[in press, *Journal of Social and Personal Relationships*, August 2018]

DISENGAGED, EXHAUSTIVE, BENEVOLENT:

THREE DISTINCT STRATEGIES OF MATE RETENTION

Guilherme S. Lopes

Todd K. Shackelford

Oakland University, United States

Postal addresses:

Oakland University

Oakland University, Rochester, MI – 48309, United States

Corresponding author:

Guilherme S. Lopes

Oakland University

Department of Psychology

107 Pryale Hall

Rochester, Michigan 48309

E-mail: gslopes@oakland.edu

DISENGAGED, EXHAUSTIVE, BENEVOLENT:
THREE DISTINCT STRATEGIES OF MATE RETENTION

Abstract

Mate retention behaviors are designed to reduce the risk of partner infidelity or relationship defection. In the current research, we used *k*-means cluster analysis to identify distinct strategies of mate retention behaviors. Participants were 637 individuals (56.3% male) in a romantic relationship with an opposite-sex individual for at least three months (M = 78.7; SD = 95.8), and aged between 18 and 70 years (M = 29.3; SD = 10.5). Participants completed the Mate Retention Inventory-Short Form (Buss, Shackelford, & McKibbin, 2008). The results suggested three distinct mate retention clusters or strategies: (1) *Disengaged* (infrequent use of *both* benefit-provisioning and cost-inflicting behaviors); (2) *Exhaustive* (frequent use of *both* benefit-provisioning and cost-inflicting behaviors); and (3) *Benevolent* (frequent use of benefit-provisioning and infrequent use of cost-inflicting behaviors). The results also indicated, for example, that men more than women use a benevolent strategy, women more than men use a disengaged strategy, and men using an exhaustive strategy report being less physically intimate with their partners than men using a benevolent strategy. We discuss the results with reference to evolutionary hypotheses of mate retention, and we highlight limitations of the current research and important directions for future research.

Keywords: *k*-means; cluster analysis; mate retention; mate retention strategies; evolutionary psychology

DISENGAGED, EXHAUSTIVE, BENEVOLENT: THREE DISTINCT STRATEGIES OF MATE RETENTION

Monogamous mating likely conferred benefits on both men and women over human evolutionary history. For men, these benefits included greater paternity certainty, and for women, these benefits included partner investment in the woman and her children (Buss, 2015). Accordingly, a partner's infidelity inflicts substantial costs on the betrayed partner: A man whose partner is unfaithful risks cuckoldry (i.e., unwitting investment in a child to whom he is genetically unrelated; Buss & Shackelford, 1997), and a woman whose partner is unfaithful risks losing partner-provisioned resources (Buss & Schmitt, 1993). Because men face the adaptive problem of paternity uncertainty, men report greater upset than do women in response to a partner's sexual infidelity (Buss et al., 1992). On the other hand, because the redirection of a partner's investment to another woman and her offspring is reproductively costly for a woman, women report greater upset in response to a partner's emotional infidelity (Edlund & Sagarin, 2017). Over human evolutionary history, continued receipt of benefits associated with monogamy, and the costs associated with a partner's infidelity, may have selected for adaptations in both sexes that motivate efforts to retain a partner—i.e., mate retention behaviors designed to reduce the risk of partner infidelity or relationship defection (Buss, 1988).

Previous research on mate retention has focused on identifying and assessing mate retention behaviors (Buss, Shackelford, & McKibbin, 2008; Lopes, Shackelford, Santos, Farias, & Segundo, 2016; Atari, Barbaro, Shackelford, & Chegeni, 2017), and investigating individual differences that may affect the use of mate retention behaviors (e.g., de Miguel & Buss, 2011; Sela, Mogilski, Shackelford, Zeigler-Hill, & Fink, 2017). One research avenue that has been relatively neglected in the mate retention literature, however, is the identification of "strategies" of mate retention. From an evolutionary psychological perspective, strategies may be defined as evolved solutions to adaptive problems, with no consciousness or awareness on the part of the strategist implied (Buss & Schmitt, 1993). Effective mate retention may require integrating mate retention behaviors into a coherent strategy. That is, individuals strategically perform sets of mate retention behaviors, and certain strategies of mate retention may be more effective to reduce the risk of partner infidelity or relationship defection than others. In the current research, we use *k*-means cluster analysis in an effort to identify distinct strategies of mate retention.

Mate retention

Previous research has identified and assessed mate retention behaviors in humans (Buss, 1988), and factor-analytical research has documented that these behaviors may be organized into two domains: *benefit-provisioning* and *cost-inflicting* (e.g., Miner, Starratt, & Shackelford, 2009). Benefit-provisioning mate retention behaviors, such as complimenting a partner on their appearance or displaying love to retain their affection (Buss & Shackelford, 1997), increase a partner's self-esteem and relationship satisfaction (Miner et al., 2009), and is therefore a low-risk method to prevent a partner's infidelity or relationship defection. In contrast, cost-inflicting mate retention behaviors, such as crying in order to keep a partner in the relationship and preventing a partner from talking to opposite-sex friends (Buss et al., 2008), reduce a partner's social support system and increase the likelihood of negative health consequences (e.g., depressive symptoms; Devries et al., 2013), and is therefore a high-risk method to prevent a partner's infidelity or relationship defection.

Cost-benefit trade-offs associated with the use of benefit-provisioning mate retention behaviors include, for example, an increase in relationship stability, but at the cost of resource investment (e.g., "Gave my partner jewelry to signify that she was taken") and hindering potential short-term mating opportunities, for example (e.g., "Put my arm around my partner in front of others;" Miner et al., 2009). The use of cost-inflicting mate retention behaviors may serve as an alternative mate retention tactic that may increase paternity certainty for men (Buss, 2015) and access to partner-provisioned resources for women (Buss & Schmitt, 1993), but at the cost of reducing a partner's social, physical, and sexual well-being (Devries et al., 2013).

Over human evolutionary history, cost-benefit trade-offs may have selected for the use of mate retention strategies that facilitate successful retention of a romantic partner. That is, continued receipt of benefits associated with evaluating cost-benefit trade-offs in the use of mate retention may have selected for adaptations in humans that motivate *strategic* efforts to retain a partner. What are the *strategies* of mate retention?

