Individual Differences and Cross-Situational Consistency of Dyadic Social Behavior

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Individual differences in behavior have interested psychologists for decades (Hall, 1951; Hebb & Thompson, 1954; Tryon, 1934; Yerkes, 1939) and remain an important theoretical problem (Gosling, 2001; Ross & Nisbett, 1991). Hebb and Thompson (1954) lamented that social psychology runs the risk of being "dangerously myopic if it restricts itself to the human literature" (p. 532) and showed how animal studies broaden theoretical models of human behavior. Hall (1951), working within evolutionary theory, called for a study of individual differences among organisms as an initial step toward determining their origin and adaptive significance. In a comprehensive review of the animal personality literature, Gosling (2001) outlined a research agenda calling for studies of nonhuman animals to elucidate basic problems in personality psychology, such as individual differences and behavioral consistency. He also identified methodological issues that have yet to be addressed adequately. Gosling advocated a position similar to that taken by Yerkes (1939), who, in his 1938 presidential address to the American Society of Naturalists, stated the following:

I am assuming that personality is the correct and adequate term for what is now known concerning the integrated behavior of the chimpanzee. Indeed, in my present thinking there is no question about the reality of chimpanzee mind, individuality, and personality. (p. 97)

These ideas support the view that personality should be studied across species in an attempt to discover those processes that are invariant and those that vary.

The present research offers a new conceptualization of individual differences and cross-situational consistency of behavior proposed on the belief that personality is a phenomenon typically embedded in a social context (Malloy & Kenny, 1986), particularly the dyadic context. This premise is not new. Nissen (1951), discussing social behavior in primates, emphasized that "behavior is an interaction" (p. 424), and even in studies of olfaction or vision, the researcher must consider the sensory process within the context of interacting organisms. Similarly, the influential cognitive affective processing system (CAPS) theory developed by Mischel and Shoda (1995, 1999) places human personality processes within the social interaction context. A general conclusion from the work on animal and human personality is that the social context is a necessary condition for the expression of a broad range of behavior in organisms, including individual differences. In the social context, multiple forms of individual differences may be defined that, in turn, lead to new insights into the meaning of the cross-situational consistency of behavior. This theoretical conceptualization is addressed empirically in a study of the dyadic social

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We will use the terms "human" and "animal" to represent human and nonhuman animals, respectively, for linguistic ease.
behavior of mice. The designs and analyses used offer solutions to most of the methodological issues raised by Gosling (2001).

Individual Differences: The Classical View

Both humans (Loehlin, 1989, 1992) and animals (Suomi, 1991) show individual differences in traits and behavior rooted in genetic variation that affect adaptation to the environment (Hall, 1951). Among humans, as genetic similarity between people increases, there is increasing similarity of personality traits (Loehlin, 1992). Monozygotic twins, for example, show more similarity on the Big Five personality factors than do dizygotic twins, and the genetic basis of personality has become an increasingly important focus of research.

Individual differences are also determined by environmental effects that, in some cases, can have a greater impact than genetic effects (Griffith, Owens, & Burke, 1999). For example, the mane of the African lion is a visible physical trait affected by ambient temperature and the male’s overall physical condition that affects mate choice and reproductive success (West & Packer, 2002). Capitanio (1984), studying rhesus macaques, demonstrated that early developmental experience with a “tolerant” animalequivalent (a dog) led to more active and more typical patterns of social interaction compared with animals exposed only to an inanimate animal-like hobbyhorse.

This classical perspective on individual differences assumes that genetic and environmental variables, alone or in combination, cause individual differences in behaviors that are consistent across social interactions with different partners. Malloy and Kenny (1986) called this an actor effect. Research has documented that these classical individual differences affect a broad range of behaviors in a broad range of species, including mice (e.g., Aldhous, 1989; Cattell & Korth, 1973; Gosling, 2001; Hebb & Thompson, 1954; Hilakivi-Clarke & Lister, 1992; Negrao & Schmidek, 1987; Pinto & Schmidek, 1994; Terranova, Laviola, & Alleva, 1993; Tryon, 1934; West & Packer, 2002).

Individual Differences in the Dyadic Context

Early research on individual differences and the cross-situational consistency of behavior among humans tended to focus on overt behavior in the social context (Hartshorne & May, 1928; Newcomb, 1929). However, following rather disappointing efforts to show high levels of cross-situational consistency in behavior, coupled with theoretical critiques of the dispositional approach (Mischel, 1968), personality psychology has tended to rely more heavily on self-reports (Ross & Nisbett, 1991). Research with animals, however, has remained focused on overt actions because self-reports and verbal measures are impossible.

Sometimes the impact of individual differences on behavior is studied in an asocial context; however, many species are studied in the dyadic context. For example, the dyadic interaction paradigm, in which members of a species interact in pairs, has been used in studies of mice (Aldhous, 1989; Hilakivi-Clarke & Lister, 1992; Jones & Nowell, 1974), rhesus monkeys (Capitanio, 1984), fish (Dunlap, 2002), and humans (Kenny, Mohr, & Levesque, 2001). Consequently, the theoretical ideas developed and tested in this study are relevant to personality research across a broad range of species and have the potential to elucidate general principles regarding individual differences and behavioral consistency in dyadic interaction.

In the dyadic context, the concept of individual differences may be extended beyond the classical view. This extension is theoretically important because it acknowledges that behavior in a dyad is reciprocal rather than unidirectional (Duncan, Kanki, Mokros, & Fiske, 1984; Kenny, 1994; Malloy & Albright, 1990; Nissen, 1951). Additionally, sources of variation in behavior may be considered that are not relevant when studying isolated humans or animals, and these sources permit a theoretical refinement of the concept of individual differences. A common empirical approach in personality psychology is to measure individual differences in behavior and to assess the consistency of that behavior across situations or social interaction partners. However, researchers often neglect individual differences among organisms in the behavior that they elicit from social partners. Such stimulus effects on perception and action are a central feature of ecological theory (Gibson, 1966; McArthur & Baron, 1983). People, like objects, have objective properties and features termed affordances that may be detected by a social partner attuned to them, because detection of others' affordances has implications for interaction with them. Mignon and Mollaret (2002) applied ecological theory in a study of trait perception and found that judges differentiated targets on the basis of responses that they elicited from others, and the authors concluded their work by calling for the application of the social relations model (SRM) to study individual differences in personality trait affordances.

