



ELSEVIER

Contents lists available at ScienceDirect

Evolution and Human Behavior

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

Kin terms and fitness interdependence

Lee Cronk^{d,*}, Dieter Steklis^a, Netzin Steklis^a, Olmo van den Akker^b, Athena Aktipis^c^a School of Comparative and Biomedical Sciences, University of Arizona, Tucson, AZ, USA^b Department of Psychology, University of Amsterdam, Amsterdam, Netherlands^c Department of Psychology, Arizona State University, Tempe, AZ, USA^d Department of Anthropology, Rutgers University, 131 George St., New Brunswick, NJ 08901-1414, USA

ARTICLE INFO

Keywords:

Kin terms

Kinship terminologies

Kinship

Genetic relatedness

Fitness interdependence

ABSTRACT

Although genetic relatedness has been shown to be an important determinant of helping and other forms of cooperation among kin, it does not correspond well to the different types of kin designated by the kin terminologies used in human societies. This mismatch between genetic relatedness and kin terms has led some anthropologists to reject the idea that kin terms have anything to do with genetic relatedness or anything else biological. The evolutionary and cultural anthropological approaches can be reconciled through an appreciation of the concept of fitness interdependence, defined as the degree to which two or more organisms positively or negatively influence each other's success in replicating their genes. Fitness interdependence may arise for a variety of reasons, including not only genetic relatedness but also mating and marriage, risk-pooling, mutual aid, and common group membership. The major kin term systems correspond to cross-culturally variable but recurrent patterns of fitness interdependence among different types of kin. In addition, changes from one kin term system to another are associated with corresponding changes in recurrent patterns of fitness interdependence among kin, and kin terms are often used metaphorically in situations in which fitness interdependence has arisen among non-kin.

1. Introduction

Let's begin with two questions. The first one is fill-in-the-blank:

- (1) On average, what proportion of your genes do you share with your father's full-sister's son thanks to the fact that you share a set of grandparents? _____

The second question is multiple choice:

- (2) What do you call your father's sister's son?
- (a) The same thing you call your father's brother's son and all your mother's siblings' sons, but not what you call your brother
- (b) The same thing you call your mother's brother's son but not the same thing you call your brother, your father's brother's son, or your mother's sister's son
- (c) The same thing you call your sister's son and your daughter's son
- (d) The same thing you call your father and your father's brother
- (e) The same thing you call your brother

- (f) A term that you use for no relative other than your father's sister's son
- (g) Any of the above, depending on where you come from

If on the first question you answered 0.125 or 1/8, congratulations! You know how to calculate coefficients of relatedness.

As for the second question, if you come from the Americas, most of Europe, a few other places, or a small-scale, immediate-return foraging society, then you might be tempted by answer *a*. However, if you come from somewhere else, then *b*, *c*, *d*, *e*, or *f* may have seemed right. Thus, the best answer is *g*: Any of the above, depending on where you come from.

This was all summed up well by cultural anthropologist Marshall Sahlins in his anti-sociobiology diatribe *The Use and Abuse of Biology* (Sahlins, 1976:26):

"... there is not a single system of marriage, postmarital residence, family organization, interpersonal kinship, or common descent in human societies that does not set up a different calculus of relationship and social action than is indicated by the principles of kin

* Corresponding author.

E-mail addresses: lcronk@anthropology.rutgers.edu (L. Cronk), steklis@email.arizona.edu (D. Steklis), nsteklis@arizona.edu (N. Steklis), ovdakker@gmail.com (O. van den Akker), aktipis@asu.edu (A. Aktipis).

<https://doi.org/10.1016/j.evolhumbehav.2018.12.004>

Received 5 April 2018; Received in revised form 12 October 2018; Accepted 20 December 2018

1090-5138/© 2018 Elsevier Inc. All rights reserved.

selection.”

The father's-sister's-son example illustrates Sahlins' point. In the terminology used by English-speaking Americans (answer a in the question above), unless one adds qualifiers such as “first,” “second,” “once removed,” and so on, cousins with very different degrees of genetic relatedness to oneself are all lumped together as undifferentiated “cousins.” In the terminology used by the Yanomamö and many other people around the world (answer b), cousins who are equidistant from you genetically are split into two different categories, one of which also includes your siblings. In the terminology used by the Maasai and many other people around the world (answer c), relatives with whom you share a variety of different degrees of genetic relatedness are lumped together under a single term. The Hopi and many other people around the world do the same thing, but in a different way (answer d). Hawaiians and some other societies around the world lump siblings together with cousins of all varieties (answer e). Perhaps the Turks and a few other societies around the world have found relief from all of this: simply give each relative a different term (answer f). But, because it takes relatives with the same degrees of genetic relatedness to oneself and puts them in different categories, this turns out to be no solution at all. In no society do the words for various types of kin map neatly on to genetic relatedness.

Anthropologists have known all of this for a very long time. Indeed, the study of kin terminologies was once the bread-and-butter of sociocultural anthropology, and the discovery that kin terms varied across cultures in limited but interesting and patterned ways was one of the discipline's first important discoveries (Morgan, 1871; Fig. 1; see also Murdock, 1949; Goody, 1970; Schwimmer, 2003; Cronk and Gerkey, 2007, and Dousset, 2011). Although it is possible to categorize kin term systems in different ways, most anthropologists recognize six basic systems. It is common to refer to them by the ethnic group in which anthropologists first identified them, even if some of the labels have since fallen out of favor as ethnonyms (e.g., Eskimo).

The system that most westerners are most familiar with is the Eskimo system, which has a special set of terms for nuclear family members, distinguishes between different generations, and then lumps more distant relatives into broad categories (e.g., aunts, uncles, and cousins) regardless of whether they are related to the focal individual (ego) through his or her mother or father, a process called “collateral merging.” Because of this system's symmetry, it is often referred to as “bilateral.” In some languages, distinctions are made on the basis of sex (e.g., French's *cousin* and *cousine*) while in others males and females in a particular category may be lumped together (e.g., English's cousin).

The Iroquois system distinguishes between two kinds of cousins. Parallel cousins are those to whom one is related by a pair of same-sex siblings, such as one's father's brother's children or one's mother's sister's children. Parallel cousins are referred to by the same terms that are used for siblings, while cross cousins are referred to by a different set of terms. Accordingly, the parents of one's parallel cousins are referred to by the terms for mother and father while the parents of one's cross cousins are referred to by a different set of terms.

The Crow system sorts people out differently depending on whether they and the speaker are in the same matrilineage. Members of one's own matrilineage are referred to by nuclear family terms: One's matrilineal uncles are “fathers,” one's matrilineal cousins are “brothers” and “sisters,” and so on. Of course, one is also closely related to the matrilineage that one's father came from. In that matrilineage, however, relatives are lumped together even if they are from different generations. Thus, the same term is used for one's father's sister as for one's father's sister's daughter and for one's father's brother as for one's father's brother's son. The Omaha system is similar to the Crow, but instead of sorting people out according to their matrilineage memberships it sorts people according to their memberships in patrilineages.

In the Hawaiian system, all male relatives of one's own generation are referred to as “brothers,” all female relatives of one's own

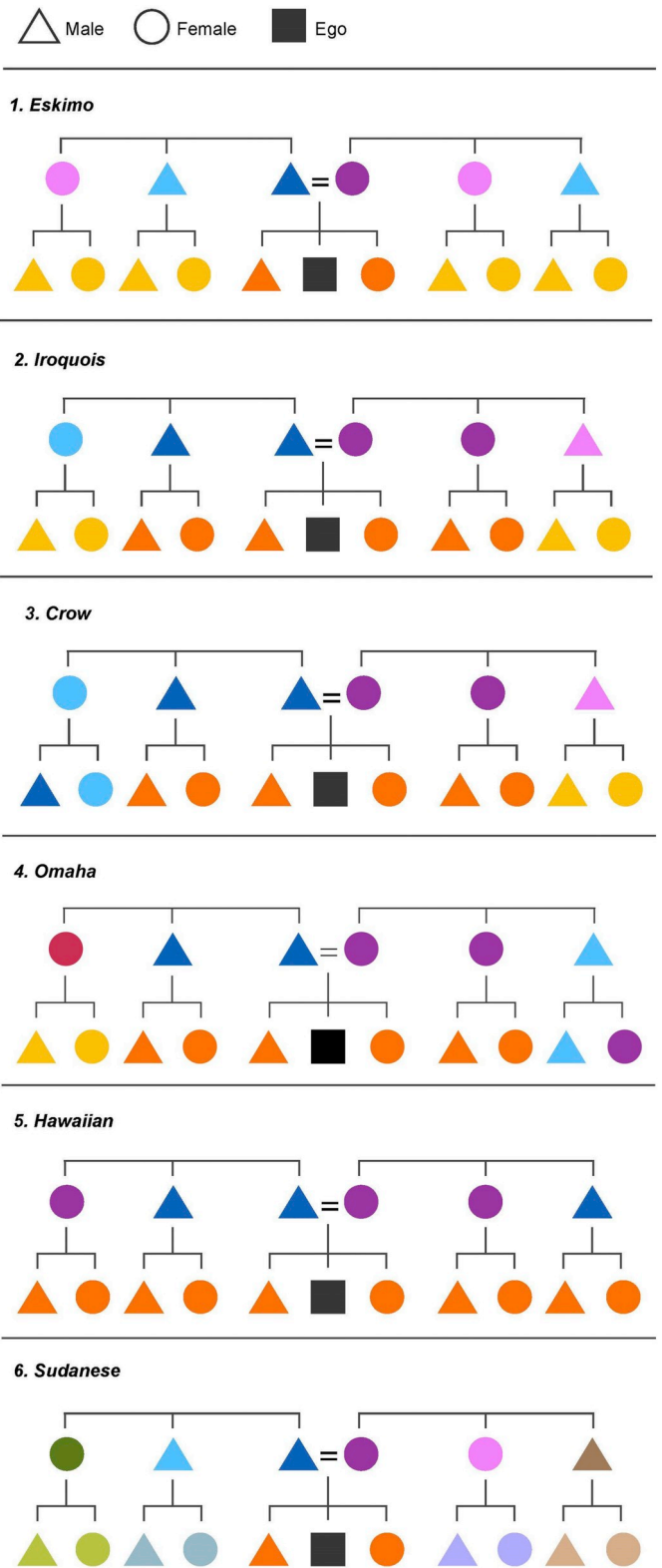


Fig. 1. The six major kin term systems. The black square represents the focal individual or ego, triangles refer to males, and circles to females. Colors correspond to the terms used by ego to refer to each type of relative.

generation are referred to as “sisters,” all male relatives of one's parents' generation are referred to as “fathers,” and all female relatives of one's parents' generation are referred to as “mothers.” This is in stark contrast to the Sudanese system, in which each type of relative is referred to by a unique term.

