Journal of Mathematical Psychology 54 (2010) 137–149

Contents lists available at ScienceDirect

Journal of Mathematical Psychology

journal homepage: www.elsevier.com/locate/jmp

Perceived association between diagnostic and non-diagnostic cues of women's sexual interest: General Recognition Theory predictors of risk for sexual coercion

Coreen Farris [a,*], Richard J. Viken [b], Teresa A. Treat [c]

[a] Carnegie Mellon University, United States
[b] Indiana University, United States
[c] Yale University, United States

ARTICLE INFO

Article history:
Received 3 April 2008
Received in revised form
9 October 2008
Available online 25 February 2009

Keywords:
Sexual perception
Sexual aggression
Social perception
Non-verbal communication
General Recognition Theory
Illusory correlation

ABSTRACT

Young men's errors in sexual perception have been linked to sexual coercion. The current investigation sought to explicate the perceptual and decisional sources of these social perception errors, as well as their link to risk for sexual violence. General Recognition Theory (GRT; [Ashby, F. G., & Townsend, J. T. (1986). Varieties of perceptual independence. *Psychological Review*, *93*, 154–179]) was used to estimate participants' ability to discriminate between affective cues and clothing style cues and to measure illusory correlations between men's perception of women's clothing style and sexual interest. High-risk men were less sensitive to the distinction between women's friendly and sexual interest cues relative to other men. In addition, they were more likely to perceive an illusory correlation between women's diagnostic sexual interest cues (e.g., facial affect) and non-diagnostic cues (e.g., provocative clothing), which increases the probability that high-risk men will misperceive friendly women as intending to communicate sexual interest. The results provide information about the degree of risk conferred by individual differences in perceptual processing of women's interest cues, and also illustrate how translational scientists might adapt GRT to examine research questions about individual differences in social perception.

Decoding sexual intent is an arguably difficult task, particularly if the perceiver hopes to decode intent early in an interaction. Women may smile, sustain eye contact, or touch their partner to convey romantic or sexual interest. However, all of these cues also could be used to convey simple warmth, friendliness or platonic interest. Given the ambiguity separating sexual interest from platonic interest and the overlapping non-verbal cues used to signal each, it should come as no surprise that individuals often disagree about the meaning of nonverbal sexual signaling. In particular, men often disagree with women about the presence or degree of women's sexual intent (see Farris, Treat, Viken, and McFall (2008b), for review). Men consistently rate female targets as intending to convey a greater degree of sexual interest than do women who rate the same targets — a finding that has been remarkably consistent across methodologies ranging from still photographs and video vignettes to live, unscripted interactions (Farris et al.). Of course, the effect is not confined to the lab. In a large survey of university women, 67% reported that they had experienced an incident in which a male acquaintance misperceived their friendliness to be an indication of sexual interest, and 26% reported that such an event had occurred within the past month (Abbey (1987); see also Haselton (2003)). In most cases, the negative consequences of sexual misperception will not extend beyond minor social discomfort. However, among a subgroup of individuals, sexual misperception may play an etiological role in the process that ultimately leads to sexual coercion.

In fact, men who report a history of sexual coercion also perceive more sexual interest in women's behavior than do men without a history of sexual violence (Farris et al., 2008b). Compared to non-coercive men, sexually coercive college men self-report more incidents in which they mistakenly thought a woman was sexually attracted to them, only to find out later that she was only trying to be friendly (Abbey & McAusland, 2004; Abbey, McAuslan, & Ross, 1998). Farris, Viken, Treat, and McFall (2006) found that decreased accuracy among high-risk men was due in part to high-risk men's relative insensitivity to women's affect, which leads them to have difficulty discriminating sexual interest from other affect categories. In addition, high-risk men's decisions about sexual interest were influenced substantially by less relevant cues such as women's clothing styles. Men who more strongly endorsed rape myths were more likely to be swayed by provocative clothing and assume that provocatively dressed women also were sexually interested. Similarly, a performance-based investigation relying on

* Corresponding address: Carnegie Mellon University, 336A Baker Hall, Pittsburgh, PA 15213, United States.
E-mail address: cfarris@andrew.cmu.edu (C. Farris).

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doi:10.1016/j.jmp.2008.10.001

a separate computational model to understand men's perceptual processing of women, found that men who pay relatively less attention to women's affective cues than to their clothing exposure also were less sensitive to women's negative, non-interest cues in a sexual vignette (Treat, McFall, Viken, & Krushke, 2001). These findings suggest that women's clothing styles, particularly provocative clothing, introduce a distracting feature to sexual signaling that may reduce accuracy in decoding sexual intent among a subset of men.

It is reasonable to hypothesize that individual differences in perceptual processing of the social environment may converge such that high-risk men are more likely to rely on non-diagnostic cues in the environment to classify women's sexual interest. Cues such as youthfulness, attractiveness, or choice of clothing may increase the likelihood that a perceiver will see a woman as an appealing potential partner. However, these cues are not person-specific, that is, any one perceiver cannot conclude, using only information about a potential partner's clothing choice, that the woman is interested in the perceiver specifically. "Person-specific" cues refer to cues that are directed to one individual to communicate interest or lack of interest in a dating or sexual relationship with that specific person. These person-specific cues are generally facial affect and verbal cues, but might also include posture, physical proximity, or hand movements. In general, it would be expected that person-specific cues are more predictive and explain more variance in *correct* classification decisions than universal cues such as attractiveness or clothing style. However, there are likely to be individual differences in men's attention to cues such as clothing style, and individuals who pay more attention to these cues will likely be less sensitive in classification tasks (Treat et al., 2001). To the extent that high-risk men rely more on universal, but non-diagnostic cues (i.e., sexually provocative clothing) rather than diagnostic, person-specific cues (i.e., facial affect), they will be increasingly likely to experience false alarms in detecting sexual interest when women are provocatively dressed, and potentially more likely to proceed with an interaction based on this misperception of sexual intent.

One explanation for the increased errors in sexual perception observed among sexually coercive men is that this group of individuals is more likely to perceive features of sexual interest and clothing style as dependent on one another (Treat et al., 2001).[1] For example, assume a simplified social task in which the observer must classify a woman's affect (friendly or sexually interested) and her clothing (conservative or provocative) and that the two dimensions are not objectively associated with one another. Suppose that the individual's *perception* of clothing choice and facial affect is not entirely orthogonal, that is, the probability of perceiving sexual interest is dependent on whether the woman is conservatively or provocatively dressed. Based on prior research, we can presume that the form of this dependency would be a positive correlation between provocativeness of dress and sexual interest (Farris et al., 2006). If one group of individuals (e.g., sexually coercive men) perceives the diagnostic and non-diagnostic dimensions to be positively associated to a greater degree than another group of individuals (e.g., non-coercive men), then it is reasonable to predict increased categorization errors, particularly when the diagnostic and non-diagnostic dimensions contradict one another. An illusory correlation explanation for error in sexual perception has never been directly tested. However, illusory correlations between dimensions that are not objectively related have been found to be important in other clinical populations. For example, individuals with anxiety symptoms are more likely to perceive feared stimuli and aversive events as positively correlated (e.g., Tomarken, Sutton, and Mineka (1995)), and women with eating disorder symptoms are more likely than other women to perceive an illusory correlation between thinness and positive affect and heaviness and negative affect (Viken, Treat, Bloom, & McFall, 2005). In this manuscript we intend to serve two purposes. One aim is to determine whether an illusory correlation between provocative clothing and sexual interest predicts sexual coercion history and risk. Second, and more broadly, the aim is to provide a concrete example of the benefit of translating cognitive models of simple perception to clinically relevant social perception. To this aim, we have included several analytic variants of the model in order to provide flexibility and choice to investigators seeking to utilize the model in unique applications.

1. General Recognition Theory (GRT) and sexual perception

Socially relevant questions such as the precise relationship between sexual misperception and sexual aggression, and the exact nature of the perceptual "abnormalities" that lead to sexual misperception, are addressed best by rigorous models of perception that can differentiate subtle differences in perceptual processing. Unfortunately, the methodological approach typically used within the field of sexual aggression lacks the rigor and specificity necessary to pursue this work. However, cognitive scientists have invested considerable effort in the previous decades to develop formalized mathematical models of simple perception (Ashby & Townsend, 1986; Green & Swets, 1966; Luce, 1959), and recent years have seen an increased effort to use other formal models of cognition and perception to address questions considered by social and clinical psychologists (e.g., Farris, Treat, Viken, and McFall (2008a), McFall and Treat (1999), Neufeld (2007), Treat et al. (2001, 2002) and Yechiam, Busemeyer, Stout, and Bechara (2005)). Given the success of such integration efforts, it is sensible to search for models of simple (non-social) perception that are sufficiently flexible to make translation to a clinically relevant question feasible, but also sufficiently rigorous so as to allow more careful examination of the nature of feature integrality. One model that possesses these traits is the General Recognition Theory (GRT; Ashby and Townsend (1986)), a generalization of signal detection theory (SDT; Green and Swets (1966)) to multidimensional space.

2. Introduction to General Recognition Theory

The following provides a brief outline of GRT; a more thorough review of observable GRT concepts follows along with analytic results. For a complete tutorial refer to Thomas (2001). GRT treats performance on an identification task as a byproduct of the operation of perceptual and decisional processes (see Ashby and Townsend (1986), Kadlec and Townsend (1992a,b) and Thomas (2001)). In the current application, for example, participants identify stimulus values along both sexual interest and clothing style dimensions. Perception of each stimulus is represented as a single point in a two-dimensional "psychological" space. The location of this perceptual effect is assumed to fluctuate across trials, producing a probability distribution of perceptual effects (often assumed to be multivariate Gaussian in form) throughout the psychological space. Perceivers then are assumed to subdivide the psychological space into regions, such that percepts falling into a given region are identified by the individual as members of that region.

