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**MICROSCALE TO MILLENNIA:
FRACTAL PROCESSES OF COLLABORATION
AMONG CHEROKEE CHILDREN AND FAMILIES IN COMMUNITY.**

A dissertation submitted In partial fulfilment
of the requirements for the degree of

Doctor of Philosophy

In

PSYCHOLOGY

by

Andrew R. Dayton

September 2023

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Abstract
Microscale to Millennia:
Fractal Processes of Collaboration
Among Cherokee Children and Families in Community
Andrew Dayton

The study synthesizes videotaped observations of Cherokee children's and families' interactions to illustrate a cultural process of harmonious collaborative practice that occurs simultaneously across developmental time scales, from the cultural/historical to the microgenetic. The study shows that in multiple scales of observation, the children's and families' interactions contribute to the moment-by-moment harmonious embodied collaboration that includes everyone present and remains harmonious and free of conflict, from their micro movements to the cultural historical situation. These processes comport with Cherokee Community Values that involve many explicit ways that Cherokee families have been directly instructed to collaborate by and with children and Elders since before European contact.

These observations exhibit patterns of historic, community-wide Cherokee practices occurring across generations while simultaneously capturing fluid collaboration unfolding in fractions of seconds. Specifically, the Cherokee children, families, and community members in this study collaborated in fluid and harmonious ways across generations within the community as they simultaneously collaborated in ways that are also fluid, harmonious, and with a high degree of mutually embodied, multi-modal interactional synchrony. Engagement in Cherokee community-scale collaborative practices fundamentally involves skillful attunement and bodily coherence in micro-scale collaboration.

Prologue

This mixed-methods ethnographic study is based on observations of child and family collaboration within a system of Cherokee community collaboration, building on Indigenous Knowledge Systems and Indigenous ways of learning. This research aims to offer the field a theory-rich, detailed, ethnographically informed and responsible narrative analysis of culturally and community embedded naturalistic video observations.

In keeping with Indigenous methodologies, we recognize that this research is a collaborative process. The first author of the study is an Indigenous researcher and Cherokee community member, working in close collaboration with his dissertation advisor and with Cherokee community members. To recognize the collaborative nature of this work, we use the plural ‘we’ in this document.

We hold continuing responsibility for the care of this study, its results, and most importantly, the contributions of Cherokee community participants and community members. The kind of trust extended by community members and stakeholders is a very important aspect of Cherokee community membership and participation. The community expectation is that any benefit that might be derived from the work will be contributed back to the broader community. An observation of cultural processes of such an important community practice as collaboration will be regarded as a useful contribution to Cherokee Communities (Bird Wolfe, Cherokee Ceremonial Grounds Chief; Joe Bird, Cherokee Nation Tribal Council Speaker; Lawrence Panther, Cherokee Speakers Consortium, *personal communications*, 2018).

With this relational accountability firmly in heart and mind, we have engaged with Cherokee community members, Elders, and outside experts to help us understand a cherished and beautiful Cherokee activity: *harmoniously collaborating all together – ႠႠႠႠႠႠႠႠ ႠႠႠႠႠႠႠႠ* (*ditsadasdelisgi itsehesdi*: ‘Everyone living, helping one another’).

Introduction

This study is intended to share cultural values and practices that Cherokee children and families “know in their bones” with the scientific community and

beyond, which is to collaborate harmoniously with the people around them. Learning to contribute in this manner is expected of Cherokee community members, throughout all interactions, and is fundamental to shared, explicit Cherokee Community Values (Smith, 2009; Teuton, 2012; Thomas, 1958).

This study aims to articulate ways that this approach to life can be seen in collaboration in tiny moments as well as in children's, families,' and other community members' collaboration across a historical scale. This involves looking at collaboration as a process that can be viewed from macro and micro perspectives simultaneously, in a fractal approach (Dayton & Rogoff, 2016; Dayton et al., 2022; Mejía-Arauz et al., 2018; Rogoff, 1995, 2003).

At a community and historic scale, we examine organizational processes of Cherokee children, families, and community members in intergenerational family and community collaboration. This is an organizational process informed by community values that have persisted for as long as there have been people, according to Cherokee oral tradition (Teuton, 2012).

We align this community/historical analysis with an examination of the participants' moment-by-moment fluid collaboration at a scale of fractions of seconds. Fluid collaboration is a microgenetic form of mutual engagement that has been observed to be common in Indigenous ways of learning (reviewed below). Our microanalysis builds on our prior research that describes fluid collaboration at a scale of milliseconds (Dayton, Aceves-Azuara, & Rogoff, 2022).