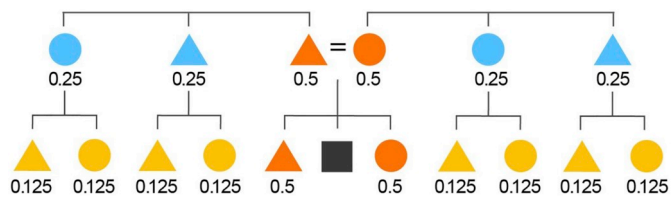


Fig. 2. An imaginary kin term system in which labels, indicated by colors, correspond to average degrees of genetic relatedness.

Outside of sociocultural anthropology, and particularly in evolutionary circles, it is less widely known that such variation exists across societies in kin terminologies and that they often do not correspond with genetic relatedness. Consider, for example, this quote from some prominent evolutionary psychologists (Daly, Salmon, and Wilson, 1997:281):

“. . . the characteristic closeness of kinship categories is always negatively correlated with the characteristic number of genealogical links defining them, and hence positively correlated with genetic relatedness (r).”

How can otherwise well-informed researchers maintain such a counterfactual belief? It may not be coincidental that most evolutionary scientists hail from societies that use the Eskimo terminology, which is the only one of the six terminological systems that maps at all well onto genetic relatedness in that it distinguishes the nuclear family from collateral (“to the side”) kin categories (aunts, uncles, and cousins). If we were to imagine a system of kin terms that did correspond to genetic relatedness (Fig. 2), then all we would need to do to move from it to the Eskimo system would be to add distinctions based on generation and sex. But a comparison between the other five systems shown in Fig. 1 with the imaginary system shown in Fig. 2 reveals that such an easy transformation is not possible in every case.

Recent years have seen several notable efforts by evolutionary scholars to explain aspects of human kinship, including kin terminologies (e.g., Chapais, 2009; Jones, 2003a, 2003b, 2004, 2010; Trautmann et al., 2011). As Trautmann et al. (2011:179) note, “the vexed problem” of “the relationship between biological and social kinship [...] has dogged the study of kinship virtually from the beginning.” They continue:

The difference between kinship as a social fact and as a biological process requires us to write across the Hegelian gap separating nature from history. In the study and everyday experience of kinship, there is a sense in which every living being has relations of shared substance with others and is the product of those relations, which can be described in biological terms or with reference to shared blood, bone, or flesh. But human kinship is also something learned and lodged in consciousness, a set of rules that can be applied, through marriage or adoption, to people who are not biological kin. These rules vary widely among humans, such that close kin in one society are not considered relatives at all in another.

Here we suggest that the concept of fitness interdependence, which includes but is much broader than genetic relatedness, may allow us to understand why kin terms correspond so poorly with genetic relatedness and thus to “write across the Hegelian gap.”

2. Kin terminologies as cultural systems

If genetic relatedness cannot fully explain the variety of kin terminologies around the world, what can? One possibility is that kin terminologies are purely cultural systems with no relationship whatsoever to genetic relatedness or anything else biological. This is the position taken by Sahlins (1976, 2013) and many other cultural anthropologists (e.g., Needham, 1971; Carsten, 2004; McKinnon, 2005).

The late David Schneider (1968, 1972, 1984) is usually seen as having been the founder of this approach. Each one of these authors has his or her favorite ethnographic examples of disparities between genetic relatedness and other biological facts on the one hand and culturally constituted kin categories and roles on the other. For example, Sahlins (1976:35–6) notes that

“In the East African Sudan, dead men marry, and barren women are fathers. For the Nuer, a woman who does not bear children counts as a man. If she can amass cattle through bride-price dues and the trade of magic, she espouses one or more other women in regular marital rites. Her wives are impregnated by a kinsman, friend, neighbor, sometimes by a member of a subordinate tribe (Dinka). But the biological father is merely the *genitor* of her children; the woman herself is the true or legal father (*pater*), as she is the legal husband of their mothers.”

Schneider (1984) pointed out that on the Micronesian island of Yap, the father-son (*citamangen-fak*) relationship is more about ‘doing’ than about ‘being.’ Such a relationship may be made stronger or weaker by whether the *citamangen* and *fak* in question conform to Yapese norms for that relationship, so much so that *citamangen-fak* relationships do not necessarily include any genetic component (though of course many of them do). For Janet Carsten, kinship among Malay on the island of Langkawi is not primarily about biology but rather co-residence: “. . . kinship is *made* in houses through the intimate sharing of space, food, and nurturance that goes on within domestic space” (2004:35, emphasis in original; cf. Shapiro, 2011). For Susan McKinnon (2005:111), kinship is not about biology but rather about “acts of nurturance and solicitude.” To her, such acts “constitute the very definition of kinship.” McKinnon illustrates this with an example from the Tanimbar Islands in Indonesia, where unrelated men who “treat each other well” are referred to as brothers, which in turn leads other individuals also to refer to them by various kin terms despite the fact that they are related neither genetically nor by marriage (see also McKinnon, 1991).

To this list we can add our own favorite examples: Among the Mukogodo, a Maa-speaking group living in north central Kenya, widows usually do not remarry but often continue to bear children who, despite the complete absence of sperm banks, are considered the legal offspring of their dead husbands. In some cases, a young woman may not marry at all but rather remain in her father’s settlement, bearing children in his name but without ever having sex with him (Cronk, 2004). The point is that in virtually every society it is indeed quite easy to find instances in which genetic relatedness and other biological facts do not dictate the way that kinship is spoken about and dealt with socially and legally.

A partial solution to the problem of mismatch between kin terms and genetic relatedness may be found in the concept of focality (Shapiro, 2008, 2016). Across languages, words may be used to refer both to a range of things that fall into a type or class and to one particular member of that type of class that, in the view of native speakers, represents the best example of it. For example, if a native English speaker is given an array of paint chips and asked to sort them into piles corresponding to English’s basic color terms (red, blue, yellow, etc.), he or she will toss chips of a variety of reddish shades into the “red” pile. But if you ask that same person to pull out one chip that best represents the core meaning of the word “red,” you will learn what that person thinks the focal referent of the term really is (for more on focality in the realm of color terminologies, see Berlin and Kay, 1991).

The principle of focality also applies to kin terms (Shapiro, 2008, 2016). Napoleon Chagnon demonstrated this by asking Yanomamö which of several kin they refer to as *abawā* (i.e., brother and parallel cousin) was their “real” *abawā*. His interviewees had no trouble both understanding the question and distinguishing between those with whom they share a mother or father rather than, say, a set of grandparents or great-grandparents (Chagnon, 1981; see also Daly et al.,

Table 1
Several ways positive fitness interdependence can arise.

Settings of fitness interdependence	Sources of positive fitness interdependence	Proximate cues associated with fitness interdependence	Example kin terms for resulting relationships
Reproduction	Genetic relatedness	Non-linguistic kin recognition mechanisms	Mother, father son, daughter, and other terms for consanguineal (i.e., genetic) kin
Mating and marriage	Shared descendants (children, grandchildren, etc.)	Sexual relationships, marriage ceremonies	Husband, wife, and terms for affinal (i.e., by marriage) kin
Dependence on same parents or other caregivers (e.g., alloparents)	Shared dependence on a common source of resources, protection, etc.	Shared rearing environment	Sibling terms: full-, half-, step-, and foster brothers and sisters
Co-residence	Shared subsistence activities, shared group defense, etc.	Co-residence itself	Use of kin terms for co-residents; use of closer kin terms (e.g., brother and sister) for co-residents than for non-co-residents (e.g., cousin)
Sharing of resources, mutual aid	Mutual support through risk-pooling and reciprocity	Such acts as sharing food, caring for the ill and injured, etc.	Use of kin terms for risk-pooling partners
Membership in the same corporate descent group in which rights and obligations are shared	Dependence on the same corporate group (lineage, clan, etc.) for important resources, help finding marriage partners, access to inherited positions, etc.	Participation in activities organized by descent groups, including subsistence (e.g., farming of jointly owned fields) and ceremonial or ritualistic (e.g., worship of common ancestors or deities) activities	Use of the same terms for both siblings and some or all cousins, as in some kin terms systems
Membership in same religious group	Dependence on the same corporate group (e.g., a congregation) for resources, advice, emotional support, etc.	Participation in religious rituals and other activities	Use of kin terms for co-religionists and/or deities
Warfare and other forms of intergroup conflict	Survival, resource acquisition and mating opportunities of individual may depend on success of the group as a whole	Awareness of a common enemy, opponent, or threat, whether through actual contact or through rituals (e.g., military parades) or symbols (e.g., uniforms, flags)	Use of kin terms for co-combatants, teammates, or allies

1997). Similarly, Australian aborigines in northeast Arnhem Land distinguish between “full” (*dangang*) and “partial” (*marrkangga*) members of kin categories (Shapiro, 2008:141; see also Shapiro, 1979). Another way to clarify a relationship is to refer explicitly to the relevant biological facts. For example, Maa speakers use their terms for brother (*olalasha*, pl. *ilalashera*) and sister (*enkanashe*, pl. *inkanashera*) to refer not only to those terms' focal referents but also to people that users of the Eskimo kin term system would refer to as cousins. However, when asked to clarify relationships they have no trouble distinguishing between those with whom they did and did not “share the breast” (*ang'ar olkina*) and, crucially, they also had no trouble understanding why anyone would ask such a question: Not all of one's *ilalashera* or *inkanashera* are the same.