[1] To be clear, despite some expectation among college students that provocative clothing and sexual interest are tightly coupled (Haworth-Hoeppner, 1998), it is in fact uncommon for women to use clothing cues to signal sexual interest (Perper & Weis, 1987).

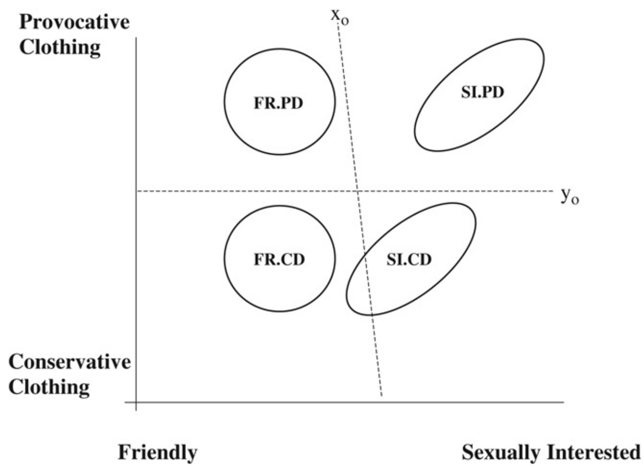

Fig. 1. Perceptual Distributions in a feature-complete factorial design. Distributions associated with the four target categories are depicted: friendly, conservatively dressed (FR.CD); friendly, provocatively dressed (FR.PD); sexually interested, conservatively dressed (SI.CD); and sexually interested, provocatively dressed (SI.PD).

Fig. 1 illustrates four equal probability-density contours from a two by two feature-complete factorial design (Ashby & Townsend, 1986). The four target categories result from the factorial combination of the two levels of intent (friendliness or sexual interest) and the two levels of clothing style (conservative or provocative). The *x*-axis depicts the interest dimension, and the *y*-axis depicts the clothing style dimension. The contours represent a cross-section of a joint density function cut by an *XY* plane such that all perceived values falling on the contour are equally likely. The center of the contour can be viewed as the perceptual prototype for the target type.

The decisional process is represented within GRT by the dashed lines separating the contours in Fig. 1. These decision lines are multidimensional extensions of decisional bias in SDT. Any perceptual effect that falls within a response region (as demarked by the bias boundaries) would lead the observer to provide the response associated with that region. For example, in Fig. 1, points to the right of the x_o boundary, and above the y_o boundary will be identified as belonging to the sexually interested, provocatively dressed target category. Note that this will result in a large proportion of targets that belong to the sexually interested, provocatively dressed distribution being categorized correctly. Errors will occur with low probability. For example, percepts falling in the tail of the friendly, provocatively dressed distribution, but beyond the x_o boundary (and above the y_o boundary) will be incorrectly categorized as belonging to the sexually interested, provocatively dressed distribution.

Feature independence is defined both within and across the four target categories. The first form of independence, *perceptual independence (PI)*, is a "micro" description of feature independence (or dependence) *within* a target category (e.g., among all friendly, conservatively dressed targets). For a perceptually independent target category, the perceptual effect of one dimension does not influence the perceptual effect of another dimension (i.e., within one distribution, the perceptual effects of interest and clothing style are statistically independent). Mathematically,

$$f_{ij} = g_{ij}(x)g_{ij}(y), \quad \text{for all } x \text{ and } y \tag{1}$$

that is, the product of the marginal densities is equivalent to the joint density. Graphically, the major and minor axes of the probability density contours of perceptually independent stimuli can be defined as parallel to the *x*- and *y*-axes. In contrast, perceptual dependence is depicted by elliptical contours with major and minor axes rotated with respect to the *x*- and *y*-axes. In Fig. 1, both sexually interested distributions are perceptually dependent, with a positive association between the two dimensions indicating that as clothing style is perceived as increasingly provocative, the observer will also perceive the intent as indicating sexual interest. Both friendly distributions are perceptually independent with no perceived association between the dimensions, and thus, are depicted as circular.

"Macro" feature independence (across target categories) is labeled *perceptual separability (PS)* in GRT. Across perceptually separable target categories, the perceptual effect of one dimension does not depend on the level of the other dimension. Mathematically, if the perceptual effect of *A* does not depend on the physical level of component *B*, then the marginal densities will be equivalent:

$$g_{A_iB_1}(x) = g_{A_iB_2}, \quad i = 1, 2 \text{ for all } x. \tag{2}$$

Graphically perceptual separability is illustrated by identical marginal densities for the two components. Concretely, in Fig. 1, the sexually interested, provocatively dressed target category is *not* perceptually separable from the sexually interested, conservatively dressed target category. That is, the sexually interested, provocatively dressed distribution is shifted to the right of the sexually interested, conservatively dressed distribution on the *x*-axis. However, the friendly, provocatively dressed target category is perceptually separable from the friendly, conservatively dressed target category. These distributions fall along the same region of the *x*-axis.

The concept of *decisional separability (DS)* is supported when the decision about the identity on one dimension (e.g., dividing sexually interested women from those that are not) does not depend on the perceived level of another dimension (e.g., clothing choice). Graphically, the decision bound between decisionally separable target categories is parallel to the *x* (or *y*) axis; that is, the observer does not shift the criterion that separates features on one dimension to be a more conservative or lenient criterion as the level of the second dimension changes. The failure of decisional separability is graphically represented as a decision line that is tilted with respect to an axis. In Fig. 1, the decisional boundary x_0 divides friendly from sexually interested targets. The negative slope reflects a decisionally inseparable boundary in which the perceiver utilizes a more lenient threshold for detecting sexual interest as clothing style becomes more provocative. The decisional boundary y_0 divides conservatively from provocatively dressed targets. It is depicted as parallel to the *x*-axis, which suggests decisional separability (i.e., the perceiver's decisional criterion for detecting provocative clothing is not dependent on intent cues).

Perceptual independence, perceptual separability and decisional separability are all unobservable. In other words, the distributions of perceptual effects that each concept is built upon are not available for direct measurement, just as in SDT. However, two directly observable properties of the data can be used to draw inferences about the perceptual GRT concepts. These properties are *sampling independence* (supported if the probability that a participant reports that two features of a stimulus are present is equal to the marginal probability that the participant reports that one feature is present multiplied by the marginal probability that the second feature is present) and *marginal response invariance* (supported if the probability that one feature is correctly identified does not depend on the feature level of the second dimension). Sampling independence and marginal response invariance provide indirect tests to determine if stimulus processing is perceptually independent and perceptually separable. Provided that decisional separability holds, perceptual independence implies sampling independence, and perceptual separability implies marginal response invariance (see Ashby and Townsend (1986) for proofs). Although the theoretical constructs (perceptual independence, perceptual separability, and decisional separability) imply particular empirical patterns (sampling independence and marginal response invariance), the observable patterns do not necessarily imply the theoretical constructs. Thus, inferences are often strengthened by the inclusion of signal detection parameters to scaffold the link between the empirical patterns and theoretical concepts.

Sampling independence and marginal response invariance are non-parametric analyses that make no assumptions about the form of the underlying perceptual distributions. Additional GRT analyses are available if one assumes that the unobserved perceptual distributions are Gaussian in form, a common assumption in traditional statistics. This allows estimation of the signal detection parameters d' (sensitivity) and β (bias) across all feature combinations (Kadlec & Townsend, 1992a,b), both within and across target categories. Marginal estimates allow an alternative route to uncover support for perceptual separability that is particularly useful in that it does not require decisional separability to hold (Kadlec & Townsend). Marginal estimates can also be employed to directly test for the presence or absence of decisional separability.

Finally, a GRT model could be formally fit to the data in order to model the equal likelihood contours of the best fitting model for an observer (Thomas, 2001). Modeling allows the generation of a precise, graphical representation of the underlying perceptual distributions. It also provides a continuous measure of the degree of perceptual dependence or perceptual inseparability. However, it should be noted that the number of parameters associated with the full GRT model is greater than the number of degrees of freedom in most study designs, including the design of the current investigation. Thus, it is usually necessary to constrain the GRT model in order to pursue a formal model fit. This solution is often possible for cognitive scientists for whom reasonable constraints are available. For example, traditional cognitive experiments are often designed so as to make decisional separability a reasonable assumption, and thus, parameters associated with modeling an inseparable decisional boundary can be constrained. Unfortunately, clinical scientists may not be at liberty to make such assumptions. For example, when modeling perception of sexual interest and clothing style, it is not immediately clear that any parameters can be constrained.[2]

Thus, perhaps the most reasonable path to pursue early in translational cognitive-clinical research is to forgo formal modeling, and instead, to rely on results from non-parametric tests of sampling independence and marginal response invariance, as well as the signal detection estimates, to provide a rough sketch of the underlying perceptual distributions. Relying only on these analyses, it is possible to provide an approximate representation of the psychological space. For example, an ordinal form of perceptual independence for each distribution can be sketched (i.e., each distribution can display perceptual independence, perceptual dependence marked by a negative relationship, or perceptual dependence marked by a positive relationship). Similarly, an ordered relationship between the locations of the four distributions can be determined along each dimension in order to sketch supported versus violated perceptual separability, and ordinal aspects of the slopes in decision boundaries can also be determined. Note that the present investigation is primarily concerned with violations on the intent dimension (friendly to sexually interested) rather than the clothing style dimension (conservative to provocative). For this reason, analyses of marginal bias, sensitivity, perceptual separability, and decisional separability on the clothing style dimension are omitted from the analyses presented below.