Strategies of mate retention

Because benefit-provisioning and cost-inflicting behaviors are low-risk and high-risk methods to prevent a partner's infidelity or relationship defection, respectively, some individuals may perform frequent benefit-provisioning behaviors, alongside infrequent cost-inflicting behaviors. For example, individuals who report to be more (vs. less) agreeable (de Miguel & Buss, 2011) and individuals who endorse more strongly (vs. less strongly) values such as safety, health, and stability (Lopes, Sela, & Shackelford, 2017), perform frequent benefit-provisioning mate retention behaviors alongside less frequent cost-inflicting mate retention behaviors.

In contrast, when partner infidelity and defection might be especially costly to the betrayed partner, individuals may perform cost-inflicting mate retention behaviors as an additional effort to retain a partner. For example, mothers and fathers (vs. individuals without children; Barbaro, Shackelford, & Weekes-Shackelford, 2016), and individuals who perceive their partner to have higher (vs. lower) mate value (Sela et al., 2017) perform more frequent benefit-provisioning *and* cost-inflicting mate retention behaviors. Therefore, another mate retention strategy may include more frequent use of *both* benefit-provisioning and cost-inflicting behaviors.

The use of different mate retention strategies may be associated with several aspects of the relationship, such as relationship satisfaction. For example, previous research documented that an individual's use of benefit-provisioning and cost-inflicting behaviors is positively and negatively associated with that individual's relationship satisfaction, respectively (e.g., Atari et al., 2017). Therefore, individuals who perform more frequent benefit-provisioning *and* cost-inflicting mate retention behaviors may be less satisfied with their relationship, relative to individuals who infrequently perform cost-inflicting mate retention behaviors alongside more frequent benefit-provisioning mate retention behaviors. In the current research, we investigate the relationships between relationship satisfaction and use of mate retention strategies by first identifying distinct strategies of mate retention.

One way to investigate mate retention strategies is to empirically identify patterns in the use of mate retention (i.e., "observation-driven, bottom-up approach;" Lewis, Al-Shawaf, Conroy-Beam, Asao, & Buss, 2017). The identification of homogeneous patterns from a heterogenous sample of individuals may help to organize behaviors—here, different mate retention domains—into manageable, observation-driven profiles. Cluster analysis is a statistical approach that identifies relatively homogeneous groups within a heterogeneous sample of individuals (Clatworthy, Buick, Hankins, Weinman, & Horne, 2005). In other words, cluster analysis uses *patterns* of behaviors to identify clusters and the characteristics unique to each cluster. In the current research, we used cluster analysis—*k*-means, in particular—in an effort to identify clusters or strategies of mate retention.

K-means cluster analysis

Cluster analysis refers to a family of algorithms designed to group objects, events, or individuals. Among these algorithms, the *k*-means algorithm is widely used because of its parsimony and computational efficiency (Jain, 2010). The *k*-means algorithm has several features that make it useful for identifying strategies in the use of mate retention. First, *k*-means is an unsupervised learning algorithm—that is, it infers hidden cluster structures from "unlabeled" data (i.e., data that do not contain information about a researcher's expected classification), thereby affording a valuable tool for exploratory data analysis (Clatworthy et al., 2005). Second, *k*-means assigns individuals to *k* clusters iteratively, contrasting alternative configurations to identify the clusters that best fit the data. This feature is particularly relevant for the study of behaviors for which clusters have not yet been identified (e.g., mate retention behaviors). Third, the *k*-means algorithm supports the use of Euclidean metrics (Jain, 2010). Euclidean metrics represent the distance between points located in a multidimensional space (here, two dimensions: *cost-inflicting* and *benefit-provisioning*). The nature of Euclidean distances reflects the computational challenges human ancestors would have faced in mating contexts (Conroy-Beam & Buss, 2017). That is, each individual performs a unique set of mate retention behaviors—a single point at the intersection of different mate retention domains.

Psychological research has used cluster analysis to identify patterns of behavioral attributes. For example, cluster analysis has been used to identify types of motivation for physical activity, such as "controlled motivation" and "autonomous motivation" (Friederichs, Bolman, Oenema, & Lechner, 2015), to identify styles of parental socialization, such as "conflictive-authoritative" and "defensive-neglectful" (Henry, Tolan, & Gorman-Smith, 2005), and to identify profiles of workaholism, such as "high work involvement" and "low work enjoyment" (Aziz & Zickar, 2006). Human mating research has identified patterns of a partner's involvement in a romantic relationship (e.g., "steady involvement," "sporadic involvement;" Rauer, Pettit, Lansford, Bates, & Dodge, 2013) and types of intimate partner violence (e.g., "congruent light and infrequent," "discrepant heavy and frequent;" Wiersma, Cleveland, Herrera, & Fischer, 2010), but no research has specifically addressed clusters or strategies of integrated mate retention behaviors. In the current research, we used the *k*-means algorithm in an effort to identify distinct clusters or strategies describing the use of cost-inflicting and benefit-provisioning mate retention behaviors.

Methods

Participants and Procedure

The dataset included responses from 897 individuals. However, we analyzed only responses provided by individuals who responded to at least 95% of the Mate Retention Inventory-Short Form (MRI-SF; see Materials), because estimates of latent variables may be biased when calculated from data containing several missing values (Schafer & Graham, 2002). The final sample included 637 individuals, aged between 18 and 70 years (M = 29.3; SD = 10.5), and mostly male (56.3%). The mean relationship length was 78.7 months (SD = 95.8). In parallel with previous research on mate retention (e.g., Buss et al., 2008; Lopes et al., 2016), this sample included only individuals in a romantic relationship with the opposite sex for at least three months. We invited prospective participants: (1) through Amazon Mechanical Turk (MTurk); interested and eligible individuals could access and complete an on-line survey, and those who completed the survey received U$2.50; (2) through the Psychology Department Subject Pool at a large Midwestern U.S. university; interested and eligible individuals were provided a link to an on-line survey, and those who completed the survey received partial course credit upon completion (see Lopes et al., 2017), and (3) through advertising on bulletin boards on the campus of the same Midwestern U.S. university; interested individuals contacted the researcher, and those who met the participation criteria and agreed to participate were escorted to a private room to answer an in-person survey, and received U$25 at the conclusion of the survey (see Pham et al., 2018). The current article reports novel analyses of a subset of data from different projects.

Materials

Participants completed a survey that included the following parts:

Mate Retention Inventory-Short Form (MRI-SF; Buss et al., 2008). The MRI-SF is a 38-item inventory in which participants report how frequently they performed each mate retention behavior in the past month using a 4-point scale varying from 0 = *Never to* 3 = *Often*. The items are often factor-analyzed into two domains: *Cost-Inflicting* (e.g., “Threatened to break up if my partner ever cheated on me”) and *Benefit-Provisioning* (e.g., “Displayed greater affection for my partner”).