The present study contributes a fractal analysis of fluid collaboration in an Indigenous Cherokee community at multiple timescales simultaneously. The fractal analysis is based on the claim that development and learning are based in people's

participation in the moments and millennia of everyday life, as a single, holistic cognitive, social, and cultural process (Dayton et al., 2022; Rogoff, 1995).

This study contributes observations of value to Cherokee communities, by bringing together observations of Cherokee family practices that encompass millennia and centuries in community, regional or even pan-continental scope and relating these to close observations of individual Cherokee children at a scale of milliseconds. The analysis examines case studies of three types of event that we designed in order to pilot research procedures for a planned study (which was blocked by COVID-19). The plan was to create community events that would allow us to observe children playing a game and to interview their mothers about how their families organize themselves in community activities.

The piloting process allowed us to learn from Cherokee elders and children in three types of pilot events: researchers working with Cherokee mothers and their children to pilot our interview in a community setting, researchers and a Cherokee elder piloting our researcher-designed game with Cherokee 6-8-year-old dyads at a Cherokee-immersion primary school, and a researcher and multi-ethnic groups of 11-17-year-olds piloting the same game at an activity day at a community school.

Before moving into the fractal analyses of the data, we first describe previous studies of cultural differences in collaboration. We summarize prior research on both fluid collaboration during microseconds in small group interaction and millennial Cherokee value systems based in intergenerational community collaboration.

Cultural Differences in Collaboration: Microseconds and Millennia

Research on collaboration has addressed differences across cultural communities in forms of working together among pairs or small groups as well as in

the organization of communities. These have been described as two key aspects of a way of learning that involves Learning by Observing and Pitching In to family and community endeavors (LOPI; Rogoff & Mejía-Arauz, 2022), which appears to be common in Indigenous communities of the Americas. The facets on which we focus – Facets 1 and 3 – are two of seven facets (see Figure 1).



Figure 1. The LOPI prism, describing features of Learning by Observing and Pitching In to family and community endeavors.

Facet 1 of LOPI describes community organization as inclusive and intergenerational, with all ages contributing together in shared endeavors. Facet 3 of the LOPI prism describes LOPI approaches to small-scale group interaction as essentially collaborative, involving flexibility, fluid coordination, and mutually paced engagement (Rogoff, 2014; Rogoff & Mejía-Arauz, 2022).

The study provides a potential contribution to the theoretical base of LOPI by engaging with the claim that human development is continuous across microgenetic, ontogenetic, cultural historical, and phylogenetic time scales (Scribner, 1985; Vygotsky, 1978). The LOPI paradigm presents the relationship of cultural patterns across timescales as a single, unified, holistic developmental process, helping to clarify speculation and growing evidence that the collaborative organization of

Indigenous American communities is continuous with a tendency to collaborate fluidly in interpersonal engagements (Chandler, 2013; Dayton & Rogoff, 2013; Rogoff, 1995; Rosado May et al., 2020).

In this section, we summarize evidence that Indigenous and Indigenous-heritage people often collaborate more fluidly than some comparison groups when observed in small-scale interactions that unfold within minutes or even fractions of seconds. Then we review ethnographic and historic evidence of the collaborative organization of Indigenous communities – especially Cherokee – at an intergenerational, community scale.

Collaboration in Small Group Interactions

In line with Facet 3 of LOPI, ethnographic and comparative studies have found more fluid collaboration among Indigenous and Indigenous-heritage peoples of the Americas, and more solo and conflictual interactions among children from families with more experience in Western institutions. Children from many Indigenous-heritage communities of the United States, Mexico, and Central America often engage as ensembles, in fluid collaboration, whereas children from middle-class communities often engage in solo or dyadic activity, often by dividing roles and activities into separate tasks (Chavajay & Rogoff, 2002; Correa-Chavez, Mangione, & Mejia-Arauz, 2016; Ellis & Gauvain, 1992; Mejia-Arauz, Rogoff, Dexter & Najafi, 2007; Paradise & de Haan, 2009).

One of the first studies to examine small-group fluid collaboration was Chavajay and Rogoff (2002), which found that Indigenous Mayan families with minimal experience with Western schooling and related practices generally collaborated fluidly while building a 3-dimensional puzzle together. They spent more

time in shared “horizontal multiparty engagement,” with the mother and three children involved in the same aspect of the puzzle with “one cohesive focus” (Chavajay & Rogoff, 2002, pg. 59). Families with extensive involvement in Western schooling and related practices more often worked on the puzzle through division of labor, generally with the mother directing the activity. Relatedly, Brown (1980) found more collaboration among enrolled Cherokee 2nd graders and more competition among European-heritage counterparts.