In summary, GRT provides a means of testing hypotheses about individual differences in perceptual organization. It is unique in that it separates independence into a micro-level analysis that provides insight into whether or not the participant processes two (or more) features independently within a target category, as well as macro-level analysis that allows investigators to determine if a featural value along one dimension is perceived similarly regardless of the identity of featural values along the other dimension.

3. Hypotheses

As noted above, sexually coercive men report histories of sexual misperception during dating interactions, and also over predict sexual interest in laboratory manipulations. With respect to perceptual organization features, it is predicted that sexually coercive men will be less sensitive to the facial affect dimension of sexual interest relative to non-coercive men. It also is predicted tentatively that sexually coercive men will have a lower threshold for detecting sexual interest relative to non-coercive men. This prediction is more speculative because evidence of risk-status differences in decisional thresholds has been less reliable across multiple measures in past research (Farris et al., 2006).

With respect to illusory associations between diagnostic and non-diagnostic sexual interest cues, it is expected that relative to non-coercive men, a perceived association will be more common among sexually coercive men. Sexually coercive men are hypothesized to be more likely to perceive orthogonal target categories as perceptually dependent (with positive illusory correlations between the dimensions). Fig. 2 illustrates this prediction by depicting all four of the bolded perceptual distributions with positive correlations between the feature dimensions. It may also be the case that the perceptual representation of sexual interest and provocative clothing dimensions would be marked by greater perceptual inseparability among sexually coercive men relative to non-coercive men. If this is the case, the four distributions will shift relative to one another. As illustrated in Fig. 2, both of the provocatively dressed distributions are shifted to the right of the paired conservatively dressed distributions on the interest dimension (i.e., targets in the provocatively dressed category are perceived as being more sexually interested than targets in the conservatively dressed category).

The application of a rigorous model of perception serves three primary purposes. First and foremost, it provides a more complete and detailed examination of individual differences in heterosocial perception that may increase the risk of sexual misperception. Second, it provides a method that can provide a formal test of the

[2] Although increasing the number of levels on each dimension would increase the degrees of freedom, these design changes unfortunately also introduce additional free parameters, and therefore, do not provide a simple solution. One alternative is to fit a series of hierarchical GRT models beginning with a simple, highly constrained model (e.g., assuming perceptual separability and perceptual independence) and comparing this model to more general models that allow some parameters to vary freely (Ashby & Lee, 1991; Thomas, 2001). This approach is closely linked to the theoretical underpinnings of GRT, and provides a method to narrow conclusions about the characteristics of individual's perceptual and decisional space. Comparing nested models has been used in experiments with small samples sizes, but the translation to studies of individual differences has been hampered by two factors. First, the results of this process may categorize participants in a non-homogenous manner. For example, a group of participants with best fitting models described as meeting conditions of perceptual separability, but with perceptual dependencies in all distributions marked by a common correlation, could include both participants with a positive association between dimensions and participants with a negative association between dimensions. Although the model that has been fit can be described similarly, the social consequences of these forms of social perception would be predicted to vary widely. Second, and most importantly, the end point of this process would divide participants into upward of 12 categorizations of best fitting models. This partitioning of the sample would lead to dramatic declines in statistical power to detect the relevant individual differences. Nonetheless, in larger samples (or in studies where individual differences are not central), this approach should be carefully considered.

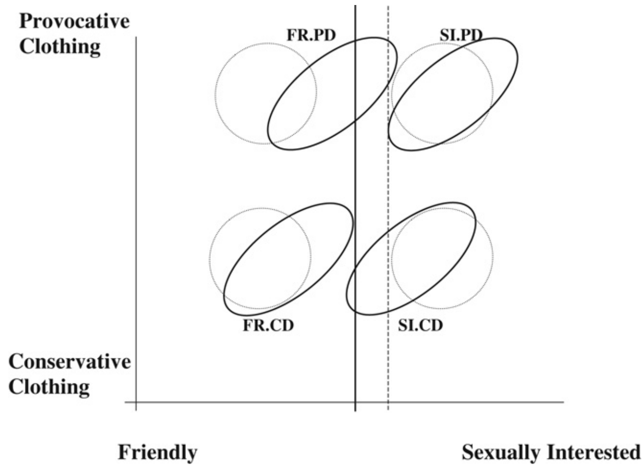

Fig. 2. Hypothesized perceptual distributions. The solid ellipses and decisional boundaries represent the perceptual and decisional differences predicted among high-risk men relative and the dashed ellipses and boundaries correspond to low-risk men. The decisional boundary on the clothing style dimension is omitted as no predictions are specified on this dimension. The perceptual distributions associated with the four target categories are depicted: friendly, conservatively dressed (FR.CD); friendly, provocatively dressed (FR.PD); sexually interested, conservatively dressed (SI.CD); and sexually interested, provocatively dressed (SI.PD).

clinically relevant illusory correlation phenomenon. And finally, it illustrates the application of GRT to individual differences research. In recent years, these forms of cross-discipline relationships have proven to be a particularly effective and efficient strategy for forging progress in multiple domains.

4. Method

4.1. Participants

A sample of 504 heterosexual, undergraduate men participated in exchange for course credit. The sample was predominately White/Caucasian (84.3%; 3.8% African–American; 6.7% Asian–American; 2.8% Hispanic; 0.6% American–Indian, and 1.8% other). The average age was 19.6 ($SD = 1.3$), and most participants had some dating (98.8%) and sexual experience (87.1%; oral or vaginal intercourse).

4.2. Identification task

Stimulus set. Extensive piloting was used to develop a set of images that vary on the dimensions of sexual interest (friendly to sexually interested) and clothing style (conservative to provocative; (Farris et al., 2006)). This process led to a final stimulus set of 70 sexually interested targets and 70 friendly targets. Half of the photographs in each affect category were conservatively dressed and half were provocatively dressed. Normative attractiveness ratings were similar across the four stimulus categories, and images were selected to ensure that clothing style and affect were not correlated in the image set.

Task. While seated in front of a computer screen in a private testing room, participants viewed each target for 1000 ms. After each target was presented, the participant's task was to categorize the image. Participants responded to two questions serially: "Was the woman provocatively or conservatively dressed?" and "Was the woman displaying sexual interest or friendliness?" The order of the questions remained the same for the entire experimental session; however, question order was counterbalanced across participants. Targets were displayed in three blocks of 140 targets for a total of 420 trials. Presentation order was randomized within block, and a mandatory 30-s break occurred between blocks. In total, there were 105 responses for each of the 4 types of targets: (a) sexually interested, provocatively dressed, (b) sexually interested, conservatively dressed, (c) friendly, provocatively dressed, and (d) friendly, conservatively dressed. The task required approximately 25 min to complete.

4.3. Measures

Sexual Experiences Survey (SES). The SES is a self-report measure of sexual coercion and aggression (Koss, Gidycz, & Wisniewski, 1987). Respondents indicate if they have or have not engaged in ten sexual behaviors that can be classified as sexual coercion, attempted rape, or completed rape. The distribution is typically L-shaped, and therefore, is dichotomized into participants who do not report a sexual coercion or rape history and participants who report committing at least one sexually coercive act. In this sample, 19.9% ($n = 100$) were categorized as sexually coercive.

Rape Myth Acceptance (RMA). The RMA scale is an 11-item questionnaire that measures beliefs in the justifiability of rape and the belief that women are responsible for victimization (Burt, 1980). Participants indicate their agreement with items such as "A woman who is stuck-up and thinks she is too good to talk to guys on the street deserves to be taught a lesson" on a scale from 1 (strongly disagree) to 7 (strongly agree). Item responses are summed for a total scale score that ranges from 11 (low endorsement) to 77 (high endorsement). Total scale score has been demonstrated to be associated with self-reported perpetration of sexual coercion or aggression (Hersh & Gray-Little, 1998; Koss & Dinero, 1988; Muehlenhard & Linton, 1987).

4.4. Association between scales

Analyses to follow utilize the SES and RMA. To rule out colinearity between these scales, a Pearson correlation coefficient was computed between SES (total scale score) and RMA. The association was significant ($r = 0.23$, $p < .001$). However, the value of the coefficients is not so large as to introduce significant concern about colinearity.

4.5. Procedure

After completing informed consent procedures, participants were shown to a private testing room where they completed the identification task and the questionnaires via computer. The entire study session was completed in 45 min on average.

5. Analytic strategy and results

In keeping with the two-fold purpose of the manuscript, the traditional approach to accuracy data and the various computational approaches associated with GRT are presented here in lockstep with the empirical results from the current investigation. The translational scientist interested in utilizing GRT would be well-served to determine the most appropriate analytic approach for his or her data and to proceed with one rather than all of the presented approaches. We include them all in order to illustrate the costs and benefits of each approach and to provide a platform from which to discuss the relative merits of each in clinical and social applications.

5.1. Analysis of accuracy data

Participant identification task performance was summarized in a 4 by 4 confusion matrix in which the four target types form the rows, the four possible participant responses form the columns, and the proportion of trials on which the participant responded to a given target type with a given response is recorded in the matrix cells. The raw data organized in these matrices provide the basis for modeling each participant's sensitivities and response biases and for conducting nonparametric tests of sampling independence and marginal response invariance.