By providing people with ways to label gradations of relatedness between themselves and different kinds of people who fall into particular kin categories, focality could help align kin terms with genetic relationships. If such modifiers were used to increase the fit between genetic relatedness and kin term, then the distinctions between the various kin terminologies would not really matter because the modifiers would create essentially equivalent terms across the different terminologies that correspond with genetic relatedness. In practice, this is not what happens. The different kin terminologies are different in ways that have real impacts on fitness-relevant behaviors (Chapais, 2009:50–51). For example, the distinction made in the Iroquois terminology between cross and parallel cousins helps determine whom one can and cannot marry: cross cousins are preferred marriage partners while parallel cousins are off limits. Kin terminologies that indicate lineage membership, such as the Crow and Omaha systems, provide fitness-relevant information about such issues as from whom one is eligible to inherit and who one's allies are likely to be in times of war. Focality is thus only a partial solution to the mismatch between genetic relatedness and kin categorizations.

3. Kin terminologies as biocultural systems

If kin terms aligned with genetic relatedness, then all languages would share a single kin term system, and the words for various kinds of kin would translate directly from language to language. Clearly, that is

not the case. If Sahlins and his colleagues were correct that kin terminologies are purely cultural systems that refer in no way to any biological facts, then we might expect hundreds or thousands of them, just as there are thousands of languages. Clearly, kinship terminology systems are not purely arbitrary cultural systems. What we have instead are six main systems (Fig. 1) and a limited number of modifications of those systems. This suggests that while kin terminologies are indeed cultural systems in the sense that they consist of socially transmitted information (Cronk, 1999; Alvard, 2003a), the ways that they can vary are constrained in some way.

Let us take a step back and consider what purpose kin terminologies serve in human societies. Given that humans have been shown to share a variety of kin recognition mechanisms with nonhumans, including situational (Westermarck, 1891; Shepher, 1971, 1983; Wolf, 1995; Lieberman et al., 2007; Lieberman and Lobel, 2012; Sznycer et al., 2016), olfactory (Weisfeld et al., 2003), and visual (De Bruine, 2002, Krupp et al., 2008) cues (for a recent review, see Mateo, 2015), kin terms may be unnecessary for distinguishing among close kin and between close and distant kin, and we must look elsewhere for their purpose. In our view, the purpose of kin terms is to provide a set of shared conventions and understandings regarding the different types of kin that are recognized in a society and the roles that they play in one another's lives so that people are able to coordinate their behaviors, manage conflicts of interest, and make fitness-enhancing decisions regarding their interactions with those with whom they are interdependent (Gerkey and Cronk, 2010; see also Cronk, 2017).

Fitness interdependence refers to “the degree to which two or more organisms positively or negatively influence each other's success in replicating their genes” (Aktipis et al., 2018; see also Roberts, 2005; Brown and Brown, 2006; Tomasello et al., 2012). Fitness interdependence between two individuals includes but is not limited to the genes they share in common. It also includes situations in which individuals have shared fates, shared interests or other dependencies that give rise to fitness interdependence. Fitness interdependence can be both positive, as when one individual's success also benefits someone else, as in mutualistic relationships, and negative, as when one individual's success necessarily comes at the expense of someone else, as in host-pathogen and predator-prey relationships. Positive fitness

interdependence can arise for a variety of reasons, including shared ancestry (i.e., genetic relatedness), shared descendants (i.e., mating and, among humans, marriage and affinal relationships), membership in the same culturally-defined group, and risk-pooling arrangements (see Table 1). Even among kin, fitness interdependence can sometimes be negative, meaning that what improves one party's fitness decreases the fitness of the other party (Shryock, 2013:272). Sibling rivalry over parental resources is an obvious example. We suggest that, although kin terms do not align well with genetic relatedness, they may align instead with patterns of fitness interdependence that vary but that also frequently recur across human societies. The fact that there are only a limited number of kin term systems may reflect this combination of significant but limited variations in patterns of fitness interdependence across human societies. This argument was anticipated by Hughes (1988:129) when he wrote that “kinship terminologies group individuals in ways that are biologically important and concentrate attention on biologically significant individuals.” Also in line with our argument is Jones' proposal that the grammar of kin terms is derived from “three universal ‘primitives’ of social cognition” that may often be major determinants of fitness interdependence: genealogical distance, social rank, and group membership (Jones, 2003a:303).

Table 1 lists some of the ways positive fitness interdependence may arise among humans. The first is already well known: genetic relatedness. A great deal of research has shown that variations in genetic relatedness are associated with helping and other social behaviors in a way that is broadly consistent with inclusive fitness theory. Although Hamilton's Rule is phrased in terms of a genetically related dyad, Jones (2000; see also Jones, 2016) has pointed out that in some circumstances it may be more efficient for multiple related individuals to work together to provide aid to another genetically related individual. This may create selection pressure in favor of the creation of groups that enforce “an ethic of unidirectional altruism toward kin” (p. 779). Jones argues that “classificatory kinship's insistence that a relative outside the sibling group be treated as equally related to all sibling group members and related customs treating kin as interchangeable may act as devices for pooling nepotism” (p. 790). This is very much in line with our suggestion about the relationship between fitness interdependence and kin terms.

In contrast with the amount of work done on the impacts of genetic relatedness on helping and other social behaviors, our understanding of the impact on fitness interdependence through the possession of shared descendants is mostly limited to studies of pair bonds and parental behavior. The impact of more distant affinal ties on fitness interdependence and behavior has been theorized (e.g., Dow, 1984; Hughes, 1988; David-Barrett, 2016), but to our knowledge only one empirical study has been conducted on this topic. Burton-Chellew and Dunbar (2011) found that, in a sample of Belgians, affinal kin are reported to be approximately as close emotionally as genetic kin, with both types of kin felt to be closer than unrelated friends. This is an important frontier for future work on kinship, fitness interdependence, and behavior.

The third source of fitness interdependence listed in Table 1 is also fairly well understood: a shared environment of rearing and nurturance. Even if the individuals so reared are not genetically related, their mutual dependence on the same caregivers creates a form of fitness interdependence. Shared rearing conditions may also trigger the non-linguistic kin recognitions described above, including but not limited to the Westermarck effect, and thus generate emotions that reflect the degree of fitness interdependence among the individuals in question. The result may be what Holland (2012) refers to as “nurture kinship,” in which what creates the feeling of kinship is not so much genetic relatedness as the act of nurturance. This is in line not only with the approach taken here that emphasizes fitness interdependence but also with cultural anthropological approaches to kinship described above that emphasize the “nurturance that goes on within domestic space” (Carsten, 2004:35). Of course, at the same time that individuals who are

dependent upon the same caregiver have aligned interests (and, thus, positive fitness interdependence) regarding the survival of the caregiver, mutual dependence on the same caregivers can also lead to rivalries (and, thus, negative fitness interdependence) over how care and other resources are allocated.

Regardless of whether it arises via shared parentage, marriage, or something else, simple co-residence can in itself lead to high degrees of fitness interdependence. This may be particularly true where mobility is limited and the household is the locus of most economic production, as in most small-scale societies. In such a situation, those with whom one is living are automatically one's coworkers and allies in combat, leading to high levels of interdependence (Murdock, 1949:147–148). For example, matrilocality may be useful in societies that experience external warfare. By bringing together men who may be unrelated genetically, matrilocality both creates fitness interdependence among those men and ties men's marital communities to their natal communities, thus creating a larger coalition than if the men were to reside patrilocally (Divale, 1974; Jones, 2011; see also Ember and Ember, 1971; Ember, 1974). In line with this is Murdock's observation that postmarital residence patterns are often fundamental determinants of other aspects of society, including kin terms: “. . . when any social system which has attained a comparatively stable equilibrium begins to undergo change, such change regularly begins with a modification in the rule of residence” (Murdock, 1949:221; cf. Opie et al., 2014).

The sharing of critical resources among people who are not co-residents (e.g., cattle in pastoralist societies) can also create fitness interdependence, and such sharing relationships are sometimes marked by kin terms or terms related to kinship. Consider, for example, the use of the term *osotua* (pl. *isotuatin*) by Maasai and other Maa-speaking pastoralists in East Africa to refer to a specific type of risk-pooling relationship involving transfers to those in need without expectation of repayment (Cronk, 2007; Aktipis et al., 2011). *Oсотua* is not a kin term in the same way that “brother” and “cousin” are kin terms. Instead, its literal meaning is “umbilical cord,” and its usage to refer to a contractually agreed upon gift-giving relationship has several effects. First, it identifies the relationship as being equivalent to a type of kinship, even if it is not one that fits into any of the categories in the version of the Omaha kin term system used by Maa-speakers. Second, it imbues such relationships with the same kind of sacredness and importance that is customary between a mother and her children. Third, it usefully leaves ambiguous the question of which of the two people involved in such a relationship is the “mother” and which is the “fetus,” which is appropriate given that the future needs of the two parties to the agreement are unknown: either of them may be the “mother” today and the “fetus” tomorrow, depending on such unpredictable events as drought, disease, and livestock theft. In sum, the use of the term *osotua* for such relationships captures the degree to which *isotuatin* have intertwined their fates.

The final three sources of fitness interdependence listed in Table 1 have in common the fact that they all involve individuals' membership in various kinds of groups. When such culturally-defined groups meet the conditions for natural selection and compete with each other, cultural group selection can shape group-level norms and characteristics (Henrich, 2004; Soltis et al., 1995; Smaldino, 2014; Richerson et al., 2016). Particularly when such groups are corporate, i.e., seen by society as legal individuals, competition among them has the potential to be a powerful selective force (Gerkey and Cronk, 2014; Cronk, 2015; Leech and Cronk, 2017). Corporate groups have high fitness interdependence because within them individuals often share benefits and costs, entwining their fitness interests with one another. Such groups often do better in competition with one another when members are willing to invest highly in the group and pay costs in order to be a part of the group (Wildman and Sosis, 2011). Cultural group selection thus favors groups that find ways to persuade their members to pay such costs and that successfully create feelings of interdependence.

