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On the relationship between interindividual cultural transmission and population-level cultural diversity: a case study of weaving in Iranian tribal populations

Jamshid J. Tehrani[a,b,*], Mark Collard[b,c]

[a]Evolutionary Anthropology Research Group, Department of Anthropology, Durham University, Durham, UK
[b]AHRC Centre for the Evolution of Cultural Diversity, University College London, London, UK
[c]Laboratory of Human Evolutionary Studies, Department of Archaeology, Simon Fraser University, Burnaby, Canada

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Abstract

It is often assumed that parent-to-child cultural transmission leads to similarities and differences among groups evolving through descent with modification ("phylogenesis"). Similarly, cultural transmission between peers, and between adults and children who are not their offspring, is widely believed to result in groups exchanging cultural traits ("ethnogenesis"). However, neither of these assumptions has been examined empirically. Here, we test them using ethnographic data on craft learning in Iranian tribal populations and the cladistic method of phylogenetic analysis. We find that parent-to-child transmission dominates learning during childhood, but the other two forms of interindividual transmission become more important in later periods. The latter do not, however, appear to have resulted in extensive exchange of cultural traits among tribes. Instead we find that most of the variation among the tribes' craft assemblages can be explained by descent with modification. This can be accounted for by the fact that weavers usually only share their knowledge with members of their own tribe and are prevented from interacting with women from other groups by social norms. These findings demonstrate that the relationship between processes of cultural evolution at the level of the individual and processes of cultural evolution at the level of the group is more complex than is usually acknowledged, and highlight the need for more integrated studies of the processes operating at both scales.

Keywords: Cultural transmission; Ethnography; Phylogenetic analysis; Iran; Evolution of material culture

1. Introduction

It has long been argued that research on human evolution should take into account the ways in which people acquire, modify, and pass on cultural traits (e.g., Baldwin, 1896; Tylor, 1881). Yet it is only in the last few decades that substantive efforts have been made to develop an explicitly Darwinian approach to the study of culture (e.g., Boyd & Richerson, 1985; Cavalli-Sforza & Feldman, 1981; Collard, Shennan, Buchanan, & Bentley, 2007; Durham, 1991; Lipo, O'Brien, Collard, & Shennan, 2006; Lumsden & Wilson, 1981; Mace, Holden, & Shennan, 2005; Mesoudi, Whiten, & Laland, 2004; Mesoudi, Whiten, & Laland, 2006; O'Brien, 1996, 2008; Richerson & Boyd, 2005; Shennan, 2002). Not surprisingly, therefore, a number of important issues are poorly understood. One of these is how patterns of cultural diversity at the level of the population relate to the ways in which individuals acquire, modify, and pass on their knowledge and skills.

Here, we report a study that focused on the impact of three forms of interindividual cultural transmission on among-group cultural diversity. The forms of social learning in question are vertical transmission, horizontal transmission, and oblique transmission. Vertical transmission involves the transfer of information from parents to children (Boyd & Richerson, 1985; Cavalli-Sforza & Feldman, 1981). Horizontal transmission occurs between members of the same generation, such as siblings, cousins, and peers (Boyd & Richerson, 1985). In oblique transmission,

* Corresponding author. Department of Anthropology, Durham University, DH1 3LE Durham, UK. Tel.: +44 0191 3341630.
E-mail address: jamie.tehrani@durham.ac.uk (J.J. Tehrani).

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information is passed from one generation to another through children copying adults other than their parents (Boyd & Richerson, 1985; Cavalli-Sforza & Feldman, 1981). This is exemplified by school-based education systems and master-apprentice relationships.

It has often been assumed that when vertical transmission is the dominant form of interindividual cultural transmission, similarities and differences among groups are likely to be the result of descent with modification from ancestral populations (e.g., Durham, 1990; Guglielmino, Viganotti, Hewlett, & Cavalli-Sforza, 1995; Hewlett, De Silvestri, & Guglielmino, 2002; Mace & Holden, 2005; Tehrani & Collard, 2002). This process has been referred to as “vertical intergroup transmission” (e.g., Hewlett et al., 2002), “demic diffusion” (e.g., Guglielmino et al., 1995), and “phylogenesis” (e.g., Collard, Shennan, & Tehrani, 2006; Durham, 1990) and is analogous to the diversification of species in biological evolution. Horizontal and oblique transmissions, on the other hand, are thought to lead to the transfer of cultural traits among contemporaneous populations as a result of members of different groups coming into contact with one another through trade, exchange, and so on (e.g., 1949; Kroeber, 1948). The resulting borrowing and blending of cultural traits is referred to as “horizontal intergroup transmission,” “cultural diffusion,” or “ethnogenesis” (e.g., Collard et al., 2006; Moore, 1994; Tehrani & Collard, 2002).

So far, these assumptions have not been evaluated empirically. Generally, researchers have either investigated interindividual processes of cultural transmission (e.g., Aunger, 2000; Greenfield, Maynard, & Childs, 2000; Hewlett & Cavalli-Sforza, 1986; Lozada, Ladio, & Weingandt, 2006; Shennan & Steele, 1999) or examined the evolution of intergroup similarities and differences in cultural behavior (e.g., Collard & Shennan, 2000; Collard et al., 2006; Jordan & Shennan, 2003; Shennan & Collard, 2005; Tehrani & Collard, 2002; Welsch, Terrell, & Nadolski, 1992). To the best of our knowledge, only one study has addressed the relationship between the two with empirical data—McElreath’s (2004) “Social learning and the maintenance of cultural variation: an evolutionary model and data from East Africa”—and that study focused on the issue of whether intergroup differences result from individuals within those groups adapting their behaviors to suit local ecological conditions or through them copying their peers. Although McElreath found evidence that some of the variation among groups can be explained by cultural transmission among individuals, he did not discriminate between the different modes of cultural transmission outlined above. As such, his study did not clarify the relationships between vertical, oblique, and horizontal transmission on the one hand and phylogenesis and ethnogenesis on the other.

The lack of empirical work is problematic because, as some researchers (e.g., McElreath & Strimling, 2008) have noted, the relationships between these various interindividual and intergroup processes of cultural inheritance are potentially much more complicated than is usually allowed. Phylogenesis is, in principle, compatible not only with vertical transmission but also with horizontal transmission and oblique transmission. If individuals have little contact with members of other groups, or have a strong tendency to conform to the behavior of the majority, then both horizontal and oblique transmissions will result in phylogenesis among groups (e.g., Henrich & Boyd, 1998; Hewlett et al., 2002; McElreath & Strimling, 2008). Similarly, it is theoretically possible that individuals mainly transmit information vertically to their children, but because the latter marry exogamously, cultural diversity at the level of the population occurs through ethnogenesis (McElreath & Strimling, 2008).

The goal of our study was to investigate the extent to which vertical transmission leads to phylogenesis and oblique and horizontal transmissions to ethnogenesis. It focused on craft production in Iranian tribal populations and was divided into two parts. First, we conducted ethnographic fieldwork among tribal communities in southwestern Iran to study the contributions made by vertical, oblique, and horizontal transmissions to craft learning and assess how far they would be expected to lead to phylogenesis or ethnogenesis among groups. We then carried out a series of phylogenetic analyses to test expectations about the impact of the different forms of craft learning on the evolution of similarities and differences among the tribes’ textile assemblages.

2. Interindividual cultural transmission

Six months fieldwork was conducted by J.J.T. among 14 tribal communities in the Zagros Mountains of southwestern Iran during three visits to the region between May 2001 and June 2003. A survey of craft production in these communities demonstrated that, by far, their most important form of manufacturing is textile weaving, which is carried out exclusively by females. The abundance of textiles in Iranian tribal material culture is probably due to the demands and opportunities of their traditional nomadic–pastoralist lifestyle (e.g., Digard, 1981, 2002; Mortensen & Nicolaisen, 1993). Wool from sheep and goats was available in abundance, while dyes could be extracted from plants, insects, and fruits. Moreover, because they can be folded and rolled, textile objects were relatively easy to carry on the long, physically challenging migrations between winter and summer camps. Although the majority (10 out of 14) of the communities included in the survey are now settled, females continue to make a wide range of textiles for domestic use and sale, including articles of clothing, blankets, saddlebags, bands and hangings to decorate the home, and carpets.