The data available in a confusion matrix also provide accuracy rates (percentage correct) for each target type. An analysis of percentage correct data is typical in conventional applied research and allows a benchmark to which results from GRT analyses can be compared. Two general linear model (GLM) analyses predicting participant percentage accuracy in judging (1) affect (friendly or sexually interested) and (2) clothing style (conservative or provocative) were conducted with the individual difference scales RMA and SES included as predictors. The first model revealed a significant effect of affect, $F(1, 491) = 160.87$, $p < .001$, $\eta_p^2 = 0.25$; percentage accuracy was higher when participants were identifying friendly targets (78.5% correct, $SD = 17.82$) rather than sexually interested targets (63.5% correct, $SD = 22.37$). There was a small negative association between endorsement of rape myths (RMA) and percentage accuracy when identifying affect categories, $F(1, 491) = 4.32, p < .05, \eta_p^2 = 0.01, r = -0.05$. In addition, men with a history of sexual coercion were somewhat less accurate in identifying affect (69.4%, $SD = 17.82$) than were non-aggressive men (72.6%, $SD = 8.91$), $F(1, 491) = 11.42$, $p < .01$, $\eta_p^2 = 0.02$. The second model revealed a significant main effect of clothing style, $F(1, 491) = 1270.91$, $p < .001$, $\eta_p^2 = 0.72$; participants were better able to identify clothing as conservative (88.4% correct, $SD = 11.14$) rather than as provocative (46.2% correct, $SD = 24.50$). Risk variables (RMA and SES) were not associated with changes in accuracy in detecting clothing style.

5.2. *Multidimensional Signal Detection Analysis (MSDA)*

The nonparametric tests of sampling independence and marginal response invariance correspond to perceptual independence and perceptual separability only if the decision boundaries are invariant with respect to the *x*- or *y*-axis. Typically, this decisional separability is guaranteed by stimulus selection that is unlikely to produce shifting decisional boundaries (such as geometric objects that vary in shape and color). However, with stimuli such as those presented in the current study and in many clinical applications, it is not clear that decisional separability can be assumed; in fact, we have hypothesized that it would fail for some men. When decisional separability is violated, then the observable probabilities in the sampling independence and marginal response invariance equalities are influenced by both the perceptual processes of interest and by the effect of the shifting decisional boundary. In this case, it is not possible to determine if an observed inequality is due to a failure of perceptual independence and perceptual separability, a failure of decisional separability, or some mixture of both. For this reason, in cases where decisional separability cannot be assumed, the approach should be shifted to alternative analytic strategies. The first strategy is to combine the GRT nonparametric tests with MSDA parameter estimates to provide direct tests of decisional separability and logical inferences about perceptual independence and perceptual separability (Kadlec & Townsend, 1992a,b). Estimating marginal sensitivity and bias parameters is also a useful tool that allows perceptual contributions to percentage accuracy data to be parsed from decisional contributions.

Marginal sensitivity. Across-target category estimates of sensitivity rely on the marginal densities and measure the perceptual distance between two levels of one dimension, holding the level of the second dimension constant. For example, $d'_{\text{AFF}|CD}$ estimates the perceptual distance between the means of the two affect categories

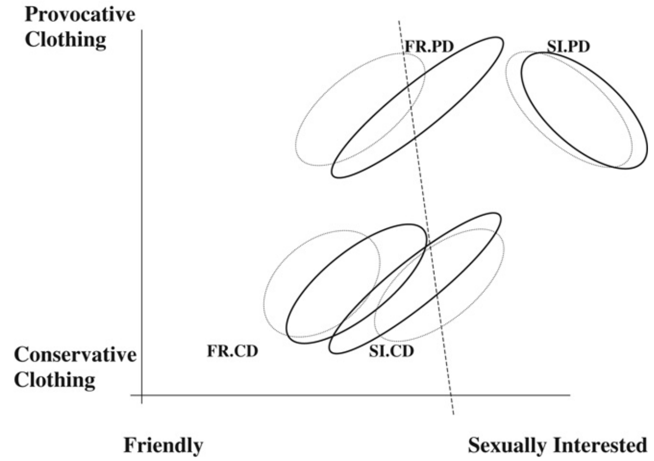

Fig. 3. Modeled perceptual distributions. The dashed ellipses and decisional boundary represent the normative results for the sample, and the solid ellipses represent the significant differences that differentiate high-risk men from the rest of the sample. Illustration of distribution means, variances and covariance are approximate, but have ordinal value relative to one another; the precise values were not directly modeled. The perceptual distributions associated with the four target categories are depicted: friendly, conservatively dressed (FR.CD); friendly, provocatively dressed (FR.PD); sexually interested, conservatively dressed (SI.CD); and sexually interested, provocatively dressed (SI.PD). The decisional boundary on the clothing style dimension is omitted as no predictions are specified on this dimension.

(friendly and sexually interested) for conservatively dressed targets. It can be visualized in Fig. 2 by examining the distance (on the *x*-axis) between the means of the friendly, conservatively dressed distribution and the sexually interested, conservatively dressed distribution. It would be computed as follows:

$$d'_{\text{AFF}|CD} = z(P(R_{SI}|SI.CD)) - z(P(R_{SI}|FR.CD)), \quad (3)$$

where z is the inverse of the normal distribution function. A sensitivity estimate of zero indicates that the perceptual distributions overlap perfectly, and the participant is wholly unable to distinguish between the two target categories. The estimate increases positively as sensitivity to the distinction between the features improves.

In this investigation, the GLM predicting marginal sensitivity to affect included the experimental factor clothing style and the individual difference variables RMA and SES. The analysis revealed main effects for clothing style ($F(1, 491) = 31.33$, $p < .001$, $\eta_p^2 = .060$), RMA, ($F(1, 491) = 6.23$, $p < .05$, $\eta_p^2 = .013$), and SES ($F(1, 491) = 5.99$, $p < .05$, $\eta_p^2 = .012$). Follow-up analyses suggested that participants were better able to discriminate between friendly and sexually interested targets when targets were dressed provocatively (1.41, $SD = .76$) rather than conservatively (1.30, $SD = .73$). Consistent with predictions, marginal sensitivity to affect was also negatively associated with RMA ($r = -0.11$), and men with a history of sexual coercion (1.28, $SD = 1.30$) were less sensitive to affect than non-aggressive men (1.43, $SD = 1.30$). As illustrated in Fig. 3, the perceptual distance between the centroids of the friendly and sexually interested distributions is greater for the provocatively dressed target categories than the conservatively dressed target categories. Note as well that the perceptual distances between the solid ellipses (high-risk men) are smaller than the perceptual distances between the dashed ellipses (low-risk men).

Marginal bias. The marginal bias parameters provide estimates of four decisional thresholds corresponding to the points at which the participant divides the perceptual space. For example, among conservatively dressed targets, as the perceptual dimension for affect increases from clearly friendly toward sexual interest, $\beta_{\text{AFF}|CD}$

represents the point at which the participant switches from a friendly to a sexually interested response. Mathematically,

$$\beta_{\mathrm{AFF}|CD} = \frac{\Phi(z(P(R_{SI}|SI.CD)))}{\Phi(z(P(R_{SI}|FR.CD)))} \tag{4}$$

where Φ is the height of the normal density function. All marginal β estimates are computed similarly. Rather than a direct criterion measure, marginal $\beta_{\mathrm{AFF}|CD}$ is a likelihood ratio that corresponds to a ratio of the height of the normal curve for sexual interest at the criterion point over the height of the normal curve for friendliness at the criterion point. The bias parameter β was natural-log-transformed to approximate a normal distribution for later statistical analyses. Given equal presentation probabilities, and under this transformation, $\ln(\beta)$ is equal to 0 when the participant is responding optimally (i.e., is not biased toward either response), becomes increasingly negative as the decisional boundary becomes more lenient (e.g., more biased to respond that target affect is sexual interest), and becomes increasingly positive as the decisional boundary becomes more conservative (e.g., more biased to respond that the target is friendly).

A GLM predicting marginal bias for affect included the clothing style factor and the individual difference scales RMA and SES. A main effect for clothing style, $F(1, 491) = 27.75$, $p < .001$, $\eta_p^2 = .053$ was significant. No other scales or interactions predicted affect bias. Participants employed a more lenient threshold for detecting sexual interest when targets were dressed provocatively (0.40, $SD = 1.33$), rather than conservatively (0.63, $SD = 1.60$). Fig. 3 depicts this shifting decisional criterion by illustrating the decisional boundary for affect with a negative slope.

Conditional MSDA parameters (d' and β) are estimated *within* a feature value, at each level of the second feature dimension, by conditioning on perception of the second feature dimension (Kadlec & Townsend, 1992b). That is, a pair of conditional parameter estimates is obtained for each component; one estimate is conditioned on the response to the component being a "hit", and the second estimate is conditioned on the response to the component being a "miss". Conditional d' and β estimates provide a useful way to test for perceptual independence (as reviewed below); however, they are estimated with far fewer trials than the marginal MSDA parameters, and thus are less stable than marginal estimates. For this reason, they are not used in the current analysis to model directly the underlying perceptual distributions, and rather, are used solely in categorical analyses of perceptual independence. Readers interested in the mathematical derivation, proofs, and equations for estimating conditional d's and βs are referred to Kadlec and Townsend (1992a).