In a related theoretical analysis, Buss (1987) introduced the concept of evocation, defined as “the actions, strategies, reputations, and coercions that are consistently and predictably elicited by individuals, or more precisely by enduring features of those individuals” (p. 1216). In a study of children, their activity levels were associated with their parents’ hostility toward them and frustration with them a year later. Highly active children also evoked more struggles for power and control with parents (Buss, 1981), although there was evidence of unique responses occurring within specific parent–child dyads with different gender compositions. In a study of social interaction of young children, Jacklin and Maccoby (1978) found that if a girl’s interaction partner was a boy, she responded with more passive behavior and social withdrawal. Kenny and Malloy (1988) showed that there are individual differences in the cognitive, affective, and behavioral responses that people elicit from others and termed this a partner effect. In a reanalysis of the Duncan and Fiske (1977) study of face-to-face dyadic interactions, Kenny and Malloy (1988) observed individual differences among partners in the elicitation of gazing, verbal behavior, smiling, and gesturing time. Duncan et al. (1984) warned that failure to consider the elicitation of behavior from others leads to a conceptual error termed pseudounilaterality. It is interesting to note that individual differences in behavior elicited from social partners have received more attention among humans (e.g., Buss, 1987; Kenny & Malloy, 1988; Kenny et al., 2001; Mignon & Mollaret, 2002) than among nonhuman animals (for exceptions, see Capitanio, 1984; Dunlap, 2002).

In addition to the actor and partner effects, humans and animals may respond uniquely to a specific social partner in a manner that deviates from the average response to social partners in general and from the average response generally elicited from social partners. That is, unique behavioral responses may occur in spe-
specific dyads. Aggression among boys occurs uniquely in specific dyads and results from biased interpretation of the intent of a specific other’s verbalizations and social gestures (Hubbard, Dodge, Cillessen, Coie, & Schwartz, 2001). A male mouse will attempt copulation with a fertile, but not an infertile, female (Hayashi & Kimura, 1974). A husband and wife may respond in an agreeable manner with their coworkers who respond similarly to them. Yet, at home their dyadic relationship is characterized by disagreeable and negative responses unique to their relationship. These examples of uniqueness in responding to a specific other are individual differences at the level of the dyad, rather than at the level of the individuals within it, and are termed relationship effects (Malloy & Kenny, 1986).

Thus, in the dyadic context, the theoretical meaning of individual differences can be extended and refined at both the individual and dyadic levels. Although evidence for cross-situational consistency of individual differences has been considered weak (Mischel, 1968), this more fined-grained analysis has the capacity to (a) determine the relative impact of the different forms of individual differences and (b) assess their longitudinal, cross-situational consistency. Past evidence that behavior is more inconsistent than consistent across situations may be due to the failure to disentangle this Gordian knot of individual differences.

Individual Differences: Generalized and Dyadic

In research with humans, some attention has been directed to generalized and dyadic individual differences, particularly in the CAPS model of Mischel and Shoda (1995, 1998). In their approach, the behavior of an individual was measured across a set of social interaction partners at multiple occasions. For example, the behavior of a person following criticism from a teacher, a reprimand by one’s mother, rejection by a friend, and scolding from one’s father would permit study of the “local predictability” (Wright & Mischel, 1987) of responses and the intra-individual consistency of behavior (Shoda, Mischel, & Wright, 1994). If responses are measured at multiple occasions when a person interacts with the same set of partners, one may compute an intraindividual correlation coefficient that quantifies the “behavioral signature” of the person. If the correlation is zero, then the person does not behave consistently with specific social partners at multiple occasions, whereas a correlation of one would indicate perfect consistency in different dyads. However, this approach does not fully consider the different forms of individual differences. One should consider the consistency of behavior emitted and elicited, as well as the consistency of unique responses to specific others. Although the CAPS model considers some facets of individual differences in dyadic interaction, other facets are ignored. Unique research designs and statistical modeling are necessary to study the multiple forms of individual differences that we have delineated and their cross-situational consistency.

Estimation of Individual Differences in Dyadic Behavior

The SRM (Kenny, 1994), an integrative methodological approach that can be applied to the study of individual differences (Malloy & Kenny, 1986), has been used in studies of different species (e.g., Capitano, 1984; Dunlap, 2002; Miller & Malloy, 2003). The interaction of two animals (i and j) permits assessment of i’s response to j and of j’s response to i. Sometimes the behavior of only one animal is analyzed after exposure to one or more stimulus animals (Aldous, 1989), or the scores of dyad members are averaged, which makes the dyad the unit of analysis (Hilakivi-Clarke & Lister, 1992; Terranova et al., 1993), or the nonindependence of dyadic scores is ignored (Smith, Hurst, & Barnard, 1994). None of these options are optimal methodologically. Analysis of data from a single dyadic interaction also has serious limitations because the distinction between the generalized and dyadic individual differences is blurred (Malloy & Kenny, 1986) because insufficient data are available to estimate all of them (Malloy & Albright, 2001).