The 14 communities have the same basic pattern of social organization. They comprise a group of households that are related to one another through the male line and share undivided rights over pastureland, water, and other communal resources. While males generally live in the same community their entire lives, postmarital residence norms dictate that females leave their natal group after marriage to reside with their husbands. Ideally, individuals are expected to marry members of their own patrilineal clan (*tira*). In practice, however, it is not uncommon for females to marry males from a different clan as long as they belong to the same tribe (*il*). In such cases, the female adopts the clan affiliation of her husband when she moves to his camp or village. These marriage and residence norms mean that women move between communities of the same tribe relatively frequently but rarely move between tribes.

The 14 communities belong to three tribes. Seven of the communities are affiliated to the Bakhtiari. Until the 20th century, the Bakhtiari were the largest and most powerful tribal confederacy in Iran, with territories stretching from the coast of the Persian Gulf to the mountains of Chahar Mahal near the city of Esfahan in central Iran. Five of the communities are affiliated with another large and historically important tribal group, the Qashqai, who inhabit the rural areas surrounding the ancient city of Shiraz. The members of the remaining two communities belong to the Boyer Ahmad. The Boyer Ahmad are less numerous than either the Bakhtiari or the Qashqai, and occupy land between the territories of the latter two tribes. The approximate locations of the Bakhtiari, Qashqai, and Boyer Ahmad are shown in Fig. 1.

The textiles produced by the communities are based on three major techniques: tablet weaving, flat weaving, and pile weaving. Tablet weaving involves threading several warp yarns through perforated cards. When the cards are rotated, the warp yarns are twisted together to produce a pattern of alternating colors. This technique is commonly used to make bands, straps, and heavy blankets. Flat weaving is sometimes referred to as tapestry weaving due to its similarity with that craft. There are several variations of the technique, but all involve wrapping a continuous yarn of dyed weft horizontally across two or more vertical warp threads on a fixed horizontal ground loom to construct a pattern of interlocking, geometric designs. Simple flat-weaving techniques are used to make tent canopies and blankets and to finish carpets and bags. More complex flat-weaving techniques are used to create "gelim" carpets, saddlebags, and animal trappings. Pile weaving is the most complex of the weaving techniques. It is only used to make rugs. In pile weaving, individual colored yarns are knotted and cut in horizontal rows across warp threads, which run vertically along the length of the loom. Each row of knots is secured by a row of weft yarn woven between alternate

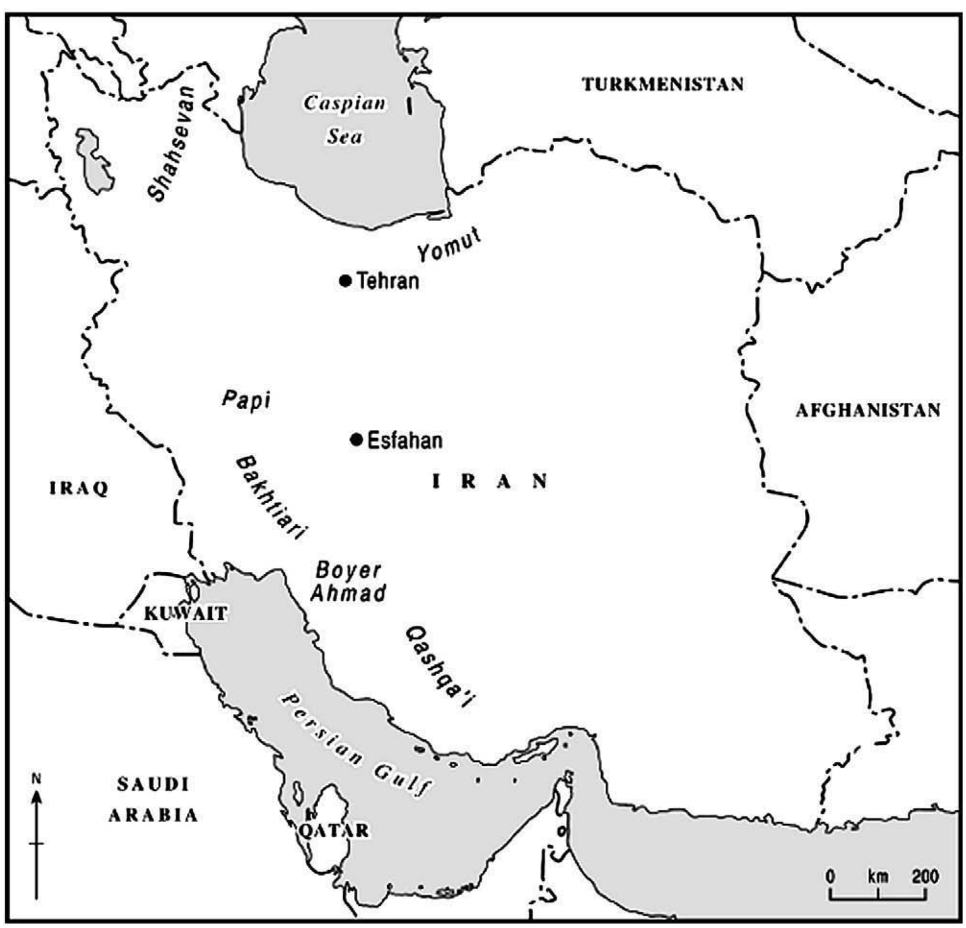

Fig. 1. Map showing locations of the tribal populations (italics) used in the study.

warp threads and beaten into place with a heavy metal comb. The pile weaving technique is extremely time-consuming. For example, a 2×1.5-m rug can take an expert weaver as long as 6 months to produce. However, it enables weavers to make patterns that are much more intricate and complex than the relatively simple, geometric shapes that are typical of tablet and flat weaving. Since pile-woven rugs are more elaborately decorated and take longer to produce than other textiles, they are far more commercially valuable than other textile products.

To study the transmission of weaving techniques and the designs that are incorporated into textiles, interviews were conducted with 62 weavers aged between 14 and 65. The interviews were carried out with the aid of two multilingual field assistants. Most of the interviews were conducted in the presence of a male relative of the weaver. The main purpose of the interviews was to establish the extent to which weaving techniques and the designs incorporated into textiles are acquired vertically from a parent, obliquely from another competent adult, or horizontally from a peer or member of another group. Interview subjects were asked to explain who taught them how to weave, the age at which they learned their skills, and how long they took to master. It has been suggested (e.g., McElreath & Strimling, 2008) that previous ethnographic studies conducted in similar small-scale nonindustrial settings (e.g., Aunger, 2000, Greenfield et al., 2000; Hewlett & Cavalli-Sforza, 1986; Lozada et al., 2006; Ohamgari & Berkes, 1997) may have inflated the importance of vertical transmission by focusing too heavily on learning in children. Childhood socialization in societies where schooling is rare tends to be based in the household, where parental influences are strongest. In later life stages, particularly from late adolescence onward, individuals are typically exposed to a greater variety of cultural models. Consequently, it is possible that by neglecting learning during these periods, previous studies may have underestimated the importance of horizontal and oblique transmissions. With this in mind, we asked weavers to explain whether they continued to learn new techniques and designs subsequent to their initial apprenticeship. This enabled us to account for possible differences between processes of cultural transmission in childhood and those in later life stages (Henrich & Gil-White, 2001).

The interviewees reported that females usually begin learning weaving techniques around 9 or 10 years of age but may start as early as 6 years of age. Initially, they learn tablet-weaving and flat-weaving techniques. Once these have been mastered, they go on to learn the more complex technique of pile weaving. Most interviewees were initially taught how to weave by their mothers. Only 2 of the 62 weavers interviewed reported learning technical skills from someone other than their mother. In both cases the skills in question were pile-weaving techniques and were taught by an aunt.

