were rated. More specifically, I examined how the factor structure of a set of 16 adjectives differed depending upon whether the 16 adjectives were the only ones rated (16-Adjective Condition) or if the 16 adjectives were nested within a larger set of 32 adjectives (16/32-Adjective Condition). The factor solution from the 16-Adjective Condition corresponded to the Valence and Arousal solution, indicating that 16 adjectives are sufficient to represent the 2-dimensional affect circumplex. The factor solution from the 16/32-Adjective Condition (based on analyzing a 16 adjective subset of the 32 adjectives rated) was surprisingly similar to the structure obtained in the 16-Adjective Condition in both the adjective and film modes. More specifically, in both the adjective and film modes the two factors correlated at .99 and .99. Visual inspection of the two solutions revealed that the circumplex structures were almost identical. Analyzing a subset of the adjectives rated in Study 2 did not result in the compressed film-mode loadings that were observed in Study 1.

One notable difference between the two solutions from Study 2, however, was the fact that there appeared to be a *very slight* rotational difference in the orientation of the axes from the 16-Adjective Condition to the 16/32-Adjective Condition. For example, extreme loading valence adjectives such as happy and sad loaded at almost zero on the Arousal axis in the 16 Adjectives Condition, whereas in the 16/32-Adjective Condition these adjectives were positioned slightly above and below (respectively) the zero point on the Arousal axis. This difference was *extremely* small, however, and suggests that, although there may be very slight adjective context effects, the interpretation of the underlying axes is not seriously influenced. Therefore, the common practice of creating emotional scales using a subset of the adjectives rated appears justified.

Exploring Higher Dimensions

Number of Factors

In addition to determining the most appropriate axes for the 2-dimensional representation of affective experiences, I also explored the viability of solutions with more than two dimensions. Inspection of the scree plot in Study suggested a 3-factor solution. A 3-factor solution may appear to be at odds with the conventional wisdom concerning the number of factors required to represent affective experiences, but this is not the case. The results of Russell’s (1980) landmark circumplex article initially suggested that more than two factors were appropriate. Indeed, Russell himself proposed at one point that three factors were appropriate (Russell & Mehrabian, 1977). Moreover, as discussed previously, Schimmack and Grob (2000) recently reviewed the literature concerning the structure of affective experiences, and concluded that there is a bias toward favoring the 2-factor emotional model by North American researchers (e.g., Lange, 1995; Larsen & Diener, 1992; Russell, et al., 1989; Thayer, 1989; Watson & Clark, 1997), whereas non-North American researchers prefer a 3-factor model of emotion (e.g., Matthews et al., 1990; Sjoberg et al., 1979; Steyer et al., 1994).

Interpretation of Factors

The three factors in Study 2 resembled Arousal, Positive Valence, and Negative Valence. This 3-factor solution is particularly interesting because it supports the distinction between the positive and negative emotions previously suggested by the PA and NA advocates (e.g., Watson et al., 1988; Cacioppo, Gardner, & Berntson, 1999). However, the 3-factor solution found in this investigation differs in a non-trivial way from the distinction between positive and negative activation proposed previously. More specifically, the positive and negative factors in this study are not characterized by a high level of arousal as are the PA and NA factors proposed by Watson et al. (1988), which are best described as high positive arousal and high negative arousal (with the positive poles representing octants 2 [pleasant activation] and 8 [unpleasant activation] in the circumplex; see Figure 1). In contrast, the positive and negative valence factors found in this investigation represent opposite ends of the valence axes (i.e., octants 3 [pleasant] and 7 [unpleasant]; see Figure 1 in Chapter 2).

Interestingly, the 3-factor solution from Study 2 is also surprisingly consistent with research investigating the brain areas involved in emotional experiences. Recall that researchers who prefer the PA and NA model of affective experiences support their argument by citing findings from affective neuroscience that greater relative activation of the left prefrontal cortex is associated with positive emotions whereas greater relative activation of the right prefrontal cortex is associated with negative emotions (Canli et al., 1998; Davidson, 2001; Davidson, 1993; Davidson & Irwin, 1999). Valence and Arousal researchers argue that, although different brain areas are involved in positive and negative emotions, the *experience* of affect remains one that most closely corresponds to valence. Furthermore, some proponents of the Valence and Arousal approach have argued that, although the valence of emotional experience appears to correspond with asymmetrical activation of the prefrontal cortex, activation of the rear right parietal area is likely responsible for the arousal component of emotional experiences (e.g., Heller, 1993; Heller, & Nitschke, 1997; Heller et al., 1997). The factors discovered in the current investigations are surprisingly consistent with the functions of all three brain areas typically identified as important. More specifically, the positive valence affect factor is consistent with left PFC activation, the negative valence affect factor is consistent with right PFC activation, and the arousal factor is consistent with rear right parietal activation.

The fact that solutions with more than three factors did not contribute significantly to the explained variation does not mean that factors from higher dimensional solutions are not meaningful or interpretable. The factors in the 3-factor solution explain what is *common* to the *set* of emotional experiences evoked by the film clips. It is plausible, and even likely, that there is unique variance associated with the specific emotions evoked by the film clips. Indeed, inspection of the MSR plots indicated that extracting additional factors increased the explained variation for very specific films in many instances. For example, the advantage of extracting 5 rather than 4 factors in Study 2 allowed the solution to account for additional variance in the anger-evoking film clips (massacre and father dies). Thus, although it appears that a substantial portion of variance in emotional reactions can be described by three factors, more than three factors are required to account for the very specific nature of certain emotions. In this study, the seven distinguishable factors were happiness, sadness, fear, anger, boredom, surprise, and serenity (although they could not all be extracted at the same time). As research in affective neuroscience becomes more precise, it will be interesting to examine the extent to which these factors are consistent with activation of certain brain areas during the experience of specific emotions. Research in this vein might help to estimate the true number of basic emotions.

Overall, the findings from Study 2 suggest that the distinction between PV, NV, and Arousal accounts for a substantial portion of the variance in self-reported emotions. Moreover, these findings are consistent with the large body of research which supports the distinction between positive and negative emotional experiences. The fact that the Valence and Arousal dimensions were the appropriate dimensions for the 2-factor solution suggests, however, that the distinction between valence and arousal is more fundamental than the distinction between positive and negative affect.

Limitations

Participants

Conclusions concerning the structure of affective experiences in this investigation were limited by the fact that the participants were not a representative random sample of the general population. All participants were female students enrolled in an introductory psychology class, and the majority of them were between the ages of 19 and 21. With regard to sex, there is a growing body of research that suggests there may be different brain areas stimulated when men and women experience similar emotions (e.g., George et al., 1996; Schneider, Habel, Kessler, Salloum, & Posse, 2000). Because the biological mechanisms behind the experience of emotions differ between men and women, it is possible that the psychological structure of emotions may also be different.

Even if the structure underlying affective experience for men and women is the same, it might be necessary to use different film stimuli to elicit emotions in men and recover the circumplex. Indeed, Lang (2002) discussed how norming data for the International Affective Picture System revealed the images men and women rated as positive and arousing were very different. The images rated as most positive and arousing by women typically depicted a variety of family situations. In contrast, the images rated as most positive and arousing by men typically depicted a variety of erotic situations. Thus, if the current investigation were to be repeated with men then a set of stimuli, featuring erotic situations, would likely be required to elicit the same emotional states the current film stimuli elicited in women.

In addition to the gender of the participants in this investigation, a potential generalizability concern could be the relatively young age of the participants. The extent to which emotional reactivity changes as a function of age is only beginning to be assessed; however, it appears that, although cardiovascular responses decrease with age, most subjective assessment of emotions and behavioral responses does not change with age (Tsai, Levenson, & Carstensen, 2000). Moreover, this finding appears to hold in different cultural groups (e.g., European Americans vs. Chinese Americans; Tsai et al., 2000). Consequently, the structure of affective experience found in this investigation might well apply to both younger and older women.

Materials

The adjectives and film stimuli used in this study were specifically chosen to represent the 2-dimensional affect circumplex; consequently, conclusions concerning the most appropriate axes for higher dimensions are correspondingly limited. This limitation is reflected in the fact that the 2-dimensional analyses resulted in the Valence and Arousal axes in both Study 1 and Study 2, whereas the interpretation of the 3-factor solution differed between these studies. In Study 2, the 3-factor solution was interpreted as Arousal, Positive Valence, and Negative Valence, whereas in Study 1 the 3-factor solution was interpreted as Valence, Arousal, and Intensity. The 3-factor solution from Study 1 is interesting because it bears a resemblance to the 3-factor solution (evaluation, potency, and activity) reported by Osgood and colleagues (1952; Osgood, Succi, & Tannenbaum, 1957). However, the factors from Study 2 (PV, NV, and Arousal) are more compelling than the Study 1 factors because they are based on larger sample size, are consistent with the evidence suggesting that positive and negative emotions are separable, and correspond with brain areas suggested to play a role in the production of emotions. Nonetheless, the different 3-factor solutions found in Study 1 and Study 2 reflect the need for caution in drawing conclusions outside the range of sampled emotions.

Obtaining a compelling estimate for the axes representing a 3-dimensional (or higher) affective space would require a generally agreed upon structure for that space so that representative adjectives and film stimuli could be selected. However, the current methodology may not be appropriate for investigating higher dimensional solutions because film clips can only be used to evoke a limited set of emotions. Indeed, it might be exceedingly difficult to create film clips to elicit emotions from a higher dimensional affective space. For example, it would be particularly difficult to evoke the emotional state of being "in love" with a film clip. Consequently, a different methodology may be required to properly assess the number of factors required to assess all emotional experiences.

Implications for Applied Research

Valence and Arousal vs. PA and NA

The most important implication of the findings from this investigation is that applied researchers who use the 2-D circumplex when conducting substantive research should consider using the Valence and Arousal axes. Moreover, use of the Positive Activation and Negative Activation measurement approach, by such scales as the PANAS, is called into question by the current findings. Researchers who prefer the PA and NA approach might argue, however, that because positive and negative emotions loaded on separate factors in the 3-factor solution there is at least weak support for the 2-factor PA and NA approach. This argument seems untenable because, although positive and negative emotions did separate in the 3-factor solution, the axes in this solution were very different in nature from the 2-factor PA and NA axes. More specifically, in the 3-factor solution (arousal, positive valence, negative valence) the positive and negative affect factors reflected opposite ends of the valence dimension (from the 2-factor solution) and reflected only moderate to low levels of activation, whereas the traditional PA and NA factors are characterized by high levels of activation. The fact that the 2-factor PA and NA axes are apparently not appropriate is particularly disturbing given the ubiquitous presence of the PANAS in applied research. Indeed, as discussed previously, the PA and NA approach is the basis for more than one meta-analysis concerning the role of affect in the workplace (c.f., Judge, Thoresen, Bono, & Patton, 2001; Thoresen et al.,

2003) – which speaks to its popularity with not only meta-analysts but also with substantive researchers.