Just as the theory of kin selection sparked an interest among animal

behaviorists in kin recognition mechanisms, the concept of fitness interdependence raises the issue of how people become aware, whether consciously or unconsciously, of the ways and degrees they are interdependent with others. As indicated in Table 1, rituals may play an important role in the creation of group identities sufficient to motivate altruistic behaviors and feelings of interdependence. Rituals may create common knowledge about who is in the group, what is expected of them (Chwe, 2003), and the challenges and opportunities that they face together (Aktipis, 2016). Through entrainment of motion and the generation of strong emotions, trances, and other unusual states of consciousness, rituals may provide participants with an intuitive rather than a purely intellectual understanding of their interdependence with the group (Aktipis, 2016), which can then lead to higher rates of cooperation (Reddish et al., 2013). Some research suggests that singing together in karaoke may help build trust among Taiwanese businessmen (Holt and Chang, 2009), suggesting that the entrainment that happens during singing together may be a reliable cue of future cooperation. Whether this ritual of singing together increases trust because it builds common knowledge about their interdependence is an open question, but perhaps one worth following up on in future work.

Recent research on religion from an evolutionary perspective provides support for the idea that religions create fitness interdependence among their members by enhancing cooperation. This effect is enhanced when members send to each other costly signals of commitment to their shared religion (Irons, 2001; Sosis and Bressler, 2003; Sosis and Ruffe, 2003). The Afro-Brazilian religion Candomblé is particularly relevant for our current purposes because it incorporates the use of kin terms (Soler, 2012). Candomblé is centered on local, autonomous congregations, known as *terreiros*. Practitioners worship *orixás*, deities that “embody *axé*, the life force of the universe” (Soler, 2012: 348). Worship services involve time consuming and exhausting divination rituals, dances, and trances, as well as the observation of a variety of behavioral stipulations and restrictions. Each *terreiro* is led by either a *mãe-de-santo* or *ialorixá* (“mother of the saint”) or a *pai-de-santo* or *babalorixá* (“father of the saint”). Their followers are known, logically, as *filhos-de-santo*, or “children of the saint.” Soler (2012) has shown that *terreiro* members who display higher levels of costly commitment to the religion also report more generous behaviors in everyday life and behave more generously in an experimental economic game. Given that *terreiros* compete with each other for members and often do not survive the deaths of their leaders, an interesting avenue for future research would be to see whether *terreiros* that succeed in eliciting from their members both more costly signs of commitment and more cooperative acts toward other members also attract more members and survive longer than other *terreiros*, as seems to have been the case with other religious communities (e.g., Sosis and Bressler, 2003).

Rituals do not need to be as dramatic as those seen in Candomblé in order for them to be effective in evoking a sense of shared fate and interdependence. Consider, for example, the subtle difference between “food sharing” and “sharing food.” The first is a technical specification: food is given by one individual to one or more other individuals. The second, in contrast, is usually used to mean something a bit different: The consumption of food by more than one person at the same time, often from common vessels. The sharing of food is thus more than simple food sharing. In addition to being a physical act, sharing food is also a ritual activity with potentially great emotional import. Witness, for example, the importance of sharing food in so many religious contexts such as, in the Abrahamic religions, Christian communion, the Jewish *seder* at Passover, and fast-breaking *iftar* dinners consumed by Muslims after the sun sets during the holy month of Ramadan. The importance of eating together for building relationships, enhancing cooperation and creating shared identity is an anecdotal fact, but also one that has been documented empirically (Argyle, 2013; Janowski, 1995). Furthermore, negotiation guides advise that eating meals together contributes to successful outcomes in negotiations (Graham and Lam, 2003; Bernard, 2009). Although we know of no experiments that

have examined whether eating together enhances trust and cooperation, some studies have found that eating the same food increases trust in the investment game (Woolley and Fishbach, 2017).

4. Modeling and measuring fitness interdependence

Roberts (2005) provides a theoretical framework for understanding fitness interdependence that is based on an extension of Hamilton's Rule (Hamilton, 1964). In Hamilton's original formulation, selection will favor individuals who help a genetically related individual to enhance his or her fitness at some cost to the individual's own fitness if the following inequality is met, where c = the cost to one's own fitness, b = the benefit to the recipient's fitness, and r = the genetic relatedness between oneself and the recipient:

$$rb - c > 0.$$

Unless the recipient is a clone or identical twin, r will be less than one, and so the benefit to the recipient will need to be considerably more than the cost to the actor in order for this inequality to be met and thus for selection to favor the behavior in question.

Roberts' innovation is to generalize r , genetic relatedness, to s , meaning any sort of stake one individual might have in the fitness of another individual, including but not limited to one arising from shared ancestry. More technically, Roberts defines stake as “a measure of the extent to which changes in the fitness of one individual are reflected in changes in the fitness of the other” (2005:902). Replacing genetic relatedness with stake and so r with s gives us the following inequality:

$$sb - c > 0$$

One implication of Robert's model is that, given that s is a broader concept than r , the circumstances in which selection might favor altruistic acts might also be broader and more common than under Hamilton's Rule alone.

Balliet et al. (2017) have taken a somewhat different – though not incompatible – approach to modeling fitness interdependence called Functional Interdependence Theory (FIT; see also Kelley and Thibault, 1978 and Kelley et al., 2003). In FIT, social situations are characterized by four dimensions: Degree of Interdependence, Degree of Correspondence, Basis of Interdependence, and Asymmetry of Dependence. Degree of Interdependence indicates the extent to which decisions made by actors in two-person games have an impact on each other's payoffs. Degree of Correspondence indicates the extent to which the interests of actors in a two-person game correspond or conflict with each other. Basis of Interdependence describes “the degree to which an individual's behavior can influence how a partner's behavior determines that individual's outcomes” (p. 366). It is a ratio of the degree to which each actor's payoff in a two-person game is determined by their partner's behavior and the degree to which each actor's payoff is determined by its own behavior (termed “Mutual Joint Control”). Asymmetry of Dependence indicates the extent to which one actor in a two-person game has the power to unilaterally determine not only their own but also their partner's payoffs.

Measuring fitness interdependence may be difficult, particularly in long-lived species such as humans, because it is difficult to measure the impacts of individual behaviors on fitness. One approach would be to instead use a currency thought to be a proxy for fitness, such as the amounts of different types of aid given and received by different categories of kin. This would be analogous to the use of calories as a proxy currency in studies of foraging (e.g., Hawkes et al., 1982). Another approach would be to characterize routine social situations in terms of characteristics indicative of interdependence, such as the dimensions described by Functional Interdependence Theory (Balliet et al., 2017). For example, Gerpott et al. (2018) developed the Situational Interdependence Scale (SIS), which maps social situations onto five dimensions of interdependence: mutual dependence, power, conflict, future

dependence, and information certainty. Another approach is to ask not about particular social situations but rather about particular target individuals. For example, Aron et al.'s (1992) Inclusion of Other in the Self Scale asks people to choose which set of seven pairs of increasingly overlapping circles best represents their relationship with another individual. Similarly, Korchmaros and Kenny (2001) developed a measure of closeness that consists of a single question – “How close do you feel to this person?” - coded on a seven point scale ranging from “not at all close” to “extremely close.” Building upon these foundations, Szyner et al. (2017 and in prep.) have developed two Perceived Fitness Interdependence scales. The PFI 1 scale measures positive interdependence by asking participants to rate on a seven-point agree-disagree scale statements such as “When [target individual] succeeds, I feel good.” The PFI 2 scale measure both positive and negative fitness interdependence via such questions as “[Target individual's] gain is [my gain/my loss].” Among US participants on Amazon Mechanical Turk, the PFI 1 and PFI 2 scales were generally better at predicting people's willingness to help target individuals in various ways (e.g., providing temporary housing, lending money, helping move, donating a kidney) than the Inclusion of Other in Self Scale, Korchmaros and Kenny's closeness scale, and, importantly for our argument, genetic relatedness (see also Brown, 1999; Brown and Brown, 2006).

Cross-cultural databases will also prove useful in testing ideas about kin terms and fitness interdependence. Indeed, they already have: a search for “kin terminology” in a comprehensive database of cross-cultural tests (Ember, 2016) yields 148 hits. In recent years, great progress has been made in cross-cultural studies thanks to the adoption of phylogenetic methods of analysis, which use language trees to control for the possibility of a lack of statistical independence among data points from different but related societies, an issue known as Galton's problem. For example, Jordan (2011) has used the phylogenetic comparative method to reconstruct ancestral patterns of terms for siblings in the Austronesian language family. An interesting feature of some languages in that family is that they have different terms for one's older and younger siblings and different terms for siblings depending on whether the speaker is male or female. Jordan's analyses indicate that early Austronesian languages had only the relative age distinction but not the relative sex distinction. For other examples of the use of the phylogenetic method to examine aspects of kinship, residence, and descent, see Jordan et al. (2009), Fortunato and Jordan (2010), Jordan (2013), Opie et al. (2014), and Guillon and Mace (2016). One shortcoming of cross-cultural tests is that, because no codes currently exist for fitness interdependence, researchers must infer interdependence based on such indicators as residence patterns and descent group membership. Such studies should therefore be complemented by field studies that test the associations between such indicators and fitness interdependence as measured by the scales described above. For some predictions regarding what such studies might find, see Table 2.

5. Fitness interdependence and the six major kin terminologies

Kin terms may help guide behavior by providing information about fitness interdependence: Who is likely to give me the most resources and other forms of help? Who are my likely allies if conflict arises? Whom am I allowed to marry, and who is forbidden as a marriage partner? What is my position relative to someone else in a familial hierarchy? And so on. In this section, we examine how each of the six kin terminology systems may help answer questions like these. The use of kin terms may also create common knowledge about the answers to these questions, helping to coordinate and possibly also reduce conflict within the groups using these kin terminology systems.