Research on individual and dyadic individual differences requires a multiple interaction design in which persons or animals interact with multiple partners. Such a design permits estimation of the actor, partner, and relationship variance components (Malloy & Kenny, 1986). In this study, a round-robin design (see Table 1) was used, and the reciprocal responses of both animals in a dyad were measured at two occasions (Time 1 and Time 2). Embedded within the round-robin matrix are elements representing the interactions of same and opposite sex animals. Consider i’s response to j on dimension X yielding $X_{ij}$. This score is represented by the SRM as

$$X_{ij} = \mu + \alpha_i + \beta_j + \gamma_{ij} + \epsilon,$$

where $\alpha_i$ is the consistency of i’s behavior across multiple dyadic interactions (actor effect), $\beta_j$ is the consistency of j’s behavior on the behavior elicited from other animals in multiple dyads (partner effect), and $\gamma_{ij}$ is i’s unique response to j after controlling for $\alpha_i$ and $\beta_j$. Terms $\mu$ and $\epsilon$ are the grand mean and random error, respectively. Terms of the model are assumed to be normally distributed random variables. Likewise, the reciprocal response of j to i is represented by

$$X_{ji} = \mu + \alpha_j + \beta_i + \gamma_{ji} + \epsilon.$$

The variances of $\alpha_i$, $\beta_j$, and $\gamma$ are computed within round-robins and pooled across groups, yielding variance components that quantify the consistency of behavior emitted generally, elicited generally, and made uniquely to specific social partners. The null hypothesis tested is that a variance component equals zero. Round-robin, or

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td><strong>Round-Robin Design for 4 Males (M) and 4 Females (F)</strong></td>
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<table>
<thead>
<tr>
<th>Actor</th>
<th>M 1</th>
<th>M 2</th>
<th>M 3</th>
<th>M 4</th>
<th>F 1</th>
<th>F 2</th>
<th>F 3</th>
<th>F 4</th>
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<td>M 1</td>
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<td>MM</td>
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<td>MM</td>
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<td>MM</td>
<td>MM</td>
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<td>FM</td>
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<td>M 3</td>
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<td>M 4</td>
<td>MM</td>
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<td>F 1</td>
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*Note. Numbers differentiate animals. MM and FF represent same-sex interactions, and MF and FM represent opposite-sex interactions.*
group, is the unit of analysis for statistical tests of the variance components.

Cross-Situational Consistency of Individual Differences

In a longitudinal study (e.g., Times 1 and 2) with a round-robin design, two forms of cross-situational consistency can be studied. Consistency of behavior within each time point in interactions with multiple partners can be studied, as well as behavioral consistency over time. Actor and partner individual differences, quantified statistically by variance components, represent cross-situational consistency of behavior emitted and elicited within time points. Actor variance occurs when there are individual differences among animals in behavior emitted that is consistent when interacting with the same social partners, and this consistency may be computed at Time 1 and at Time 2. The actor effect is conceptually equivalent to the classical approach to individual differences. Partner variance occurs when there are individual differences among animals in the behavioral responses consistently elicited from the same social partners and are likewise estimable at Times 1 and 2. Thus, within each of the two times of the study, the actor and partner individual differences were estimated and represented within-time behavioral consistency. The occasion-specific actor and partner effects may also be assessed for longitudinal consistency. Relationship individual differences are dyad specific, and their consistency is best assessed longitudinally; however, they may be assessed within time when multiple indicators of the same underlying behavioral dimension are measured. With multiple indicators, one may assess whether unique responses to specific social partners are made on multiple indicators of a single latent construct. One can estimate the longitudinal consistency of unique responses to specific social partners on the construct over time.

The present study included multiple indicators of behavioral constructs and was longitudinal. Consequently, we were able to estimate all of the individual differences in behavior of theoretical interest and their cross-situational consistency. The longitudinal consistency of actor effects assesses the extent to which consistent responses to the same social partners within time are stable across time. The longitudinal consistency of partner effects assesses the extent to which the responses elicited consistently from multiple social partners within time are stable across time. And finally, the longitudinal consistency of relationship effects assesses the extent to which unique responses to a specific social partner at one occasion are consistent at a second occasion. This estimate of longitudinal dyadic consistency is an optimal estimate of the behavioral signature (Mischel & Shoda, 1995, 1999) because it is not entangled with the actor and partner effects. The psychological meaning of the individual differences at the individual and dyadic levels and their estimation by SRM variance components are summarized in Table 2. Also presented is the psychological interpretation of the longitudinal cross-situational consistency coefficients.

Hypotheses

We hypothesized that the dyadic social behavior of mice would be determined by generalized (i.e., actor and partner effects) and dyadic (i.e., the relationship effect) individual differences. This prediction was derived from our theoretical analysis and from research with humans (Kenny et al., 2001), rhesus macaques (Capitanio, 1984), and fish (Dunlap, 2002) that has shown similar patterns of individual differences in dyadic behavior. This research indicates that relationship effects have the strongest impact, followed by actor effects, with relatively weak partner effects. That is, the consistency of behavioral responses emitted to other animals generally and to specific animals is stronger than the consistency of responses elicited from other animals. We anticipated a similar pattern of results among mice. Because olfaction is a primary sensory system for the detection of information about a social partner among mice (Bowers & Alexander, 1967), we anticipated evidence for generalized and dyadic individual differences on measures of an olfaction construct.

We anticipated longitudinal consistency of the actor, partner, and relationship individual differences. Actor and partner effects, which are themselves measures of behavioral consistency within time, should be consistent over time if they are stable dispositional. Likewise, we anticipated consistency of dyadic (i.e., relationship) individual differences over time because if dyad members’ traits do not change, their unique dyadic responses should show temporal stability.