The transmission of weaving techniques involves little explicit verbal instruction. Rather, mothers teach mostly through a mixture of demonstration, participation, and intervention. This requires a high degree of coordination between the activities of the mother and daughter. Initially, girls help their mothers prepare small quantities of wool using a spindle and practice knots on miniature looms. Once they have learned the basics of wool preparation and loom use, they graduate to assisting their mothers with their projects. While assisting their mothers, girls learn the techniques required to manufacture textiles, including setting up the loom and warp, creating patterns from knots, and fastening the sides and ends of a piece. Over time, girls gradually assume responsibility for weaving increasingly large and complex sections of the textile until they have memorized every detail of its production. Girls generally continue to work as assistants to their mothers until they reach adolescence. At this stage, most girls have mastered a more or less complete repertoire of techniques and are in a position to start working on their own projects. According to the interviewees, weavers rarely, if ever, learn new techniques after they gain independence. Thus, the acquisition of weaving techniques is dominated by mother-to-daughter vertical transmission.

The interviewees reported that a weaver learns many of the designs she uses from her mother at the same time she learns the techniques of weaving. However, mother-to-daughter vertical transmission does not account for all the designs used by weavers. The responses of the interviewees indicated that some designs are normally acquired via oblique and horizontal transmissions. Once a weaver begins to work on her own projects she often learns designs from women other than her mother. More than half (35 out of 59) of the interviewees reported that they regularly compared and exchanged weaving designs with older sisters, aunts, sisters-in-law, and/or friends. Many women said that, for a reasonably skilled weaver, it is easy to memorize new designs just by looking at them. They did not distinguish between designs learned from their mothers and those learned from other women and claimed that, in principle, any part of any pattern from any kind of textile could be borrowed from another weaver. In general, weavers are only able to copy other members of their community. This is due to social norms that prevent women from traveling on their own, except to collect herbs or visit local shrines. The main way in which weavers come into contact with women belonging to other communities is when they get married and move to their husband's village. However, as mentioned previously, norms of tribal endogamy mean that females usually only marry males belonging to their own tribe. As a result, there are few opportunities for weavers belonging to different tribes to interact with one another.

The interviews revealed two other ways weavers learn designs once they begin working on their own projects. One is copying patterns knot-by-knot from "cartoons" distributed by rug merchants. Most rug merchants operate out of cities. They visit tribal villages to commission pile carpets and then return a few months later to collect the finished items. The rug merchants either sell the carpets in urban markets or supply them to export companies. Forty-two of the 62 women interviewed reported entering into a contract with a rug merchant at least once. In all cases, the commissions were for pile carpets, which, as noted earlier, are more commercially valuable than other textile products.

The other way weavers learn designs once they begin working on their own projects is employment in rural carpet workshops. Rural carpet workshops have been in existence for at least 200 years (Willborg, 2002). In the past, workshops were typically situated in the residences of tribal leaders and were managed by their wives (Macbean Ross, 1921). Today, they are mainly run as commercial enterprises and are distributed throughout the Zagros region where they employ weavers from many tribal communities often on a short-term or casual basis. However, since they generally draw their labor force from communities in the immediate surrounding area, they are a less pervasive influence than cartoons. This is reflected in the fact that only four of the women interviewed said that they learned designs from a workshop. The four women were from the same Bakhtiari village and worked in the same workshop, which is located a few miles from their village. As with cartoons, workshop production is focused entirely on pile carpets. The designs weavers learn in workshops are not used on other kinds of textiles.

In sum, the interview data suggest that there is a difference in the transmission of the techniques used to produce textiles and the transmission of the designs incorporated into them (Table 1). The acquisition of weaving techniques is dominated by vertical interindividual transmission, while the design repertoires of individual weavers are built up through a combination of vertical, oblique, and horizontal interindividual transmissions. The instances of oblique and horizontal interindividual transmissions of designs that occur normally involve members of the same tribe rather than members of different tribes. Some weavers, however, may incorporate designs into their pile carpets that have been copied from rug merchant cartoons and/or learned from female members of other tribes they have worked with in rural carpet workshops.

Table 1
Sources of craft learning reported by 62 weavers interviewed in southwestern Iranian tribal communities

	Mother	Other group member[a]	External sources
Tablet-weaving techniques	62 (100%)	0	0
Tablet-weaving designs	62 (100%)	0	0
Pile-weaving techniques	60 (97%)	2 (3%)	0
Pile-weaving designs	62 (100%)	35 (56%)	42 (68%) from cartoons 4 (6%) from workshops
Flat-weaving techniques	62 (100%)	0	0
Flat-weaving designs	62 (100%)	35 (56%)	0

Cell values represent number of individuals who acquired traits from the specified source.

[a] None of the weavers reported directly acquiring craft traits from females belonging to a different tribe.

3. Population-level patterns of cultural diversity

Based on the findings reported above, we derived two hypotheses relating to the evolution of cultural diversity at the level of the tribe. The primary hypothesis was that phylogenesis has been more important than ethnogenesis in the diversification of the tribes' woven assemblages. This follows from the finding that weavers obtain the bulk of their knowledge from their mother and other members of their tribe and rarely interact with members of other tribes. To reiterate, vertical transmission, oblique transmission, and horizontal transmission are all likely to lead to phylogenesis when populations are endogamous and when there is little contact among members of different groups. The secondary hypothesis was that the designs incorporated into pile rugs have been transmitted among tribes in significantly greater numbers than the techniques used to produce textiles or the designs incorporated into nonpile textiles. This follows from the finding that pile carpet designs have the potential to circulate among tribes via rug merchant cartoons and workshop, whereas the techniques used to produce textiles and the designs incorporated into nonpile textiles do not.

To test these hypotheses, we used data derived from weavings produced by six tribes: the Qashqai, Boyer Ahmad, Shahsevan, Bakhtiari, Papi, and Yomut. The approximate locations of the tribes are shown in Fig. 1. The weavings of the Qashqai, Boyer Ahmad, and Bakhtiari were studied during JJT's 6 months of fieldwork in the Zagros Mountains. Those of the Papi and Shahsevan were studied from photographs and descriptions published in monographs of field-collected materials (Mortensen & Nicolaisen, 1993; Tanavoli, 1985). Data on the Yomut were gathered from museum collections (Thompson, 1980; Tzavera, 1984). A total of 122 characters were derived from the textile sample. They comprised techniques of preparation and fabrication (e.g., spinning, knotting) and variation in decorative features (e.g., carpet designs, border patterns). Character states were coded as present or absent in each of the assemblages. Examples of the characters used in the analyses are shown in Fig. 2. A breakdown of the data sources is provided in Table 2. A list of characters and the character state data matrix are provided as supplementary materials (see appendix on the journal's website at www.ehbonlline.org).

The data were analyzed using the cladistic method of phylogenetic reconstruction (Kitching, Forey, Humphries, & Williams, 1998; Page & Holmes, 1998; Schuh, 2000). Cladistics is one of the main methods of phylogenetic reconstruction used in biology (e.g., Cap, Deleporte, Joachim, & Reby, 2008; Dohrmann, Janussen, Reitner, Collins, & Wörheide, 2008; Mallegni, 2007; O'Leary & Gatesy, 2008; Smith & Grine, 2008; Wills, Barrett, &