5.3. Categorical analysis of independence and separabilities

As noted above, the primary GRT constructs of perceptual independence and perceptual separability are not available for direct measurement as the distributions represent unobservable, internal perceptual effects. The confusion matrices that form the observed data gleaned from an identification experiment bear little resemblance to the graphically and mathematically rich probability distributions. However, the confusion matrices are theoretically linked to perceptual independence and perceptual separability through observable tests of sampling independence and marginal response invariance. Provided that decisional separability holds, perceptual independence implies sampling independence, and perceptual separability implies marginal response invariance (Ashby & Townsend, 1986). When it is reasonable to assume decisional separability, support for the observable concepts provides some evidence that the unobservable concepts are accurate representations of the individual's perceptual space. See Ashby and Townsend (1986) (see also Kadlec & Townsend, 1992a) for limitations to this logic.

Sampling independence (SI) is the observable micro-level analysis that corresponds to perceptual independence provided decisional separability holds (Ashby & Townsend, 1986). It is supported in stimulus A_iB_j, if and only if, the probability of jointly reporting that both features are present is equal to the marginal probability that feature A is reported (regardless of the level of feature B) multiplied by the marginal probability that feature B was reported (regardless of the level of feature A). Mathematically:

$$P(R_{a_1b_1}|A_iB_j) = \left[P(R_{a_1b_1}|A_iB_j) + P(R_{a_1b_2}|A_iB_j)\right] * \left[P(R_{a_1b_1}|A_iB_j) + P(R_{a_2b_1}|A_iB_j)\right], \tag{5}$$

where $R_{a_ib_j}$ indicates that response a_ib_j was provided. It can be tested by extracting the above probabilities from the subject's confusion matrix, and comparing the result to the expected values with ordinary chi-square tests of independence (Thomas, 2001). So long as decisional separability holds, finding support for sampling independence suggests that perceptual independence also holds (i.e., within a given stimulus, the viewer perceives the features independently). Note that sampling independence is tested for all feature combinations. It is theoretically possible to obtain data that suggest among certain target types, the two features are perceived integrally (i.e., lack perceptual independence), but that for other target types, the features are perceived independently (i.e., possess perceptual independence). More concretely, to test for sampling independence in a participant's perception of sexually interested, provocatively dressed targets, the form would be:

$$P(R_{SI.PD}|SI.PD) = [P(R_{SI.PD}|SI.PD) + P(R_{SI.CD}|SI.PD)] * [P(R_{SI.PD}|SI.PD) + P(R_{FR.PD}|SI.PD)]. \tag{6}$$

Turning attention to macro level, or across stimuli perception, *marginal response invariance* is the observable, nonparametric test that corresponds to perceptual separability provided that decisional separability holds (Ashby & Townsend, 1986). Marginal response invariance holds whenever the probability of correctly identifying one feature does not depend on the level of the second feature. For example, the probability of correctly identifying that a target is sexually interested is the same whether the target woman is dressed provocatively or conservatively. Mathematically, for $i = 1, 2$:

$$P(R_{a_ib_1}|A_iB_1) + P(R_{a_ib_2}|A_iB_1) = P(R_{a_ib_1}|A_iB_2) + P(R_{a_ib_2}|A_iB_2), \tag{7}$$

and computed similarly for $j = 1, 2$:

$$P(R_{a_1b_j}|A_1B_j) + P(R_{a_2b_j}|A_1B_j) = P(R_{a_1b_j}|A_2B_j) + P(R_{a_2b_j}|A_2B_j). \tag{8}$$

Like sampling independence, marginal response invariance can be tested by extracting the necessary probabilities from response behavior. Equality of the two probabilities can be tested via a z-test (Ashby & Townsend, 1986). If the above equality holds, marginal response invariance is supported, and if decisional separability can also be assumed, then the combination provides some support for perceptual separability. For example, to test whether the probability of correctly identifying that a woman is sexually interested depends on clothing style, the form would be:

$$P\ (R_{SI.PD}|SI.PD) + P\ (R_{SI.CD}|SI.PD) = P\ (R_{SI.PD}|SI.CD) + P\ (R_{SI.CD}|SI.CD)\,. \tag{9}$$

Note that for both nonparametric tests, in order to map the observable data to the characteristics of the unobservable perceptual distributions, it is necessary for the decision boundary to be invariant with respect to the x- or y-axis. Typically, this decisional separability is guaranteed by stimulus selection that is unlikely to produce shifting decisional boundaries (such as geometric shape and color). However, with stimuli such as those presented in the current study, it is not clear that decisional separability can be assumed. For example, we might expect that participants' decisional criteria for labeling women's affect sexual interest may be more lenient when they are dressed provocatively rather than conservatively, a prediction that if true, would indicate that decisional separability had been violated. When decisional separability is violated, then the observable probabilities in the sampling independence and marginal response invariance equalities are influenced by both the perceptual effect of interest and by the effect of the shifting decisional boundary. In this case, it is not possible to determine if an observed inequality is due to a failure of the tested higher order construct, a failure of decisional separability, or by some mixture of both. For this reason, in cases where decisional separability cannot be assumed, the approach should be shifted to alternative analytic strategies. The first is to combine the GRT nonparametric tests with multidimensional signal detection analysis parameter estimates to provide direct tests of decisional separability and logical inferences about perceptual independence and perceptual separability (Kadlec & Townsend, 1992a,b). The second is to use a regression approach to predict a continuous form of sampling independence and marginal response invariance with an estimate of decisional separability included as a covariate. Both approaches have analytic advantages and disadvantages and both are described in detail below.

To address this problem of non-correspondence between observable tests and perceptual concepts when decisional separability fails, Kadlec and Townsend (1992a,b) developed a set of logical relationships between the nonparametric GRT tests (sampling independence and marginal response invariance), and the marginal and conditional d' and β estimates. The nonparametric tests and multidimensional signal detection analysis parameter estimates can be combined to produce categorical decisions about the presence versus absence of various characteristics of the underlying perceptual distributions that are not directly observable (see Kadlec and Townsend (1992a) for mathematical proofs and Kadlec and Townsend (1992b) for illustrations). The approach is particularly useful for drawing inferences about the operation of perceptual processes across target categories, as it allows conclusions to be made about the presence or absence of perceptual separability irrespective of whether decisional separability holds or fails. It provides less useful information with respect to perceptual independence. Although in some cases the approach can provide support for perceptual independence, this conclusion continues to rely on the presence of decisional separability. In other cases, the conclusions about perceptual independence are less clear. Finally, marginal MSDA estimates can be combined with marginal response invariance results to test directly for the presence or absence of decisional separability.

The logical conclusions available via a combination of sampling independence, marginal response invariance, and marginal and conditional d' and β estimates often rely on a decision about whether a pair of d' or β estimates are equal (Kadlec & Townsend, 1992a,b). For the current application, the equality of pairs of marginal and conditional d' and β estimates from a single participant is determined by first calculating the variance of each sensitivity estimate via the Gourevitch and Galanter (1967) approximation and the variance of each bias estimate by extrapolating between models of bias variance from Kadlec (1999). Given variance estimates, equalities of pairs of parameter estimates were then tested via a 95% confidence interval approach (Kadlec, 1999).

Decisional separability. Based on the logical combination of GRT tests and MSDA parameter estimates described above, within the *affect dimension* (across levels of clothing style), 102 participants (20.2%) provided identification data that were consistent with a decisionally separable perceptual space. That is, these participants did not change their decisional threshold for indicating that affect was sexual interest as clothing style changed.

Decisional separability within the affect dimension definitively failed for 258 participants (51.2%). When marginal βs were examined, the majority of participants for whom decisional separability failed ($n = 181$, 70.2%) had negative values for the β difference. For most participants, the failure of decisional separability was due to more lenient thresholds for determining sexual interest when clothing style was provocative rather than conservative (a negatively sloped decisional boundary).

Finally, within the affect dimension, there was a subgroup of participants ($n = 107$, 21.2%) for whom no conclusions about decisional separability could be drawn. An additional 37 (7.3%) participants provided data that might be due to a failure of decisional separability, but that might also be explained by unequal marginal variances.

Analysis of individual differences in decisional separability was approached with caution. First, it is unclear whether participants for whom no conclusions about decisional separability could be drawn should be included in the analysis. They may not represent a homogenous set of participants as they are unable to be categorized. Second, the group of individuals for whom decisional separability fails represents two types of decisional inseparability: (a) positively sloped, decisional thresholds, and (b) negatively sloped, decisional thresholds. Thus, the final approach was to utilize three decisional separability categories to represent participants whose perceptual space was (a) decisionally separable, (b) decisionally inseparable with a negative slope, or (c) decisionally inseparable with a positive slope. Participants for whom no conclusions about decisional separability could be drawn were excluded from the analysis. Note that this introduces sampling bias as some groups of participants may be over or underrepresented in this uncategorized group.

To examine the relationship between the continuous individual difference measures and decisional inseparability, a GLM with a decisional separability factor (decisionally separable, positively sloped inseparability, or negatively sloped inseparability) predicting to RMA was conducted. There was a significant effect of decisional separability on RMA, $F(2, 354) = 3.03, p < .05, \eta_p^2 = .017$. Post-hocs revealed that participants with perceptual spaces that were decisionally separable or with negatively sloped decisional inseparability were marginally more likely to endorse rape myths than participants with positively sloped decisional inseparability (Tukey's HSD $< .10$).

A Pearson chi-square was conducted to examine the relationship between the categorical variables of sexual coercion history (SES) and decisional separability within the affect category. Sexual coercion history was not related significantly to decisional thresholds for determining sexual interest in the affect dimension, $\chi^2(2) = 3.56, p = ns$.

Perceptual independence. The logical relationships between marginal bias, marginal sensitivity, and the non-parametric test of sampling independence were used to produce the final conclusions about each individual's perceptual organization within each stimulus distribution. These analyses converged to suggest that perceptual independence was supported for approximately 25%–30% of the participants across the four target categories.