The implications for using Valence and Arousal rather than PA and NA are not trivial. Indeed, using an incorrect axis orientation can not only obscure the nature of the affect construct, but can also result in misleading relationships between affect and other measures. Consider, for example, a study which investigated the relationship between intent to resist an organizational change and the affect circumplex for the two axis orientations using *component scores* (Herscovitch, Meyer, & Stanley, 1999). When PA and NA were the axes used, then PA correlated -.34 with intent to resist, whereas NA correlated .46 with intent to resist. In contrast, when Valence and Arousal were the axes used, then Valence correlated -.57 with intent to resist the change whereas Arousal correlated .06. Thus, the relationship between affect and criterion measures differs depending upon the 2-dimensional rotation is used. The extent to which other findings in the organization literature differ meaningfully of course, remains to be seen. Therefore, re-examining much of the basic organizational affect research using Valence and Arousal poses a particularly interesting direction for future research.

Measuring Valence and Arousal

An important first step in re-examining existing findings in the context of Valence and Arousal will be establishing a measurement approach. Simply using component scores for a Valence and Arousal rotation of the PANAS adjectives will not suffice because the 20-item PANAS includes only the high arousal adjectives from Octants 2 (pleasant activation) and 8 (unpleasant activation; adjectives from the poles of the relevant axes) and neglects the emotions in the remaining six octants. Fortunately, factor scores could be created from the more comprehensive 60-item PANAS-X to measure Valence and Arousal. Component scores cannot be used in all situations, however, and there is currently not a standardized set of adjectives for creating Valence and Arousal scale scores. Therefore, one option is to measure Valence and Arousal axes using the single item affect grid measure (Russell, Weiss, & Mendelsohn, 1989). But, I suggest that because the 2-dimensional solution from the current investigation was robust across Study 1 and Study 2 these adjectives could be used as the basis for guiding the development of a standardized measure of Valence (cheerful, depressed, downhearted, happy, miserable, sad, satisfied, warm-hearted) and Arousal (aroused, drowsy, quiet, sleepy, startled, still, stimulated, surprised). Alternate starting points for developing standardized Valence and Arousal scales include the adjectives examined by Feldman Barrett and Russell (1998) as well as those examined by Remington et al. (2000). Clearly though, regardless of the starting point used, additional research will be required to develop the optimal set of adjectives to create scale score measures of Valence and Arousal.

Number of Dimensions

The question of how many dimensions should be used by applied researchers is a difficult one. The current investigation revealed a very robust 2-dimensional solution; however, it also suggested that a nontrivial amount of additional variance in emotional reactions can be modeled with three factors. The results did not imply, however, that three factors were sufficient to account for the nature of all specific emotions. Indeed, distinctions could be made in the current data for up to seven distinct emotional factors which accounted for the nature of very specific emotional experiences.

If affect is considered a predictor variable, then the answer to the question of how many dimensions are appropriate may depend on the criterion used. A long-standing finding in the social psychological literature is that specific attitudes predict specific behaviors, whereas general attitudes predict behavior at a general level (Ajzen & Fishbein, 1977; Eagly & Chaiken, 1998; Fishbein & Ajzen, 1975). That is, the optimal level of predictive power is obtained when the level of specificity in the predictor and criterion are compatible. It seems likely that this logic could be applied in the context of emotional experiences. Reconsider the organizational change example discussed previously. The relatively large Valence and Arousal factors were useful for predicting general intent to resist an organizational change. However, it may be that smaller, more specific factors (e.g., anger) might be more useful for predicting very specific behaviors (such as sabotage). Thus, the two approaches are not incompatible. Consistent with Watson and Clark's (1994) instructions for the PANAS-X, an emotional rating scale could be used that includes adjectives to measure the two (or possibly three) affect dimensions, as well as a number of additional adjectives, to fully measure a specific emotion (e.g., anger) that is expected to predict a specific course of action (e.g., sabotage). This approach appears especially viable given the current finding that adjective context effects do not significantly influence the orientation of axes defining emotional space.

Conclusions

The study of affect in the workplace has changed organizational research substantially, so much so that Barsade et al. (2003) termed it a new paradigm. To be meaningful, new constructs must have an empirically supported conceptual definition and be measured appropriately. The current investigation examined the 2-factor circumplex model of emotional experiences and provided support for the Valence and Arousal interpretation of the underlying structure. Future research will need to focus on both the best method of measuring affect in terms of Valence and Arousal as well as using methodological refinements to determine the most appropriate higher-dimensional conceptualization of affect. Most importantly, the current research indicates that the popular practice of measuring affect in terms of PA and NA might carry a risk of producing misleading findings.

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APPENDIX A

Ethics approval

The University of Western Ontario
Department of Psychology

October 21, 2002

M E M O R A N D U M

To: David Stanley
From: Jim Olson on behalf of the Ethics and Subject Pool Committee
Re: Ethical review of "Movies and mood"
Protocol # 02 10 05

STATUS

_x_ Approved
___ Approved conditional to making changes listed below (please file changes with your application to use the subject pool with Helen Harris in Rm. 7304)
___ Please make the changes listed below and resubmit for review

---

SIGN-UP POSTER

___ Briefly describe the task required of subjects
___ Do not "hype" the advertising of your study
___ Use 10cpi or 12cpi, with standard letter size, for description
___ Other (see attached sheet)

INFORMED CONSENT SHEET

___ Briefly describe the task the subjects are agreeing to perform
___ Promise that the data will be kept confidential and used for research purposes only
___ Promise that audio and/or video tapes will be erased, in part or entirely, at the subjects' wishes at any time
___ State how many credits the subjects will receive for participation
___ State that subjects may terminate the experiment at any time without loss of promised credit(s)
___ State that there are no known risks to participation or state the risks
___ State that subjects will receive written feedback at the end of the session or study and/or that subjects have had an opportunity to ask questions about the study
___ Other (see attached sheet)

WRITTEN FEEDBACK

___ Elaborate your feedback
___ Rewrite your feedback at a level that is understandable to a Psychology 020/023 student
___ Add a few references at the end and/or your name and how you can be reached
___ Other (see attached sheet)

OTHER ___ See attached comments

---

c. J. Meyer

APPENDIX B

List of Pretest / Study 1 films

Graph Label	Movie Title	Description
bully	My Bodyguard	A bully beats up boy
chase killer	The Silence of the Lambs	A female police officer chases a killer
comedian	Robin Williams Live	Amusing drug and alcohol anecdotes
dance (energetic)	Flash Dance	Woman auditions and gets into dance school
door burst	Capricorn One	Secret agents suddenly burst through door
father dies	The Champ	A boy cries at his father's death
father's love	Curly Sue	A young girl finds out her fear that her father abandoned her is unjustified
forest escape	True Lies	A secret agent escapes in a forest chase
monkey	Baraka	A monkey bathes in a hot spring with snow all around
scary hall	The Shining	A boy walks down a hall to very ominous music
scenery	Baraka	Various mountain landscapes

APPENDIX C

Study 1: Materials

Emotional Film Selection Study

Letter of Information/Informed Consent

In this study you will be asked to view a variety of film clips and provide information about how they make you feel. If a film clip makes you feel uncomfortable you may close your eyes and wait until the next film starts. Similarly, if at any point during the experiment you feel uncomfortable, you can withdraw from the study and receive full credit for Psych 020. The task will take approximately 90 minutes and you will receive 2 credits for participation. There are no known risks to this experiment other than the emotions evoked by the films. You will receive written feedback at the end of the session.

Your data will be kept confidential and used for research purposes only.

I understand and agree to participate.

____________________ __________________________
(print name) (print student number)

____
(signature)

Emotional Film Selection Study Instructions

In this experiment we are interested in your emotions. More specifically, we are interested in how you feel after watching a short film clip. For some people, watching a film can produce strong emotions. Therefore, psychologists sometimes use film clips to produce emotional reactions in people as part of their experiments. Before using a film though, it is important to know if the film *is able to* evoke emotions. As well, if a film does produce an emotional response, it is equally important t*o know what that response is*.

The purpose of this study is to develop a standardized set of films that psychologists can use in their experiments. Some of the films you watch may have a large effect on how you feel whereas others may have little or no effect at all. Please be as honest as possible in rating how the films make you feel.

Films are complex and you may feel many emotions through the course of the film. In order for us to compare the emotional responses of all participants to a film, though, it is important that everyone rate their emotions at the same point in time. Therefore, we ask that you use the questionnaire to ***describe how you felt at the instant the film ended***. As well, we are not interested in how you believe other people will feel after watching the film, ***we want to know how <u>you</u> feel after watching the film***.

Recording how you feel

At the end of each film clip you will be asked to record how you feel using a series of emotional adjectives. It would be impossible for us to provide a complete list of every possible emotion that you could feel, therefore, we use a shorter set of adjectives as "reference points". The rating scale you will be provided with is shown below:

Please use the rating scale below to describe how <u>you</u> felt at the <u>instant</u> the film ended.

1	2	3	4	5
Not at all	A Little	Somewhat	A Lot	Extremely

surprised ____	quiet ____	stimulated ____	still ____	hostile ____	afraid ____
peppy ____	bored ____	excited ____	drowsy ____	tense ____	startled ____
happy ____	depressed ____	cheerful ____	sad ____	satisfied ____	gloomy ____
calm ____	angry ____	relaxed____	distressed ____	grouchy ____	uncomfortable ____

It may be difficult to express how you feel using such a short list of emotions, but please do your best.

Again, we are not interested in how you feel during the film – we are interested in you feel at the <u>instant</u> the film ends.

As well, we are not interested in how you think the film would make other people feel – we are interested in how <u>you</u> feel at the instant the film ends.

Film Clip #1

Please use the rating scale below to describe how you felt at the instant the film ended.