Several other studies contribute similar findings. Indigenous-heritage US Mexican children more frequently engaged as fluid ensembles than middle-class European-heritage children, who more frequently engaged in dyadic or solo form while folding origami figures (Mejia-Arauz, Rogoff, Dexter & Najafi, 2007). In a Mazahua community in central Mexico, mothers and children (unlike teachers with the children) collaborated in building a roof for a simulated market stand, contributing different steps to the process as needed, with mothers providing neither direction nor prompting the children’s initiative (Paradise & de Haan, 2009). Navajo children more often remained engaged in a collaborative task even at the times when they were not the person leading the task, whereas European American children were more often distracted when not in control, sometimes to the point of leaving the task altogether (Ellis & Gauvain, 1992). Mexican Indigenous-heritage siblings more often engaged in fluid collaboration with shared thinking, coordinating their moves and blending ideas as a fluid ensemble, whereas middle-class European-heritage counterparts spent most of their time dividing roles, ignoring their partner, or engaging in conflict (Alcalá, Rogoff, & López, 2018, Ruvalcaba & Rogoff, 2022).

These studies analyzed interactions at a scale employing segments of fractions of minutes. Only one study has focused on cultural differences in collaboration at a scale of fractions of seconds. Mayan mothers and their two small children collaborated as a fluid ensemble more often than middle-class European American mothers and their two small children, coded in segments at a scale of 200 milliseconds (Dayton, Aceves-Azuara, & Rogoff, 2022). Fluid collaboration involved the entire triad engaging as a coherent, synchronous group — an ensemble — in their fine-grained movements while exploring a series of novel objects presented to them during a researcher’s visit to their home. These ensembles appeared to function as *one organism with many limbs* in a common envelope of activity. By contrast, middle class European American families more often engaged as dyads with one person left out, did not engage with each other at all, or resisted each other.

Across distinct studies we suggest that very fine-grained microgenetic observations of Indigenous American approaches to collaboration may be similar to patterns observed at cultural/historic time scales. The present study contributes the first examination of the coherence of collaborative patterns across developmental timescales, from microgenetic to cultural/historic, within the same families in a single Indigenous community.

To our knowledge, only one study one has empirically related cultural/historical Indigenous American practices and individual people’s behavior. Tsethlikai and Rogoff (2013) found that Tohono O’odham children whose families more often engaged with traditional Tohono O’odham practices that are “embedded in a larger system of activities and meanings” — such as traditional storytelling — showed more incidental recall of a story (Tsethlikai & Rogoff, 2013, pg. 12).

Although this study did not focus on community organization or collaborative engagement, it makes an important contribution to connecting relationships of patterns across timescales in an Indigenous American traditional practice, storytelling.

The current study relates processes of collaboration between individuals and traditional Indigenous practices. It examines the relationship of Indigenous American approaches to the collaborative organization of the community across generations and children's, families,' and other community members' embodied collaborative engagement. The previous research has found that Indigenous and Indigenous-heritage children have been more likely to collaborate during research tasks as well as to be participant members of families and communities that often collaborate at wide, intergenerational scales. The current study offers the first observations of the coherence of the collaborative organization and process of Indigenous American practices across timescales with the same children and families in one investigation.

Collaboration in Intergenerational Community Engagement

The central feature of LOPI (Facet 1) describes community organization as involving learners in family and community endeavors regardless of age (Rogoff, 2014; Rogoff & Mejía-Arauz, 2022). Indigenous communities tend to embody this value in action by organizing to include people of all generations, from the very oldest to the very youngest, in important community and family practices (Morelli, Rogoff, & Angelillo, 2003; Rogoff, 2014; Thomas, 1972). Regardless of highly dynamic and constantly changing differences in individual interests, ages, or experience, Indigenous and Indigenous heritage families and communities in the Americas tend to organize in ways that include everyone in central activities (Cooter,

1998; Flores, Chamoux, Lorente Fernández, & López, 2015; Rosado May, Urrieta, Dayton, & Rogoff, 2020; Thomas, 1993; Urrieta, 2015). The collaborative organization of Indigenous families and communities in the Americas has been described as holistic and inclusive in ethnographic and historic records, in widely separated communities in the Americas, and at different times in history (Corona, 2011; Flores et al, 2015; Paradise & Robles, 2016; Pelletier, 1970; Rogoff, 2011; Urrieta, 2015).