Demographic questions. We included demographic questions (e.g., age, sex), as well as questions about the romantic relationship, to which participants responded on a 10-point Likert scale (1 = *Low* and 10 = *High*): “To what extent are you satisfied with your relationship?”, “What is the average level of physical intimacy in your current relationship?”, and “What is the average level of emotional intimacy in your current relationship?”. Finally, participants were asked to indicate the length of the relationship [“What is your relationship length (in months)?”].

The surveys included several unrelated measures and demographic questions not relevant to the aims of the current article[1].

Data analysis

The use of *k*-means clsuter analysis proceeds in five steps (Jain, 2010): (1) The researcher assigns *k* clusters; then, the algorithm (2) randomly chooses *k* individuals, whose response means serve as initial “centroids,” (3) assigns each individual to the cluster with the “nearest” centroid, then (4) re-calculates the cluster centroids based on the mean of the individuals in each cluster; and (5) iteratively runs steps “3” and “4” until all individuals are assigned to the cluster with the “nearest” centroid. A sixth step may occur when the current structure fit (k_1) is compared against the fit of alternative structures (i.e., k_2, k_3, etc.). In short,

[1] Complete surveys and dataset can be found at: https://osf.io/ef94q/?view_only=b1ff9a5842ed45609447e9bfac763dc0.

the researcher assigns the number of clusters prior to running the *k*-means algorithm, and the *k*-means algorithm allocates each individual in one cluster among a number of clusters assigned by the researcher. The allocation of an individual into a cluster reflects that their responses are more similar to responses of other individuals in that cluster than to responses of individuals allocated to other clusters.

Results

Preliminary analysis

Previous research has identified different configurations for mate retention behaviors, including two (Buss, 1988; Intrasexual manipulations and Intersexual manipulations), five (Buss et al., 2008; e.g., Direct guarding, Positive inducements, Public signals of possession), and nineteen (Buss et al., 2008; e.g., Vigilance, Emotional manipulation, Resource display). Multiple configurations of mate retention may lack parsimony and theoretical focus, which hinder scientific advancement when the results of studies are to be compared or meta-analyzed. Several studies have documented the validity, reliability, utility, and parsimony of a two-factor structure of the MRI-SF (*Cost-Inflicting* and *Benefit-Provisioning*; e.g., Miner et al., 2009; Lopes et al., 2016, 2017; Sela et al., 2017). Therefore, for parsimony and in line with previous research (e.g., Miner et al., 2009), we constructed the two domains of mate retention from the mean scores of the constituent items: *Cost-Inflicting* (22 items; $M = 0.52$; $SD = 0.57$; $\alpha = 0.95$) and *Benefit-Provisioning* (16 items; $M = 1.33$; $SD = 0.58$; $\alpha = 0.88$). Additionally, because the goal of the current research is to identify the broadest clusters or strategies of mate retention, because sample size directly affects statistical power (Sullivan & Feinn, 2012), and because the identification of a mate retention strategy is not affected by specific sex differences in the use of that strategy, we combined data provided by men and women from the three samples.

We assessed kurtosis (κ) and skewness (γ) for each domain, in which scores greater than 1.96 indicate a non-normal distribution. The results indicated normal distributions for both domains (Cost-inflicting: $\kappa = 0.91$, $\gamma = 1.30$; and Benefit-provisioning: $\kappa = -0.32$, $\gamma = -0.13$). The two domains reflect different methods for retaining a long-term mate (Miner et al., 2009), and previous research has documented that performance frequencies for the domains are moderately positively correlated (e.g., Lopes et al., 2016; Sela et al., 2017; Atari et al., 2017). Because collinearity may reduce the accuracy of estimates in cluster analysis, we calculated the Variance Inflation Factor (VIF) between the domains to investigate the presence of collinearity (i.e., VIF > 10 indicates substantial collinearity; O'Brien, 2007). The results did not indicate substantial collinearity between the domains (VIF = 1.31). Finally, we investigated cluster tendency—that is, whether the data are appropriate for clustering. The Hopkins statistic (H) investigates whether the data contain clusters that are substantially different from randomly generated clusters, with $H \approx 0.5$ indicating cluster tendency (Banerjee & Dave, 2004). The results indicated that the data contain clusters moderately different from randomly generated clusters ($H = 0.1$).

Cluster analysis

The k-means algorithm requires the researcher to specify in advance k clusters. To specify the number of clusters, we used three criteria. The *elbow criterion* (Ketchen & Shook, 1996) compares the total within-cluster sum of squares (WSS_{total}) from k clusters, suggesting retention of the model with smallest k for which the addition of clusters does not significantly increase the WSS_{total}. The results suggested a four-cluster structure ($k = 4$; see Figure 1A). The *silhouette criterion* (Kaufman & Rousseeuw, 2009) estimates the distances of the individuals to their own cluster compared to neighboring clusters ("silhouette") for alternative models ($k > 1$), such that the model with optimal k produces the largest average silhouette. The results suggested the retention of three clusters ($k = 3$; see Figure 1B). Finally, the *gap statistic* *criterion* (g; Tibshirani, Walther, & Hastie, 2001) compares alternative models ($k > 1$) with a randomly generated model ($k = 1$) with estimated g derived from B bootstrapped datasets (here, $B = 500$). The model with optimal k contains the smallest k for which g is at least one standard deviation away from the random model's g. The results indicated that the optimal model contains three clusters ($k = 3$; see Figure 1C).