1	2	3	4	5
Not at all	A Little	Somewhat	A Lot	Extremely

surprised ____	quiet ____	stimulated ____	still ____	hostile ____	afraid ____
peppy ____	bored ____	excited ____	drowsy ____	tense ____	startled ____
happy ____	depressed ____	cheerful ____	sad ____	satisfied ____	gloomy ____
calm ____	angry ____	relaxed____	distressed ____	grouchy ____	uncomfortable ____

Please indicate how large of an overall emotional reaction you were experiencing when this film ended by *circling* a number below:

1	2	3	4	5
Not at all	A Little	Somewhat	A Lot	Extremely

Demographic Information

Now we would like to know a bit more about who participated in our study

1. Please indicate the extent to which you consider yourself an emotional person:

1	2	3	4	5
Not at all	**A Little**	**Somewhat**	**A Lot**	**Extremely**

2. Year of Birth: ____________

3. We would also like to know if you are taking medication that might influence your mood. Two types of medications we are especially interested in are antidepressants and medication designed to help people stop smoking.

If you are taking antidepressants or medication to help you stop smoking please check this box: ☐

Thank-you for participating in our study!

Emotional Film Selection Study
Debriefing

Thank-you for participating in our study! In this study we investigated how a variety of films made you feel. The information you provided us with will be used to determine which films make good stimuli for future experiments. Your assistance in this endeavor is greatly appreciated.

In addition to validating films, we will use the information that you provided us with to learn more about the structure of emotion. In the same way that our language has evolved to provide labels for dozens of colors (e.g., blue, brown, yellow) it has evolved to include labels that we apply to a large number of emotion states (e.g., happy, excited, depressed, etc.). Some psychologists suspect, however, that a very small number of underlying factors may combine to produce the very large number of emotions we experience. This is conceptually similar to mixing a small number of primary colors to produce the nearly infinite number of colors we see everyday. The information you provided us with will help us determine the few factors that combine to produce a large number of emotional experiences.

To learn more about the structure of emotion you might like to consult the following sources:

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David Stanley
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stanley@uwo.ca

Dr. J Meyer
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meyer@uwo.ca

APPENDIX D

Study 1: Standard deviations for preprocessed data cube

Study 1: Standard Deviation For Each Adjectives Across Occasions (Films)
When the Data Cube is Collapsed Across Participants

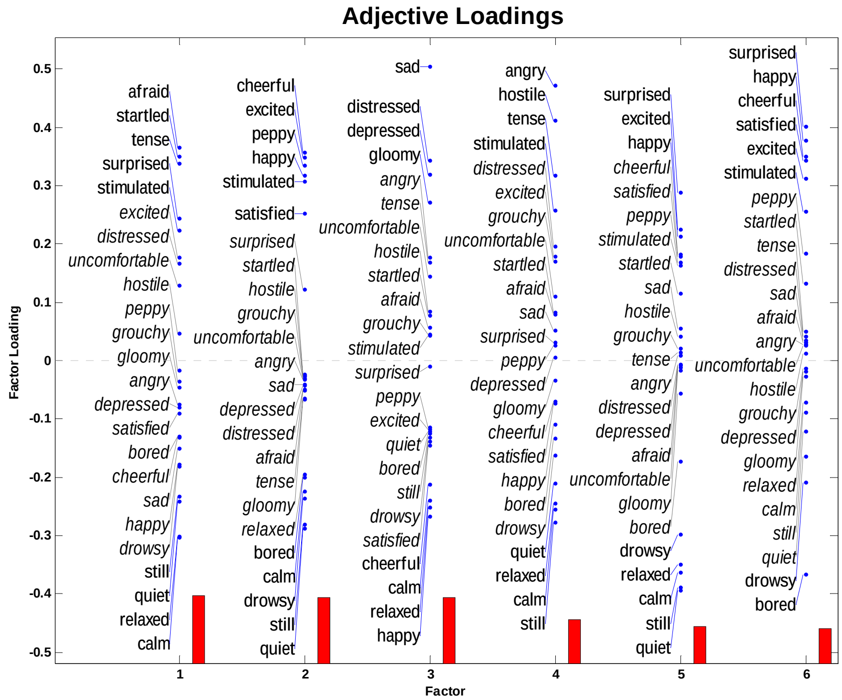
Adjective	SD
surprised	0.49
peppy	0.64
happy	0.90
calm	0.75
quiet	0.62
bored	0.43
depressed	0.57
angry	0.68
stimulated	0.59
excited	0.66
cheerful	0.85
relaxed	0.74
still	0.63
drowsy	0.53
sad	0.92
distressed	0.73
hostile	0.50
tense	0.81
satisfied	0.60
grouchy	0.22
afraid	0.72
startled	0.66
gloomy	0.49
uncomfortable	0.41

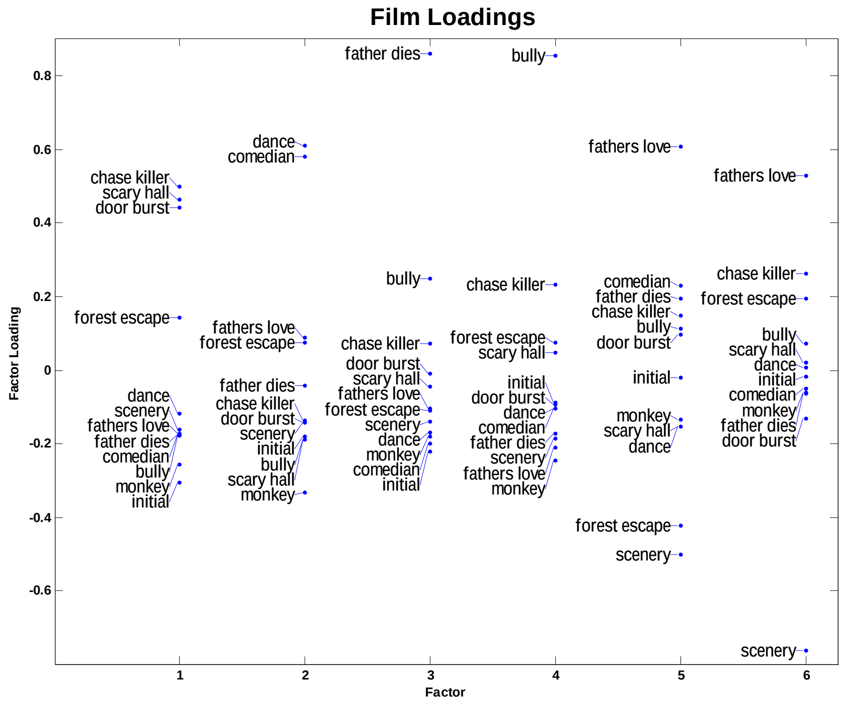
Note:
Standard deviations are based on the raw data collected using a 5-point rating scale.

APPENDIX E

Study 1: Additional factor solutions

Study 1: One-way plot of 6-factor solution





Note: Vertical bars illustrate relative sizes of factors

A lighter italicized font is used for adjectives with factor loadings less than .20

Study 1: 6-Factor Solution

Variance in ratings accounted for by the factors (%)

57.6%

Relative size of factors (% of explained variance)

22% 21% 21% 13% 12% 11%

Iterations to convergence

150

Individual Mode Factor Correlations

1.00	0.00	0.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00	0.00	0.00
0.00	0.00	1.00	0.00	0.00	0.00
0.00	0.00	0.00	1.00	0.00	0.00
0.00	0.00	0.00	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	1.00

Adjective Mode Factor Correlations

1.00	0.31	0.39	0.64	0.58	0.37
0.31	1.00	-0.13	0.31	0.88	0.89
0.39	-0.13	1.00	0.55	0.20	-0.10
0.64	0.31	0.55	1.00	0.55	0.26
0.58	0.88	0.20	0.55	1.00	0.85
0.37	0.89	-0.10	0.26	0.85	1.00

Film Mode Factor Correlations

1.00	-0.19	0.01	0.17	-0.07	0.17
-0.19	1.00	-0.20	-0.19	0.15	0.14
0.01	-0.20	1.00	0.22	0.27	0.03
0.17	-0.19	0.22	1.00	0.04	0.21
-0.07	0.15	0.27	0.04	1.00	0.64
0.17	0.14	0.03	0.21	0.64	1.00

APPENDIX F

Study 2: List of film stimuli

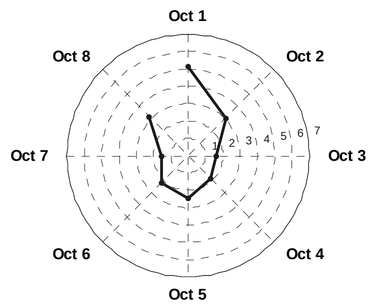
Graph Label	Movie Title	Description
bambi	Bambi	Bambi's mother dies
beating	Fight Club	A man is violently beaten
birds startle	Sea of Love	Pigeons startle a police officer investigating a noise
bond	James Bond: Tomorrow Never Dies	Bond narrowly averts a nuclear disaster
bully	My Bodyguard	A bully beats up boy
chase killer	The Silence of the Lambs	A female police officer chases a killer
children	A River Runs Through It	Two children play outside in the wilderness
comedian	Robin Williams Live	Amusing drug and alcohol anecdotes
dance (energetic)	Flash Dance	Woman auditions and gets into dance school
door burst	Capricorn One	Secret agents suddenly burst through door
father dies	The Champ	A boy cries at his father's death
father's love	Curly Sue	A young girl finds out her fear that her father abandoned her is unjustified
horse head	The Godfather	A man wakes up with a horse head in his bed
lecture	Blake Teaching	A very boring lecture
massacre	Cry Freedom	South African police open fire on a crowd
messy meal	Wallace & Gromit	An amusing accident with oatmeal at breakfast
monkey	Baraka	A monkey bathes in a hot spring with snow all around
panda	The Amazing Panda Adventure	A montage of a boy and a panda playing
rain	Angela's Ashes	A montage of sad images most with rain in them
reunion	On Golden Pond	A mother and daughter are reunited
scary hall	The Shining	A boy walks down a hall to very ominous music
scenery	Baraka	Various mountain landscapes
suicide	An Officer and a Gentleman	An officer finds the body of his best friend who has committed suicide
tropical	Grenada Tourism Video	A montage of tropical landscapes/seascapes