The kin terminology system we are most familiar with in Western societies is known as the Eskimo system. Does the Eskimo kin term system reflect patterns of fitness interdependence in societies that use it? The Eskimo system is common in societies in which the nuclear family is an important unit and in which descent groups (e.g., lineages

Table 2

Some predictions regarding the relationship between kin terminologies and fitness interdependence.

- (1) The Eskimo system will be used predominantly in societies in which fitness interdependence, as measured by such tools as the Situational Interdependence Scale (Gerpott et al., 2018) and the Perceived Interdependence Scales (Szyner, 2017), is typically and markedly greater between individuals in the same nuclear family (e.g., siblings) than between individuals in related but different nuclear families (e.g., cousins).
- (2) The Iroquois kin terminology system will be found primarily in societies in which fitness interdependence, as measured by the scales mentioned above, is heightened among cross cousins by the custom of preferential cross-cousin marriage.
- (3) The correspondences between the Omaha, Crow, and Hawaiian terms systems and patrilineality, matrilineality, and ambilineality, respectively, will reflect recurrent patterns of fitness interdependence, as measured by the scales mentioned above, in these three types of societies. For example, the lumping of relatives from different generations that occurs in the Omaha and Crow systems to people one is related to through one's non-linking parent (i.e., one's mother in a patrilineal society and one's father in a matrilineal society) will reflect lower levels of average fitness interdependence between oneself and those relatives than between oneself and other members of one's lineage.
- (4) Across all kin term systems, the use of the same kin term (including modifiers that increase the term's specificity) for different kinds of relatives will reflect similarities across those types of relatives in terms of the degrees and kinds of interdependence, as measured by the scales mentioned above, that people in a society routinely experience with them. Conversely, the use of different terms for different kinds of relatives will reflect dissimilarities in terms of the degrees and kinds of interdependence that people in a society routinely experience with them.
- (5) When societies shift from the use of one type of kin term system to another, this will reflect corresponding shifts in recurrent patterns of fitness interdependence, as measured by the scales mentioned above.
- (6) When people use kin terms to refer to others to whom they are not related genetically or by marriage, this will reflect either (a) the reality of the degree and type of fitness interdependence they have with each other, (b) a desire on the part of one or both parties to create the kind and degree of fitness interdependence typically indicated by the term in question, or (c) an attempt by a signaler to manipulate the behavior of a receiver by evoking a sense of fitness interdependence.

and clans) are absent (Fox, 1967). These include Western industrialized societies and immediate-return foraging societies (e.g., Ju/'hoansi: Lee, 1993). In such societies, the nuclear family is usually the basic unit of domestic and social organization. As a result, nuclear family members are likely to have higher levels of fitness interdependence with one another than with relatives outside the nuclear family. Thus, the Eskimo system does reflect recurrent patterns of fitness interdependence in the societies in which it is used.

The distinction made in the Iroquois system between cross cousins and parallel cousins is relevant to fitness and fitness interdependence for a very important reason: One is allowed to marry only people who fall in the cross-cousin category; sex and marriage with anyone in the parallel cousins category, who are referred to by the same terms as one's siblings, are forbidden and considered incestuous. Among the Yanomamö, for example, a man refers to his female cross-cousin as his *suaböya*, which translates into English not only as “female cross-cousin” but also, in principle, as “potential wife,” “wife,” “potential sister-in-law,” and “sister-in-law” (in case he ends up marrying her sister). Not surprisingly, this system is common in societies where cross-cousin marriage is preferred or required. Thus, kin terms may serve to identify individuals with whom one has different kinds of fitness interdependence. Those individuals whom one calls mother, father, brother or sister are individuals likely to have an immediate stake in one's wellbeing and to help with day-to-day needs. On the other hand, cross-cousins will be individuals with whom one has a more distant relationship, but one that could turn into a mating relationship, with fitness interdependence arising largely from the potential for shared offspring.

The importance of kin terms among the Yanomamö is reflected in the ways in which they attempt to manipulate the system. Adult males use the term *suaböya* to refer to more of their relatives than should be in that category if the rules are strictly applied, thus attempting to

increase their pool of eligible marriage partners. Juvenile males, on the other hand, use the term for mother more often than they should, thus perhaps attempting to increase the number of adult females who are willing to care for them (Chagnon, 1988, 2000). Such a kin terminology system may have emerged in the context of arranged marriages and direct exchange of spouses between unilineal descent groups. When such practices occur repeatedly between the same families over generations, the result is a pattern of cross-cousin marriage (Irons, 1981).

In many societies, people organize themselves into groups based on shared descent from a particular ancestor. The most common way to do this is from a common male ancestor through all male links, a system known as patrilineal or patrilineality. Many patrilineal societies use the Omaha kin terminology, which sorts people based on whether they are in the same patrilineage as oneself. Similarly, many matrilineal societies use the Crow terminology, which sorts people based on whether they are in the same matrilineage as oneself. The contrast in these systems between the fine-grained distinctions made within one's own lineage and the lumping that occurs in the lineage to which one is related but not a member may reflect differences in recurrent patterns of fitness interdependence with these two groups of relatives. Specifically, it is from members of one's own lineage that one is likely to gain access to land and other crucial resources. These ideas about both the Crow and Omaha systems could be tested through fieldwork focusing on the expectations and behaviors associated with different kin terms. The associations between the Crow system and matrilineality and the Omaha system and patrilineality raise an additional question: why are some societies matrilineal and some patrilineal? This question is outside the range of our argument, but, fortunately, many ideas have been offered on this topic over the years. They include explanations that focus on paternity confidence (e.g., Flinn, 1981), warfare (Divale, 1974, Ember and Ember, 1971; Ember, 1974; Jones, 2011), livestock (Aberle, 1961; Holden and Mace, 2003), polygyny (Fortunato, 2012), and matrilineality as daughter-biased parental investment (Holden et al., 2003, Mattison, 2011). For a good review of this literature, see Mattison (2011). Interestingly, all of these proposed explanations for matrilineality vs. patrilineality – paternity confidence, warfare, marital systems, etc. – have potentially important effects on fitness interdependence of individuals within these systems, suggesting that this may be a fruitful direction for future research.

Yet another way to form descent groups is neither patrilineally nor matrilineally but ambilineally. Ambilineal descent systems (also known as cognatic descent systems) have some built-in flexibility that patrilineal and matrilineal societies lack: An individual's lineage membership is determined not solely by birth but rather by some combination of male and female ties back to the founding ancestors of the society's existing lineages. Societies with ambilineal descent often use the Hawaiian kin term system, which, as we have seen, distinguishes among relatives only on the basis of sex and generation. We predict that the flexibility inherent in both ambilineal descent and the Hawaiian kin term system reflects a situation in which degrees of fitness interdependence among relatives are more flexible and situational than in societies with unilineal descent systems.

The Sudanese system is an outlier with regard to the other kin terms systems in that it makes distinctions among many different kinds of relatives, with minimal lumping. Sudanese systems are usually found in complex, hierarchical societies with important class divisions. One example is the Old English kin term system, which distinguished between mothers, fathers, matrilineal uncles and aunts, and patrilineal uncles and aunts. This is thought to have reflected a situation in which fine-grained distinctions between different types of relatives were important for inheritance and other types of legal procedures (Schwimmer, 2003). Later, when extended kin ties weakened and the nuclear family became more important, the English shifted to the Eskimo system.

The historical shift in English kin terms from the Sudanese to the Eskimo system suggests that human cultural systems may be able to respond to the underlying reality of fitness interdependence,

dynamically shifting kin terminologies so that culturally defined social relationships map better onto fitness interdependence. We predict that a society's kin terminology system is most likely to shift when the fitness interdependence underlying social relationships shifts. The Choctaw provide a possible example. Like many other Native American peoples in what is now the Southeastern United States, when their kin term system was first documented it was clearly Crow, reflecting their matrilineal social system. However, following their forcible move to Indian Territory (now Oklahoma), a variety of social, political, and economic forces led to a shift to a more patrilineal system, and their kin terms began incorporating elements of the Omaha system (Eggan, 1937a).

Dole (1969) documented a different kind of kin term change among the Kuikuru of Brazil. Although they had previously practiced cross-cousin marriage and used an Iroquois-type terminology, after depopulation and social disruption, that system fell apart and they began using sibling terms for both parallel and cross cousins, creating a system sometimes referred to as “Cheyenne” (Eggan, 1937b) that has features of both the Iroquois and Hawaiian systems. Dole argued that such a shift has occurred repeatedly in the aftermath of demographic and social disruption in North America, South America, and Oceania. In Africa, a shift among Bantu-speaking peoples from matrilineality to patrilineality following their acquisition of cattle is well documented and studied (Holden and Mace, 2003; see also Aberle, 1961 and Schneider, 1964). If Bantu matrilineal groups had been using the Crow terminology, then it would be reasonable to predict that the shift to patrilineality should be associated with a shift to the Omaha terminology. However, Guillon and Mace (2016) found only weak support for that hypothesis. The reason appears to be that the most widespread term system among Bantu-speakers, past and present, is the Iroquois system, which can accommodate both matrilineality (e.g., Iroquois) and patrilineality (e.g., Yanomamö), making a terminological change unnecessary despite the changes in fitness interdependence that came with the shift from matrilineality to patrilineality.

6. Fitness interdependence and fictive, chosen, or voluntary kin

It is not uncommon for people around the world to use kin terms to refer to people to whom they have neither a genetic nor a marital link. Such usage is referred to as “fictive,” “chosen,” “voluntary,” or “non-genealogical” (Jones, 2000) kinship. The existence of chosen kin may reflect important and real aspects of fitness interdependence. Consider, for example, the use of terms such as “brother” among co-combatants (e.g., Ambrose, 2002). Such usage is evocative and powerful because it captures a particularly intense and important form of fitness interdependence that arises in the life-or-death situations that combat units face.