We anticipated that the sex composition of dyads would affect behavior. Malloy and Kenny (1986) described how the random variables of the SRM (i.e., actor, partner, and relationship variance components) may be affected by fixed variables, such as the sex of dyad members. Specifically, we expected that males would consistently show more aggression and olfactory exploration of social partners (a main effect) and that this would be heightened when interacting with other males (in terms of aggression) and with

<table>
<thead>
<tr>
<th>Variance component</th>
<th>Type of individual difference</th>
<th>Psychological meaning of cross-situational consistency</th>
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<tbody>
<tr>
<td>Actor</td>
<td>Individual differences among animals in behavior that is consistent across multiple social partners</td>
<td>Extent to which behavior emitted consistently with a set of social partners within time is consistent over time</td>
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<tr>
<td>Partner</td>
<td>Individual differences among animals in behavior consistently elicited from multiple social partners</td>
<td>Extent to which behavior elicited consistently from a set of social partners within time is consistent over time</td>
</tr>
<tr>
<td>Relationship</td>
<td>Individual differences among animals in behavioral responses to specific social partners</td>
<td>Extent to which unique responses to a specific social partner within time are consistent over time</td>
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females (in terms of olfactory exploration and copulation), resulting in interaction effects. Also, we anticipated that females would show more defensive behavior than males and that this would be the strongest when interacting with males as opposed to females.

Method

Subjects, Apparatus, and Procedure

A sample of 80 adult CD1 mice (Mus musculus; 40 males and 40 females) was obtained from the Charles River Laboratory (Boston, MA). This study was undertaken with Mus musculus because of the high level of experimental control we could achieve with this species; a similar study with humans would have been impossible logistically. Also, we wanted to demonstrate the broad generality of the theoretical distinctions proposed.

Animals were housed in 16 cages, with 5 same-sex animals in each cage. Food and water were available ad libitum. Mice were assigned randomly to 1 of 10 round-robins (i.e., groups of 8 animals) with the constraint that mice were not cage mates. A 44 × 26 × 12-cm Plexiglas apparatus was constructed; a night–day cycle was established, and observations were made during the night cycle. Because CD1 mice do not see well in bright light, cardboard was placed over a laboratory window and red cellophane was placed over fluorescent lights. Each mouse was placed in the apparatus with each member of their round-robin for a 3-min period, and behaviors were video-recorded by a camera positioned above the apparatus. Between dyadic interactions, the apparatus was cleaned with a solution of alcohol and water (50%) each and then dried, to remove odors left by previous mice. Researchers swabbed their gloves with rubbing alcohol in order to avoid the transfer of odors.

There was a total of 28 dyadic interactions per round-robin at two occasions 1 week apart (Times 1 and 2), yielding 56 dyadic interactions per round-robin. The mice were identified by their social group number and a letter code represented by a specific color on each mouse with a permanent ink felt-tip marker. Before each observation, an identification card was displayed to ensure proper classification. The behavior of each animal in all dyads was coded independently by the same two assistants who viewed each dyad twice, each time coding a different mouse. One mouse died prior to the beginning of the study, and equipment failure led to the loss of three of the 10 dyads.

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Behavioral Measures

We selected the following social behaviors commonly studied in mice (e.g., Aldhous, 1989; Hilakivi-Clarke & Lister, 1992; Smith et al., 1994; Terranova et al., 1993) for inclusion in this study: following (distance between mice less than 1 cm), climbing (placing at least two limbs on the side of the apparatus), self-grooming (grooming own fur or limbs), social grooming (grooming the fur of the other mouse), sniffing AG (sniffing the anogenital region [AG] of the other mouse), nose (sniffing the facial region of the other mouse), body (sniffing any other part of the body of the other mouse not categorized by sniffing AG or nose), copulation (mounting the other mouse), aggression (biting, rapid pursuit), passive body contact (undirected body contact not classified above), and defense (running away, pushing, or kicking). Total activity was the sum of all behaviors. Behaviors in all dyads were coded independently by two coders. Reliability was .71, .90, .67, .00, .84, .81, .74, .81, .48, .82, .83, and .86 for the behaviors, respectively. The reliability for social grooming was zero because this behavior occurred very infrequently, and although there was complete agreement among coders that this did not occur, the trivial variance produced low reliability.

Estimation of Variance Components

Each round-robin, or group, was composed of 4 males and 4 females. Analyses of interactions in the eight animal round-robins were conducted by using SOREMO software (Kenny, 1995). Because there were two scores for each dyadic behavior in each interaction (coders 1 and 2), error variance was partitioned from stable construct variance (i.e., actor, partner, and relationship variance).

Results

Mean Levels of Dyadic Behavior

A repeated measures ANOVA with group (i.e., round-robin) as the unit of analysis and three within-subjects factors was conducted. The factors were time (1 and 2), sex of actor (male or female), and sex of partner (male or female). The dependent measure was the mean level of behavior within groups; results are summarized in Table 3.

Effects due to time. Overall, the mean levels of dyadic behavior did not evidence much variability at the two occasions of social interaction. A time main effect was observed with more following behavior at Interaction 1 than at Interaction 2, $F(1, 8) = 6.14, p < .04$, and more sniffing of the AG region of a social partner during the first interaction, $F(1, 8) = 6.75, p < .03$. A time main effect was also observed for the total activity variable, $F(1, 8) = 8.91, p < .02$, with more behavior occurring during the first interactions.

Sex-of-actor effects. Sex-of-actor main effects were observed on 9 of 11 dyadic behaviors and on the total activity variable. Males followed their partners more than did females, $F(1, 8) = 19.67, p < .002$. Males also engaged in more self-grooming, $F(1, 8) = 30.16, p < .001$, and social grooming, $F(1, 8) = 11.32, p < .01$, than did females. On the three indicators of the olfaction construct, a main effect was observed; males sniffed the faces, $F(1, 8) = 79.37, p < .001$, the AG region, $F(1, 8) = 78.42$, and the body, $F(1, 8) = 72.82, p < .001$, of their social partners to a greater extent than did females. Only males copulated with females, and this produced a sex-of-actor main effect, $F(1, 8) = 23.52, p < .001$. Males exhibited more aggressive behavior than did females, $F(1, 8) = 13.67, p < .006$, and females displayed more defensive behavior than did males, $F(1, 8) = 13.42, p < .006$. For the sum of all behaviors (total activity), a main effect showed that males emitted more overall behavior than did females, $F(1, 8) = 124.34, p < .001$.