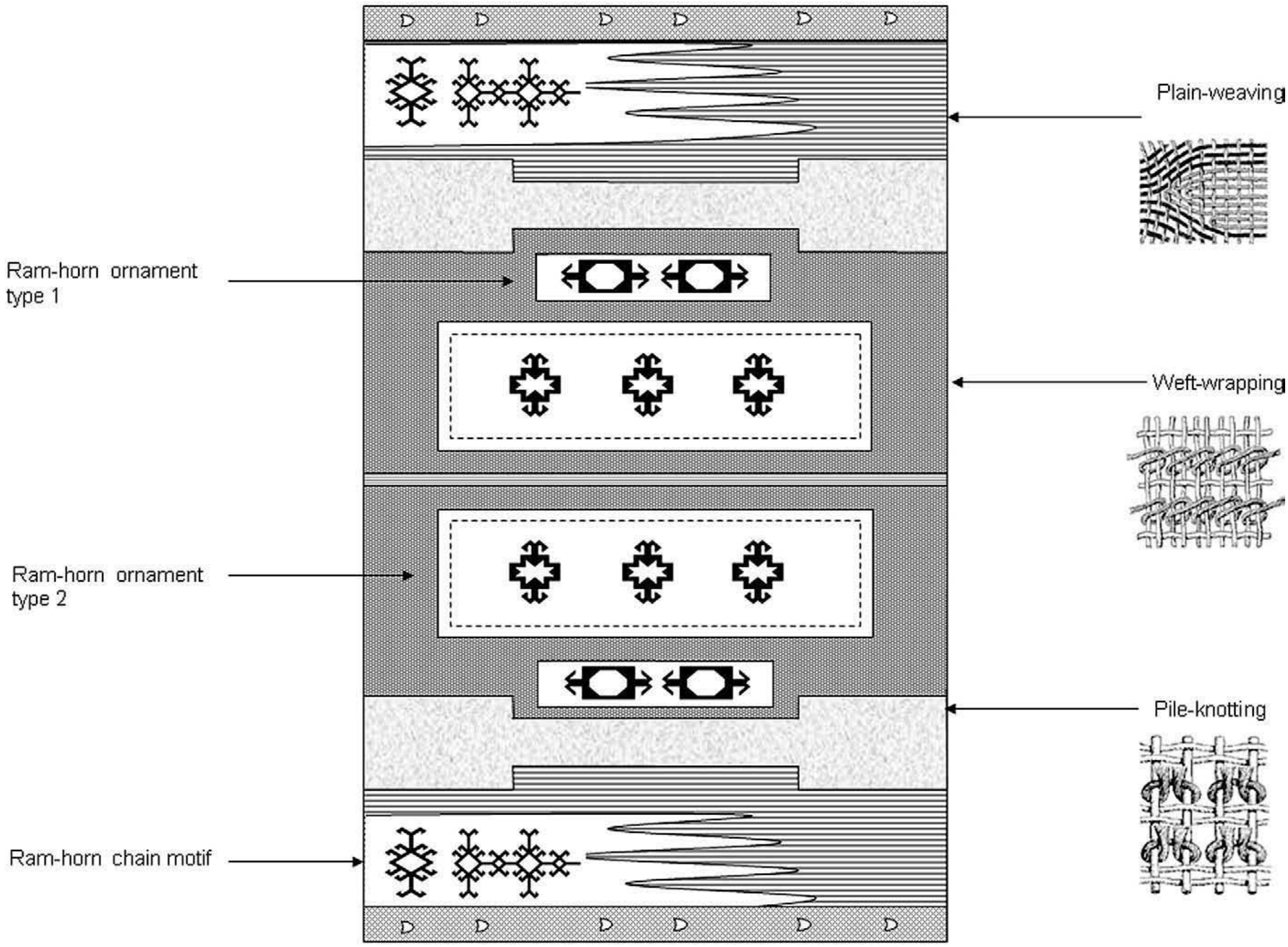

Fig. 2. Examples of decorative and technical characters (extracted from a saddle bag).

Heathcote, 2008) and has become used in a number of other disciplines in which phylogenetic relationships are important, including anthropology (e.g., Buchanan & Collard, 2007, 2008; Collard et al., 2006; Coward, Shennan, Colledge, Conolly, & Collard, 2008; Jordan & Shennan, 2003; Lycett, 2007, 2009; Lycett & Collard, 2005; Lycett et al., 2007; O'Brien et al., 2001; O'Brien & Lyman, 2003; Robson-Brown, 1996; Shennan & Collard, 2005; Skelton, 2008; Tehrani & Collard, 2002), historical linguistics (e.g., Ben Hamed, Darlu, & Vallée, 2005; Gray & Jordan, 2000; Holden, 2002; Rexová, Frynta, & Zrzavy, 2003), textual philology (e.g., Eagleton & Spencer, 2006; Robinson & O'Hara, 1996; Spencer, Davidson, Barbook, & Howe, 2004), and business studies (e.g., Baldwin, Allen, Winder, & Ridgway, 2005; McCarthy, 2005).

Table 2
Source data for the material culture data set used in the analyses

Tribal group	Ethnicity	Region	Source data
Bakhtiari	Lor (Iranian)	Central Zagros	Field survey
Boyer Ahmad	Lor (Iranian)	Southern Zagros	Field survey
Papi	Lor (Iranian)	Northern Zagros	Mortensen and Nicolaisen (1993)
Qashqa'i	Oghuz (Turk)	Southern Zagros	Field survey
Shahsevan	Oghuz (Turk)	Western Caspian Sea	Tanavoli (1985)
Yomut Turkmen	Oghuz (Turk)	Eastern Caspian Sea	Thompson (1980), Tzavera (1984)
Prehistoric Pazyryk tribes	Unknown	Altai Mountains	Rudenko (1970)

Cladistics uses shared derived character states to reconstruct phylogenetic relationships. Within the cladistic framework, if two taxa exhibit a derived character state that is not exhibited in a third taxon, this provides evidence that they are descended from a common ancestor of more recent origin than the last common ancestor shared with the third taxon and therefore are more closely related to each other than either is to the third taxon. Ideally, the distribution of character states among a group of taxa will be such that the characters support relationships that are congruent with one another. Normally, however, a number of characters will suggest relationships that are incompatible. This problem is overcome by finding the phylogeny that requires the least number of evolutionary changes to account for the distribution of character states among the taxa (the "shortest length cladogram"). This approach is based on the principle of parsimony, the methodological injunction that states that explanations should never be made more complicated than is necessary (Sober, 1988). Similarities that are consistent with the most parsimonious phylogeny are assumed to be the consequence of shared ancestry and are referred to as "homologies." Similarities that conflict with the most parsimonious phylogeny are labeled "homoplasies" (Sanderson & Hufford, 1996). Homoplasies can arise through several processes, including convergence, parallelism, and horizontal transmission among lineages (Collard & Wood, 2001; Lockwood & Fleagle, 1999; Sanderson & Hufford, 1996).

The rationale for using cladistics to measure the contributions of phylogenesis and ethnogenesis is that when cultural assemblages are generated mainly by the former process, the similarities and differences among them should be consistent with a tree-like model of descent with modification. If, on the other hand, populations frequently borrow and blend cultural traits, this would result in more complex and conflicting distributions of similarities and differences (e.g., Collard et al., 2006; Dewar, 1995; Durham 1990, 1992; Gray & Jordan, 2000; Hurles, Matisoo-Smith, Gray, & Penny, 2003; Moore, 1994; Tehrani & Collard, 2002; Terrell, 1988). Consequently, under phylogenesis, the majority of shared derived traits can be expected to be consistent with the shortest-length cladogram, whereas under ethnogenesis, we would expect to find a large number of shared derived traits that are incompatible with the shortest-length cladogram. In our view, cladistics is preferable to the other techniques that have been used to investigate intergroup cultural transmission—regression analysis using linguistic similarity as a proxy for vertical intergroup transmission and geographic proximity as a proxy for horizontal intergroup transmission (e.g., Guglielmino et al., 1995; Welsch et al., 1992), and network analysis (e.g., Hurles et al., 2003; Lipo, 2006). The problem with the former is that because phylogeny and geography are usually highly correlated, it is likely to inflate the importance of ethnogenesis and underestimate the importance of phylogenesis (Tehrani & Collard, 2002). The problem with the latter is that network-building algorithms do not distinguish between shared derived and shared ancestral character states, and this limits their ability to accurately reconstruct transmission processes. This is supported by a recent study by Spencer et al. (2004). These authors compared how well different phylogenetic methods managed reconstruct the history of an experimentally generated manuscript tradition and found that cladistics outperformed the two network-based methods they utilized.

Recently, Borgerhoff Mulder, Nunn, and Towner (2006) challenged the use of cladistics to investigate the relative contribution of phylogenesis and ethnogenesis to the evolution of cultural diversity. They argue that because it employs an algorithm that is designed to maximize the fit between a data set and the tree model, it is incapable of assessing the role played by non-tree-like processes in the evolution of cultural data sets. However, the claims of Borgerhoff Mulder et al. (2006) lack empirical support. In fact, studies where there is independent evidence for phylogenesis and ethnogenesis suggest that cladistics is sensitive to the latter. For example, a cladistic analysis of Californian Indian basketry by Jordan and Shennan (2003) returned a much poorer fit with the bifurcating tree model than a cladistic analysis we carried out on Turkmen woven assemblages several years ago (Tehrani & Collard, 2002). The contrasting results returned by these analyses are consistent with the available ethnographic and historical data. They indicate that ethnogenesis is likely to be more important among Californian Indians than among the Turkmen. Whereas the Californian groups engaged in extensive trade and intermarriage, Turkmen tribes were endogamous and had generally hostile relationships with one another. Analyses of Turkmen textiles produced in different historical periods provides further evidence that cladistics is sensitive to ethnogenesis. The historical data suggest that the amount of intertribe borrowing among the Turkmen may have increased after the tribes were pacified by the Russian empire and began producing textiles commercially. We therefore predicted that an analysis of colonial period weavings should find an increase in ethnogenesis relative to an analysis of precolonial period weavings. The results of our analyses were consistent with this prediction. Together, these observations indicate that, contrary to what Borgerhoff Mulder et al. (2006) contend, cladistics is capable of assessing the relative importance of phylogenesis and ethnogenesis.