Criteria for determining the number of clusters suggested different numbers of clusters (silhouette, gap statistic, $k = 3$; elbow, $k = 4$). We then performed two k-means cluster analyses ($k = 3$ and $k = 4$), using two global fit indices for model comparison: Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). These global fit indices compare the fit of a model relative to alternative models, such that smaller values indicate better fit (Burnham & Anderson, 2002). The model with four clusters ($k = 4$) showed a slightly better fit than the model with three clusters ($k = 3$). However, differences in AIC and BIC are less informative than within-model criteria (i.e., elbow, silhouette, and gap statistic) for specification of optimal k (Burnham & Anderson, 2003), and within-model criteria suggested $k = 3$. Specifically, two of three criteria (silhouette and gap statistic) suggested a three-cluster structure, and the total within-cluster sum of squares clearly flattens at 3 (elbow criterion; see Figure 1a), corroborating the other two criteria (the interpretation of the elbow criterion is relatively subjective; Ketchen & Shook, 1996). Moreover, the addition of clusters decreases the total within-cluster sum of squares, which may inflate Type II error (Burnham & Anderson, 2003)—for example, AIC incrementally decreased with the addition of clusters up to $k = 11$, even though within-model criteria suggested $k = 3$. Because differences in AIC and BIC are less informative than within-model criteria for specification of optimal k, differences in these criteria should not outweigh within-model criteria in model selection, especially in cases where the competing models have similar fit—both models showed > 70% explained variance and relatively small differences in AIC and BIC (see

Burnham & Anderson, 2002, 2003). Moreover, a fourth cluster encompasses individuals performing benefit-provisioning behaviors at a "moderate" frequency, and therefore does not seem theoretically meaningful. Therefore, we used the model with three clusters (k = 3) for further analyses (see Figure 2). The results are summarized in Table 1.

We labeled Cluster 1 "Disengaged" because individuals using this strategy infrequently perform either benefit-provisioning or cost-inflicting mate retention behaviors. We labeled Cluster 2 "Exhaustive" because individuals using this strategy frequently perform *both* cost-inflicting and benefit-provisioning behaviors. We labeled Cluster 3 "Benevolent" because individuals using this strategy frequently perform benefit-provisioning, but infrequently perform cost-inflicting mate retention behaviors.

Individual differences in the use of mate retention strategies

We first calculated a chi-squared test of proportions to investigate sex differences in the use of mate retention strategies, adjusting p-value threshold to correct for Type I error (Bonferroni correction). The results indicated that men [observed (expected) = 72.0% (62.3%)] more than women [observed (expected) = 28.0% (37.7%)] use a benevolent mate retention strategy (χ^2 = 10.446; p = 0.001), men [observed (expected) = 70.7% (62.3%)] more than women [observed (expected) = 29.3% (37.7%)] use an exhaustive mate retention strategy (χ^2 = 3.946; p = 0.047), and women [observed (expected) = 52.7% (37.7%)] more than men [observed (expected) = 47.3% (62.3%)] use a disengaged mate retention strategy (χ^2 = 23.216; p < 0.001; see Figure 3).

As part of the evaluation of the three-cluster structure, we performed a Multivariate Analysis of Variance (MANOVA) to evaluate sex differences and differences in mean scores between the three mate retention strategies (disengaged, exhaustive, and benevolent), in terms of three relationship satisfaction variables: "To what extent are you satisfied with your relationship?", "What is the average level of physical intimacy in your current relationship?", and “What is the average level of emotional intimacy in your current relationship?”. Although these variables may reflect a single construct (i.e., relationship satisfaction; $\alpha = 0.84$), we separated them to detect small effects between the three mate retention strategies and each relationship satisfaction variable—in particular, we ought to detect small effects regarding physical intimacy and emotional intimacy, because previous research has documented sex differences in reactions to physical (sexual) infidelity and emotional infidelity (Buss et al., 1992).

The results indicated differences in mean scores on these variables for sex [Wilks' $\lambda = 0.97$, $F(3, 576) = 6.59$, $p < 0.001$], but not for strategies [Wilks' $\lambda = 0.99$, $F(6, 1152) = 1.40$, $p = 0.212$] or for the interaction between sex and strategies [Wilks' $\lambda = 0.99$, $F(6, 1152) = 0.79$, $p = 0.581$]. Specifically, reports of physical intimacy [$F(1, 578) = 19.78$, $p < 0.001$], emotional intimacy [$F(1, 578) = 6.99$, $p = 0.008$], and relationship satisfaction [$F(1, 578) = 6.34$, $p = 0.012$] varied according to sex. Univariate tests (Bonferroni correction) revealed that men ($M = 7.73$; $SD = 1.82$) reported to be more physically intimate with their partners ($t = 4.74$, $p < 0.001$; Cohen's $d = 0.41$) than women ($M = 6.81$; $SD = 2.58$), men ($M = 7.99$; $SD = 1.84$) reported to be more emotionally intimate with their partners ($t = 2.62$, $p = 0.009$; Cohen's $d = 0.23$) than women ($M = 7.50$; $SD = 2.46$), and men ($M = 8.29$; $SD = 1.64$) reported to be more satisfied with the relationship ($t = 2.52$, $p = 0.012$; Cohen's $d = 0.22$) than women ($M = 7.87$; $SD = 2.14$).

Additionally, reports of physical intimacy [$F(2, 578) = 2.59$, $p = 0.076$], and relationship satisfaction [$F(2, 578) = 2.65$, $p = 0.072$] varied according to mate retention strategy at a marginal level ($p < 0.1$; Gelman, 2013). Univariate tests (Bonferroni correction) revealed that individuals using a benevolent mate retention strategy ($M = 7.69$; $SD = 2.15$) reported to be more physically intimate with their partners than individuals using disengaged ($M = 7.11$; $SD = 2.24$; t = 2.87, $p = 0.013$; Cohen's $d = 0.26$) and exhaustive strategies ($M =$

7.20; $SD = 2.17$; $t = 2.03$, $p = 0.043$; Cohen's $d = 0.23$). Additionally, individuals using a benevolent mate retention strategy ($M = 8.31$; $SD = 1.88$) reported to be more satisfied with the relationship ($t = 2.14$, $p = 0.033$; Cohen's $d = 0.24$) than individuals using an exhaustive strategy ($M = 7.87$; $SD = 1.81$). Specifically, men (but not women) using a benevolent mate retention strategy ($M = 7.98$; $SD = 1.96$) reported to be more physically intimate with their partners ($t = 2.00$, $p = 0.046$; Cohen's $d = 0.28$) than their same-sex counterparts using an exhaustive strategy ($M = 7.47$; $SD = 1.74$). For reportorial completeness, we investigated whether relationship length is associated with the mate retention strategies. The results indicated no difference in relationship length among the mate retention strategies [F (2, 527) $= 0.916$; $p = 0.401$].