APPENDIX G

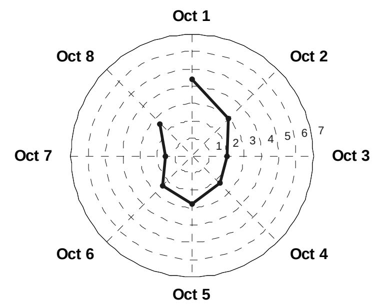
Study 2: Octant means for each film clip

Study 2: Plot of octant means

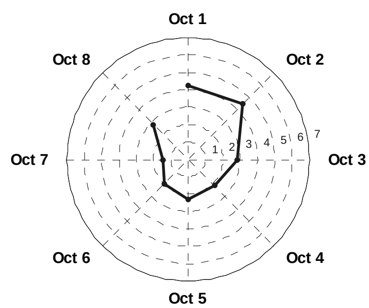
door smash



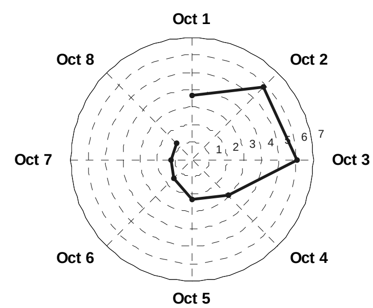
birds startle



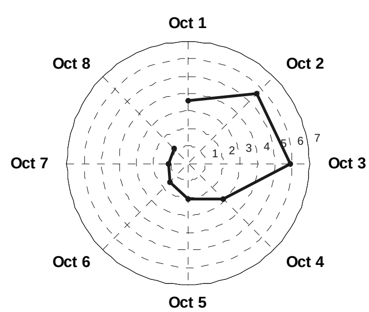
James Bond



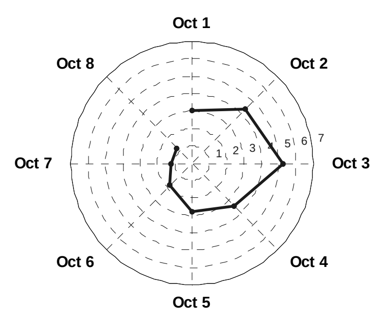
dance (energetic)



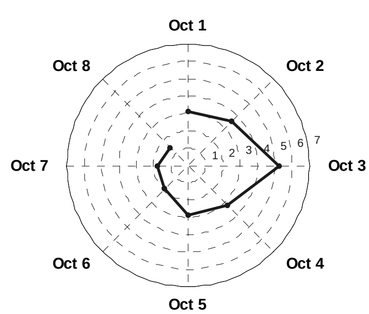
comedian



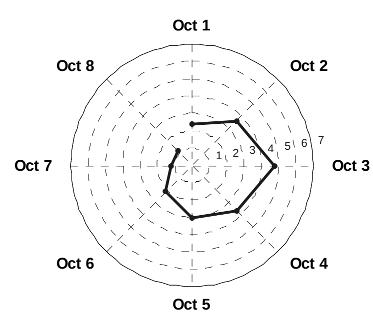
messy meal



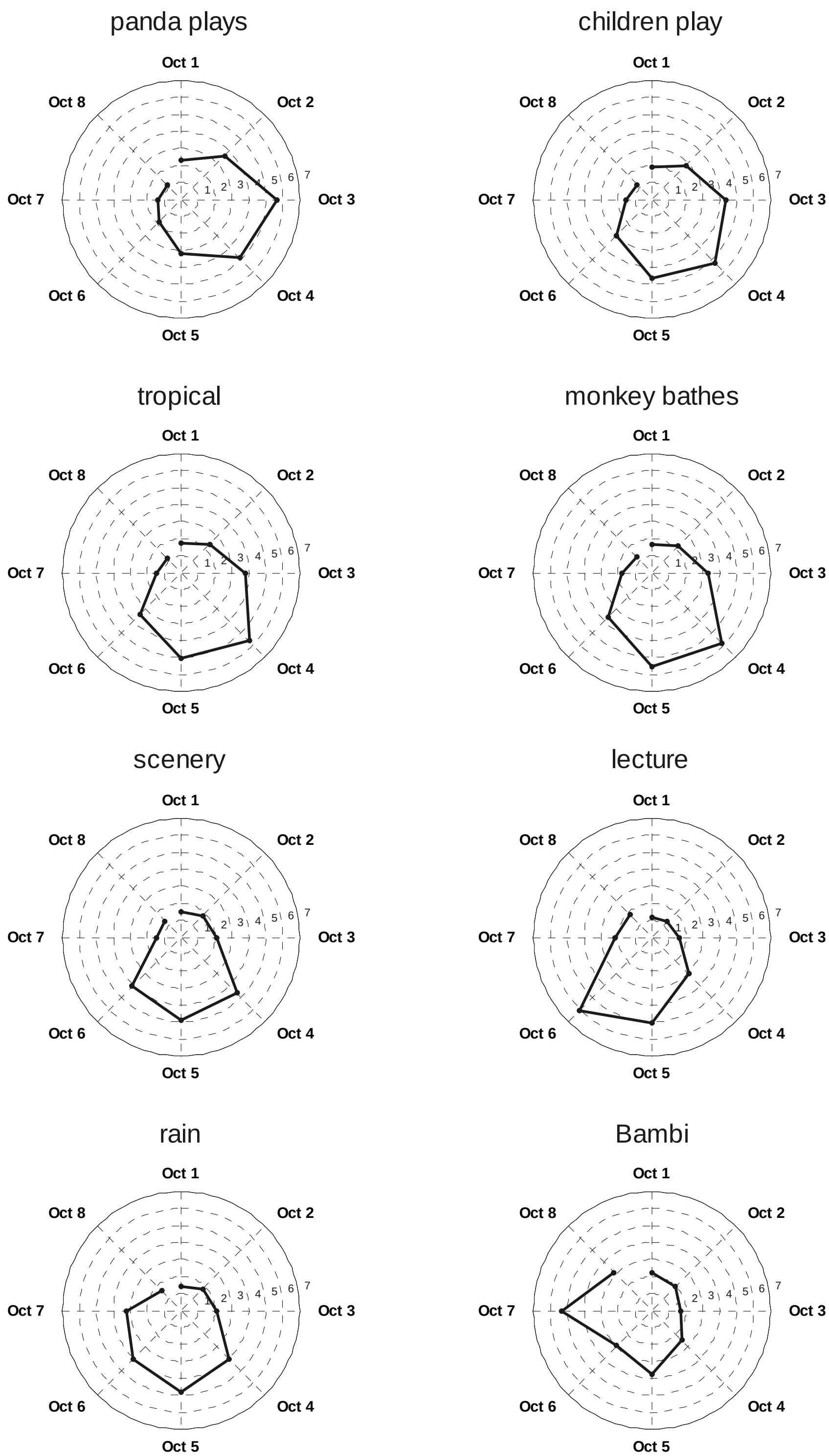
father's love



reunion

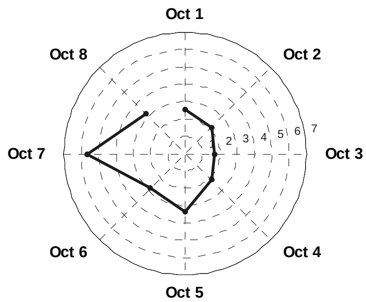


Study 2: Plot of octant means (continued)

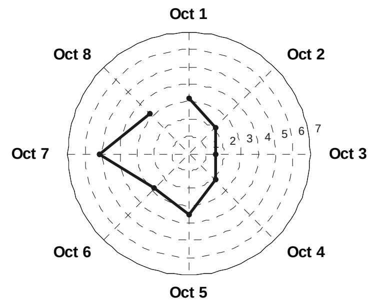


Study 2: Plot of octant means (continued)

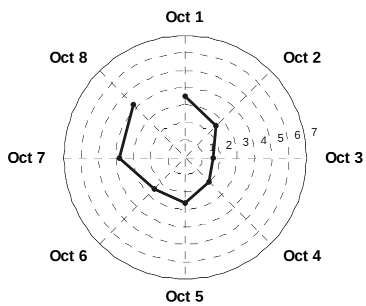
father dies



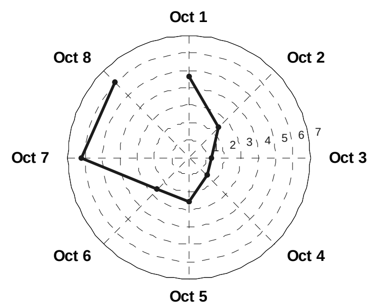
suicide



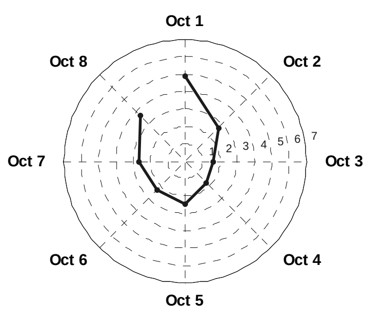
bully



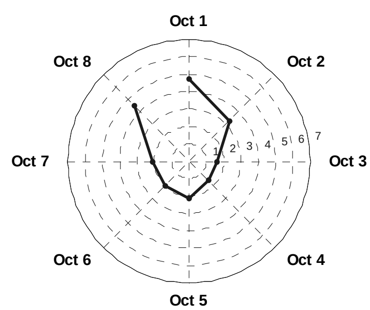
massacre



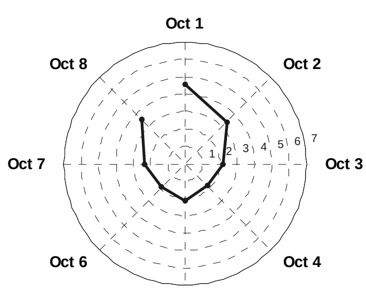
horse head



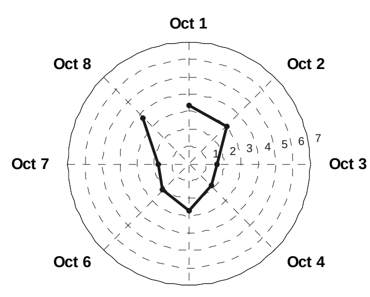
chase killer



violent beating



scary hall



APPENDIX H

Study 2: 16-Adjective condition materials

Emotional Film Selection Study

Letter of Information/Informed Consent

In this study you will be asked to view a variety of film clips and provide information about how they make you feel. If a film clip makes you feel uncomfortable you may close your eyes and wait until the next film starts. Similarly, if at any point during the experiment you feel uncomfortable, you can withdraw from the study and receive full credit for Psych 020. The task will take approximately 90 minutes and you will receive 2 credits for participation. There are no known risks to this experiment other than the emotions evoked by the films. You will receive written feedback at the end of the session.