Feelings of kinship and even the use of kin terms may sometimes be extended to nonhumans (Charles 2014; Charles and Davies 2008). Dogs appear to be the species most likely to be considered a member of the family, and a recent study of naming errors (i.e., using the wrong name for a familiar individual) found that people often commit such errors when referring to dogs, but not cats or other pet species (Deffler et al., 2016). Our species' close relationship with dogs may extend far back in our evolutionary history (Shipman, 2009), and even today dogs are sometimes important for subsistence (e.g., Koster and Tankersley, 2012).

However, chosen kinship may be a double-edged sword. At the same time that kin terms may often be used to label relationships characterized by real positive fitness interdependence, kin terms are also frequently used in political and religious rhetoric, sometimes with an eye toward convincing people to do things that are not in their best fitness interests. For example, the use of such terms as “brother,” “sister,” “fatherland,” and “motherland” are common in political rhetoric. Research has shown that such usage increases the persuasiveness of such rhetoric (Salmon, 1988) and that people are more tolerant of violence toward out-group members if those who act

violently use kin terms such as “brothers” and “family” among in-group members (Abou-Abdallah et al., 2016). Similarly, religious organizations that require celibacy often use kin terms (e.g., the Roman Catholic use of such terms as “mother,” “father,” “sister,” and “brother”), and organizations that train suicide bombers use kin terms to manipulate and motivate their recruits (Qirko, 2004, 2009). Thus, at the same time that kin terms can help people make adaptive choices by informing them about their interdependences with others, they also have the potential to manipulate people into doing things that might be harmful to themselves or others. Perhaps this is an example of the problem of novel environments: While the use of kin terms as markers of different degrees and types of fitness interdependence may be largely beneficial in the sorts of small scale societies in which our ancestors lived, the fact that we now live in large scale societies and can form relationships with a much wider range of people creates opportunities for this formerly adaptive ability to form bonds of kinship with non-relatives to become a vulnerability.

7. Kin terms, genetic relatedness, and behavior

If kin terms do not correspond with genetic relatedness, what do we make of the many published demonstrations of Hamilton's Rule's ability to predict patterns of altruism, generosity, and aid among humans (e.g., Hawkes, O'Connell, and Blurton Jones, 1989; Nolin, 2010; Case, Lin, McLanahan, 2000)? Our answer is that genetic relatedness is an important type of fitness interdependence that has a correspondingly important role to play in explaining human behavior. But, as is already well known, it cannot explain all cooperation.

Consider, for example, cooperation and food sharing in the community of Lamalera on the Indonesian island of Lembata. Lamalerans make a living from the sea, mainly by hunting whales and other large marine animals, which is done cooperatively, and by fishing, which can be done individually. Cooperative hunting is more productive, but because their boats are small, not everyone who may want to participate in a particular whale hunt can do so. One way to determine who is eligible to ride in a particular boat would be by genetic relatedness: Those who are more closely related to the boat's owner could have a better claim on a seat in his boat than his more distant relatives. But conflicts could still arise among kin with similar degrees of relatedness to the boat owner. Instead, Lamalerans solve this problem with reference not to genetic relatedness but to people's memberships in patrilineages. Patrilineage membership, unlike genetic relatedness, is a matter of kind rather than of degree: One either is or is not a member of the patrilineage that owns a particular boat. Thus, using patrilineage membership creates a clear-cut guide to who does and who does not have dibs on a seat in a particular boat (Alvard, 2003b; see also Alvard and Nolin, 2002).

On the other hand, genetic relatedness does play an important role in other aspects of the Lamalerans' lives. For example, genetic relatedness is a good predictor of who will end up receiving some of the meat when those who participated in the hunt distribute it in the community (Nolin, 2010). The difference between these two instances may be whether one's behavior needs to be coordinated with that of others. In the case of food sharing, it does not: a person who controls food or some other resource can, *ceteris paribus*, give it to whomever he wishes, and so genetic relatedness may overwhelm other considerations. In the case of hunt participation, on the other hand, coordination is indeed a problem, and social coordination conventions can help solve such problems by creating shared understandings of how they are to be solved (Gerkey and Cronk, 2010; Cronk, 2017; Chwe, 2003).

8. Conclusion

“The issue between sociobiology and social anthropology is decisively joined on the field of kinship.” (–Marshall Sahlins 1976:18)

To Sahlins, biological and cultural explanations of human behavior are engaged in battle with each other, and only one can be victorious. Fortunately, this is not how scholarship works. Although explanatory frameworks do compete with one another, science is primarily a cooperative endeavor, and human behavior is a large and complicated enough subject matter that many approaches have something to offer to its explanation.

Despite Sahlins' attempt to shut it down in its infancy, the evolutionary biological study of human behavior has developed into a wide-ranging and powerful approach. One important development in this area has been the incorporation of the concept of culture and an appreciation of the role culture plays in human adaptation (Irons, 1979; Boyd and Richerson, 1985; Durham, 1991; Sperber, 1996; Cronk, 1999; Alvard, 2003a; Mesoudi, 2011; Morin, 2016). As a result, we now realize that it is false to assume that a choice must always be made between biological and cultural explanations of behavior. Cultural forms are not *sui generis*, but rather grow from who we are as organisms. As is often the case, when their relationship to one another is properly understood, it turns out that cultural and biological explanations of human behavior complement rather than compete with one another (e.g., Cronk and Leech, 2013).

The concept of fitness interdependence thus has the potential to reconcile the cultural anthropological and evolutionary approaches to the study of kinship generally and the study of kin terms in particular. After all, when Schneider (1984) points out that father-son (citemangen-fak) relationships on Yap are more about “doing” than “being,” when Carsten (2004:35) explains that kinship on Langkawi is about the “intimate sharing of space, food, and nurturance,” and when McKinnon (2005:111) argues that kinship is about “acts of nurturance and solitude,” what are they referring to if not interdependence?

Fitness interdependence offers a way of understanding kinship that does not place cultural and evolutionary explanations in opposition to one another. Rather, fitness interdependence provides a framework that can reconcile issues that both sides of the debate have raised: from the lack of correspondence of kin terminology systems with genetic relatedness to the clear importance that people ascribe to genetic relatives across cultures. Although it is true that kin terms do not correspond well with one particular aspect of our biology – genetic relatedness – they do appear to be related to the broader concept of fitness interdependence.

Acknowledgements

We gratefully acknowledge the Wissenschaftskolleg zu Berlin (Institute for Advanced Study, Berlin) for supporting the workshop “Kinship, Conflict and Cooperation: Reconceptualizing kinship for the 21st century,” at which these ideas were synthesized. We also would like to acknowledge all the participants in this workshop who contributed to these ideas. In addition, we would like to thank Montserrat Soler and the members of the Human Generosity Project for their comments and the John Templeton Foundation for their financial support to LC and AA. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the John Templeton Foundation.

Declaration of interests

None.

References

- Aberle, D. F. (1961). Matrilineal descent in cross-cultural comparison. In D. Schneider, & K. Gough (Eds.). *Matrilineal kinship* (pp. 655–730). Berkeley, CA: University of California Press.
- Abou-Abdallah, M., Kashima, Y., & Harb, C. (2016). “Brothers” in arms: Does meta-phorizing kinship increase approval of parochial altruism? *Journal of Cognition and Culture*, 16(1–2), 37–49.