Central to the Cherokee worldview, specifically, is the idea that all beings are included in all aspects of life -- everything is always interconnected (Cooter, 1998; McGloughlin, 1992; Smith, 2007; Teuton, 2012; Thomas, 1993). In particular, the inclusion of both elders and young children in valuable forms of family and community engagement is considered vital to children's development as well as to the continuance and flow of Cherokee culture across generations (Smith, 2007; Teuton, 2012; Thomas, 1993). Cherokee traditionalist Hastings Shade gives evidence of historic, intergenerational, inter-familial collaboration (*S'kadug* in the Cherokee language) in accounts of Eastern Oklahoma Cherokees, focusing on the organic, community-wide collaboration practiced by "traditional Cherokees" (Teuton, 2012, p. 84).

Traditional Cherokee oral knowledge aligns with theoretical work suggesting that a collaborative, intergenerational approach to organizing Indigenous American families and communities has persisted for millennia and continues today despite changes to particular cultural activities (Dayton & Rogoff, 2013). Noted Cherokee anthropologist Robert K. Thomas describes this collaborative, intergenerational

approach, which he claimed persisted from the 1920's to the 1990's among
"traditional" Cherokee communities in Eastern Oklahoma where he grew up:

Indian (sic) parents have no notion that they are "raising" a child or molding a human being or do things for the good of the child. A child is simply a small kinsman and one lives in harmony with a small kinsmen. That does not mean that one expects a small kinsmen to be as knowledgeable as a large kinsmen or even as efficient as a large kinsmen, but a small kinsman has the same rights and in some senses the same responsibilities as a large kinsman...

Learning and tasks are voluntary so that children, like adults, learn at their own pace, participating and helping one another at things they feel competent to "take hold of". Cherokee children are never told when to take part in an activity in order to learn, or when not to take part in an activity in order not to lessen the efficiency of the activity." (Thomas, 1993, pg. 10)

This oral knowledge is supported by over 200 years of academic scholarship noting the essentially collaborative organization and processes within and across Cherokee families and communities (in chronological order: Timberlake, 1765; Cherokee Chief Dragging Canoe, 1775; Tatham, 1830; Ramsey, 1853; Mooney, 1902; Starr, 1922; Thomas, 1972; McLoughlin, 1992; Perdue, 1998; Teuton, 2012). The present study examines the connection between large scale collaborative Cherokee community organization and small scale collaborative processes among Cherokee children, families, and other community members, within Cherokee communities.

In Cherokee communities, the carrying of local scientific knowledge comes from "Tradition Keepers" or "Knowledge Keepers" (in Cherokee Tribal government, "Cherokee Living National Treasures"). These specialists are the equivalent of academic scholarly experts; their documents are oral traditions and beaded wampum. (See Figure 2.)

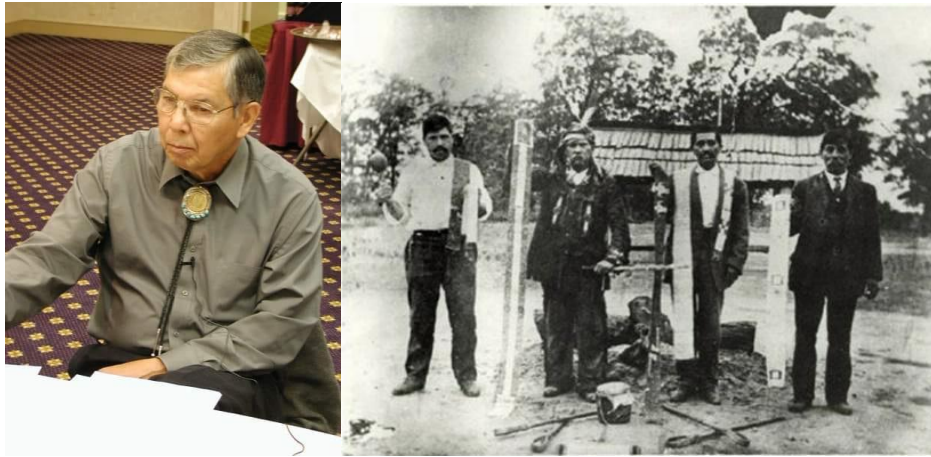


Figure 2. Benny Smith, grandson of Redbird Smith (second from left holding a wampum that represents millennial principles regarding right actions), was a Cherokee first-language speaker, venerated Elder, and translator and interpreter of the Cherokee Community Values presented here. The left hand image is Benny Smith around 2009, the right hand image is around 1907 (Mooney, 2006 [1902]). These Elders hold wampum that are displayed and spoken each year in the summer.

The wampum are interpreted aloud at ceremonial events and widely used for language instruction. The bead interpreter recounts versions of 13 written principles, circulated by the Cherokee Nation Tribal government and other Cherokee official organizations. (The wampum and the interpretation of them follow protocols much like academic writing, for roughly the same reasons – to produce and organize cumulative knowledge.)