Your data will be kept confidential and used for research purposes only.

I understand and agree to participate.

____________________ __________________________
(print name) (print student number)

____
(signature)

Emotional Film Selection Study Instructions

In this experiment we are interested in your emotions. More specifically, we are interested in how you feel after watching a short film clip. For some people, watching a film can produce strong emotions. Therefore, psychologists sometimes use film clips to produce emotional reactions in people as part of their experiments. Before using a film though, it is important to know if the film *is able to* evoke emotions. As well, if a film does produce an emotional response, it is equally important t*o know what that response is*.

The purpose of this study is to develop a standardized set of films that psychologists can use in their experiments. Some of the films you watch may have a large effect on how you feel whereas others may have little or no effect at all. Please be as honest as possible in rating how the films make you feel.

Films are complex and you may feel many emotions through the course of the film. In order for us to compare the emotional responses of all participants to a film, though, it is important that everyone rate their emotions at the same point in time. Therefore, we ask that you use the questionnaire to ***describe how you felt at the instant the film ended***. As well, we are not interested in how you believe other people will feel after watching the film, ***we want to know how <u>you</u> feel after watching the film***.

Recording how you feel

At the end of each film clip you will be asked to record how you feel using a series of emotional adjectives. It would be impossible for us to provide a complete list of every possible emotion that you could feel, therefore, we use a shorter set of adjectives as "reference points". The rating scale you will be provided with is shown below:

For each adjective, indicate how <u>you</u> felt at the <u>instant the film ended</u>.
Please use the rating scale below:

1	2	3	4	5	6	7	8	9
Not at all		A Little		Somewhat		Very		Extremely

excited ____	still ____	stimulated ____	afraid ____	sad ____	calm ____
quiet ____	cheerful ____	relaxed ____	peppy ____	bored ____	distressed ____
drowsy ____	miserable ____	surprised ____	happy ____		

It may be difficult to express how you feel using such a short list of emotions, but please do your best.

Again, we are not interested in how you feel during the film – we are interested in you feel at the <u>instant</u> the film ends.

As well, we are not interested in how you think the film would make other people feel – we are interested in how <u>you</u> feel at the instant the film ends.

Before beginning we would like to know more how about how you ***typically feel*** (Section 1) and how ***you feel right now*** (Section 2).

Section 1: How you feel MOST OF THE TIME

For each adjective, indicate how you feel most of the time.
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drowsy ____	miserable ____	surprised ____	happy ____		

Section 2: How you feel AT THIS INSTANT

For each adjective, indicate how you feel at this instant.
Please use the rating scale below:

1	2	3	4	5	6	7	8	9
Not at all		A Little		Somewhat		Very		Extremely

excited ____	still ____	stimulated ____	afraid ____	sad ____	calm ____
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drowsy ____	miserable ____	surprised ____	happy ____		

Film Clip #1

For each adjective, indicate how you felt at the instant the film ended.
Please use the rating scale below:

1	2	3	4	5	6	7	8	9
Not at all		A Little		Somewhat		Very		Extremely

excited ____	still ____	stimulated ____	afraid ____	sad ____	calm ____
quiet ____	cheerful ____	relaxed ____	peppy ____	bored ____	distressed ____
drowsy ____	miserable ____	surprised ____	happy ____		

Demographic Information

Now we would like to know a bit more about who participated in our study

1. Do you speak more than one language? (please circle)

YES NO

If YES,

What is the first language you learned to speak?

____

What is the second language you learned to speak?

____

2. Please indicate the extent to which you consider yourself an emotional person:

1	2	3	4	5
Not at all	**A Little**	**Somewhat**	**A Lot**	**Extremely**

3. Year of Birth: ____________

4. We would also like to know if you are taking medication that might influence your mood. Two types of medications we are especially interested in are antidepressants and medication designed to help people stop smoking.

If you are taking antidepressants ***or*** medication to help you stop smoking please check this box: ☐

Thank-you for participating in our study!

Emotional Film Selection Study
Debriefing

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APPENDIX I

Study 2: 32-Adjective condition materials

Emotional Film Selection Study

Letter of Information/Informed Consent

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Please use the rating scale below:

1	2	3	4	5	6	7	8	9
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excited ____	still ____	stimulated ____	afraid ____	sad ____	calm ____
quiet ____	cheerful ____	relaxed ____	peppy ____	bored ____	distressed ____
drowsy ____	miserable ____	surprised ____	happy ____	enthusiastic ____	sleepy ____
startled ____	tense ____	downhearted ____	serene ____	gloomy ____	satisfied ____
tranquil ____	attentive ____	depressed ____	hostile ____	dull ____	angry ____
aroused ____	warmhearted ____				

It may be difficult to express how you feel using such a short list of emotions, but please do your best.

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aroused ____	warmhearted ____				

Section 2: How you feel AT THIS INSTANT

For each adjective, indicate how you feel at this instant.
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aroused ____	warmhearted ____				

Film Clip #1

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startled ____	tense ____	downhearted ____	serene ____	gloomy ____	satisfied ____
tranquil ____	attentive ____	depressed ____	hostile ____	dull ____	angry ____
aroused ____	warmhearted ____				

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1	2	3	4	5
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APPENDIX J

Study 2: Standard deviations for preprocessed data cube

Study 2: Standard Deviation For Each Adjective Across Occasions (Films) When the Data Cube is Collapsed Across Participants

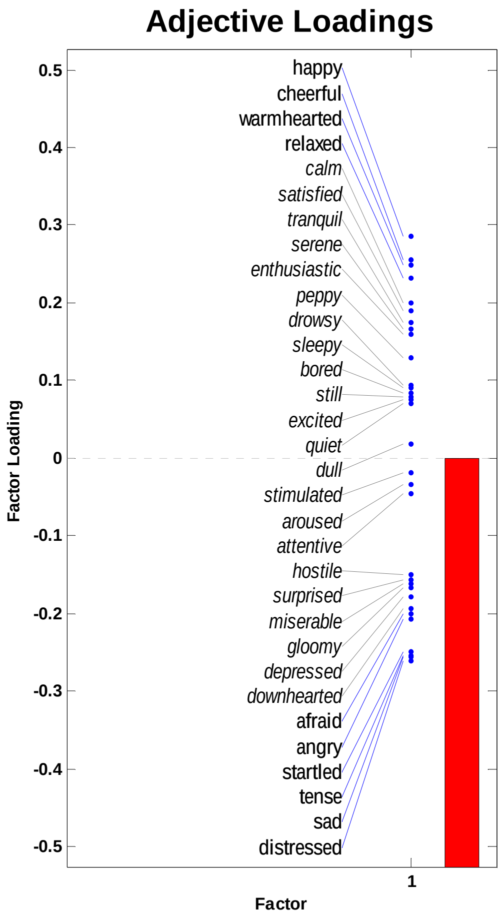
Adjective	SD
startled	1.88
surprised	1.57
aroused	1.00
stimulated	1.21
attentive	1.16
excited	1.41
enthusiastic	1.42
peppy	1.21
cheerful	1.83
satisfied	1.36
happy	1.97
warmhearted	1.74
relaxed	1.51
serene	1.22
calm	1.47
tranquil	1.42
drowsy	1.27
sleepy	1.19
bored	1.49
still	1.15
quiet	1.27
dull	1.13
gloomy	1.31
sad	2.12
depressed	1.42
downhearted	1.49
miserable	1.22
angry	1.58
hostile	1.10
distressed	1.58
afraid	1.50
tense	1.70

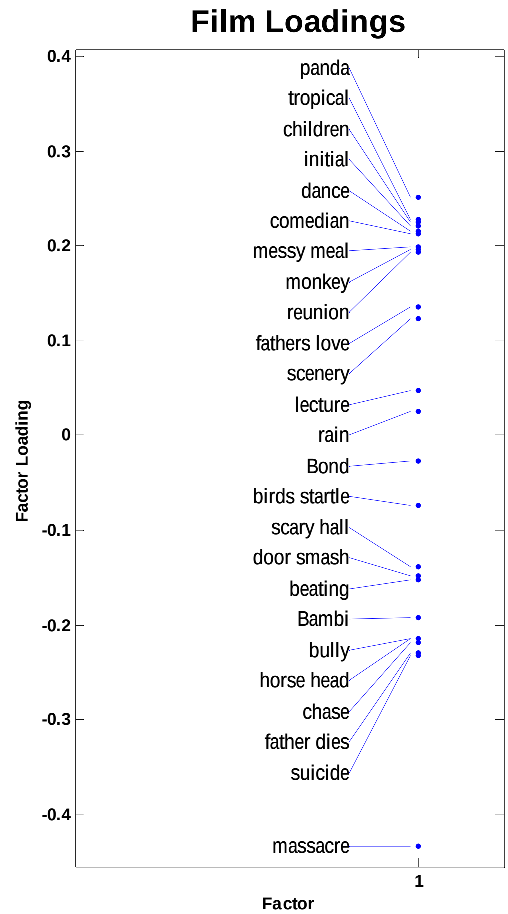
Note:
Standard deviations are based on the raw data collected using a 10-point rating scale.