For some participants, sampling independence was supported (suggesting the possibility of perceptual independence), but the marginal sensitivity, marginal bias, or both estimates were unequal. This combination of relationships produces unclear conclusions. Kadlec and Townsend (1992b) have characterized this pattern as suggesting "possible weak support" for perceptual independence, but the inequality in marginal estimates makes a stronger statement unwise. This pattern of results was quite common across perceptual distributions (34.7%–53.8% of participants).

Finally, when sampling independence fails, it suggests that either perceptual independence or decisional separability has failed. Inequality of marginal sensitivity and bias estimates cannot further narrow this choice. However, the direct tests of decisional separability reviewed above can rule out decisional inseparability in some cases. For a given perceptual distribution, if the perceptual space is decisional separable on *both* dimensions, then a failure of sampling independence suggests a failure of perceptual independence. In this data set, this strong statement of failed perceptual independence was only rarely applicable. For only 1.2%–2.6% of participants (depending on the perceptual distribution) was it accurate to state clearly that perceptual independence had failed.

Analyses of the association between perceptual independence conclusions and individual difference variables were not conducted. As was the case with decisional separability, it was deemed necessary to exclude the group of participants for whom no conclusion could be drawn, as this group was likely formed with individuals with heterogeneous perceptual spaces failing either perceptual independence, decisional separability, or both. After this group was excluded, membership in the remaining categories was dramatically uneven, with the vast majority of the participants providing data that supported or weakly supported perceptual independence and less than four percent providing data suggestive of perceptual inseparability. Thus, pursuing a GLM test of individual differences was untenable.

Perceptual separability. The logical relationships between marginal sensitivity, marginal bias, and the Ashby and Townsend (1986) test of marginal response invariance were used to reject or provide support for perceptual separability (Kadlec & Townsend, 1992a). The decision regarding perceptual separability reduces to whether or not the marginal sensitivity parameters are equal. For this reason, the perceptual separability conclusion may apply to one or both features on the dimension. For example, when the marginal sensitivity estimates on the affect dimension are unequal, perceptual separability is rejected for friendliness, sexual interest, or both.

Reviewing the results for the affect dimension only, perceptual separability was supported for sexual interest and friendliness among 363 participants (72.0%) and rejected among 141 participants. To determine the form of the perceptual inseparability among the 141 participants, two techniques were employed. First the differences in the values of the marginal sensitivity estimates were examined. Of the 141 participants for whom perceptual separability failed for the affect features, 101 (71.6%) failed because the marginal sensitivity for affect when clothing was provocative was larger than marginal sensitivity for affect when clothing was conservative. The mean value for this difference was .24 ($SD = .76$).

The alternative technique for investigating perceptual separability is to examine marginal response invariance among participants for whom decisional separability held. When marginal response invariance fails for these participants, the raw probabilities used to compute marginal response invariance can be examined to determine the relative position of the distributions to one another. This approach has the advantage of allowing an examination of perceptual separability for each feature of a dimension (e.g., friendliness and sexual interest) independently, rather than being coupled as is necessary when inferences are tied to marginal sensitivity. However, it has the disadvantage of excluding all participants for whom decisional inseparability fails, which introduces sampling bias into the conclusions. To examine marginal response invariance for friendliness and sexual interest, decisional separability must hold for the affect dimension. However, of the 102 participants (20.2%) with invariant decisional thresholds on the affect dimension, there were no participants for whom marginal response invariance failed. This was true both for the friendly feature as well as the sexual interest feature.

Thus, the association between perceptual separability (or inseparability) and the individual difference variables RMA and SES was examined using only the first (marginal sensitivity) test of perceptual separability. Just as was the case with the decisional separability results, participants for whom perceptual separability failed did so for two distinct perceptual reasons: sensitivity to affect was (a) greater, or (b) reduced when clothing style was provocative rather than conservative. Thus, participants' perceptual space across the affect features was described as (a) perceptually separable, (b) perceptually inseparable with sensitivity greater when clothing style was provocative rather than conservative, and (c) perceptually inseparable with sensitivity reduced when clothing style was provocative rather than conservative. A GLM with this perceptual separability factor predicting to the continuous individual difference variable was used to determine the relationship between RMA and perceptual separability on the affect dimension. A Person chi-square was used to test for a relationship between perceptual separability and the dichotomous variable SES. Contrary to predictions, perceptual separability was not significantly related to RMA, $F(2, 494) = 0.55$, $p = ns$ or SES, $\chi^2(2) = 0.74$, $p = ns$.

Conclusion. In this sample, decisional separability (or inseparability) was inconclusive for nearly 30% of the participants. Given the uncertainty about decisional space, it was necessary to exclude these participants from later analyses, thus dramatically decreasing the power to detect the covariation with individual difference variables such as sexual coercion history. Furthermore, approximately half of the participants provided identification data that suggested that their decisional boundary for detecting sexual interest shifted as clothing style changed. Although this shift was predictable and significant, it served to complicate the picture methodologically. Strong inferences about perceptual independence are mathematically dependent on the demonstration of decisional separability (Ashby & Townsend, 1986), and strong support for decisional separability was found for only a minority of the sample. It was a rare exception among participants that a clear failure of perceptual independence was uncovered. In fact, it was so rare that follow-up analyses to explore the nature of these failures and possible association with risk for sexual violence were not appropriate given the limited sample size.

Thus, in some ways, the promise of GRT as a model that would provide a clear mapping of illusory correlations between men's perception of women's diagnostic and non-diagnostic interest cues was not immediately realized in this implementation. The emphasis on placing participants into discrete categories of perceptual processing leads to an unnecessary loss of information. It necessitates the exclusion of a large proportion of participants, and even those participants who are retained are placed within categories that are themselves impoverished in form. For example, we might imagine that perceptual independence, when violated, could range from a minimal covariance between the dimensions to a strong covariance. We might also predict that the strength of this covariance is systematically related to individual difference variables associated with risk for sexual coercion. The categorical approach would not allow us to test such a prediction as the resulting data indicate only that perceptual independence is violated or upheld, rather than providing a continuous estimate of the degree of covariance between the dimensions. Treating perceptual independence and perceptual separability as continuous measures may provide one solution to the difficulty encountered above.

However, before transitioning to this alternative approach to GRT analysis, it is important to be clear that the categorical approach is the better-established approach. Therefore, it should be the *preferred* approach whenever investigators are working with populations or experimental paradigms in which decisional separability is common, or when few participants are excluded due to inconclusive evidence for or against perceptual independence. It should not be assumed that all translational scientists working within socially or clinically relevant topic areas will necessarily need to bypass a categorical GRT approach. For example, experimental manipulations of basic perceptual processing among participants with schizophrenia may utilize stimuli for which decisional separability is quite common in both the control and schizophrenia samples, and therefore, may not require use of an alternative approach. With that caveat, when statistical power drops dramatically due to excluded participants or when decisional inseparability is either common or of interest, then the following may prove useful.

5.4. *Regression approach to perceptual independence and perceptual separability*

The test for sampling independence converts the difference between the observed and expected probabilities into a chi-square value that is compared to a table value for significance to determine whether sampling independence has failed or is supported. If the step to determine significance is abandoned, we are left with a continuous, chi-square-distributed variable describing sampling independence as it ranges from clear independence to extreme dependence. The continuous nature of this variable may be useful when investigators are interested in questions of degree or covariance with continuous individual difference variables. In addition, by allowing retention of all participants in the subsequent analyses, it preserves statistical power. However, in order for the variable to be useful in a regression framework, it is necessary that it approximate a Gaussian form. In this data set, a normal distribution was approximated by taking the third root of the chi-square-distributed sampling independence estimate.

Of course, sampling independence cannot be used to provide direct evidence for perceptual independence as it continues to be susceptible to contamination by failures of decisional separability. In a regression approach, this problem can be addressed to some extent by including a continuous measure of decisional separability as a covariate, thus controlling for the influence of decisional separability on sampling independence estimates. A candidate for a continuous approximation of decisional separability is the difference between the log-transformed marginal β estimates. For example, in this investigation, the difference in marginal β estimates for affect across the two levels of clothing style would be computed:

$$\beta_{\mathrm{DIFF.AFF}} = \ln\left(\beta_{\mathrm{AFF}|PD}\right) - \ln\left(\beta_{\mathrm{AFF}|CD}\right). \tag{10}$$

When $\beta_{\mathrm{DIFF.AFF}}$ is equal to zero, this suggests that decisional separability holds and thus would not influence the sampling independence estimate; when the estimate is negative the decisional boundary is negatively sloped (i.e., the threshold for responding that affect is sexual interest is more lenient when clothing style is provocative than it is when clothing is conservative); and when the estimate is positive the decisional boundary is positive sloped (i.e., the threshold for responding that affect is sexual interest is more conservative when clothing style is provocative than when clothing style is conservative). Higher absolute values indicate a greater degree of decisional inseparability. Note that the difference in marginal β estimates is a continuous *approximation* of decisional separability. All β estimates are influenced by participant sensitivity (Macmillan & Creelman, 2004) and are therefore somewhat contaminated themselves. Nonetheless, the measure may provide a useful stand-in for degree of decisional inseparability for investigators who wish to use it as a continuous covariate in a regression analysis, thus allowing sampling independence to approximate perceptual independence.

The test of marginal response invariance compares two probabilities via a z-score that is compared to a table value to reduce the measure into a dichotomous variable indicating failure or support for decisional separability. Again, abandoning the dichotomous, significance test provides a continuous measure of marginal response invariance that is normally distributed in this data set. Just as with sampling independence, this continuous measure can be used in a regression approach as an estimate of perceptual separability provided a continuous measure of decisional separability, such as β_{DIFF}, is included as a covariate.