To test the primary hypothesis that vertical intergroup transmission has been more important than horizontal intergroup transmission in the diversification of the tribes' woven assemblages, we subjected the complete data set to a parsimony analysis in PAUP 4.0∗ (Swofford, 1998). All the characters were treated as binary characters, and the search was carried out with the branch-and-bound routine, which is guaranteed to find the shortest length cladogram for a given data set. To determine the direction of character state change for each character, we used outgroup analysis (Arnold, 1981; Maddison, Donoghue, & Maddison, 1984). Outgroup analysis entails examining a close relative of the study group. When a character occurs in two states among the study group, but only one of the states is found in the outgroup, then the state found in both the study group and the outgroup is deemed to be the primitive one and the state found in only the study group to be the derived one. The reason for this is that it is more parsimonious to assume that the state shared by both the study group and the outgroup was inherited from a common ancestor than it is to assume that the state was independently evolved in the study group and the outgroup. We used a prehistoric archaeological textile assemblage as the outgroup. The assemblage consists of artifacts excavated from the ice-filled tombs of a nomadic people that inhabited the Altai

Mountains of Siberia in the 4–5th century BCE (Rudenko, 1970). The artifacts include decorative felts, woven fabrics, items of clothing, and an almost complete pile carpet featuring repetitive field ornaments that carpet scholars have compared to those found in contemporary tribal weavings (e.g., Opie, 1989). Although the exact provenance of the so-called Pazyryk assemblage has been much debated, it represents the best available information on the roots of weaving among Central and Western Asian nomadic pastoralists (e.g., Helfgott 1994). As such, it provides a useful means of inferring the likely ancestral states of the characters used in the present study.

Next, we examined how well the cladogram accounted for patterns of variation in the textile assemblages with the retention index (RI). The RI is a measure of the number of homoplastic changes a cladogram requires that are independent of its length (Farris, 1989a, 1989b). The RI is a particularly useful goodness-of-fit measure because, unlike some other measures (e.g., the consistency index), it is not affected by number of taxa or number of characters and can therefore be used to compare phylogenetic signals in different data sets and character sets. The RI of a single character is calculated by subtracting the number of character state changes required by the focal cladogram (s) from the maximum possible amount of change required by a cladogram in which all the taxa are equally closely related (g). This figure is then divided by the result of subtracting the minimum amount of change required by any conceivable cladogram (m) from g. The RI of two or more characters is computed as $(G - S)/(G - M)$, where G, S, and M are the sums of the g, s, and m values for the individual characters. A maximum RI of 1 indicates that the cladogram requires no homoplastic change, and the level of homoplasy increases as the index approaches 0. To evaluate the RI of the textile cladogram, we generated 1000 data sets by randomly reshuffling character states among the taxa. Each data set was subjected to a parsimony analysis and the RI for the shortest length cladogram(s) calculated. We then compared these RI scores with the RI of the original cladogram.

Subsequently, we carried out a bootstrap analysis to further assess the fit between the cladogram and the textile data set. While the RI measures the overall fit between a data set and a cladogram, the phylogenetic bootstrap measures the support for individual clades (Felsenstein, 1985; Kitching et al., 1998). It involves generating cladograms from pseudo-data sets randomly sampled with replacement from the original data set, and then calculating the percentage of the cladograms that retain clades from the original cladogram. Clades that fit the data with little conflicting signal will return high bootstrap support percentages, and vice versa. Support for a clade was deemed to be high if it equaled or exceeded 70%, since experimental work with taxa of known phylogeny has suggested clades that are supported by 70% or more in a bootstrap analysis can be considered reliable (Hillis & Bull, 1993).

To test the secondary hypothesis that the designs incorporated into pile rugs have been transmitted among tribes in significantly greater numbers than the techniques used to produce textiles or the designs incorporated into nonpile textiles, we divided the complete data set into a data set comprising designs that occur exclusively on pile rugs, a data set consisting of technical traits (e.g., methods for spinning wool, plying yarn, types of knot, etc.), and a data set comprising designs that occur on nonpile textiles. The pile designs data set had 24 traits, the technical traits data set, 42, and the nonpile textile designs data set, 56. These data sets were then fitted to the most parsimonious cladogram yielded by the complete data set. Thereafter, their RIs were compared. We reasoned that, if the hypothesis is correct, the RI for the pile designs should be markedly lower than the RI for the technical traits and the RI for the nonpile designs. This analysis is similar to those reported recently by Lycett, Collard, and McGrew (2007) and Cap et al. (2008), and was carried out with MacClade (Maddison & Maddison, 2000).

The parsimony analysis of the complete data set yielded a single most parsimonious cladogram. This cladogram is shown in Fig. 3. It suggests that the textile assemblages of the Shahsevan, Qashqai, Boyer Ahmad, Bakhtiari, and Papi are descended from a common ancestor that is not shared by the textile assemblages of the Turkmen. The textile assemblages of the Qashqai, Boyer Ahmad, Bakhtiari, and Papi comprise a clade that excludes the Shahsevan textile assemblage. The subclades within the (Qashqai, Boyer Ahmad, Bakhtiari, Papi) clade suggest that the Boyer Ahmad, Bakhtiari, and Papi textile assemblages are more closely related to one another than they are to the Qashqai textile assemblage and that the textile assemblages of the Bakhtiari and Papi derive from an exclusive common ancestor.

The RI of the cladogram yielded by the complete data set was 0.59. As noted earlier, a maximum RI of 1 indicates that the cladogram requires no homoplastic change, and the level of homoplasy increases as the index approaches 0. Thus, the RI of the cladogram is consistent with the hypothesis

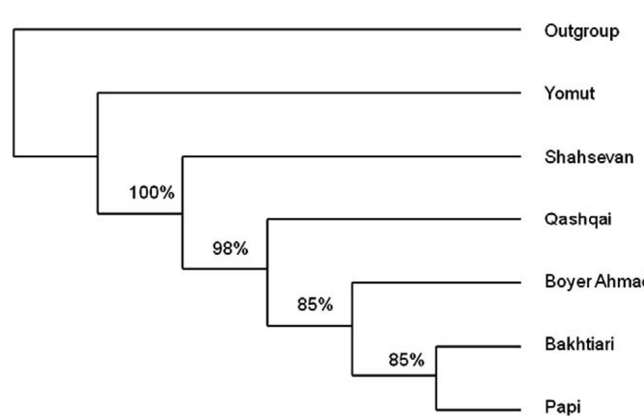

Fig. 3. Most parsimonious cladogram for the woven assemblages. The cladogram had a RI of 0.59. The percentages at the nodes represent the level of support given to each clade in the bootstrap analysis.

that the similarities and differences among the tribes' woven assemblages are primarily the result of phylogenesis. The RIs of the randomized data sets ranged from 0.24 to 0.36, with a mean value of 0.27. The RI of the original textile cladogram is therefore much higher than the RIs of any of the cladograms obtained from the randomized data sets and is more than twice as high as the mean of the randomized data sets' RIs. Thus, the fit between the cladogram and the textile data, though not perfect, is much higher than would be expected by chance. This provides further evidence to support the hypothesis that phylogenesis has been more important than ethnogenesis in the diversification of the tribes' woven assemblages.