APPENDIX K

Study 2: Additional factor solutions

Study 2: One-way plot of 1-factor solution

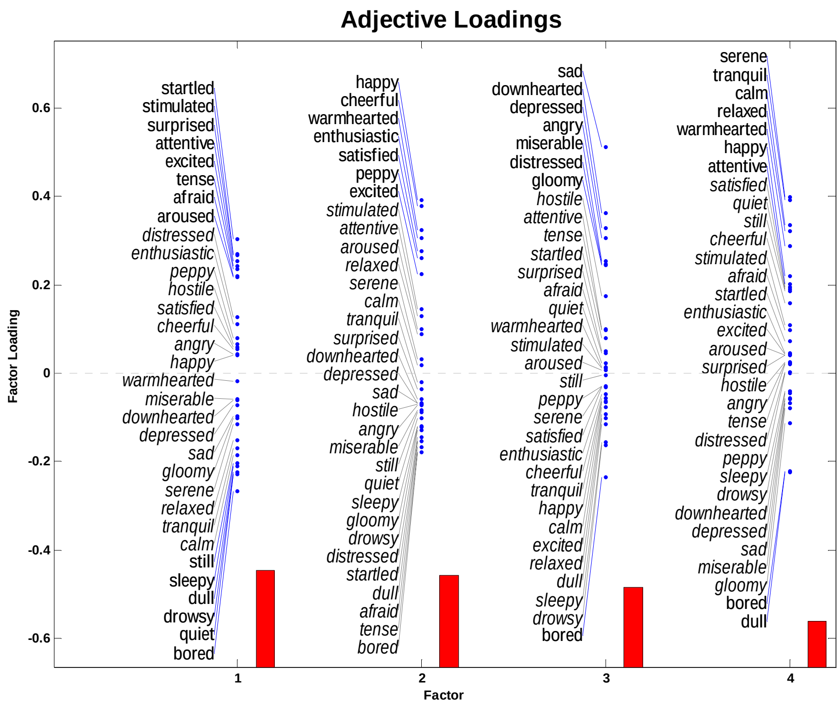


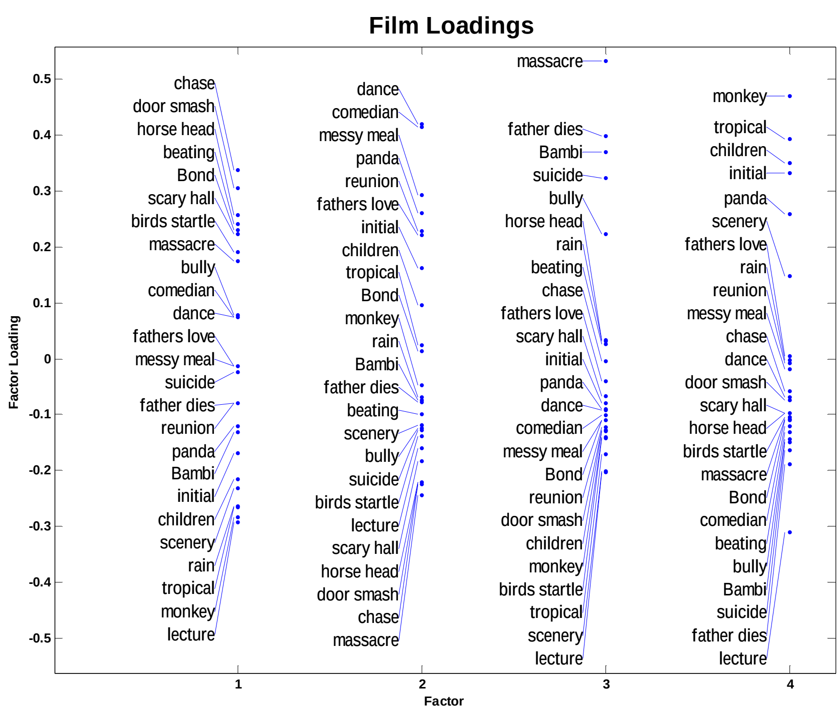


Proportion of explained variation = 26.9%

Note: Vertical bars illustrate relative sizes of factors
A lighter italicized font is used for adjectives with factor loadings less than .20

Study 2: One-way plot of 4-factor solution

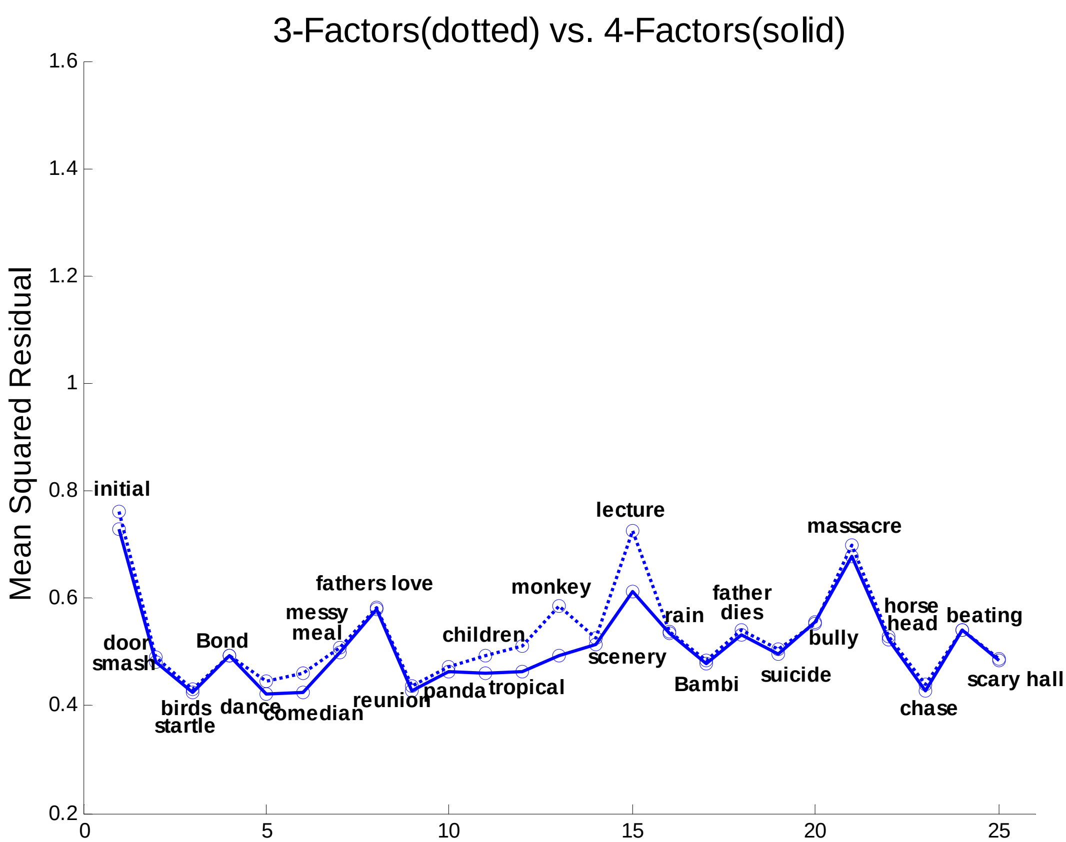




Note: Vertical bars illustrate relative sizes of factors

A lighter italicized font is used for adjectives with factor loadings less than .20

Study 2: Residual plot of 3- and 4-factor solutions



Study 2: 4-Factor Solution

Variance in ratings accounted for by the factors (%)

50.8%

Relative size of factors (% of explained variance)

31% 29% 25% 15%

Iterations to convergence

260

Individual Mode Factor Correlations

1.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00
0.00	0.00	1.00	0.00
0.00	0.00	0.00	1.00

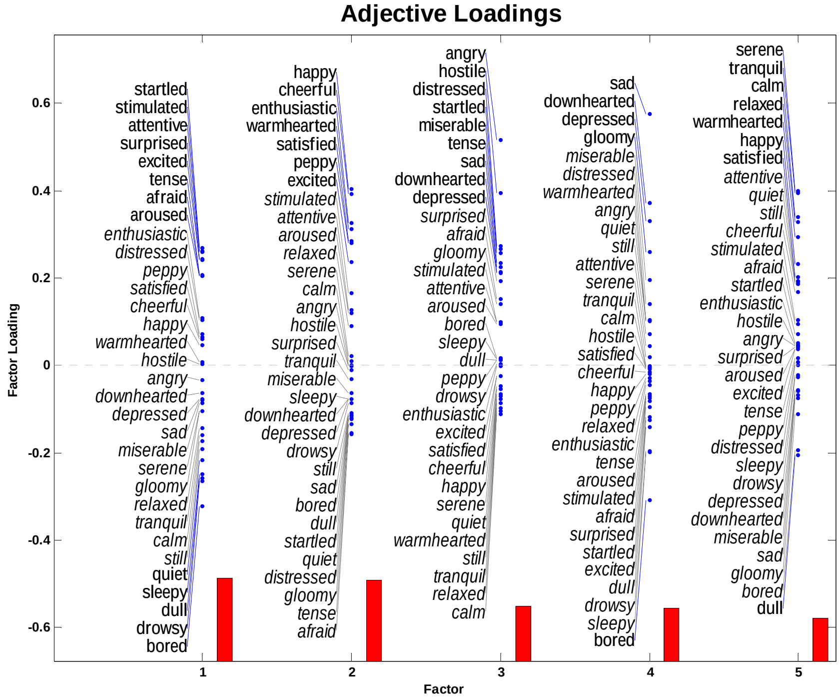
Adjective Mode Factor Correlations

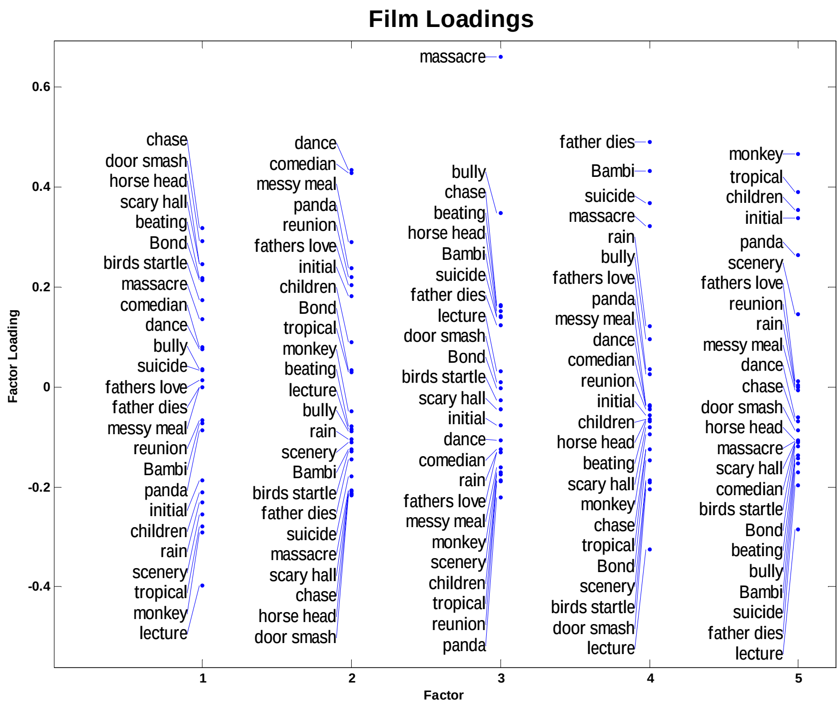
1.00	0.28	0.18	0.03
0.28	1.00	-0.28	0.44
0.18	-0.28	1.00	-0.27
0.03	0.44	-0.27	1.00