Sex-of-partner effects. Sex-of-partner main effects were observed on 8 of 11 dyadic behaviors and for the overall activity variable. An ANOVA revealed that females were followed more than males, $F(1, 8) = 5.22, p = .05$, and that animals (male and female) self-groomed to a greater extent when interacting with females, $F(1, 8) = 9.11, p < .02$. Sex-of-partner effects were observed on the three indicators of the olfaction construct. The AG regions, $F(1, 8) = 46.23, p < .001$; the faces, $F(1, 8) = 68.11, p < .001$; and the bodies, $F(1, 8) = 14.61, p = .005$, of females were sniffed reliably more in comparison to males. Copulation occurred...
only with females, $F(1, 8) = 23.52, p = .001$. Female partners were more often the recipients of aggression, $F(1, 8) = 10.96, p = .001$, and male partners elicited reliably more defensive behavior than did female partners, $F(1, 8) = 33.33, p < .001$. For the total activity variable, females elicited more behavior from interaction partners than did males, $F(1, 8) = 19.36, p = .002$.

**Sex-of-Actor $\times$ Sex-of-Partner interaction effects.** Statistically reliable interaction effects for sex of actor and partner were observed for 6 of 11 dyadic behaviors and moderated the main effects previously reported for 4 behaviors (AG sniffing, copulation, aggression, and defense). Males and females climbed more, $F(1, 8) = 27.13, p = .001$, and made more passive body contact, $F(1, 8) = 18.60, p = .003$, in the presence of a same-sex interaction partner. As predicted, males showed uniquely high levels of sniffing of the AG region of female partners, $F(1, 8) = 11.06, p = .01$, and copulated only with females, $F(1, 8) = 24.25, p = .001$. Also as predicted, males displayed uniquely high levels of aggression when interacting with other males, $F(1, 8) = 9.52, p = .02$, and females displayed uniquely high levels of defensive behavior when interacting with males, $F(1, 8) = 13.95, p = .006$.

**Consistency of Behavior Emitted With Multiple Interaction Partners**

Actor variances measure the consistency of individual differences in social behaviors with multiple interaction partners and are presented in a standardized metric (i.e., proportion of total variance) in Table 4. At Time 1, 7 of 11 actor variance components were reliably different from zero ($p < .05$), with a range from .12 (defense) to .38 (sniff). Across the 11 variables, the median actor variance at Time 1 was .16. The actor variance component of the total activity variable was .39 and was reliably different from zero ($p < .05$). At Time 2, 8 of 11 actor variance components were reliably different from zero ($p < .05$), with a range from .05 (defense and self-grooming) to .41 (sniffing) and a median of .14 across the 11 variables. The actor variance for the total activity

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Mean Levels of Behavior in Same and Opposite Sex Interactions</th>
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<tbody>
<tr>
<td>Behavior</td>
<td>Time 1</td>
</tr>
<tr>
<td></td>
<td>MM</td>
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<tr>
<td>Following</td>
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<tr>
<td>Self-grooming</td>
<td>1.69</td>
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<tr>
<td>Social grooming</td>
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<td>Anogenital sniffing</td>
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<tr>
<td>Nose sniffing</td>
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<tr>
<td>Body sniffing</td>
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<tr>
<td>Copulation</td>
<td>0.00</td>
</tr>
<tr>
<td>Passive body</td>
<td>2.22</td>
</tr>
<tr>
<td>Aggression</td>
<td>1.18</td>
</tr>
<tr>
<td>Defense</td>
<td>1.22</td>
</tr>
<tr>
<td>Total activity</td>
<td>35.25</td>
</tr>
</tbody>
</table>

**Note.** Sex of actor is designated by the first letter and sex of partner by the second letter. M = male; F = female.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Actor, Partner, and Relationship Variances at Time 1 and Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Time 1</td>
</tr>
<tr>
<td></td>
<td>Actor</td>
</tr>
<tr>
<td>Following</td>
<td>.14*</td>
</tr>
<tr>
<td>Climbing</td>
<td>.16*</td>
</tr>
<tr>
<td>Self-grooming</td>
<td>.08</td>
</tr>
<tr>
<td>Social grooming</td>
<td>.00</td>
</tr>
<tr>
<td>Sniffing</td>
<td>.29*</td>
</tr>
<tr>
<td>Nose</td>
<td>.39*</td>
</tr>
<tr>
<td>Body</td>
<td>.30*</td>
</tr>
<tr>
<td>Copulation</td>
<td>.18*</td>
</tr>
<tr>
<td>Passive</td>
<td>.03</td>
</tr>
<tr>
<td>Aggression</td>
<td>.17</td>
</tr>
<tr>
<td>Defense</td>
<td>.12*</td>
</tr>
<tr>
<td>Total activity</td>
<td>.39*</td>
</tr>
</tbody>
</table>

**Note.** df = 9 (N groups − 1). Variance components are standardized and show the relative proportion of the total variance in behavior.

* $p < .05$. 

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MALLOY, BARCELOS, ARRUDA, DEROSA, AND FONSECA
variable was reliably different from zero \((p < .05)\) at Time 2, with a value of .45.

Considering the three olfaction variables, actor variance was statistically reliable \((p < .05)\) on all three variables at Time 1 (mean variance of .33) and Time 2 (mean variance of .41). Actor variances in the olfaction variables were larger in magnitude than variances on any of the eight remaining behavioral measures. Overall, and as predicted, a majority of the actor variance components were statistically reliable at Times 1 and 2. These findings documented consistency of individual differences in dyadic social behavior, across multiple interaction partners, and within each of the two occasions of interaction. Also as anticipated, olfaction behavior was characterized by the strongest consistency of individual differences in multiple dyads at each of the two occasions.