Perceptual independence. Keeping in mind contamination due to decisional inseparability, the continuous sampling independence variables may serve as indicators of perceptual independence. Thus, a GLM predicting continuous estimates of sampling independence was conducted. The model included the experimental, within-person factors of affect (sexually interested versus friendly) and clothing style (provocative versus conservative), as well as the individual difference variables SES and RMA as between-persons factors. Finally, two β_{DIFF} covariates were included to control for decisional inseparability on the affect dimension and the clothing style dimension.

The estimate of decisional separability on the affect dimension explained a small proportion of the variance in sampling independence estimates, $F(1, 491) = 6.10$, $p < .05$, $\eta_p^2 = .012$. However, the estimate of decisional separability on the clothing style dimension did not significantly influence sampling independence, $F(1, 491) = 0.26$, $p = ns$. After the effect of decisional separability was accounted for, there continued to be significant main effects for both experimental factors. Participants perceived the clothing style and affect dimensions to be more dependent in the sexually interested distributions (1.066, $SD = 0.24$) than in the friendly distributions (1.032, $SD = 0.27$), $F(1, 491) = 14.28$, $p < .001$, $\eta_p^2 = .028$. Similarly, they perceived the two dimensions to be more dependent in the provocative clothing style distributions (1.096, $SD = 0.24$) than in the conservative clothing style distributions (1.00, $SD = 0.27$), $F(1, 491) = 73.05$, $p < .001$, $\eta_p^2 = .130$. The direction of the covariance was determined via a comparison of observed and expected confusion matrix values as described in the earlier section on categorical analysis of perceptual independence. Contrary to prediction, in the sexually interested, provocatively dressed distribution, the illusory correlation was negative. As clothing was perceived as increasingly provocative, affect increasingly was perceived to be friendly. In the remaining three distributions, the perceived association was positive as predicted. As perception of clothing became increasingly provocative, the perception of affect increased toward sexual interest.

With respect to the individual difference variables, there was a main effect of SES, $F(1, 491) = 7.00$, $p < .05$, $\eta_p^2 = .014$. Participants with a history of sexual coercion (1.075, $SD = 0.40$) perceived the dimensions to be more correlated than nonaggressive participants (1.023, $SD = 0.20$). Finally, the main effect for SES was modified by a three-way interaction with the affect and clothing style factors, $F(1, 491) = 5.82$, $p < .05$, $\eta_p^2 = .012$. Follow-up analyses revealed that SES was related to sampling independence only in the inconsistent distributions (i.e., sexually interested, conservatively dressed; and friendly, provocatively dressed; Tukey's HSD, $ps < .05$). In these distributions, the association was positive as predicted. However, the failure to find an association between SES and increased feature integrality in the consistent distributions (i.e., sexually interested, provocatively dressed; and friendly, conservatively dressed) was not predicted. Finally, although there was no main effect of RMA, an interaction between RMA and affect was significant, $F(1, 491) = 6.40$, $p < .05$, $\eta_p^2 = .013$. The endorsement of rape myths was associated with greater perceptual dependency in the friendly distributions than in the sexually interested distributions.

Perceptual separability. The relationship between perceptual inseparability and individual differences in risk for sexual coercion was re-examined via the same regression-based approach used to examine perceptual independence above. The statistical model predicted marginal response invariance values for the affect dimension only and included an estimate of marginal response invariance for perception of friendly targets across the two levels of clothing style and an estimate of marginal response invariance for perception of sexually interested targets across the levels of clothing style. A within-subjects experimental factor for affect summarized these two estimates. RMA and SES were added as continuous and categorical between-subjects factors (respectively). Finally, $\beta_{\text{DIFF|AFF}}$ was included as a covariate to control for the effect of decisional separability (affect dimension) on the marginal response invariance estimates.

The decisional separability covariate explained a significant proportion of the variance in marginal response invariance estimates, $F(1, 492) = 102.64$, $p < .001$, $\eta_p^2 = .173$. However, after the effect of decisional separability was accounted for, experimental and individual difference variables continued to predict marginal response invariance. The experimental factor for affect was significant, $F(1, 492) = 141.27$, $p < .001$, $\eta_p^2 = .223$; values for marginal response invariance across the clothing levels for friendly (1.05, $SD = 2.6$) and sexually interested (1.82; $SD = 2.2$) were both positive, suggesting that the provocatively dressed distributions were shifted to the right on the affect dimension relative to the conservatively dressed distributions, on average. The observation that the value for sexually interested marginal response invariance was higher than the value for friendly marginal response invariance, in combination with the significant main effect for affect, suggests that this relative shift was greater in the sexually interested targets than in the friendly targets. The location of the dashed ellipses in Fig. 3 provides an approximate illustration of this result. Both provocatively dressed distributions are shifted to the right of the conservatively dressed distributions on the x-axis, with a greater shift for the sexually interested target category. As predicted, history of sexual coercion (SES), $F(1, 492) = 5.77$, $p < .05$, $\eta_p^2 = .012$, and risk for sexual coercion (RMA), $F(1, 492) = 5.39$, $p < .05$, $\eta_p^2 = .011$, were both significantly associated with perceptual separability. Compared to non-aggressive men (1.19, $SD = 2.02$), men with a history of sexual coercion (1.68, $SD = 4.08$) perceived provocatively dressed targets to be more sexually interested than conservatively dressed targets. Similarly, men who more strongly endorsed rape myths perceived an increasing degree of sexual interest in provocatively dressed targets relative to conservatively dressed targets ($r = .10$).

6. Conclusion

By taking a regression-based approach to GRT, in which the influence of decisional inseparability was controlled statistically, it was possible to examine and uncover clinically relevant individual differences in perceptual processing of women's interest cues. The categorical approach had precluded examination of individual differences in perceptual independence (due to a large number of excluded cases) and had found no effect of risk status on perceptual separability. Yet when statistical power was protected by taking steps to retain the entire sample and by utilizing continuous rather than dichotomous representations of perceptual independence and perceptual separability, the analyses revealed small, but reliable, individual differences. Risk status was associated with an increased tendency to perceive an illusory correlation within some distributions, and was also associated with increased perception of sexual interest in provocatively dressed distributions. Although the categorical approach is to be preferred when possible, a regression-based approach provides one solution to investigators working with stimuli likely to produce violations of decisional separability.

7. Discussion

Perhaps it is best to start by noting that a conventional measure of percentage accuracy provided limited insight into the perceptual organization of high-risk men. Although accuracy rates for identifying women's affect were significantly lower among men with a history of sexual coercion, the percentage difference does not clarify the source of these errors. Thus, the application of computational models of perception to the exploration of clinically relevant individual differences provided insight that would not have been available otherwise.

The multidimensional signal detection analysis parameters for marginal bias and marginal sensitivity to affect were remarkably consistent with previous findings using Choice Model (Luce, 1959, 1963) sensitivity and bias estimates (Farris et al., 2006). As in Farris et al. (2006), participants were better able to discriminate sexually interested targets from friendly targets when the women were dressed provocatively rather than conservatively. Provocative clothing may signal observers to pay closer attention to diagnostic cues of sexual interest, and thus, may improve (rather than distract from) accurate decoding of sexual interest. Nonetheless, difficulty discriminating between interest cues was related to theoretically relevant individual differences. Men who were less sensitive to women's affect were also more likely to have sexual coercion histories and to endorse high-risk attitudes such as the belief that rape is justifiable in some situations and that women deserve to be assaulted. Unfortunately, one common rape myth is that a woman who has "led on" her partner deserves to be raped, and perceptual insensitivity may increase the probability that high-risk men will perceive a woman's behavior as unpredictable.

Turning to marginal bias, these estimates were also significantly influenced by women's clothing styles. Although participants tended to err on the side of responding that women's intent was platonic rather than sexual, their thresholds dropped significantly when clothing was provocative. That is, compared to perception of conservatively dressed women, men required less compelling evidence to believe that a woman who was wearing provocative clothing might be interested in a sexual encounter. As with many changes in decisional thresholds, this increasingly lenient threshold will ensure that more sexually interested women are detected as potential partners; however, the dangerous trade off will be that an increasing number of friendly women will be misperceived simply because they are wearing clothing that is provocative. Examination of decisional separability among participants for the affect dimension as clothing style varied produced similar conclusions to the marginal bias estimates. This should be expected as both marginal bias and decisional separability tap the same decisional process. Risk status was not associated with more lenient thresholds for detecting sexual interest. High-risk men were no more or less biased to detect sexual interest than were low-risk men. Although this difference was predicted tentatively, the failure to find the effect is not surprising given the inconsistent evidence in previous research. Although, it may seem intuitively appealing to assume that sexually coercive men employ relatively lenient thresholds for detecting sexual interest in women's nonverbal cues, increasing evidence seems to suggest that incorrect identification is more often due to perceptual insensitivity to subtle distinctions between friendly and sexual interest cues rather than differences in decisional bias (Farris et al., 2006).

Using a regression-based approach to parse decisional separability from perceptual processes statistically, perceptual dependencies were found to be associated with experimental factors and individual difference measures. As predicted, perceptual dependencies between clothing style and facial affect were more common among men with a history of sexual violence. The positive association between the dimensions created a perceptual space that was more likely to produce errors in the predicted direction (provocatively dressed women mistakenly categorized as sexually interested and conservatively dressed women mistakenly categorized as friendly). It is interesting to note that for sexually coercive men this positive illusory correlation was most common in the target categories that provided contradictory diagnostic and non-diagnostic information (i.e., conservatively dressed, sexually interested women and provocatively dressed, friendly women). It may be that men with sexual coercion histories are more likely to rely on one feature dimension to perceptually process the second feature dimension when they do not perceive the woman's signals as cohesive.