Discussion

In the current research, we used *k*-means cluster analysis to identify distinct clusters or strategies of mate retention. This analysis identified three mate retention strategies, which we labeled benevolent, exhaustive, and disengaged. First, the results revealed a mate retention cluster or strategy in which individuals frequently perform benefit-provisioning but rarely perform cost-inflicting mate retention behaviors, which we labeled "benevolent." Previous research has documented individual differences that may facilitate use of a benevolent strategy. For example, men's and women's self-esteem and relationship satisfaction are positively associated with their performance of benefit-provisioning (but not cost-inflicting) mate retention behaviors (Atari et al., 2017), suggesting that individuals who have high (vs. low) self-esteem and high (vs. low) relationship satisfaction may use a benevolent strategy to retain their partners. Corroborating this interpretation, individuals using a benevolent mate retention strategy report to be more satisfied with the relationship than individuals using an exhaustive strategy. Because the benevolent strategy includes frequent use of benefit-provisioning but infrequent use of cost-inflicting behaviors, the benevolent strategy may be more frequently used by individuals who are emotionally attached to the relationship or partner, but who do not perceive a high risk of partner infidelity (e.g., men perform more cost-inflicting behaviors when a female partner is known or suspected to have been recently sexually unfaithful; Goetz & Shackelford, 2006). Longitudinal research might profitably investigate whether low perceived risk of partner infidelity precedes use of a benevolent strategy, for example.

The results revealed a second cluster or strategy in which individuals frequently perform benefit-provisioning *and* cost-inflicting mate retention, which we labeled "exhaustive." Individuals may perform cost-inflicting mate retention behaviors as an additional effort to retain a partner when the perceived risk of partner infidelity or defection is especially high. For example, our findings revealed that men (but not women) using an exhaustive mate retention strategy report to be less physically intimate with their partners than their same-sex counterparts employing a benevolent strategy, perhaps because less (relative to more) physical intimacy may suggest higher risk of infidelity, especially for men (Buss, 2015). Moreover, previous research identified circumstances in which individuals may use an exhaustive mate retention strategy. For example, individuals who perceive that they could less easily replace their partner, and who perceive that their partner could more easily replace them, perform more frequent benefit-provisioning *and* cost-inflicting mate retention (Sela et al., 2017), perhaps because high mate value discrepancy suggests high risk of relationship defection in a long-term context (e.g., women who are independently rated as having higher mate value than their husbands report greater likelihood of divorcing him; Shackelford & Buss, 1997). Additionally, mothers and fathers perform more benefit-provisioning *and* cost-inflicting mate retention behaviors than individuals without children (Barbaro et al., 2016), perhaps because the diversion of a partner's investment is reproductively costly for a woman and her offspring (Buss & Schmitt, 1993), and a partner's defection may be especially costly for a man who has invested resources in the offspring (Buss, 2015).

The results revealed a third cluster or strategy in which individuals rarely perform cost-inflicting or benefit-provisioning mate retention behaviors, which we labeled "disengaged." Individuals using a disengaged strategy rarely perform mate retention behaviors, perhaps because they are emotionally detached from the relationship (i.e., humans may have evolved a mate ejection module designed to facilitate relationship dissolution and detachment; Boutwell, Barnes, & Beaver, 2015). This interpretation is consistent with our findings that individuals using a disengaged strategy also report to be less physically intimate with their partners than individuals using a benevolent strategy, for example. Female ejection of a mate may be triggered when men threaten to cease resource-provisioning (Boutwell et al., 2015). Future research might investigate whether a disengaged mate retention strategy is used by women in the period of a relationship that precedes the use of mate ejection tactics, for example. Additionally, a disengaged strategy may be used by individuals who perceive low partner infidelity risk (e.g., husbands' and wives' performance reports of mate retention decreases from the newlywed year to the fourth year of marriage; Kaighobadi, Shackelford, & Buss, 2010).

The elbow criterion suggested the existence of a fourth cluster. However, this cluster does not seem theoretically meaningful—it encompasses individuals who infrequently perform cost-inflicting behaviors and "moderately frequently" perform benefit-provisioning behaviors. That is, our findings did not reveal a mate retention cluster or strategy in which individuals frequently perform cost-inflicting but rarely perform benefit-provisioning behaviors (e.g., what we might have labeled a "hostile" strategy). Because individuals who frequently perform cost-inflicting behaviors also perform benefit-provisioning behaviors (but not vice-versa), it is possible that the performance of cost-inflicting behaviors *succeeds* the performance of benefit-provisioning behaviors. That is, because the performance of cost-inflicting behaviors may have devastating consequences for the partner (Devries et al., 2013), individuals may perform cost-inflicting behaviors only when the benefits are perceived to outweigh the costs—for example, under high risk of partner infidelity (e.g., Goetz & Shackelford, 2006). Consistent with this interpretation, individuals using an exhaustive strategy report to be less physically intimate with their partners than individuals performing benevolent mate retention strategies. Future research might investigate whether men who have sexually coerced their partners (e.g., Goetz & Shackelford, 2006), for example, more frequently perform cost-inflicting but rarely perform benefit-provisioning mate retention behaviors.

Alternatively, because some benefit-provisioning mate retention behaviors may require substantial resource expenditure (e.g., “Took my partner to a nice restaurant”), individuals who do not have sufficient resources (e.g., time, money, etc.) to afford benefit-provisioning behaviors may perform more cost-inflicting behaviors in an effort to retain their partner. Because cost-inflicting behaviors may cause negative health consequences for the partner (Devries et al., 2013), however, it is possible that individuals who cannot afford perfoming benefit-provisioning behaviors resort to a disengaged strategy. Future research might investigate whether individuals who use a disengaged strategy have sufficient resources to afford performing benefit-provisioning behaviors. Additionally, several benefit-provisioning behaviors captured by the MRI-SF require substantial resource expenditure (e.g., “Gave my partner jewelry to signify that she was taken”), such that the benefit-provisioning domain does not specifically represent “low-cost” benefit-provisioning behaviors. Future research may investigate whether individuals using a disengaged strategy also perform “low-cost” benefit-provisioning behaviors (e.g., giving compliments).

The results indicated no difference in relationship length between the mate retention strategies. We assessed the use of mate retention strategies by only one partner per couple. Perhaps, differences in strategies of mate retention between partners may have affected the relationships between relationship length and mate retention strategies. Future research may assess the use of mate retention strategies for each partner in a couple. Alternatively, relationship length may not represent well the effectiveness of a mate retention strategy, because strategies used in briefer relationships may effectively retain a partner, and individuals in longer-duration relationships sometimes experience partner infidelity or relationship defection. Future research may investigate the use of mate retention strategies longitudinally. Moreover, the results revealed that men more than women use a benevolent mate retention strategy, and women more than men use a disengaged mate retention strategy. We are not prepared to speculate about these sex differences. Future research may attempt to replicate these results.