**Consistency of Behavior Elicited From Multiple Interaction Partners**

The partner variance components estimated the extent to which there were consistent individual differences in the social behaviors elicited from social interaction partners. At Time 1, 4 of 11 partner variances were reliably different from zero \((p < .05)\), with a range from .07 (copulation) to .18 (defense). Across the 11 variables, the median partner variance was .05. For the total activity variable, the partner variance at Time 1 was .00. At Time 2, partner variance components were reliably different from zero \((p < .05)\) for 6 of 11 variables, with a range from .02 (aggression) to .31 (defense) and a median of .05. Partner variance for total activity was .06 at Time 2 and not reliably different from zero. As anticipated, there were individual differences among animals in the behavior elicited consistently from other animals, particularly on such behaviors as sniffing AG and defense. However, across a broader range of social behaviors, partner effects were weak. These results are summarized in Table 4.

**Unique Behavioral Responses in Dyads**

The relationship variance components estimated the extent to which animals behaved uniquely in different dyads after controlling for actor and partner effects. As seen in Table 4, the relationship variance components are much larger than either actor or partner variances. At Time 1, 9 of 11 relationship variances were reliably different from zero \((p < .05)\), with a range from .29 (sniffing) to .67 (climbing), and for the 11 behaviors the median was .51. The relationship component of the total activity variable was .44 at Time 1 and was reliably different from zero \((p < .05)\). At Time 2, relationship variances were reliably different from zero \((p < .05)\) for 9 of 11 variables, with a range from .28 (body) to .58 (aggression). Across the 11 variables, the median relationship variance was .46. As anticipated, animals made unique behavioral responses to specific social partners, on two different occasions.

**Longitudinal Consistency of Actor, Partner, and Relationship Effects**

Actor, partner, and relationship effects quantified generalized and dyadic individual differences in behavior with multiple interaction partners at Times 1 and 2. The longitudinal consistency of these occasion-specific individual differences was also estimated. The longitudinal consistency of animals’ actor and partner effects (see Table 5) was estimated by correlating actor and partner effect estimates, on the basis of interactions with the same group of male and female partners, at Times 1 and 2. Longitudinal cross-situational consistency coefficients for actor effects were statistically reliable for 8 of the 11 variables \((p < .05)\) and ranged from \(r = .67\) (defense) to \(r = 1.00\) (sniffing), with a median of \(r = .78\). The consistency of the actor effects for total activity was \(r = .84\) and was statistically reliable. On the three olfactory variables, the median longitudinal consistency coefficient was \(r = .98\). Mice that behaved consistently while interacting with multiple partners at Time 1 also showed substantial behavioral consistency when interacting with those same partners at Time 2.

Statistically reliable \((p < .05)\) longitudinal consistency of partner effects was observed for 6 of the 11 variables and ranged from \(r = .62\) (defense) to \(r = 1.00\) (self-grooming and copulation) with a median of \(r = .69\). Reliable longitudinal instability was observed for climbing behavior \((r = −.64, p < .05)\), although this was not predicted. On the three olfactory variables, the median longitudinal consistency coefficient for partner effects was \(r = .65\). As predicted, mice that consistently elicited a behavioral response from multiple partners at Time 1 elicited similar behaviors from those same partners at Time 2.

Individual differences in behavioral responses in specific dyads (i.e., relationship effects), although statistically reliable within Times 1 and 2, were inconsistent across time for the 11 variables (median consistency of \(r = .05\)). Longitudinal consistency of relationship effects for the total activity variable was \(r = −.06\). Contrary to our expectations, unique responses of one animal to another showed very weak longitudinal, cross-situational consistency over a 1-week period (see Table 5).

**Discussion**

A new conceptualization of individual differences and cross-situational consistency of behavior in the dyadic social context was
proposed and tested in this research. In addition to the classical view that individual differences produce similar behavior in different situations (an actor effect), we considered the disposition to elicit similar responses from multiple social partners (a partner effect) and the disposition to respond uniquely to specific social partners (a relationship effect). These different facets of individual differences have distinct psychological meaning that should not be conflated conceptually or empirically. At the level of individuals, cross-situational consistency is reconceptualized as the stability of behavior emitted to and elicited from multiple social partners within time, as well as the longitudinal stability of that behavior over time. At the dyadic level, the consistency of responses to a specific social partner over time was considered and is particularly relevant in modern personality theory. The variance of relationship effects is the optimal measure of the behavioral signature proposed in the CAPS model (cf. Mischel & Shoda, 1995).

**Individual Differences and Cross-Situational Consistency**

The dyadic social behavior of mice was determined simultaneously by individual differences in behavior emitted by actors and elicited by social partners and by the unique responses one animal made to another. Although individual differences in dyadic behavior of mice have been studied (e.g., Terranova & Laviola, 2001; Terranova et al., 1993; Terranova, Loggi, Chiarotti, & Laviola, 2000), we know of no study that simultaneously isolates the individual and dyadic effects in this species. Because these individual differences have very different psychological meaning, theoretical precision was achieved, and the failure to partition these effects reduces conceptual clarity.