The categorical approach to measurement of perceptual separability revealed that perceptual separability was more likely to be supported than rejected. That is, across target categories, perception of women's sexual interest was more likely to be invariant across the two categories of clothing style. However, for those participants who did produce identification data suggestive of perceptual inseparability, the failure was most often in the predicted direction (i.e., among sexually interested targets, perception of provocative dress was associated with perceiving intent as more sexual). Unexpectedly, these failures of perceptual separability for some participants were not significantly associated with either sexual coercion history or risk for sexual coercion. Although this was the case when perceptual separability was examined using the traditional categorical approach, the regression-based approach (with its associated increase in power) revealed that high risk men were more likely to perceive the target categories as perceptually inseparable. That is, targets from the provocatively dressed categories were perceived as more sexually interested than targets from the conservatively dressed categories. This is despite the fact that the images were carefully selected to represent the same degree of interest. Thus, the predicted association between high-risk status and an illusory correlation between clothing style and sexual intent was supported when assessed via regression-based GRT tests of perceptual dependence and perceptual inseparability.

It must be noted that when individual differences in perceptual and decisional processing were linked to the risk for and history of sexual coercion, the effect sizes were quite small in magnitude. However, small effects are not necessarily clinically insignificant. In multidetermined phenomenon such as sexual aggression, reliable but small effects may be crucial in understanding the convergence of perceptual, situational, attitudinal, and personality factors that ultimately result in sexually coercive behavior (Bernat, Calhoun, & Stolp, 1998). In addition, multiple paths may lead to sexually aggressive behavior; perceptual differences may be implicated in some but not all paths, thus constraining the size of the effect in averaged data. For example, acute alcohol intoxication is associated with increased estimates of women's sexual interest (Abbey, Zawacki, & McAuslan, 2000). Thus, it will be important for future work to examine the magnitude of risk-linked processing of women under specific situational conditions such as acute alcohol intoxication or periods of sexual arousal.

It is our hope that the current investigation serves two purposes. First, it provides crucial information about the underlying perceptual source of errors in sexual perception and the degree of risk conferred by differences in perceptual processing of women's diagnostic and non-diagnostic sexual interest cues. Second, it provides a concrete example for translational scientists interested in adapting GRT in order to be mathematically explicit about individual differences in social perception. Although cognitive science has already contributed significantly to clinical psychology and assessment (Busemeyer & Stout, 2002; (McFall & Treat, 1999; Neufeld, 2007; Treat et al., 2001)), the promise of clinical-cognitive science has only begun to be tapped.

Acknowledgments

We thank Richard M. McFall and James T. Townsend for guidance in study design and methods. This research was supported by NRSA funding to the first author from the National Institute on Alcoholism and Alcohol Abuse and dissertation grants from the American Psychological Association, Indiana University, and the Society for a Science of Clinical Psychology.

References

Abbey, A. (1987). Misperceptions of friendly behavior as sexual interest: A survey of naturally occurring incidents. *Psychology of Women Quarterly*, *11*, 173–194.

Abbey, A., & McAusland, P. (2004). A longitudinal examination of male college students' perception of sexual assault. *Journal of Consulting and Clinical Psychology*, *72*, 747–756.

Abbey, A., McAuslan, P., & Ross, L. T. (1998). Sexual assault perpetration by college men: The role of alcohol, misperception of sexual intent, and sexual beliefs and experiences. *Journal of Social and Clinical Psychology*, *17*, 167–195.

Abbey, A., Zawacki, T., & McAuslan, P. (2000). Alcohol's effect on sexual perception. *Journal of Studies on Alcohol*, *61*, 688–697.

Ashby, F. G., & Lee, W. W. (1991). Predicting similarity and categorization from identification. *Journal of Experimental Psychology: General*, *120*, 150–172.

Ashby, F. G., & Townsend, J. T. (1986). Varieties of perceptual independence. *Psychological Review*, *93*, 154–179.

Bernat, J. A., Calhoun, K. S., & Stolp, S. (1998). Sexually aggressive men's responses to date rape analogue: Alcohol as a disinhibiting cue. *The Journal of Sex Research*, *35*, 341–348.

Burt, M. R. (1980). Cultural myths and supports for rape. *Journal of Personality and Social Psychology*, *38*(2), 217–230.

Busemeyer, J. R., & Stout, J. C. (2002). A contribution of cognitive decision models to clinical assessment: Decomposing performance on the Bechara gambling task. *Psychological Assessment*, *14*, 253–262.

Farris, C., Treat, T. A., Viken, R. J., & McFall, R. M. (2008a). Perceptual mechanisms that characterize gender differences in decoding women's sexual intent. *Psychological Science*, *19*, 348–354.

Farris, C., Treat, T. A., Viken, R. J., & McFall, R. M. (2008b). Sexual coercion and the misperception of sexual intent. *Clinical Psychology Review*, *28*, 48–66.

Farris, C., Viken, R., Treat, T., & McFall, R. (2006). Heterosocial perceptual organization: Application of the choice model to sexual coercion. *Psychological Science*, *17*, 869–875.

Gourevitch, V., & Galanter, E. (1967). A significance test for one parameter isosensitivity functions. *Psychometrika*, *32*, 25–33.

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics*. New York: Wiley.

Haselton, M. G. (2003). The sexual overperception bias: Evidence of a systematic bias in men from survey of naturally occurring events. *Journal of Research in Personality*, *37*, 34–47.

Haworth-Hoeppner, S. (1998). What's gender got to do with it: Perceptions of sexual coercion in a university community. *Sex Roles*, *38*, 757–779.

Hersh, K., & Gray-Little, B. (1998). Psychopathic traits and attitudes associated with self-reported sexual aggression in college men. *Journal of Interpersonal Violence*, *13*, 456–471.

Kadlec, H. (1999). Statistical properties of d' and β estimates of signal detection theory. *Psychological Methods*, *4*, 22–43.

Kadlec, H., & Townsend, J. T. (1992a). Implications of marginal and conditional detection parameters for the separabilities and independence of perceptual dimensions. *Journal of Mathematical Psychology*, *36*, 325–374.

Kadlec, H., & Townsend, J. T. (1992b). Signal detection analyses of dimensional interactions. In *Multidimensional models of perception and cognition* (pp. 181–231). Hillsdale, NJ: Lawrence Erlbaum.

Koss, M. P., & Dinero, T. E. (1988). Predictors of sexual aggression among a national sample of male college students. *Annals of the New York Academy of Sciences*, *528*, 133–147.

Koss, M. P., Gidycz, C. A., & Wisniewski, N. (1987). The scope of rape: Incidence and prevalence of sexual aggression and victimization in a national sample of higher education students. *Journal of Consulting and Clinical Psychology*, *55*, 162–172.

Luce, R. D. (1959). *Individual choice behavior*. New York: Wiley.

Luce, R. D. (1963). Detection and recognition. In R. D. Luce, R. R. Bush, & E. Galanter (Eds.), *Handbook of mathematical psychology*: *Vol. 1* (pp. 103–189). New York: Wiley.

Macmillan, N. A., & Creelman, C. D. (2004). *Detection theory: A user's guide*. New York: Cambridge University Press.

McFall, R. M., & Treat, T. A. (1999). Quantifying the information value of clinical assessments with Signal Detection Theory. *Annual Review of Psychology*, *50*, 215–241.

Muehlenhard, C. L., & Linton, M. A. (1987). Date rape and sexual aggression in dating situations: Incidence and risk factors. *Journal of Counseling Psychology*, *34*, 186–196.

Neufeld, R. W. J. (2007). *Advances in clinical cognitive science: Formal modeling of processes and symptoms*. Washington, DC: American Psychological Association.

Perper, T., & Weis, D. L. (1987). Proceptive and rejective strategies of US and Canadian college women. *The Journal of Sex Research*, *23*, 455–480.

Thomas, R. D. (2001). Characterizing perceptual interactions in face identification using multidimensional signal detection theory. In M. J. Wenger, & J. T. Townsend (Eds.), *Computational, geometric, and process perspectives on facial cognition: Contexts and challenges* (pp. 193–227). Mahwah, NJ: Lawrence Erlbaum.

Tomarken, A. J., Sutton, S. K., & Mineka, S. (1995). Fear-relevant illusory correlations: What types of associations promote judgmental bias? *Journal of Abnormal Psychology*, *104*, 312–326.

Treat, T. A., McFall, R. M., Viken, R. J., & Krushke, J. K. (2001). Using cognitive science methods to assess the role of social information processing in sexually coercive behavior. *Psychological Assessment*, *13*, 549–565.

Treat, T. A., McFall, R. M., Viken, R. J., Nosofsky, R. M., MacKay, D. B., & Krushke, J. K. (2002). Assessing clinically relevant perceptual organization with multidimensional scaling techniques. *Psychological Assessment*, *14*, 239–252.

Viken, R. J., Treat, T. A., Bloom, S., & McFall, R. M. (2005). Covariation bias and its relationship to eating disorder symptoms. *International Journal of Eating Disorders*, *38*, 65–72.

Yechiam, E., Busemeyer, J. R., Stout, J. C., & Bechara, A. (2005). Using cognitive models to map relations between neuropsychological disorders and human decision-making deficits. *Psychological Science*, *16*, 973–978.