The current research has several limitations. First, the *k*-means algorithm generates non-overlapping spherical clusters. Spherical shapes are parsimonious, and there is no clustering algorithm that has been shown to "dominate" other algorithms across all application domains (Jain, 2010). Future research might investigate the suitability of different shapes in the mate retention context (e.g., Mahalanobis metric has been used to detect hyper-ellipsoidal clusters; Mao & Jain, 1996). Additionally, the *k*-means algorithm is appropriate for exploratory research—it allocates individuals into *k* clusters by infering membership of individuals without *a priori* classifications (Clatworthy et al., 2005). Future research might use a confirmatory approach to investigate, for example, the *fit* of strategies to the performance of mate retention behaviors (e.g., Gaussian mixture models; Press, Teukolsky, Vetterling, & Flannery, 2007).

Previous research has identified myriad mate *selection* strategies (for a review, see Buss, 2015). For example, women may use a *mate switching* strategy—defecting from one romantic relationship and entering into another—when confronted with certain unanticipated circumstances (e.g., the arrival of a new and interested potential partner of sufficient mate value to offset the costs of relationship dissolution; Buss, Goetz, Duntley, Asao, & Conroy-Beam, 2017). Additionally, men may benefit from a *short-term* strategy, for example, because it increases sexual access to multiple partners (e.g., ancestrally, men achieved greater reproductive success primarily through increased numbers of sexual partner, not through more offspring per partner; Buss & Schmitt, 1993). Mate selection strategies thus have been subjected to empirical scrutiny. The current research is the first to investigate how mate retention behaviors may be integrated and strategically deployed by humans, guided by a *k*-means cluster analysis.

The use of the *k*-means algorithm to identify clusters or strategies of mate retention adds to a growing body of research using different statistical approaches to investigate evolutionarily-informed hypotheses. For example, Mogilski (2017) conducted a conjoint analysis to investigate how individuals make romantic relationship trade-offs when evaluating a set of individual attributes, providing insights into the evolved mechanisms that guide decision-making in human mating contexts. Additionally, Conroy-Beam and Buss (2017) demonstrated the utility of a Euclidean algorithm for predicting attraction to potential mates, and documented that mate value and mate preferences are integrated in mate choice (e.g., short-term and long-term mate values discriminatively predicted short-term and long-term attraction).

The current research contributes to the mate retention literature by providing evidence for three mate retention clusters or strategies: (1) *Disengaged* (i.e., rare benefit-provisioning and cost-inflicting); (2) *Exhaustive* (i.e., frequent benefit-provisioning and cost-inflicting);

and (3) *Benevolent* (i.e., frequent benefit-provisioning, and rare cost-inflicting). Mate retention strategies may serve as a complementary approach to the assessment of mate retention, and may allow researchers to generate hypotheses regarding individual differences in the use of different strategies of mate retention. Mate retention strategies may be useful in practical contexts such as in developing educational programs, marital counseling, and marital therapy. In sum, the current research provides insight into how mate retention behaviors may be integrated and strategically deployed by humans, and validates the use of clustering algorithms for understanding human mating strategies—here, mate retention strategies.

References

Atari, M., Barbaro, N., Shackelford, T.K. & Chegeni, R. (2017). Psychometric evaluation and cultural correlates of the Mate Retention Inventory-Short Form (MRI-SF) in Iran. *Evolutionary Psychology, 15,* 1-11.

Aziz, S., & Zickar, M. J. (2006). A cluster analysis investigation of workaholism as a syndrome. *Journal of Occupational Health Psychology*, *11*, 52-62.

Banerjee, A., & Dave, R. N. (2004). Validating clusters using the Hopkins statistic. *2004 IEEE International Conference on Fuzzy Systems*, *1*, 149-153.

Barbaro, N., Shackelford, T. K., & Weekes-Shackelford, V. A. (2016). Mothers and fathers perform more mate retention behaviors than individuals without children. *Human Nature*, *27*, 316-333.

Boutwell, B. B., Barnes, J. C., & Beaver, K. M. (2015). When love dies: Further elucidating the existence of a mate ejection module. *Review of General Psychology*, *19*, 1-9.

Burnham, K. P., & Anderson, D. R. (2004). Multimodel inference: understanding AIC and BIC in model selection. *Sociological Methods & Research*, *33*, 261-304.

Burnham, K. P., & Anderson, D. R. (2003). *Model selection and multimodel inference: a practical information-theoretic approach*. New York, NY: Springer Science & Business Media.

Buss, D. M. (1988). From vigilance to violence: Tactics of mate retention in American undergraduates. *Ethology and Sociobiology*, *9*, 291-317.

Buss, D. M. (2015). *Evolutionary psychology: The new science of the mind*. New York, NY: Pearson.

Buss, D. M., & Schmitt, D. P. (1993). Sexual strategies theory: An evolutionary perspective on human mating. *Psychological Review*, *100*, 204-232.

Buss, D. M., & Shackelford, T. K. (1997). From vigilance to violence: mate retention tactics in married couples. *Journal of Personality and Social Psychology*, *72*, 346-361.

Buss, D. M., Goetz, C., Duntley, J. D., Asao, K., & Conroy-Beam, D. (2017). The mate switching hypothesis. *Personality and Individual Differences*, *104*, 143-149.

Buss, D. M., Shackelford, T. K., & McKibbin, W. F. (2008). The Mate Retention Inventory – Short Form (MRI–SF). *Personality and Individual Differences*, 44, 322–334.

Clatworthy, J., Buick, D., Hankins, M., Weinman, J., & Horne, R. (2005). The use and reporting of cluster analysis in health psychology: A review. *British Journal of Health Psychology*, *10*, 329-358.

Conroy-Beam, D., & Buss, D. M. (2017). Euclidean distances discriminatively predict short-term and long-term attraction to potential mates. *Evolution and Human Behavior*, *38*, 442-450.

de Miguel, A., & Buss, D. M. (2011). Mate retention tactics in Spain: Personality, sex differences, and relationship status. *Journal of Personality*, *79*, 563-586.

Devries, K. M., Mak, J. Y., Garcia-Moreno, C., Petzold, M., Child, J. C., Falder, G., ... & Pallitto, C. (2013). The global prevalence of intimate partner violence against women. *Science*, *340*, 1527-1528.