Unique responses to specific social partners, the relationship effect, was the strongest determinant of dyadic social behavior and was observed reliably for 86% of the variables at Times 1 and 2; however, relationship effects were occasion specific and temporally unstable. This showed that although mice behaved uniquely with specific partners, those unique responses were unstable over time when interacting with the same animal. The behavioral signature for mice appears to be very unstable. The tendency to emit behaviors at a similar level when interacting with multiple social partners (i.e., the actor effect) was the next strongest determinant of social behavior and reliably impacted 68% of the behaviors measured at the two occasions of social interaction. It is important to note that actor effects were highly stable over a 1-week period. These results are theoretically important because they demonstrate stable, individual differences in social responses to the same social partners within time that remained stable over time. The median longitudinal, cross-situational consistency coefficient for actor effects was \( r = .78 \) across the 11 variables of the study. Even more striking was the result for the olfactory construct with a longitudinal, cross-situational consistency coefficient of \( r = .98 \). For olfaction, a primary sensory mechanism of mice for gathering information about the environment, individual differences were almost perfectly stable longitudinally. Note that these consistency coefficients are for variables assumed to have the same latent, underlying cause at Times 1 and 2 and should be interpreted as reliability coefficients (Ozer, 1985). So for olfaction, the actor variances for this construct at Times 1 and 2 show 98% common or overlapping variance spaces. In addition, because the variance components are random effect estimates (Warner, Kenny, & Stoto, 1979), the results generalize beyond the specific animals included in the study. Therefore, we would expect that if the animals had interacted with different, rather than the same, partners at the two occasions, we would have observed similar levels of behavioral consistency. These results offer strong and compelling evidence for “animal personality” as described by Gosling (2001) and stand in contrast to claims that cross-situational consistency coefficients, based primarily on studies of humans, rarely exceed \( r = .30 \). Among mice, on such specific dimensions of behavior as olfaction, generalized responses to the same set of social partners approached perfect reliability (i.e., longitudinal cross-situational consistency of actor effects) and offer compelling support for stable, enduring individual differences in behavior.

The weakest determinant of dyadic behavior was the partner effect, although statistically reliable partner effects were observed for approximately 46% of the behaviors at Times 1 and 2, with statistically reliable longitudinal consistency for 64% of the variables. Longitudinal consistency of partner effects was substantial, with a median \( r = .62 \) for the set of 11 variables and a median \( r \) of .69 for the olfactory variables. These results provide a new glimpse into one facet of individual differences that has received insufficient theoretical and empirical attention—that is, the consistency of behavior elicited from multiple social partners (cf. Buss, 1987; Duncan et al., 1984; Kenny & Malloy, 1988; Kenny et al., 2001; Malloy & Kenny, 1986). Although the partner effects were weaker than actor or relationship effects, we did find reliable evidence for individual differences among mice in the consistency of the behavior elicited. Furthermore, individual differences in behavior elicited from partners at one occasion remained fairly consistent over a 1-week period. The partner effect is an important individual difference that should not be neglected, and we hypothesize that the strongest partner effects will be found in studies that manipulate stimulus features of social partners (age, weight differential, point in the estrus cycle, or dominance status) rather than holding them constant or allowing them to vary randomly as we did in this study. In studies of humans, partner effects should be most strong in asymmetric dyads with status, racial, or gender differences within dyads (e.g., Miller & Malloy, 2003; Peters, Kinsey, & Malloy, 2004). At the minimum, we have demonstrated that partner effects are a reliable determinant of dyadic social behavior of mice both within and over time, although within the context of our study they were the weakest determinant.

“From Mice to Men”

An explicit call (Gosling, 2001) has been made for a comparative approach to personality research “from mice to men.” A recent quantitative review of seven studies of human dyadic behavior that partitioned actor, partner, and relationship variances offers some notable similarities to the present results (Kenny et al., 2001). Among humans, the strongest determinant of dyadic behavior was the relationship effect, but unlike the present study, relationship variance was confounded with error in all but one of the studies reviewed. Consequently, the extent to which these relationship variances indicate uniqueness of behavioral responses or random error is not clear. Among mice however, approximately 40%–50% of the variance in social behavior was dyadic (i.e., a relationship effect) within Times 1 and 2. We hypothesize that among humans, the relationship effect will be a strong determinant of behavior that
will be longitudinally stable. Moreover, we predict that studies of animals higher on the phylogenetic scale will show the greatest evidence for longitudinally stable dyadic effects on behavior. This hypothesis is relevant in studies of people with a close relationship or in dyads where status is asymmetric. In dyads where the members’ outcomes are yoked, as in the case of spouses, or when control of outcomes is asymmetric, as in the case of the powerful and the powerless, there should be substantial relationship variance in behavior, affect, and perception that is stable across time.

Among mice we found that unique dyadic responses are occasion specific and longitudinally unstable, and a test of the prediction that longitudinally stable relationship variance will increase as one ascends the phylogenetic scale awaits further research.

Actor effects explained about 30% of the total variance in human behavior (Kenny et al., 2001), whereas among mice 18% of the total variance was due to the actor. Yet for olfactory behaviors, actor variance averaged across Times 1 and 2 was 37% of the total variance. This is unsurprising because olfaction is known to be a primary mechanism for kin discrimination (Aldhous, 1989), sexual attraction (Hayashi & Kimura, 1974), and dominance relationships (Jones & Nowell, 1974) in mice. This is surely why we observed a median longitudinal stability coefficient for actor effects in olfaction of .98. Behaviors that are key to adaptation and survival in a species should be characterized by individual differences that are consistent across situations. Partner effects on behaviors in mice and humans appear to be weak in dyadic interaction, with mean variance components of .07 and .02 in the respective species.

A unique discovery of this study is the substantial temporal stability of actor and partner effects, relative to the much weaker stability of relationship effects. Mice do not appear to form unique relationships with other mice that endure over time, whereas this is obviously true of humans and some other animals. In general, we expect that actor and partner effects will be strong determinants of behavior and longitudinally stable among animals whose behavior is primarily determined by genetically prescribed patterns. Among animals with weaker genetic control of behavior, such as humans, we expect increasing evidence for relationship variance in behavior.

Sex Differences in Mean Levels of Behavior

The sex of an animal affected behavior, and reliable sex-of-actor effects on mean levels of behavior were observed for 83% of the variables studied. Males exhibited significantly higher mean levels of behavior than females on nine variables. This finding conflicts with previous research (Terranova et al., 1993) that reported greater affiliation in female mice. Research (Pinto & Schmidek, 1994) has shown that male mice may emit high frequencies of behavior in one domain (e.g., food hoarding) and that females may show higher frequencies in other domains (e.g., exploration and burrowing). This inconsistency across studies appears to be due primarily to differences in the variables studied and to differences in experimental procedures. Our findings indicated that in a dyadic context, male mice were more active behaviorally than female mice.