Each of these community values is stated in a one-word, present-tense verb, which have a collective form. Roughly, “You and we (“Y’all to each other”) are continually doing this thing (“From now on; from here on out).” (Ryan Mackey, 2014: <https://www.youtube.com/watch?v=nqU7wRGJHJg&t=1253s>). Here are three roughly of the community values; others of the 13 community values are used in the analyses of this study. The 13 verbs on the list of community values are seen as different ways of stating one central principle.

“*Ōhi BŌ Shʁʁʁʁʁʁʁʁʁʁ nani ’v yvwi detsatloyadisgesv*
 Include everyone, all human kind; however many.

communities, which can be directly observed in fractal patterns across timescales (Dayton & Rogoff, 2016; Dayton et al., 2022; Rogoff, 1995, 2003). This study intends to illuminate the ideas that cultural, social, and cognitive development are a single holistic process; that embodied participation in this holistic process is a fundamental, dynamic aspect of children's learning and the creation of learning contexts; that the continual process of meaningful engagement among these dynamic social phenomena are fundamentally cultural; and that these processes can be observed directly using ethnographic video analysis (Condon & Ogsten, 1967; Dayton & Rogoff, 2016; Dayton et al., 2022; Erickson, 2011; Goodwin, 2018; McDermott, Gospodinoff, & Aron, 1978; Rogoff, 1995, 2003; Spivey, 2017; Trevarthen, 2010; Vygotsky, 1978).

The overall aim of this synthesis is to demonstrate a fractal relationship within ethnographic video observations in continuous time-sequenced events. This analysis cross-cuts theoretical interest in human development (LOPI, Vygotsky), cognitive science (non-linear dynamics), and Indigenous Knowledge Systems (Holism and Relationism). These converging theoretical and empirical traditions situate our study, providing the theoretical base for examining evidence that individual, social, and cultural development are a single holistic process of dynamic transformation that can be directly observed in fractal patterns across timescales.

The Present Study – Fractal Analysis of Fluid Collaboration Across Timescales

To provide evidence of a fractal relationship of collaboration across cultural/historic and micro-genetic developmental timescales, the present study

examines microscale collaborative engagement and community-scale family collaboration in a Cherokee community. Each of three videotaped settings provides evidence of collaboration of families in their communities – an organizational process informed by LOPI Facet 1 – as well as microgenetic fluid collaboration among individuals and groups – informed by LOPI Facet 3.

The three fractal analyses in the present study bring ethnographic analysis to bear on understanding key moments of videotaped interactions, deriving from pilot sessions for a study of children’s collaboration in family and community. The pilot sessions were in preparation for the originally planned study, to interview Cherokee mothers about how their families organize themselves in community activities, and to correlate their statements with observations of their children collaborating during a cooperative/competitive game.

We carried out extensive piloting in collaboration with community members and institutions, over 3 years of involvement in the community in preparation for this study (in addition to the first author’s prior family involvement in Cherokee communities and the authors’ continuing involvement). The piloting process is often overlooked in research; we believe it is key to research design.

The extensive piloting is based in our commitment to designing procedures with the aid of participants. This approach combines ethnographic methods with methods aiming to generalize across cases (Angelillo, Rogoff, & Chavajay, 2007). It also embodies a process of designing research that is responsive to the lived experience of the participants – whether attempting to compare cultural practices, the lives of children of different ages, or people’s differing approaches to distinct conditions or settings (Rogoff, Callanan, & Dahl, 2018). The piloting process also

engages in relational accountability together with the participating community, an antidote to drive-by research studies, enacting a key aspect of Indigenous methodologies (Wilson, 2008).

Our plans for a correlational study were interrupted by lack of access to participants due to closure of the schools and society because of the Covid pandemic. We are grateful to the corona virus for making us focus on our pilot data. A spark for the present study came in one key pilot session, when we noticed that the fractal nature of Cherokee collaboration was observable simultaneously across timescales. The fractal analyses of this study start with this moment, which illuminates the fractal quality of intergenerational and fluid collaboration across microscale and millennia.

The fractal analysis we use in all three settings more closely reveals the processes of interest than our original design, and more closely aligns with the ideas of Indigenous Knowledge Systems. The three settings are: piloting the interview of mothers regarding their family's ways of engaging in community events, piloting a cooperative/competitive children's game, and piloting the game semi-naturalistically during a school activity day. (The individuals who participated in the piloting gave consent for this use of the videotaped data.) In each of the three settings, we build on the coding schemes that had been developed in planning for the correlational study, and we pinpoint observations in the pilot video data that help us illustrate the theoretical claim that microscale and millennial scales (and everything between) are aspects of one ongoing process.