The scores returned for the various clades of the cladogram are shown in Fig. 3. Support for all the clades exceeded 70%, which suggests that all of the phylogenetic relationships hypothesized in the cladogram can be considered robust (Hillis & Bull, 1993). The clade comprising all the textile assemblages except for the Yomut was supported by 100% of the bootstrap cladograms. Similarly, strong support was found for the next most inclusive clade, which included the Qashqai, Boyer Ahmad, Bakhtiari, and Papi. This clade was returned by 98% of the bootstrap cladograms. Support for the remaining two clades, although not quite as strong, was nevertheless still high. The clade comprising the Boyer Ahmad, Bakhtiari, and Papi was supported by 85% of the bootstrap cladograms, as was the clade comprising the Bakhtiari and Papi. Thus, the bootstrap analysis also suggests the fit between the cladogram and data set is good and therefore also supports the hypothesis that phylogenesis has been more important than ethnogenesis in the diversification of the tribes' woven assemblages.

The RIs obtained in the test of the secondary hypothesis are shown in Table 3. The traits that fitted the cladogram best were the designs used on textiles other than pile rugs. They returned an RI of 0.60. Techniques and pile rug designs both returned an RI of 0.59. Given the small difference between the RI for the techniques and the RI for the nonpile designs, these results are consistent with the idea that techniques and nonpile designs should fit the cladogram equally well. However, the results are inconsistent with the notion that the exposure of weavers to other tribes' designs via rug merchant cartoons and workshops would result in pile designs fitting the most parsimonious cladogram markedly worse than the technical traits and nonpile designs. Instead, the pile designs fit the cladogram almost as well as nonpile designs and fit just as well as the techniques. Thus, contrary to expectation, we found no evidence that pile designs have circulated in significantly greater number than technical traits or designs on nonpile textiles.

Table 3
Retention indices obtained from different trait sets when fitted to the most parsimonious cladogram for the textile assemblages

Data set	No. of characters	RI
1. All traits	122	0.59
2. Techniques	42	0.59
3. Nonpile textile designs	56	0.60
4. Pile rug designs	24	0.59

4. Discussion

In the first part of our study, we examined the contributions made by different forms of cultural transmission to the acquisition of weaving knowledge among Iranian tribal women. We found that vertical transmission is by far the most important process. In all but two cases, weavers learned their techniques during childhood under the tutelage of their mothers. Vertical transmission also plays a major role in the transmission of designs, particularly during the early stages of a weaver's career. A strong vertical bias has been found in other studies of cultural transmission, including subsistence practices and social skills among Aka foragers (e.g., Hewlett & Cavalli-Sforza, 1986), hunting and fishing techniques among the James Bay Cree (Ohamgari & Berkes, 1997), ethno-medicine among the Mapuche of Northwest Patagonia (Lozada et al., 2006), and food taboos in the Ituri rainforest of the Democratic Republic of Congo (Aunger, 2000). The importance of mother-to-daughter transmission also fits with the results of a global survey of the ethnographic literature by Shennan and Steele (1999). Shennan and Steele found that, in most small-scale societies, men and women acquire the majority of their craft skills from their fathers and mothers, respectively.

It has been suggested (e.g., Shennan & Steele, 1999; Tehrani & Riede, 2008) that the dominance of vertical transmission reported by these studies can be explained by the fact that craft and subsistence techniques are difficult to learn without the aid of a teacher. The latter usually incurs significant costs to train a novice, in whom they invest a significant investment of time and energy that could be spent pursuing other goals. In the case of vertical transmission, these costs can be offset by the long-term fitness advantages of providing one's offspring with skills that are likely to enhance their reproductive success (e.g., Hamilton, 1964).

However, this hypothesis has been criticized recently in a paper by McElreath and Strimling (2008) who argue that vertical transmission is adaptive only within a narrow range of conditions. They suggest on the basis of the results of a modeling exercise that vertical transmission is only effective when the environment is relatively stable and risk of mortality is such that survival to parenthood is itself an indicator of an individual's worth as a cultural role model. However, when the environment changes from one generation to the next and risk of mortality is lower, learners will tend to benefit from copying role models other than their parents (i.e., individuals who have adapted most successfully to the new environment) through oblique and/or horizontal transmission. McElreath and Strimling (2008) suggest that the current evidence for the dominance of vertical transmission is likely to be biased by the fact that most have focused almost exclusively on childhood learning since horizontal and oblique transmissions are likely to increase in importance as children grow into adulthood and are exposed to a greater variety of role models.

We found some evidence to support this critique. Our findings clearly demonstrate that nonvertical transmission increases in importance after childhood. Forty-seven of the 62 weavers who were interviewed said they adopted woven traits from nonmaternal sources following their initial apprenticeship. These included their peer group (35), cartoons provided by rug merchants (42), and employment in commercial workshops (4). A similar trend toward increasing levels of horizontal and oblique transmissions with age has been reported by Hewlett and Cavalli-Sforza (1986) among the Aka and by Aunger (2000) among populations in the Ituri rainforest. Hewlett and Cavalli-Sforza (1986) note that although Aka males learn the majority of their hunting techniques from their fathers during childhood, many seek to increase their skills during adolescence by observing the most accomplished men in their community. Similarly, Aunger (2000) describes how, following an initial intensive period of household-based cultural learning between the ages of 11 and 20, individuals in the Ituri Forest adopt a significant number of additional taboos and other food avoidances as a result of their social interactions with members of different families, clans, and ethnicities. Taken together, the results of our study and those of the studies carried out by Hewlett and Cavalli-Sforza (1986) and Aunger (2000) indicate that current evidence relating to cultural transmission is likely to have underestimated horizontal and oblique transmissions due to its strong focus on childhood learning.

In the second part of our study, we examined the impact of vertical and horizontal/oblique transmission on population-level cultural diversity. First, we tested the hypothesis that similarities and differences among the tribes' woven assemblages are likely to have evolved primarily through descent with modification from common ancestral assemblages rather than from borrowing and blending among contemporaneous assemblages. The hypothesis was based on two findings from our fieldwork. First, endogamous marriage norms mean that weavers are almost always born into the same tribe as their mothers so do not usually inherit from them traits that are foreign in origin. Second, restrictions on the movement of women mean that weavers do not generally interact with members of other tribes. Therefore, even though horizontal transmission increases in importance as weavers grow into adulthood, it is unlikely to lead to borrowing among groups. Next, we tested a secondary hypothesis, which was that the designs incorporated into pile rugs have been transmitted among tribes in significantly greater numbers than the techniques used to produce textiles or the designs incorporated into nonpile textiles. This follows from the finding that pile carpet designs have the potential to circulate among tribes via rug merchant cartoons and workshop, whereas the techniques used to produce textiles and the designs incorporated into nonpile textiles do not.

The results of our cladistic analyses supported the primary hypothesis. They returned a single most parsimonious cladogram that had a much higher RI than RIs obtained from randomized data sets. Furthermore, a bootstrap analysis found robust support for all the relationships hypothesized in the cladogram. Thus, as expected by the primary hypothesis, both analyses found a strong phylogenetic signal in the craft data. Subsequent analyses found that the phylogenetic signal is just as strong in designs as techniques, meeting our prediction that horizontal transmission among individual weavers has not resulted in ethnogenesis among groups. Even pile rug designs, which we had thought would be more likely to circulate among groups as a result of commercial influences, were found to be consistent with a tree-like model of descent with modification.

These results are consistent with the results of a number of other studies of group-level cultural evolution. For example, many languages have been found to exhibit similarities that can be traced back to common ancestral populations that existed thousands of years ago (Gray & Atkinson, 2003; Gray & Jordan, 2000; Holden, 2002; Rexová et al., 2003). Strong evidence of descent has also been found in studies of neolithic pottery assemblages (Collard & Shennan, 2000), Turkmen weaving traditions (Tehrani & Collard, 2002), kinship and subsistence traits in Africa (Guglielmino et al., 1995; Hewlett et al., 2002), and material culture diversity in the north coast of New Guinea (Moore & Romney, 1994; Roberts, Moore, & Romney, 1995; Shennan & Collard, 2005). Even in cases where borrowing and blending among neighboring groups dominate cultural evolution, they do not appear to have completely wiped out all traces of descent. For example, Jordan and Shennan (2003) report that while indigenous Californian basketry traditions evolved primarily through ethnogenesis, some traits (i.e., twining techniques) appear to have been mainly inherited from ancestral populations rather than borrowed from neighboring groups.