Statistically reliable sex-of-partner effects were observed on 75% of the variables, and animals of both sexes exhibited significantly higher levels of behavior when interacting with female partners on seven variables. Male mice may emit more behavior than females, whereas females may elicit more behavior from social partners. However, on some dimensions of behavior, this general pattern was not observed. Animals (both males and females) responded more aggressively and defensively when interacting with male partners than when interacting with female partners. As Kenny and Malloy (1988) discussed in their research, one’s partner effect is due to one’s actor effect because consistent behavior emitted with multiple social partners leads them to respond similarly to the actor. In this study, males showed higher levels of aggression than did females consistent across social interactions. Aggressive males elicited defensive and aggressive responses from social partners, whereas less aggressive males did not. Partner effects may also originate from invariant features of the actor. For example, ethnicity, gender, and physical attractiveness are features of people that do not vary across dyadic interactions and may lead different social partners to respond similarly. Research shows that men are more likely to be perceived as leaders than women (Eagly & Karau, 1991) and demonstrates how an invariant feature of the partner affects another person’s evaluation of the partner on a personality dimension.

The mean level of behavior was affected significantly by the sex composition of the dyad for 50% of the variables. Climbing and passive body contact were uniquely high in same-sex dyads, and aggression was uniquely high when males interacted with other males. In mixed-sex dyads, defensive behavior was uniquely high when females interacted with males, and males sniffed the AG region and copulated at uniquely high levels with females. To further elucidate the relationship between olfaction and copulation in mixed-sex dyads, we correlated females’ partner effects on the olfactory behaviors (AG, nose, and body) they elicited from males with their partner effects on copulation with males. These correlations averaged at .49 and .82 at Times 1 and 2, respectively. Females that elicited high levels of olfactory exploration by males were the females with whom the males copulated.

From Interactionism to an Interpersonal Psychology of Personality

Theoretical models of human personality have increasingly emphasized an interactional perspective focusing on how the situation moderates the responses of persons that vary on an individual difference dimension (Endler & Magnusson, 1976; Magnusson & Endler, 1977; Snyder & Ickes, 1985), or how responses are moderated when interacting with a specific other (Malloy & Kenny, 1986) or persons from a specific social category (Mendoza-Denton, Downey, Purdie, Davis, & Pietrzak, 2002; Miller & Malloy, 2003). A social partner is a salient, important feature of the psychological situation (Mischel & Shoda, 1995; Rotter, 1954) for humans (Malloy & Kenny, 1986) and animals (Nissen, 1951). Data from this study show that this is true for mice. A partner may be a friend or a foe, and different people create a different psychological situation for the actor. Among mice, a dyad composed of two males is a context for establishing dominance, whereas a male–female dyad is a context for copulation. This is a central premise of the CAPS model (Mischel & Shoda, 1995, 1999), in which interactions with different people represent different contexts that produce different cognitive appraisal of the situation, as well as different affective and behavioral responses. We agree and propose that most personality processes unfold in social contexts,
Methodology for an Interpersonal Psychology of Personality

Individual differences and their cross-situational consistency have been considered the core problems of personality psychology among human (e.g., Hartshorne & May, 1928) and nonhuman animals (e.g., Tryon, 1931a, 1931b) and are as important today as they were in the early 20th century. Yet, much remains to be learned. Refinement of the concepts of individual differences and cross-situational consistency within the interpersonal dyadic context offers a distinct theoretical advantage by broadening and clarifying their meaning. The intuitive appeal of an interpersonal psychology of personality is readily apparent. Imagine a solitary organism living entirely alone in the environment. In this world, the concept of individual difference is meaningless and the concept of variance is undefined mathematically. Moreover, the concept of cross-situational consistency as indexed by the correlation coefficient is necessarily zero in the absence of variance. Individual differences in traits, such as the olfactory acuity of mice or extraversion among humans, are most meaningful within a social context that contains information relevant to coordinated social interaction with one’s conspecifics. Identification of the behavioral signature of a person requires placing that person in multiple interactions with multiple others (Mischel & Shoda, 1995) and is likewise meaningless in an asocial context. Research on individual differences and cross-situational consistency should be studied in the interpersonal context and should be designed to adequately view the rich texture of personality processes.

Because actor, partner, and relationship effects determine the behavior of mice, humans, and other species, research designs and measurement operations that permit estimation of each effect should be used. We used the round-robin design that permitted us to partition the generalized and dyadic individual differences and to study how the sex composition of the dyad affected mean levels of behavior.2 The use of multiple measures of behavior within time (i.e., multiple coders quantifying behavior in the same dyad) and the interaction of the same animals on two occasions permitted estimation of unique responses in specific dyads, as well as the longitudinal consistency of actor, partner, and relationship effects. The methods we used responded to many of the methodological criteria set forth by Gosling (2001) for personality research and produced some striking results. Perhaps the most remarkable is the estimate of cross-situational consistency of individual differences (actor effects) in olfactory behavior directed to other mice of \( r = .98 \). This is near-perfect cross-situational consistency of behavior. If this research had not been designed to partition actor effects from partner and relationship effects, this estimate would have necessarily been attenuated and biased in the direction of cross-situational instability. In research on the behavioral signature (Mischel & Shoda, 1995), it is necessary to determine whether a response to another is a relationship effect (which appears to be presumed) or a partner effect (an effect that the partner has on multiple others, including the focal individual). Conceptualizing individual differences and cross-situational consistency in the dyadic context, coupled with variance component analysis, has the potential to yield important theoretical contributions and to enhance experimental validity (Albright & Malloy, 2000) in personality psychology.

References


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