Film Mode Factor Correlations

1.00	-0.26	0.16	-0.52
-0.26	1.00	-0.35	0.28
0.16	-0.35	1.00	-0.41
-0.52	0.28	-0.41	1.00

Study 2: One-way plot of 5-Factor Solution

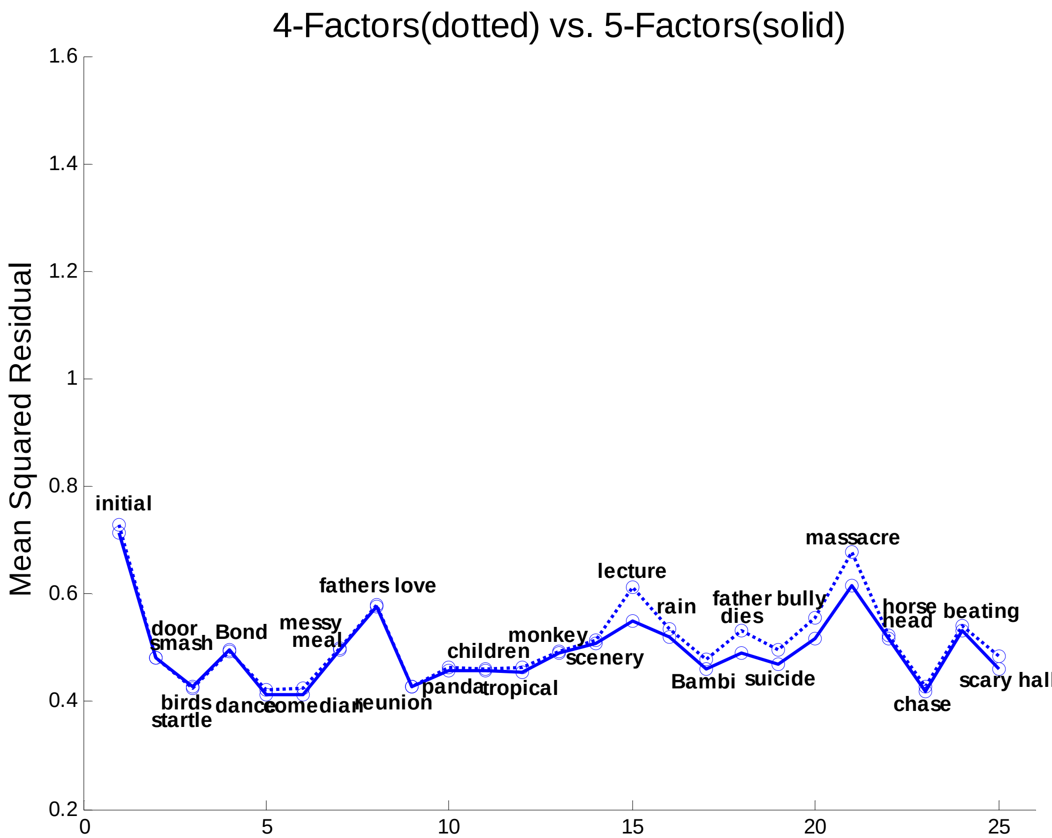




Note: Vertical bars illustrate relative sizes of factors

A lighter italicized font is used for adjectives with factor loadings less than .20

Study 2: Residual plot of 4- and 5-factor solutions



Study 2: 5-Factor Solution

Variance in ratings accounted for by the factors (%)

52.7%

Relative size of factors (% of explained variance)

27% 26% 17% 17% 14%

Iterations to convergence

602

Individual Mode Factor Correlations

1.00	0.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00	0.00
0.00	0.00	1.00	0.00	0.00
0.00	0.00	0.00	1.00	0.00
0.00	0.00	0.00	0.00	1.00

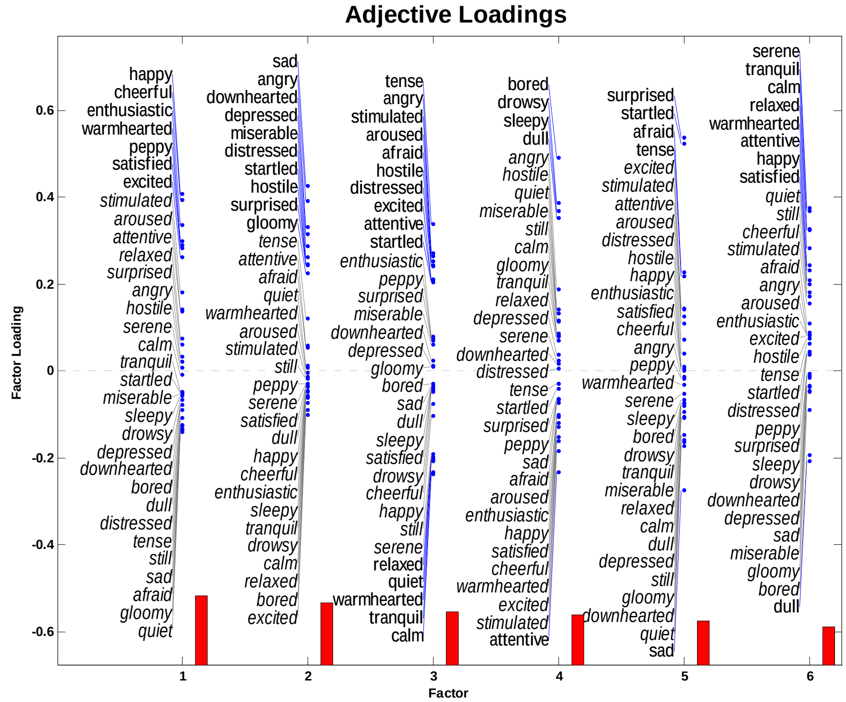
Adjective Mode Factor Correlations

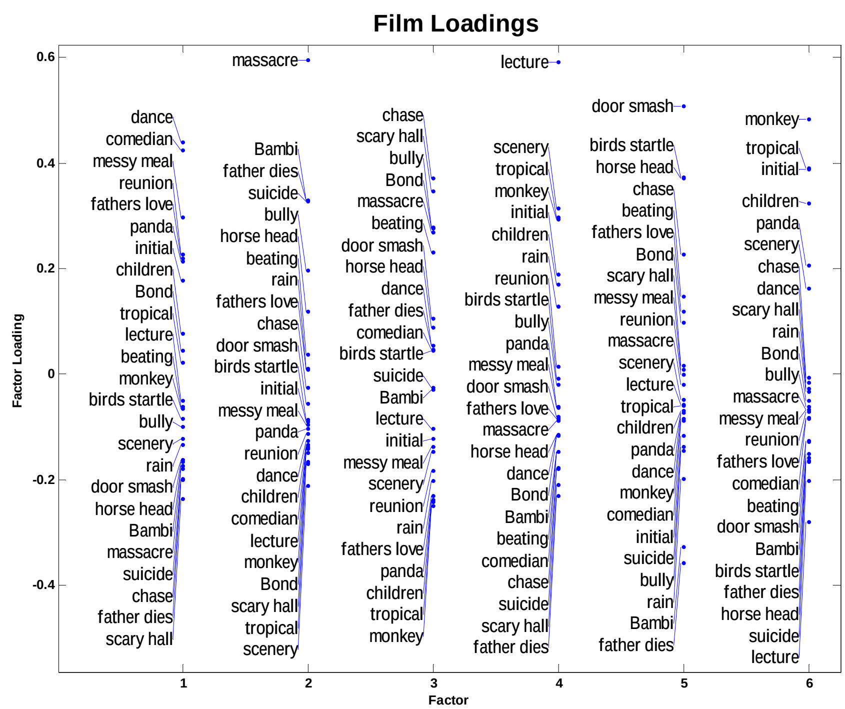
1.00	0.36	0.31	-0.07	0.09
0.36	1.00	-0.40	-0.16	0.39
0.31	-0.40	1.00	0.33	-0.51
-0.07	-0.16	0.33	1.00	-0.07
0.09	0.39	-0.51	-0.07	1.00

Film Mode Factor Correlations

1.00	-0.22	0.44	0.04	-0.53
-0.22	1.00	-0.56	-0.16	0.29
0.44	-0.56	1.00	0.46	-0.55
0.04	-0.16	0.46	1.00	-0.24
-0.53	0.29	-0.55	-0.24	1.00

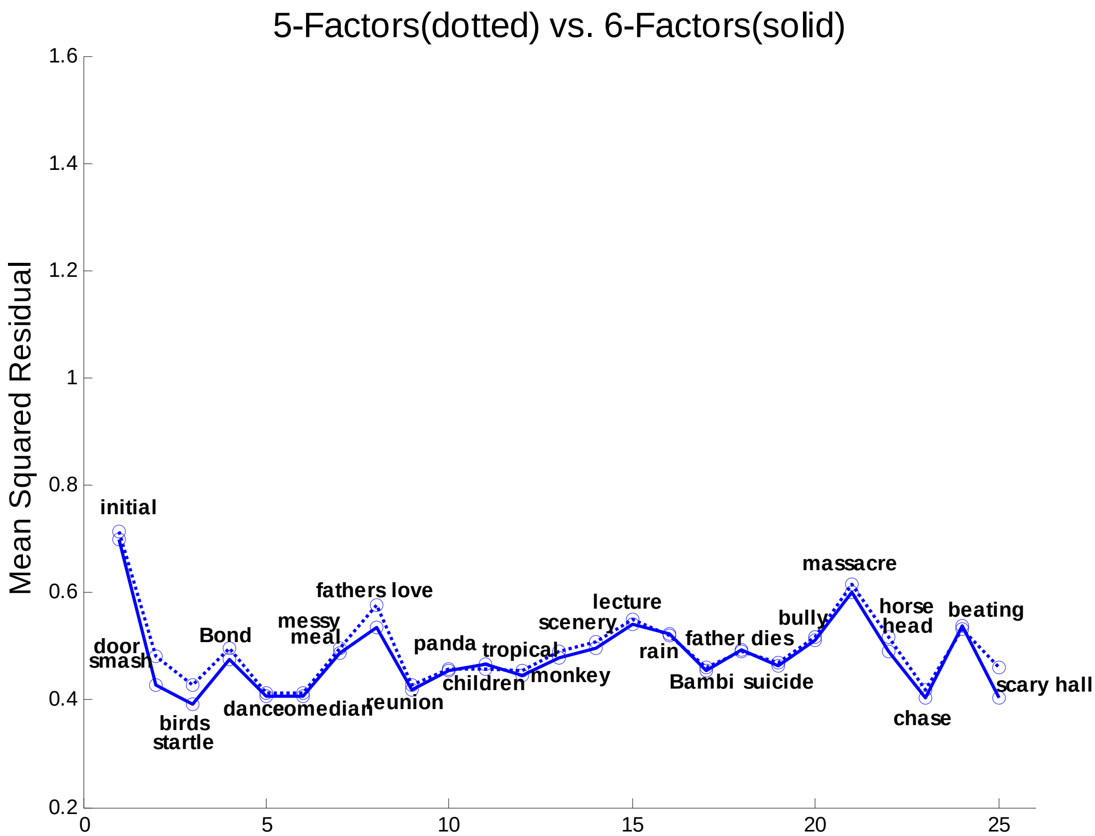
Study 2: One-way plot of 6-Factor Solution