- Aktipis, A. (2016). Principles of cooperation across systems: From human sharing to multicellularity and cancer. *Evolutionary Applications*, 9, 17–36.
- Aktipis, A., Cronk, L., & de Aguiar, R. (2011). Risk-pooling and herd survival: An agent-based model of a Maasai gift-giving system. *Human Ecology*, 39, 131–140.
- Aktipis, A., Cronk, L., Alcock, J., Ayers, J. D., Baciu, C., Balliet, D., Boddy, A. M., Curry, O. S., Krems, J. A., Munoz, A., Sullivan, D., Szczyr, D., Wilkinson, G. S., & Winfrey, P. (2018). Understanding cooperation through fitness interdependence. *Nature Human Behaviour*, 2, 429–431.
- Alvard, M. (2003b). Kinship, lineage identity, and an evolutionary perspective on the structure of cooperative big game hunting groups in Indonesia. *Human Nature*, 14, 129–163.
- Alvard, M., & Nolin, D. (2002). Rousseau's whale hunt? Coordination among big game hunters. *Current Anthropology*, 43, 533–559.
- Alvard, M. S. (2003a). The adaptive nature of culture. *Evolutionary Anthropology: Issues, News, and Reviews*, 12, 136–149.
- Ambrose, S. E. (2002). *Band of brothers: E company, 506th regiment, 101st Airborne from Normandy to Hitler's Eagle's nest*. New York: Simon and Schuster.
- Argyle, M. (2013). *Cooperation: The basis of sociability*. New York: Taylor & Francis.
- Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, 63(4), 596.
- Balliet, D., Tybur, J. M., & Van Lange, P. A. (2017). Functional interdependence theory: An evolutionary account of social situations. *Personality and Social Psychology Review*, 21(4), 361–388.
- Berlin, B., & Kay, P. (1991). *Basic color terms: Their universality and evolution*. Berkeley: University of California Press.
- Bernard, P. E. (2009). Bringing soul to international negotiation. *Negotiation Journal*, 25, 147–159.
- Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process*. Chicago: University of Chicago Press.
- Brown, S. L. (1999). *Evolutionary Origins of Investment: Testing a Theory of Close Relationships*. PhD dissertation, Arizona State Univ.
- Brown, S. L., & Brown, R. M. (2006). Selective investment theory: Recasting the functional significance of close relationships. *Psychological Inquiry*, 17, 1–29.
- Burton-Chellew, M. N., & Dunbar, R. I. M. (2011). Are affines treated as biological kin? A test of Hughes' hypothesis. *Current Anthropology*, 52, 741–746.
- Carsten, J. (2004). *After Kinship*. Cambridge: Cambridge University Press.
- Case, A., Lin, I.-F., & McLanahan, S. (2000). How hungry is the selfish gene? *Economic Journal*, 110, 781–804.
- Chagnon, N. A. (1981). Terminological kinship, genealogical relatedness and village fissioning among the Yanomamö Indians. In R. D. Alexander, & D. W. Tinkle (Eds.). *Natural selection and social behavior* (pp. 490–508). New York: Chiron Press.
- Chagnon, N. A. (1988). Male Yanomamö manipulations of kinship classifications of female kin for reproductive advantage. In L. Betzig, M. Borgerhoff Mulder, & P. Turke (Eds.). *Human reproductive behaviour: A Darwinian perspective* (pp. 23–48). Cambridge: Cambridge University Press.
- Chagnon, N. A. (2000). Manipulating kinship rules: A form of male Yanomamö reproductive competition. In L. Cronk, W. Irons, & N. A. Chagnon (Eds.). *Adaptation and human behavior: An anthropological perspective* (pp. 115–131). New York: Aldine de Gruyter.
- Chapais, B. (2009). *Primeval kinship: How pair-bonding gave birth to human society*. Harvard University Press.
- Chwe, M. S.-Y. (2003). *Rational ritual: Culture, coordination, and common knowledge*. Princeton: Princeton University Press.
- Cronk, L. (1999). *That complex whole: Culture and the evolution of human behavior*. Boulder, CO: Westview Press.
- Cronk, L. (2004). *From Mukogodo to Maasai: Ethnicity and cultural change in Kenya*. Boulder, CO: Westview Press.
- Cronk, L. (2007). The influence of cultural framing on play in the trust game: A Maasai example. *Evolution and Human Behavior*, 28, 352–358.
- Cronk, L. (2015). Human cooperation: Evolutionary approaches to a complex phenomenon. In J. Turner, R. Machalek, & A. Maryanski (Eds.). *Handbook on evolution and society: Toward an evolutionary social science* (pp. 441–459). St. Paul, MN: Paradigm Publishing.
- Cronk, L. (2017). Culture's influence on behavior: Steps toward a theory. *Evolutionary Behavioral Sciences*, 11, 36–52.
- Cronk, L., & Gerkey, D. (2007). In R. Dunbar, & L. Barrett (Eds.). *The Oxford handbook of evolutionary psychology* (pp. 463–478). Oxford: Oxford University Press Kinship and descent.
- Cronk, L., & Leech, B. L. (2013). *Meeting at Grand Central: Understanding the social and evolutionary roots of cooperation*. Princeton, NJ: Princeton University Press.
- Daly, M., Salmon, C., & Wilson, M. (1997). Kinship: The conceptual hole in psychological studies of social cognition and close relationships. In J. A. Simpson, & D. T. Kenrick (Eds.). *Evolutionary social psychology* (pp. 265–296). New York: Lawrence Erlbaum Associates.
- David-Barrett, T. (2016). *Affinal inclusive fitness. oral presentation at the meeting of the human behavior and evolution society*. Vancouver, BC.
- DeBruine, L. M. (2002). Facial resemblance enhances trust. *Proceedings of the Royal Society of London B: Biological Sciences*, 269, 1307–1312.
- Deffler, S. A., Fox, C., Ogle, C. M., & Rubin, D. C. (2016). All my children: The roles of semantic category and phonetic similarity in the misnaming of familiar individuals. *Memory & Cognition*, 44, 989–999.
- Divale, W. T. (1974). Migration, external warfare, and matrilineal residence. *Behavior Science Research*, 9(2), 75–133.
- Dole, G. E. (1969). Generation kinship nomenclature as an adaptation to endogamy. *Southwestern Journal of Anthropology*, 25(2), 105–123.
- Dousset, L. (2011). Understanding human relations (kinship systems). In N. Thieberger (Ed.). *The Oxford handbook of linguistic fieldwork* (pp. 209–234). Oxford: Oxford University Press.
- Dow, J. (1984). The genetic basis for affinal cooperation. *American Ethnologist*, 11, 380–383.
- Durham, W. H. (1991). *Coevolution: Genes, culture, and human diversity*. Stanford: Stanford University Press.
- Eggan, F. (1937a). Historical changes in the Choctaw kinship system. *American Anthropologist*, 39, 34–52.
- Eggan, F. (1937b). The Cheyenne and Arapaho kinship system. In F. Eggan (Ed.). *Social anthropology of North American tribes* (pp. 35–95). Chicago: University of Chicago Press.
- Ember, C. R. (1974). An evaluation of alternative theories of matrilineal versus patrilineal residence. *Behavior Science Research*, 9, 135–149.
- Ember, C. R. (Ed.). (2016). *Explaining human culture*. New Haven, CT: Human Relations Area Files <http://hraf.yale.edu/ehc>.
- Ember, M., & Ember, C. R. (1971). The conditions favoring matrilineal versus patrilineal residence. *American Anthropologist*, 73(3), 571–594.
- Flinn, M. (1981). Uterine versus agnatic kinship variability and associated cross-cousin marriage preferences: An evolutionary biological analysis. In R. D. Alexander, & D. W. Tinkle (Eds.). *Natural selection and social behavior: Recent research and new theory* (pp. 439–475). New York & Concord: Chiron Press.
- Fortunato, L. (2012). The evolution of matrilineal kinship organization. *Proceedings of the Royal Society B: Biological Sciences*, 279(1749), 4939–4945.
- Fortunato, L., & Jordan, F. (2010). Your place or mine? A phylogenetic comparative analysis of marital residence in Indo-European and Austronesian societies. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 365(1559), 3913–3922.
- Fox, R. (1967). *Kinship and marriage*. Harmondsworth: Penguin.
- Gerkey, D., & Cronk, L. (2010). Why do we need to coordinate when classifying kin? *Behavioral and Brain Sciences*, 33, 385–386.
- Gerkey, D., & Cronk, L. (2014). What is a group? Conceptual clarity can help integrate evolutionary and social scientific research on cooperation. *Behavioral and Brain Sciences*, 37, 260–261.
- Gerpott, F. H., Balliet, D., Columbus, S., & Molho, C. (2018). How do people think about interdependence? A multidimensional model of subjective outcome interdependence. *Journal of Personality and Social Psychology*, 115, 716–742.
- Graham, J. L., & Lam, N. M. (2003). The Chinese negotiation. *Harvard Business Review*, 81, 82–91.
- Guillon, M., & Mace, R. (2016). A phylogenetic comparative study of Bantu kinship terminology finds limited support for its co-evolution with social organisation. *PLoS One*, 11(3), e0147920.
- Hamilton, W. D. (1964). The genetical evolution of social behaviour I and II. *Journal of Theoretical Biology*, 7, 1–16 17–52.
- Hawkes, K., Hill, K., & O'Connell, J. F. (1982). Why hunters gather: Optimal foraging and the Ache of eastern Paraguay. *American Ethnologist*, 9(2), 379–398.
- Hawkes, K., O'Connell, J. F., & Blurton Jones, N. G. (1989). Hardworking Hadza grandmothers. In V. Standen, & R. A. Foley (Eds.). *Comparative socioecology: The behavioural ecology of humans and other mammals* (pp. 341–366). London: Basil Blackwell.
- Henrich, J. (2004). Cultural group selection, coevolutionary processes and large-scale cooperation. *Journal of Economic Behavior & Organization*, 53, 3–35.
- Holden, C. J., & Mace, R. (2003). Spread of cattle led to the loss of matrilineal descent in Africa: A coevolutionary analysis. *Proceedings of the Royal Society of London B: Biological Sciences*, 270, 2425–2433.
- Holden, C. J., Sear, R., & Mace, R. (2003). Matriliney as daughter-biased investment. *Evolution and Human Behavior*, 24(2), 99–112.
- Holland, M. (2012). *Social bonding and nurture kinship*. Createspace Independent Publishing Platform.
- Holt, R., & Chang, H.-C. (2009). Business negotiation and Taiwanese relationship building: Mediated experiences in karaoke singing. *International Journal of Chinese Culture and Management*, 2, 206–220.
- Hughes, A. L. (1988). *Evolution and human kinship*. Oxford: Oxford University Press.
- Irons, W. (1979). Cultural and biological success. In N. A. Chagnon, & W. Irons (Eds.). *Evolutionary biology and human social behavior: An anthropological perspective* (pp. 284–302). North Scituate, MA: Duxbury Press.
- Irons, W. (1981). Why lineage exogamy? In R. D. Alexander, & D. W. Tinkle (Eds.). *Natural selection and social behavior: Recent research and new theory* (pp. 476–489). New York: Chiron.
- Irons, W. (2001). Religion as a hard-to-fake sign of commitment. In R. M. Nesse (Ed.). *Evolution and the capacity for commitment* (pp. 292–309). New York: Russell Sage Foundation.
- Janowski, M. (1995). The hearth-group, the conjugal couple and the symbolism of the rice meal among the Kelabit of Sarawak. In J. Carsten, & S. Hugh-Jones (Eds.). *About the house: Levi-Strauss and beyond* (pp. 84–104). Cambridge: Cambridge University Press.
- Jones, D. (2000). Group nepotism and human kinship. *Current Anthropology*, 41, 779–809.
- Jones, D. (2003a). The generative psychology of kinship, part I: Cognitive universals and evolutionary psychology. *Evolution and Human Behavior*, 24, 303–319.
- Jones, D. (2003b). The generative psychology of kinship, part II: Generating variation from universal building blocks with Optimality Theory. *Evolution and Human Behavior*, 24, 320–350.
- Jones, D. (2004). The universal psychology of kinship: Evidence from language. *Trends in Cognitive Sciences*, 8, 211–215.
- Jones, D. (2010). Human kinship, from conceptual structure to grammar. *Behavioral and Brain Sciences*, 33, 367–416.
- Jones, D. (2011). The matrilineal tribe, an organization of demic expansion. *Human*