Edlund, J. E., & Sagarin, B. J. (2017). Sex differences in jealousy: A 25-year retrospective. *Advances in Experimental Social Psychology*, *55*, 259-302.

Friederichs, S. A., Bolman, C., Oenema, A., & Lechner, L. (2015). Profiling physical activity motivation based on self-determination theory: a cluster analysis approach. *BMC Psychology*, *3*, 1-12.

Gelman, A. (2013). *P* values and statistical practice. *Epidemiology*, 24, 1, p. 69-72.

Goetz, A. T., & Shackelford, T. K (2006). Sexual coercion and forced in-pair copulation as sperm competition tactics in humans. *Human Nature, 17*, 265-282.

Henry, D. B., Tolan, P. H., & Gorman-Smith, D. (2005). Cluster analysis in family psychology research. *Journal of Family Psychology*, *19*, 121-132.

Jain, A. K. (2010). Data clustering: 50 years beyond K-means. *Pattern Recognition Letters*, *31*, 651-666.

Kaighobadi, F., Shackelford, T. K., & Buss, D. M. (2010). Spousal mate retention in the newlywed year and three years later. *Personality and Individual Differences*, *48*, 414-418.

Ketchen Jr, D. J., & Shook, C. L. (1996). The application of cluster analysis in strategic management research: an analysis and critique. *Strategic Management Journal*, *17*, 441-458.

Lewis, D. M., Al-Shawaf, L., Conroy-Beam, D., Asao, K., & Buss, D. M. (2017). Evolutionary psychology: A how-to guide. *American Psychologist*, *72*, 353-373.

Lopes, G. S., Sela, Y., & Shackelford, T.K. (2017). Endorsement of existence values predicts mate retention behaviors. *Personality and Individual Differences, 113*, 184-186.

Lopes, G. S., Shackelford, T. K., Santos, W. S., Farias, M. G., & Segundo, D. S. (2016). Mate retention inventory-short form (MRI-SF): Adaptation to the Brazilian context. *Personality and Individual Differences*, *90*, 36-40.

Mao, J., & Jain, A. K. (1996). A self-organizing network for hyperellipsoidal clustering (HEC). *IEEE Transactions on Neural Networks*, *7*, 16-29.

Miner, E. J., Starratt, V. G., & Shackelford, T. K. (2009). It's not all about her: Men's mate value and mate retention. *Personality and Individual Differences*, *47*, 214-218.

Mogilski, J. K. (2017). *Human Mating and Romantic Decision-Making: A Conjoint Analytic Approach* (Doctoral dissertation). Ann Arbor, MI: ProQuest LLC.

O'Brien, R. M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality & Quantity*, *41*, 673-690.

Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. (2007). Gaussian mixture models and k-means clustering. In B. P. Flannery, S. Teukolsky, W. H. Press, & W. T. Vetterling (Eds.). *Numerical Recipes: The Art of Scientific Computing, 3rd ed.* (p. 842-850). New York, NY: Cambridge University Press.

Rauer, A. J., Pettit, G. S., Lansford, J. E., Bates, J. E., & Dodge, K. A. (2013). Romantic relationship patterns in young adulthood and their developmental antecedents. *Developmental Psychology*, *49*, 1-24.

Kaufman, L., & Rousseeuw, P. J. (2009). *Finding groups in data*. Hoboken, NJ: Wiley Online Library.

Schafer, J. L., & Graham, J. W. (2002). Missing data: our view of the state of the art. *Psychological Methods*, 7, 147.

Sela, Y., Mogilski, J. K., Shackelford, T. K., Zeigler□Hill, V., & Fink, B. (2017). Mate value discrepancy and mate retention behaviors of self and partner. *Journal of Personality*, *85*, 730-740.

Sullivan, G. M., & Feinn, R. (2012). Using effect size—or why the P value is not enough. *Journal of Graduate Medical Education*, *4*, 279-282.

Tibshirani, R., Walther, G., & Hastie, T. (2001). Estimating the number of clusters in a data set via the gap statistic. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, *63*, 411-423.

Wiersma, J. D., Cleveland, H. H., Herrera, V., & Fischer, J. L. (2010). Intimate partner violence in young adult dating, cohabitating, and married drinking partnerships. *Journal of Marriage and Family*, *72*, 360-374.

Table 1
Global fit indices and descriptive statistics of cluster structures (n = 637)

Cluster structure	BP		CI		SS_w	SS_b	EV	AIC	BIC
	M	*SD*	*M*	*SD*					
k = 3						299	70.1%	139.5	166.2
1 (disengaged; n = 243)	0.75	0.34	0.15	0.20	37.7				
2 (exhaustive; n = 133)	1.73	0.47	1.49	0.38	48.7				
3 (benevolent; n = 261)	1.67	0.31	0.36	0.25	41.1				
k = 4						327	76.6%	115.7	151.4
1 (n = 126)	0.48	0.25	0.36	0.19	12.5				
2 (n = 124)	1.71	0.47	1.53	0.37	43.2				
3 (n = 168)	1.86	0.26	0.45	0.27	23.6				
4 (n = 219)	1.20	0.21	0.21	0.23	20.5				

Note: BP = Benefit-Provisioning Mate Retention Behaviors; CI = Cost-Inflicting Mate Retention Behaviors; SS_w = Sum of squares within clusters; SS_b = Sum of squares between clusters; EV = Explained variance; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; *M* = Mean; *SD* = Standard deviation; k = number of clusters.