What makes these analyses Fractal Analyses is the claim that patterns that can be seen at a microscale can also be seen at a millennial scale, in a single ongoing continuous process (Dayton & Rogoff, 2016; Rogoff, 1995, 1998, 2003; Werner,

1948). Our aim is to use Fractal Analysis to examine a specific pattern that we expected to be able to see across micro and millennial scales, which corresponds to LOPI Facets 1 and 3 and the Cherokee Community Value Systems that we explained above. We argue that our observations of fluid collaboration and inclusion at micro and millennial scales simultaneously are enactments of a cohesive pattern, observed across scales. Fractal Analysis could also be used, and has been, to examine a contrasting pattern – of dividing people and resources – that appear at microscale and millennial scales in the interactions common in highly schooled communities (such as in Dayton, Aceves-Azuara, & Rogoff, 2022; Rogoff, 2003; Rogoff et al., 1993; and many of the comparative collaboration studies of Rogoff and colleagues that we reviewed above. Fractal Analysis can be used to examine multiple patterns, whether a pattern of harmonious (inclusive, fluid, collaborative) social interaction or a pattern of dividing and separating actors and resources, at multiple scales.

Fractal Analysis 1. Fractal microanalytic and cultural/historic perspective in an interview on family-in-community collaboration. The analysis focuses on a videotaped interview with a Cherokee mother, with her 6- and 11-year-old children present, about how the family organizes for community activities. In one clip, she describes her family’s intergenerational community collaboration as they organize to join with others in a traditional regional and Cherokee activity, while simultaneously fluidly collaborating with her children and the researchers. The fractal analysis combines microanalysis of the collaboration in this family with cultural/historical analysis that rests on literature documenting longstanding Cherokee historic guiding principles, supporting the fractal idea that similar patterns can be seen at multiple scales. Fractal Analysis 1 highlights a pattern of inclusion of everyone and harmonious engagements that are described in LOPI Facets 1 and 3, and that are called for in the Cherokee Community Value System.

Fractal Analysis 2. Fractal microanalytic and cultural/historic perspective on pairs of children collaborating in piloting a game. This examines two sessions

involving pairs of Cherokee children and the researchers piloting a cooperative/competitive game, along with a classroom teacher/Cherokee Elder who is also helping with piloting. We focus microanalytically on how the children along with the researchers and the teacher engage together and how their collaboration reflects Cherokee cultural/historic values and practices. Specifically, this fractal analysis illustrates the Cherokee Community Value System and LOPI Facets 1 and 3, focused on inclusion and harmonious engagement, especially in a guidance situation involving a teacher/Elder enacting these values with subtle, gentle means.

Fractal Analysis 3. Fractal microanalytic and cultural/historic perspective on groups of children managing a conflictual situation harmoniously, in accessing the game during a school activity day. In Fractal Analysis 3, distinct groups of students engaged harmoniously as they fluidly collaborated in a takeover of the cooperation/competition game, during a STEM activity at their school. We analyze the interactions among the groups, both microanalytically for fluid collaboration and cultural/historically for Cherokee cultural/historic values and practices around maintenance of group harmony as the groups of students managed a conflictual situation. Specifically, this fractal analysis illustrates the Cherokee Community Value System and LOPI Facets 1 and 3, focused on inclusion and harmonious conflict resolution through subtle fluid collaboration within and across groups.

Fractal Analysis 1: Fractal Microanalytic and Cultural/historic Perspective in an Interview on Family-in-Community Collaboration

The moment on which we focus captures the essence of our research aim – to document intergenerational fluid collaboration that seems to track, at one and the same time, at a scale of fractions of seconds and at a historic scale involving Cherokee community values and practices over generations. Our analysis synthesizes the family’s embodied communication regarding management of a potential interruption and their simultaneous explanation of an event that is based in longstanding Cherokee values and practices.

Participants

Participants were three Cherokee mothers and two children (ages 11 and 7) of one of the mothers, being interviewed by a research assistant trainee and the first author. (See Figure 3.) During the piloting, the interviewer asks the questions and provides culturally appropriate backchannel nods and umhums and aahs that indicate that she is listening respectfully.



Figure 3. The mother and older child respond to a question from the interviewer (on the left), as the younger child emerges into the interview room from another room where he has been playing with a phone. The interview room is in a community center; notice wall decorations including the Cherokee syllabary, a photo of former Principal Chief Wilma Mankiller, and a map of Oklahoma.

Procedure for the Family-in-Community Interview and Analysis

Our aim in the interviews was to document how Cherokee families organize to engage in Family-in-Community Collaboration, an organic form of collaborative community engagement that involves age-mixing, time flexibility, flexibility of organization and leadership structure, and intergenerational involvement. To get mothers to describe their family's form of organization, the interviews asked them to reflect on how their family organizes to engage together in common community activities (such as going swimming, shopping for groceries, managing yard sales and fundraisers, looking after cemeteries, and participating in sports).