- Nature*, 22, 277–300.
- Jones, D. (2016). Socially enforced nepotism: How norms and reputation can amplify kin altruism. *PLoS One*, 11(6), e0155596. <https://doi.org/10.1371/journal.pone.0155596>.
- Jordan, F. (2013). Comparative phylogenetic methods and the study of pattern and process in kinship. In P. McConvell, I. Keen, & R. Hendery (Eds.). *Kinship systems: Change and reconstruction* (pp. 43–58). Salt Lake City: University of Utah Press.
- Jordan, F., Gray, R. D., Greenhill, S. J., & Mace, R. (2009). Matrilocal residence is ancestral in Austronesian societies. *Proceedings of the Royal Society B-Biological Sciences*, 276, 1957–1964.
- Jordan, F. M. (2011). Comparative phylogenetic methods and the study of pattern and process in kinship. In P. McConvell, I. Keen, & R. Hendery (Eds.). *Kinship systems: Change and reconstruction* (pp. 43–58). Salt Lake City: University of Utah Press.
- Kelley, H. H., Holmes, J. G., Kerr, N. L., Reis, H. T., Rusbult, C. E., & Van Lange, P. A. M. (2003). *An atlas of interpersonal situations*. Cambridge, UK: Cambridge University Press.
- Kelley, H. H., & Thibaut, J. W. (1978). *Interpersonal relations: A theory of interdependence*. New York: John Wiley & Sons.
- Korchmaros, J. D., & Kenny, D. A. (2001). Emotional closeness as a mediator of the effect of genetic relatedness on altruism. *Psychological Science*, 12(3), 262–265.
- Koster, J. M., & Tankersley, K. B. (2012). Heterogeneity of hunting ability and nutritional status among domestic dogs in lowland Nicaragua. *Proceedings of the National Academy of Sciences*, 109, E463–E470.
- Krupp, D. B., DeBruine, L. M., & Barclay, P. (2008). A cue of kinship promotes cooperation for the public good. *Evolution and Human Behavior*, 29, 49–55.
- Lee, R. (1993). *The Dobe Ju/'hoansi* (2). Forth Worth: Harcourt Brace.
- Leech, B. L., & Cronk, L. (2017). Coordinated policy action and flexible coalitional psychology: How evolution made humans so good at politics. *Cognitive Systems Research*, 43, 89–99.
- Lieberman, D., & Lobel, T. (2012). Kinship on the kibbutz: Coresidence duration predicts altruism, personal sexual aversions and moral attitudes among communally reared peers. *Evolution and Human Behavior*, 33, 26–34. <https://doi.org/10.1016/j.evolhumbehav.2011.05.002>.
- Lieberman, D., Tooby, J., & Cosmides, L. (2007). The architecture of human kin detection. *Nature*, 445, 727–731. <https://doi.org/10.1038/nature05510>.
- Mateo, J. M. (2015). Perspectives: Hamilton's legacy: Mechanisms of kin recognition in humans. *Ethology*, 121, 419–427.
- Mattison, S. M. (2011). Evolutionary contributions to solving the “matrilineal puzzle”: A test of Holden, Sear, and Mace's model. *Human Nature*, 22, 64–88.
- McKinnon, S. (1991). *From a shattered sun: Hierarchy, gender, and alliance in the Tanimbar Islands*. Madison: University of Wisconsin Press.
- McKinnon, S. (2005). A critique of the genetic and gender calculus of evolutionary psychology. In S. McKinnon, & S. Silverman (Eds.). *Complexities: Beyond nature and nurture* (pp. 106–131). Chicago: University of Chicago Press.
- Mesoudi, A. (2011). *Cultural evolution: How Darwinian theory can explain human culture & synthesize the social sciences*. Chicago: University of Chicago Press.
- Morgan, L. H. (1871). *Systems of consanguinity and affinity of the human family*. Washington, DC: Smithsonian Institution.
- Morin, O. (2016). *How traditions live and die*. Oxford: Oxford University Press.
- Murdock, G. P. (1949). *Social structure*. New York: Free Press.
- Needham, R. (1971). *Rethinking kinship and marriage*. London: Taylor & Francis.
- Nolin, D. A. (2010). Food-sharing networks in Lamalera, Indonesia: Reciprocity, kinship, and distance. *Human Nature*, 21, 243–268.
- Opie, C., Shultz, S., Atkinson, Q. D., Currie, T., & Mace, R. (2014). Phylogenetic reconstruction of Bantu kinship challenges Main Sequence Theory of human social evolution. *Proceedings of the National Academy of Sciences*, 111(49), 17414–17419.
- Qirko, H. N. (2004). Altruistic celibacy, kin-cue manipulation, and the development of religious institutions. *Zygon: Journal of Religion and Science*, 39, 681–706.
- Qirko, H. N. (2009). Altruism in suicide terror organizations. *Zygon: Journal of Religion and Science*, 44, 289–322.
- Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PLoS One*, 8, e71182. <https://doi.org/10.1371/journal.pone.0071182>.
- Richerson, P. J., Baldini, R., Bell, A. V., Demps, K., Frost, K., Hillis, V., ... Zefferman, M. (2016). Cultural group selection plays an essential role in explaining human cooperation: A sketch of the evidence. *Behavioral and Brain Sciences*, 39, 1–68. <https://doi.org/10.1017/S0140525X1400106X>.
- Roberts, G. (2005). Cooperation through interdependence. *Animal Behaviour*, 70, 901–908.
- Sahlins, M. (1976). *The use and abuse of biology: An anthropological critique of sociobiology*. Ann Arbor: University of Michigan Press.
- Sahlins, M. (2013). *What kinship is – And is not*. Chicago: University of Chicago Press.
- Salmon, C. (1988). The evocative nature of kin terminology in political rhetoric. *Politics and the Life Sciences*, 17, 51–57.
- Schneider, D. M. (1968). *American kinship: A cultural account*. Chicago: University of Chicago Press.
- Schneider, D. M. (1972). What is kinship all about? In P. Reining (Ed.). *Kinship studies in the Morgan centennial year* (pp. 32–63). Washington: Anthropological Society of Washington.
- Schneider, D. M. (1984). *A critique of the study of kinship*. Ann Arbor: University of Michigan Press.
- Schneider, H. K. (1964). A model of African indigenous economy and society. *Comparative Studies in Society and History*, 7, 37–55.
- Schwimmer, B. (2003). Kinship and social organization. <https://www.umanitoba.ca/faculties/arts/anthropology/tutor/kinmenu.html>.
- Shapiro, W. (1979). *Social organization in aboriginal Australia*. Canberra: Australian National University.
- Shapiro, W. (2008). What human kinship is primarily about: Toward a critique of the new kinship studies. *Social Anthropology*, 16, 137–153.
- Shapiro, W. (2011). What is Malay kinship primarily about? or, the new kinship studies and the fabrication of ethnographic fantasy. In D. Jones, & B. Milicic (Eds.). *Kinship, language, and prehistory: Per Hage and the renaissance in kinship studies* (pp. 141–151). Salt Lake City: University of Utah Press.
- Shapiro, W. (2016). Why Schneiderian kinship studies have it all wrong. *Structure and Dynamics*, 9.
- Shepher, J. (1971). Mate selection among second-generation kibbutz adolescents: Incest avoidance and negative imprinting. *Archives of Sexual Behavior*, 1, 293–307.
- Shepher, J. (1983). *Incest: A biosocial view*. New York: Academic Press.
- Shipman, P. (2009). The woof at the door. *American Scientist*, 97, 286–289.
- Smaldino, P. E. (2014). Group-level traits emerge. *Behavioral and Brain Sciences*, 37, 281–295.
- Soler, M. (2012). Costly signaling, ritual and cooperation: Evidence from Candomblé, an Afro-Brazilian religion. *Evolution and Human Behavior*, 33, 346–356.
- Soltis, J., Boyd, R., & Richerson, P. J. (1995). Can group-functional behaviors evolve by cultural group selection?: An empirical test. *Current Anthropology*, 36, 473–494.
- Sosis, R., & Bressler, E. (2003). Cooperation and commune longevity: A test of the costly signaling theory of religion. *Cross-Cultural Research*, 37, 211–239.
- Sosis, R., & Ruffe, B. J. (2003). Religious ritual and cooperation: Testing for a relationship on Israeli religious and secular kibbutzim. *Current Anthropology*, 44, 713–722.
- Szycer, D., De Smet, D., Billingsley, J., & Lieberman, D. (2016). Coresidence duration and cues of maternal investment regulate sibling altruism across cultures. *Journal of Personality and Social Psychology*, 111, 159–177. <https://doi.org/10.1037/pspi0000057>.
- Szycer, D., Sullivan, D., van den Akker, O., Gervais, M., Muñoz Castro, A., Cronk, L., & Aktipis, A. (2017). *Fitness interdependence shapes helping decisions*. Annual meeting of the Human Behavior and Evolution Society, Boise, ID.
- Szycer, D., Sullivan, D., van den Akker, O., Gervais, M., Muñoz Castro, A., Cronk, L., & Aktipis, A. (in prep). Perceived fitness interdependence predicts willingness to help.
- Trautmann, T. R., Feeley-Harnik, G., & Mitani, J. C. (2011). Deep kinship. In A. Shryock, & D. L. Smail (Eds.). *Deep history: The architecture of past and present* (pp. 177–204). Berkeley: University of California Press.
- Tomasello, M., Melis, A. P., Tennie, C., Wyman, E., & Herrmann, E. (2012). Two key steps in the evolution of human cooperation: The interdependence hypothesis. *Current anthropology*, 53(6), 673–692.
- Weisfeld, G. E., Czilli, T., Phillips, K. A., Gall, J. A., & Lichtman, C. M. (2003). Possible olfaction-based mechanisms in human kin recognition and inbreeding avoidance. *Journal of Experimental Child Psychology*, 85, 279–295.
- Westermarck, E. A. (1891). *The history of human marriage*. London: Macmillan & Company.
- Wildman, W. J., & Sosis, R. (2011). Stability of groups with costly beliefs and practices. *Journal of Artificial Societies and Simulation*, 14, 6.
- Wolf, A. P. (1995). *Sexual attraction and childhood association: A Chinese brief for Edward Westermarck*. Stanford: Stanford University Press.
- Woolley, K., & Fishbach, A. (2017). A recipe for friendship: Similar food consumption promotes trust and cooperation. *Journal of Consumer Psychology*, 27, 1–10.