The results of our study and the evidence of phylogenesis reported by the studies mentioned in the previous paragraph challenge the long-standing assumption that the potential for cultural traits to be transmitted horizontally as well as vertically means that patterns of cultural diversity are bound to be much more complex and intertwined than patterns of biological diversity (e.g., Boas, 1940; Kroeber, 1948; Moore, 1994; Terrell, 1988; Terrell, Hunt, & Gosden, 1997). As our study shows, it is important to take into account that even when individuals do learn traits from nonparental sources, it is easier to access knowledge from members of the same community than from members of different communities. Whereas horizontal transmission among members of the same group is facilitated by their physical proximity, common language, and shared cultural norms, communication among members of different groups is often impeded by the existence of ecological boundaries, language barriers, endogamy, and xenophobic prejudices (e.g., Barth, 1969; Durham, 1990, 1992; Gil-White, 2001; McElreath, Boyd, & Richerson, 2003). Consequently, despite the clear differences between cultural transmission and genetic transmission at the individual level, cultural evolution at the level of the group often appears to be remarkably similar to the evolution of species diversity (Collard et al., 2006).

With regard to the secondary hypothesis, the results of the analyses failed to support the prediction that pile rug designs are more likely to have been influenced by ethnogenesis than other kinds of designs or techniques. As noted earlier, the hypothesis was based on the fact that pile rug designs can be copied from external sources such as cartoons and workshops, which may allow commercially popular designs to circulate among groups. In contrast, techniques are only transmitted vertically while nonpile designs are only copied from other members of the weaver's group. The analyses found that, contrary to expectation, pile-woven designs fitted the most parsimonious cladogram derived from all the weaving data just as well the other kinds of traits, which suggests that pile designs have not been significantly affected by the exposure of weavers to commercial influences. One possible explanation for this is that the transmission of pile-woven rug designs might be influenced by a "conformity bias" (e.g., Henrich & Boyd, 1998). Conformity bias involves an individual copying those traits that are most frequent in the population and has been argued to play a significant role in maintaining between-group variation (e.g., Henrich & Boyd, 1998; Hewlett et al., 2002; McElreath & Strimling, 2008). Although we lack quantitative data to test for conformity, informal conversations with weavers and other members of the study communities indicated that such a bias may be present. In all the groups that were visited, people explained that accurate reproductions of recognized patterns are much more highly regarded than novelties or inventions. Thus, while weavers may frequently employ new and unfamiliar designs when producing rugs for sale, they are likely to favor more commonly used traditional patterns when making rugs to furnish their own households.

One of the corollaries of this finding is that the homoplasies in our data set are not limited to pile carpet designs. Given that weavers do not appear to exchange weaving techniques and nonpile designs with members of other tribes, it would appear that process other than transmission must account for approximately two thirds of the homoplasy in the complete data set. There are several possibilities in this regard. The generation of textile patterns can be strongly constrained by the use of specific materials or techniques (e.g., Mallett, 1998), producing similarities among assemblages that are not due to common descent nor borrowing and blending. Similarities of this type are analogous to parallelisms in biology. Independent invention is another potential source of homoplasy. Specific techniques for manufacturing textiles and for processing raw materials like wool and dyes may not all derive from a single source but could have arisen in separate lineages. Similarities of this type correspond to convergences in biological evolution. A third possibility is that some traits, having been invented, are subsequently lost and perhaps even reinvented again. This process is known in phylogenetics as character state reversal, and has the potential to be important source of homoplasy in cultural evolution, where rates of innovation are usually considered to be high.

Although independent evolution has been discussed in relation to human subsistence behavior and social organization (e.g., Guglielmino et al., 1995; Hewlett et al., 2002; Mace & Holden, 2005; Mace & Pagel, 1994), it has been neglected in relation to other cultural behaviors. For example, it is usually assumed that similarities in material culture are either due to inheritance from common ancestral assemblages or from borrowing and blending among groups (e.g., Collard et al., 2006; Dewar, 1995; Moore, 1994; Tehrani & Collard, 2002; Temkin & Eldredge, 2007). Consequently, most studies in this area have interpreted homoplasy as evidence of ethnogenesis. Our findings indicate that this may overestimate the actual rate of borrowing among groups and that more attention needs to given to other potential sources of homoplasy, such as those outlined above.

The last issue we will address is the relationship between the textile data and the other lines of evidence pertaining to the tribes' population histories. To the best of our knowledge, there are no genetic data for the groups. Documentary evidence for their origins and dispersals is also very limited (e.g., Barthold, 1962; Garthwaite, 1983; Tapper, 1991, 1997). Currently, then, the only lines of evidence that the textile data can be compared with are linguistic affiliations and oral history (e.g.,Amanolahi, 1988; Barthold, 1962; Beck 1986; Grimes, 2002; Johanson, 1998; Oberling, 1974). These suggest the populations can be divided into two main lineages. The first lineage comprises the Boyer Ahmad, Bakhtiari, and Papi, who are collectively known as the Lors. The Lors are endemic to western Iran and speak an Iranian language, Lori. The second lineage comprises the Qashqai, Shahsevan and Yomut. These populations claim descent from Oghuz Turkic hordes that invaded Iran between the 10th and 14th centuries (e.g., Barthold, 1962; Beck 1986; Oberling, 1974) and speak Turkic languages.

The textile cladogram agrees with ethnohistorical and linguistic data regarding the monophyly of the Iranian-speaking groups. The weavings of the three Lor populations are grouped together in a clade that excludes all the Turkic groups, implying that they inherited their weaving traditions from a common ancestral population. However, the textile cladogram disagrees with the ethnohistorical and linguistic data with respect to the monophyly of the Turkic-speaking groups. The parsimony analysis failed to return a clade linking all the Turkic groups to the exclusion of the Iranian ones. Instead, the most parsimonious cladogram suggests that the Turkic-speaking Shahsevan and Qashqai share a more recent common ancestor with the Lors than they do with the Yomut. The cladogram further suggests that the Qashqai are more closely related to the Lors than they are to the Shahsevan.

These anomalies should not be interpreted as evidence that the craft phylogeny is inaccurate. As mentioned earlier, experimental studies (e.g., Hillis & Bull, 1993) suggest that false relationships are unlikely to receive such high levels of bootstrap support as those returned in our analyses. Therefore, we suggest three possible explanations for the apparent conflict between patterns of craft inheritance and other data on population histories. The first explanation is that all the groups' weaving traditions are ultimately derived from the ancestors of the three Turkic-speaking groups who brought the practice of weaving with them when they invaded what is now Iran. The Turkic lineage then diversified in such a way that the Shahsevan and Qashqai inherited their weaving traditions from an exclusive common ancestor not shared with the Yomut. Subsequently, the ancestors of the present-day Lor populations adopted the practice of weaving as well as specific weaving techniques and designs from the ancestors of the Qashqai after the latter split from the ancestors of the Shahsevan.

This explanation is supported by several lines of evidence. The Shahsevan and Qashqai both speak Azeri, which belongs to the western branch of Oghuz Turkic languages, whereas the Yomut speak Turkmani, which belongs to the eastern branch of Oghuz Turkic languages (Grimes, 2002; Johanson, 1998). Furthermore, literary evidence indicates that the tribes that gave rise to the Qashqai in the 18th century originated in Azerbaijan, in northwestern Iran, where the territories of the Shahsevan are located (Beck, 1986; Oberling, 1974). It is therefore entirely plausible that the Shahsevan and Qashqai are descended from a common ancestral population that is of more recent origin than the ancestor they share with the Yomut. As for the relationship between the Qashqai and the Lor assemblages, ethnohistorical data (e.g, Beck, 1986; Oberling, 1974) suggest that ancestors of the Qashqai migrated to the Zagros region of southwestern Iran some 500 years ago, before the Boyer Ahmad, Bakhtiari, and Papi existed as distinct tribal entities (Amanolahi, 1988). This supports the idea that the common ancestor of these groups may have acquired weaving by interacting with the new Turkic-speaking arrivals, before subsequently splitting and giving rise to the modern-day assemblages of the Boyer Ahmad, Bakhtiari, and Papi.