Figure 4 shows one form of 'going swimming,' a traditional regional and Cherokee activity that was one of the activities that the interview prompted mothers

to reflect on. The interview asked the mother (who was not part of the specific day shown in Figure 4) how they organize their family to engage in each activity. (See Appendix A for the complete procedure for the interviews.)



Figure 4. In this ‘Going swimming’ event, families gathered at the creek on a hot summer day. About 3 or 4 families were set up with potluck picnic provisions on the shore, with adults and children dipping into the creek from time to time. One of the pilot interviewees described how her family organizes to go swimming in the summertime, in the sort of intergenerational, fluid process that we call Family-in-Community Collaboration (described below).

“To go swimming? Oh, well, normally we go with people, yeah, uh, family or, like, even just to the pool I have my brother, his friend, my nieces, my nephews, my sisters, so yeah, we try to go with people...I mean, but it’s always been like that.”

The piloting allowed us to hone the coding scheme that we had developed at UCSC (piloting with friends and colleagues), to use in the original correlational study. The coding scheme aimed to contrast Family-in-Community Collaboration with forms of organization that are often characteristic of Western institutions, such as coordination via division of time and resources (Flores et al., 2015; Purdue, 1998; Rogoff, 2003; Rosado-May et al., 2020). Fractal Analysis 1 focuses on the pilot data, using the coding categories as descriptions of alternative ways that families organize to engage in community activities.

Family-in-Community Collaboration involves an activity and leadership structure that is flexible and dynamic, with an organic and “self-organizing” use of time that recognizes and works with the probability of unanticipated events, and a collective use of property and space that flows improvisationally with shared function and convenience of storage, adapted to the process of use (e.g., not sorting sports

items by individual in the car trunk). This is typically intergenerational, involving extended and mixed family networks of various ages within the same activity. These responses use inclusive terms (“we” or “them and us” together, based in Cherokee language and values) such as plural kinship terms (e.g., “the cousins”, “my nieces”, “all of us”, and the like). For example, a Cherokee mother describes how her family organizes to play stickball, a traditional Cherokee activity:

I think whoever like grew up with it knows that, what's gonna go down for that day. So the day normally organizes itself, you know. If, for instance somebody says, a stickball today, at such and such, everybody knows to come, how to come and what to do when they come.”.

Family Coordination via Division is an alternative to Family-in-Community Collaboration. It involves an activity and leadership structure that is fixed, prescribed or hierarchical. It is typically “segmented,” divided by age or age group, distinguishes nuclear family from extended family by distinct roles, and divides time into schedules, sequences, or compartmentalized units. The same mother quoted above went on to contrast her family organization with the form of organization used in some official competitive stickball leagues:

They have a lot of tournaments, they're very... straight-out-there [explicit, top-down] too. I mean, they got like *rosters* for [organizing] shoes.... Yeah, that's, *that's* what you call...very *conducted*, you know? Yeah. Like, [in the voice of the organizer] ‘This is how it's gonna go down, ‘you’re playing defense, you're down here...’.

We also considered the possibility of responses that did not involve family collaboration, in which the activity organization is for individuals to engage and manage the activity isolated from other family members, routinely doing an activity alone. For example, one Cherokee mother responded to the question of how her family organized to engage in sports: “Dad went off to play softball after work.”

Results: Fractal Analysis 1, the videotaped mother interview

In the interview we focus on here, the Cherokee mother and children have agreed to help us test the camera set-up and the interview questions. The mother is a colleague of the first author with two children in the age range we were planning to include in the game task. (See Figure 3, showing this family during the clip that the analysis focuses on.)

The clip shows the simultaneous process of two grains of analysis. The mother and the older child explain their family's way of organizing involvement in a traditional Cherokee and regional activity, in a way that embodies continuing Cherokee historical cultural values and practices (Family-in-Community Collaboration). At the same time, the mother and the two children engage in fluid collaboration at a scale of fractions of seconds, managing what could have been an interruption by the younger child but which the family negotiates without interruption of the narrative regarding continuing historical cultural values and practices. This fractal process is visible in the following 1-2-minute clip, as shown in the images and account that follows. In the clip, we focus on the events occurring in the family's response to the interview and their interactions as the younger child enters, engaging as a triad.