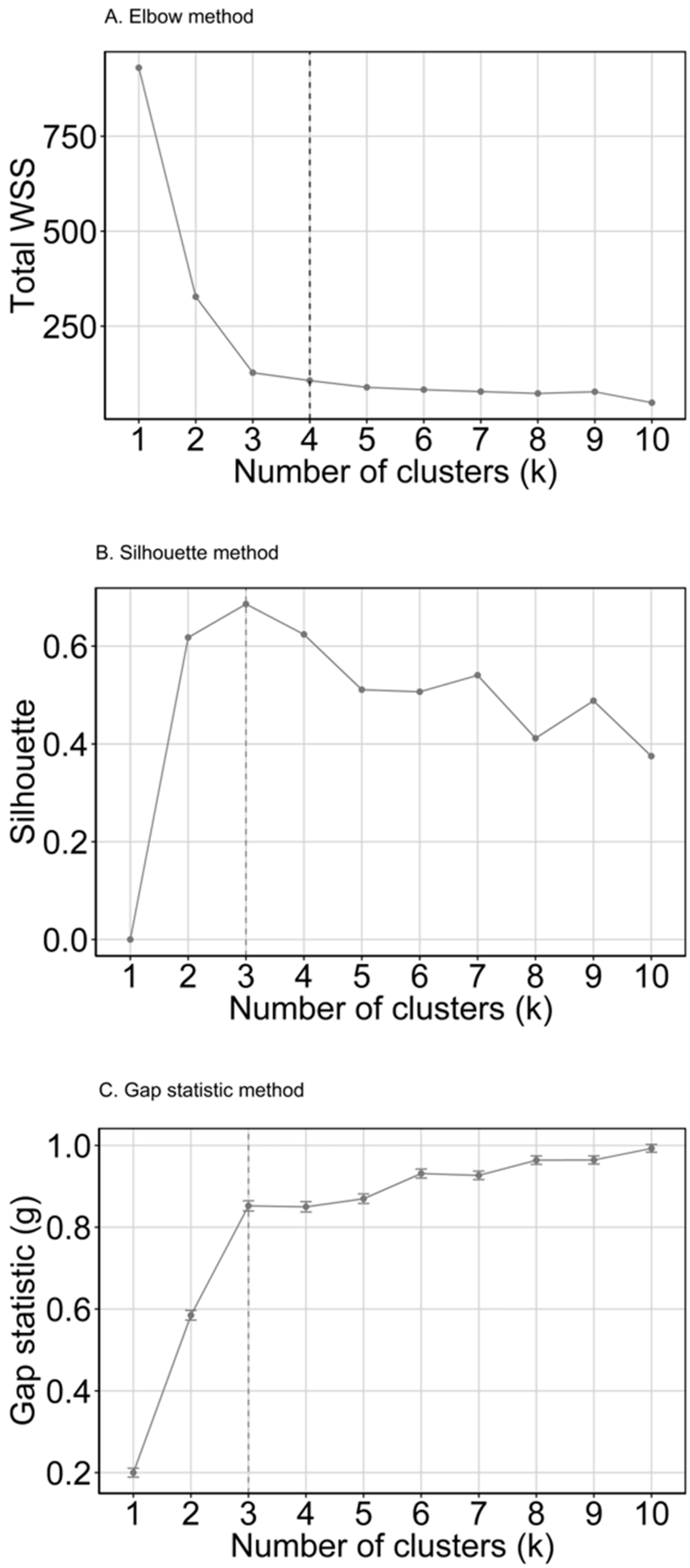

Figure 1 — Determining the optimal number of clusters (*k*)

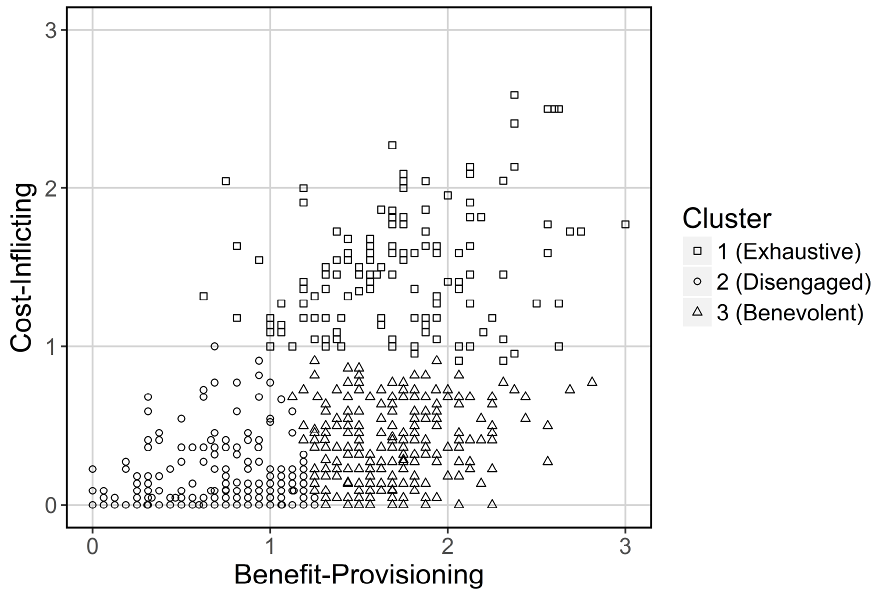

Figure 2 — Assignment of individuals to clusters ($k = 3$)

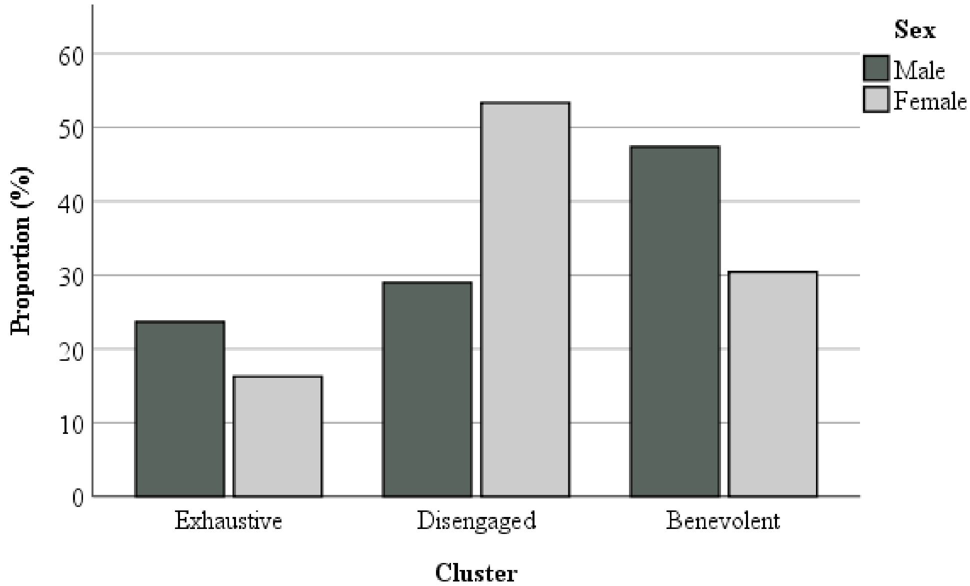

Figure 3 — Sex differences in the use of mate retention strategies

Note: Proportion reflects the percentage of men and women per mate retention strategy