Although the hypothesis that the Lors originally acquired weaving from Turkic-speaking groups conflicts with our ethnographic data, which suggest that intertribe borrowing is limited to pile carpet designs, studies conducted elsewhere suggest that the processes involved in the initial spread of cultural knowledge can be different from those by which it is subsequently maintained. For example, Hewlett and Cavalli-Sforza (1986) describe how the Aka of the Democratic Republic of Congo acquired crossbow hunting and manioc planting from neighboring horticulturalists. These new skills spread rapidly within the community through oblique and horizontal learning. But adults subsequently passed them on to their offspring in the same way as the majority of other foraging skills. Lozada et al. (2006) argue that similar processes were involved in the diffusion of folk medicine in Patagonia, where knowledge that is now routinely passed down within families was the sole preserve of shamans only a few generations ago. Lozada et al. (2006) contend that is likely that this knowledge initially spread to the lay community through horizontal transmission and was subsequently transmitted vertically by mothers to their children.

A second possible explanation for the mismatch between the textile cladogram and the linguistic and ethnohistorical data involves a linguistic shift rather than a change in material culture-related practices. That is, the branching points of the textile cladogram correspond to population splits, but the linguistic affinities of the tribes do not. In this scenario, the ancestors of the Boyer Ahmad, Bakhtiari, and Papi were Turkic speakers who shared a common ancestor with the Qashqai that was not shared by the Shashevan. The ancestors of the Boyer Ahmad, Bakhtiari, and Papi separated from the ancestors of the Qashqai and then proceeded to adopt a new language from surrounding Indo-Iranian populations.

Such a scenario would fit with recent work suggesting that mismatches between language and genetic history are common among pastoralist populations in the Middle East (e.g., Nettle & Harris, 2003). As Barth (1961) explained in his classic study of nomads of South Persia, linguistic and ethnic identities are often based on a group's political affiliations rather than its actual historical origins. Barth (1961) describes several cases where groups are known to have adopted the language of politically dominant groups, initially becoming bilingual but ultimately switching completely to their new tongue.

A further possibility that should be considered is that there may be differences in the population histories of males and females in Lor tribes. Studies of population genetics suggest that the territories of Middle Eastern pastorialist groups often shift through time as some patrilines expanding at the expense of others, with invading males marrying local females (e.g., Chaix et al., 2007; Comas et al., 1998; Hamilton, Stoneking, & Excoffier, 2005; Perez-Lezaun et al., 1999). Thus, even though these groups are currently endogamous, it is conceivable that the conflict between linguistic and ethnohistorical sources on the one hand and the textile cladogram on the other may be due to the assimilation of Turkic females by patrilineal Lor groups during a period of expansion in the past.

In principle, it should be relatively easy to determine which of these hypotheses provides the best explanation for the (Qashqai, Bakhtiari, Papi, Boyer Ahmad) clade. Such a study would involve collecting mitochondrial DNA and Y-chromosome data from Iranian tribal communities and comparing them to the textile and linguistic data. A close correspondence between the mtDNA, Y-chromosome, and linguistic data would support the hypothesis that the Lors adopted the practice of weaving from the Qashqai after the latter moved into the Zagros Mountains, whereas a close correspondence between the mtDNA, Y-chromosome, and textile data would support the hypothesis the Lors are in fact Turkic in origin and switched to an Iranian language after splitting from the Qashqai. Alternatively, if the Y-chromosome data match the linguistic and ethnohistorical data but the mtDNA data indicate significant introgression of Turkic females into Lor tribes, the third hypothesis would be supported. Testing these different explanations for the relationship between the weavings of the Lors and the Qashqai will be a priority for our future work in this area. In the meantime, we can neither assume that borrowing is the source of this relationship nor can we rule it out.

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Appendix 1
List of characters

Character	Trait	Category
1	ground loom	technique
2	vertical loom	technique
3	open shed	technique
4	needle weave	technique
5	perforated cards	technique
6	spinning	technique
7	plying	technique
8	rolled felts	technique
9	shaped felts	technique
10	weft-twining (1)	technique
11	weft twining (2)	technique
12	twined baskets	technique
13	colied baskets	technique
14	weft-wrapping	technique
15	countered wefts	technique
16	diagonal wefts	technique
17	weft-faced plain	technique
18	goat-hair weft weave	technique
19	slit-tapestry	technique
20	shared warp weave	technique
21	interlocking warps	technique
22	warp-faced plain weave	technique
23	double-faced warp pattern	technique
24	wapr-faced *jajim* weave	technique
25	weft-knotting	technique
26	weft-wrapped knots	technique
27	pile knots	technique
28	symmetrical knots	technique
29	asymmetric knots	technique
30	depressed warp threads	technique
31	weft shots	technique
32	1 weft shot	technique
33	2 weft shots	technique
34	3 weft shots	technique
35	gabbeh weave	technique
36	plaiting	technique
37	weft float brocade	technique
38	compound weave with pile floats	technique
39	goat hair selvages	technique
40	corded selvages	technique
41	ends folded	technique
42	ends stitched	technique
43	A-shapes on bands	flat-weave design
44	X-shapes on bands	flat-weave design
45	Evil eye	flat-weave design
46	Bricks in alternating colours	flat-weave design
47	Central medallion	flat-weave design
48	piano-key pattern	flat-weave design
49	all-over patterns	flat-weave design
50	diamond lattice	flat-weave design
51	diamond dazzle pattern	flat-weave design
52	stepped diamond	flat-weave design
53	comb-edge diamond	flat-weave design
54	diamond chain	flat-weave design
55	hooked diamonds	flat-weave design
56	memling	flat-weave design
57	animal-head hooks	flat-weave design
58	rose bush	flat-weave design
59	stylised shrubs	flat-weave design
60	angular flowers	flat-weave design
61	dart-like flowers	flat-weave design
62	floating darts	flat-weave design
63	peacock motif	flat-weave design
64	simple animal shapes	flat-weave design
65	2-headed birds	flat-weave design
66	simple human shapes	flat-weave design
67	rosettes	flat-weave design
68	palmettes	flat-weave design
69	serrated palmette	flat-weave design
70	serrated palmette with trunk & branches	flat-weave design
71	ram-horn diamond	flat-weave design
72	*Gul*	flat-weave design
73	8-pointed stars	flat-weave design
74	stepped star	flat-weave design
75	beetle	flat-weave design
76	oak leaf	flat-weave design
77	geometric leaves	flat-weave design
78	triangle boat border	flat-weave design
79	saw-tooth border	flat-weave design
80	crab-claw border	flat-weave design
81	interlocking hooks	flat-weave design
82	bird hooks	flat-weave design
83	animal head hooks	flat-weave design
84	helmet-like hooks	flat-weave design
85	soldat	flat-weave design
86	V border	flat-weave design
87	S borders	flat-weave design
88	continuous S's	flat-weave design
89	interlocking s's	flat-weave design
90	lozenge s's	flat-weave design
91	geometric swaztika	flat-weave design
92	reciprocal triangles	flat-weave design
93	reciprocal laleh	flat-weave design
94	reciprocal rose border	flat-weave design
95	diamond with projecting arrows	flat-weave design
96	infinity motif constructed from ram horn	flat-weave design
97	endless knots	flat-weave design
98	diamond border	flat-weave design
99	ornaments repeated on plain field	pile-weave design
100	diamond medallion	pile-weave design
101	plain field with animal shapes	pile-weave design
102	field divided into compartments	pile-weave design
103	khesthi compartments	pile-weave design
104	ensi style	pile-weave design
105	lions	pile-weave design
106	naturalistic palmette	pile-weave design
107	tree of life in rosettes	pile-weave design
108	tree of life in palmettes	pile-weave design
109	ram-horn tree	pile-weave design
110	*kochak*	pile-weave design
111	*chemche*	pile-weave design
112	naturalistic cypress trees	pile-weave design
113	abstract cypress	pile-weave design
114	*boteh*	pile-weave design
115	large inverted boteh	pile-weave design
116	*Tekke Gul*	pile-weave design
117	serrated leaves	pile-weave design
118	serrated leave boat border	pile-weave design
119	curled leaf boat border	pile-weave design
120	herati pattern	pile-weave design
121	*Yomut gul*	pile-weave design
122	interlocking bird swaztika	pile-weave design