Note: Vertical bars illustrate relative sizes of factors
A lighter italicized font is used for adjectives with factor loadings less than .20

Study 2: Residual plot of 5- and 6-factor solutions



Study 2: 6-Factor Solution

Variance in ratings accounted for by the factors (%)

54.4%

Relative size of factors (% of explained variance)

22% 20% 17% 16% 14% 12%

Iterations to convergence

2280

Individual Mode Factor Correlations

1.00	0.00	0.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00	0.00	0.00
0.00	0.00	1.00	0.00	0.00	0.00
0.00	0.00	0.00	1.00	0.00	0.00
0.00	0.00	0.00	0.00	1.00	0.00
0.00	0.00	0.00	0.00	0.00	1.00

Adjective Mode Factor Correlations

1.00	-0.41	-0.00	-0.58	0.18	0.37
-0.41	1.00	0.39	-0.07	0.06	-0.40
-0.00	0.39	1.00	-0.26	0.57	-0.38
-0.58	-0.07	-0.26	1.00	-0.38	-0.45
0.18	0.06	0.57	-0.38	1.00	0.01
0.37	-0.40	-0.38	-0.45	0.01	1.00

Film Mode Factor Correlations

1.00	-0.46	-0.39	0.03	-0.10	0.21
-0.46	1.00	0.32	-0.43	-0.26	-0.41
-0.39	0.32	1.00	-0.57	0.30	-0.47
0.03	-0.43	-0.57	1.00	-0.14	0.44
-0.10	-0.26	0.30	-0.14	1.00	-0.20
0.21	-0.41	-0.47	0.44	-0.20	1.00

CURRICULUM VITAE

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Education

In Progress
Ph.D., Industrial & Organizational Psychology
Advisor: Dr. J.P. Meyer
The University of Western Ontario

1998
M.A., Industrial & Organizational Psychology
Advisor: Dr. J.P. Meyer
The University of Western Ontario

1996
B.A., Psychology, Minor in Mathematics
Advisors: Dr. D.R. Bobocel & Dr. M.P. Zanna
University of Waterloo

Awards

1999
Best Paper, Organizational Behaviour Division: Stanley& Meyer (1999) *Cynicism and skepticism about organizational change: Measure development and evaluation***.** Annual meeting of Administrative Sciences Association of Canada

1999
Thesis Recognition Award
(awarded for M.A. thesis but open to M.A. and Ph.D.)
Society of Industrial & Organizational Psychology Division
Ontario Psychology Association

1998
Leola E. Neal Memorial Thesis Award (for M.A. thesis)
The University of Western Ontario

1996
Psychology Departmental Award Winner
(highest psychology average at graduation)
University of Waterloo

1996
Honourable Mention, Psychology Undergraduate Thesis Competition
University of Waterloo

1996
R.H. Walters Award, Psychology
University of Waterloo

Scholarships

1998-2002	**Social Sciences and Humanities Research Council Fellowship**
1998-2002	**Graduate Tuition Scholarship** The University of Western Ontario
1998-1999	**President's Scholarship for Graduate Studies (Declined)** The University of Western Ontario
1997-1998	**Ontario Graduate Scholarship**
1996-1997	**Ontario Graduate Scholarship**
1996-1997	**President's Scholarship for Graduate Studies** The University of Western Ontario

Publications

Stanley, D.J., Meyer, J.P., & Topolnytsky, L. (2005). Employee cynicism and resistance to organizational change. *Journal of Business and Psychology*, *19*, (in press).

Meyer, J.P., Stanley, D. J., Herscovitch, L., Topolnytsky, L. (2002). Affective, continuance, and normative commitment to the organization: A meta-analysis of the antecedents, correlates, and consequences. *Journal of Vocational Behavior, 61,* 20-52.

Stanley, D. J., & Meyer, J. P. (1999). Cynicism and skepticism about organizational change: Measure development and evaluation*. Selected proceedings of the annual meeting of the Administrative Sciences Association of Canada, 20 (5)*, 1-10.

Bobocel, D.R., Son Hing, L.S., Davey, L.M., Stanley, D.J., & Zanna, M.P. (1998). Justice-based opposition to social policies: Is it genuine?. *Journal of Personality and Social Psychology, 75(3)*, 653-669.

Presentations & Posters

Invited

Stanley, D.J. (2003, June). *Determining the intrinsic factor structure of self-reported emotions: Dealing with the system-variation requirement of 3-mode PARAFAC factor analysis*. Invited presentation at the tri-annual conference: Trilinear Methods in Chemometrics and Psychometrics, Lexington, Kentucky.

Meyer, J.P., Stanley, D.J., Heathcoate, J.M., & Powell, D.M. (2003, May). *Cross-cultural generalizability of the three-component model of commitment: Methodological issues and preliminary findings*. Invited presentation at the Franci Foundation Symposium on Organizational Behavior, the Catholic University of Louvain, Louvain-la-Neuve, Belgium.

Peer Reviewed

Stanley, D.J., & Meyer, J.P. (2003). *The affect circumplex conundrum: Resolving the rotation riddle*. Poster presented at the annual convention of the American Psychological Association, Toronto, Ontario.

Powell, D. M., Tai, J. Y., Herscovitch, L., Stanley, D. J., & Meyer, J.P. (2002) *Employee commitment as a mediator of the relation between psychological contract violation and OCB*. Poster presented at the 63rd Annual Convention of the Canadian Psychological Association, Vancouver, British Columbia.

Topolnytsky, L., Herscovitch, L., Meyer, J.P., & Stanley, D. J. (2001). *Commitment and reactions to organizational change: Form and focus matter*. Poster presented at the annual meeting of the Society for Industrial and Organizational Psychology, San Diego, California, April 2001.

Hecht, T.D., Gill, H.K., Herscovitch, L., McCarthy, J., Stanley, D. J, & Allen, N. J. (July, 2000). *Taking stock of the impact of I/O psychology*. Paper presented at the annual conference of the Administrative Sciences Association of Canada, Montreal, Quebec.

Stanley, D. J., Meyer, J. P., Herscovitch, L., & Topolnytsky, L. (1999). *Antecedents and correlates of three components of commitment: A meta-analysis*. Poster presented at the annual meeting of the Society for Industrial and Organizational Psychology, New Orleans, Louisiana, April 2000.

Stanley, D. J., & Meyer, J. P. (1999). *Cynicism and skepticism about organizational change: Measure development and evaluation.* Paper presented at the annual meeting of the Administrative Sciences Association of Canada, St. John, New Brunswick, June.

Stanley, D. J., Meyer, J. P., Topolnytsky, L., & Herscovitch, L. (1999). *Affective, continuance and normative commitment: Meta-analyses of interrelations and outcomes*. Poster presented at the annual meeting of the Society for Industrial and Organizational Psychology, Atlanta, Georgia, April 1999.

Davey, L. M., Bobocel, D. R., Stanley, D. J., & Zanna, M. P. (1997, June). *Reactions to an affirmative action program beneficiary*. Poster presented at the annual convention of the Canadian Psychology Association, Toronto, Ontario.

Davey, L. M., Bobocel, D. R., Stanley, D. J., & Zanna, M. P. (1996, August). *Development and validation of two resource allocation surveys*. Poster presented at the International Congress of Psychology, Montreal, Quebec.

Stanley, D. J., Davey, L. M., Zanna, M. P. & Bobocel, D. R. (1996, May). *Prejudicial and merit-based objections to affirmative action*. Poster presented at the annual meeting of the Society for the Psychological Study of Social Issues, Ann Arbor, Michigan.

Relevant Work Experience

2003-2004	**Instructor, Psychology 380: Statistics Using Computers (1 Fall Section & 2 Winter Sections)** The University of Western Ontario
2002-2003	**Instructor, Psychology 380: Statistics Using Computers (1 Fall Section & 1 Winter Section)** The University of Western Ontario
1997-2003	**Research Assistant, Dr. Meyer** The University of Western Ontario

2001-2002 **Teaching Assistant, Psychology 485: Honours Thesis (2 terms)**
Guided and evaluated 20 students
The University of Western Ontario

2000-2001 **Teaching Assistant, Psychology 281: Statistics (2 terms)**
Conducted labs and marked assignments as well as exams
The University of Western Ontario

1996-1998 **Teaching Assistant, Psychology 280: Research Methods (3 terms)**
Conducted labs and marked assignments.
The University of Western Ontario

Computer Development

1999 **The Meta-Analyzer**
Developed this SPSS compatible meta-analysis program (based on Hunter & Schmidt (1990)) with a Windows 95/98/NT/XP interface.

2003 **Factor Analysis and Multidimensional Scaling**
Developed MatLab programs to conduct 3-mode PARAFAC factor analysis, 2-mode principal components analysis, and 2-mode multidimensional scaling.

Professional Services

2000-2001 **Canadian Society of Industrial and Organizational Psychology**
Student representative on the executive committee