Of course, the family triad's engagement is only part of what is going on in the broader episode (about a minute). The interviewer is listening respectfully to the spoken account. In addition, the researchers are also 'present:' The first author had been in the room, tinkering and eavesdropping and providing occasional guidance for the interview. At the start of this episode, he was moving around the room to avoid being pulled into the interview by the mother and the interviewer, and exited momentarily. And the second author is 'present' through the camera lens

(asynchronously) and as the advisor collaborating in iterative testing of the interview script.

These accompanying aspects of the episode could also be used to illustrate the fractal nature of what was going on. A fractal analysis of these other aspects of the 1-2 second episode could also open out to a timeframe of decades and centuries. For example, the pilot interviewer is the first author's daughter, so this interview is about relations between two extended Cherokee families, which have intertwined histories over years and generations and millennia.

However, our analysis focuses on the family triad in a 1-2- second clip from a 1-minute episode. The episode is about mid interview, and the mother was describing an ongoing process of intergenerational collaboration within her family while simultaneously involved with her two children. The interviewer and the mother had been going through the interview questions together. They had already talked about the family's way of organizing for several other activities, so the mother was familiar with the script. The interview script (see Appendix A) was projected on a screen, and the mother suggested jumping to Question 4, about swimming (see Figures 3 and 4). The written version of Question 4 was, "Does your family go to creeks, rivers or lakes in the summer?" "How does that get organized?" "Are there other families?" "Is there a schedule?"

This 1-minute episode began as the interviewer paraphrased Question 4 to the mother: "Did your family go to creeks, rivers? How is that logistically? Would you call this a part of your community? And how does the logistics and the schedule work for that?"

The mother elaborated freely on her family's approach. She mentioned the intergenerational, shared aspect and the fluid approach to time and space that we call Family-in-Community Collaboration:

But as far as swimming, yes. So from May, to July, October, late September, whenever it starts to cool off, we are there on weekends. As far as scheduling goes, I call my aunt or my sister and I'm like, 'Hey, we're going to Creek this weekend, just FYI,'

This statement shows Family-in-Community Collaboration: She said that the family organized to go to the creek by organically connecting with family members of different generations, her aunts, cousins (who live in the broader community), and their grandmother, who lives on the land where the family goes to the creek. The use of the term 'Grandma' here indicated a matriarch within longstanding matrilineal Cherokee communities. Since Grandma is this mother's mother, by reference to Grandma the mother established her community position via kinship relations.

The mother continued to elaborate, and her older son engaged together with her. At one point, he chimed in, embedding further explanation, co-vocalizing along with her in a shared mutual rhythm.

"Because we had to drive through [Grandma's] property to get to it. We used to drive through my grandparents' property. But over time – Child: "things grow" – trees grow and things get washed out. And so now we go to the backside. We're in the process of trying to get my grandmother's place cleaned up for her so.... So she likes, for her [Grandma], the community aspect. She likes to see the cars come down because, cuz whenever people go to the Creek, they stop and say hi to Grandma. Oh, and so or when people are leaving the creek and they come back through, they stop and say bye to grandma."



Figure 5. Mother and son explain the changing paths through Grandma's property.

While giving this explanation, the mother used her hands to create a dynamic spatial model of the family's changes in movement through the Grandma's property, to the creek (see Figure 5). She moved her hands in the model to reference the space, using a specific, deliberate rhythm that was matched by the rhythm of her speech. Her movements coordinated with the subtle movements of the child beside her, whose head movements and small hand fidgets occurred at the shared mutual pace established by the mother. His comment on the overgrowth of the vegetation coordinated with her explanation. He simultaneously attended keenly to the room as well as to the younger brother's movements in the doorway of next room.

His mother continued talking about the importance of community for Grandma, "and for her she's missed out on that for the last 10 years." The mother explained why the grandmother has missed out on the community aspect, "...[because it's so] grown up" so now they take another route due to the overgrowth.





As she explained this, the younger brother leapt out from the adjacent room. (Figure 6.) The analysis of the next 1-2 second clip drills down to greater detail in the synchrony of the triad's involvement in both elaborating the explanation and engaging with the entry and exit of the younger child.





Figure 6. Younger brother leaps in from the adjacent room..

As he entered the interview room, the younger brother immediately shifted to match the rhythm of movement of the family, adjusting the pace and direction of his

movement as he emerged from the other room with a phone that he seemed to want to show everyone. The family handled the entry of the younger child by tending to the

	<p>The older child intercepts the younger brother by catching the younger brother's eye and moving his right hand toward the younger brother, capturing and matching the speed and direction that the younger child is moving and moving him into the mother's field of view like leading a dance.</p>
	<p>The younger child follows the older child's lead, moving into the shared reference space. The older child continues leading the younger by turning his trunk, head, and eye head movement in the pace already established by the mother's vocal rhythm, gesture pacing, and body movement. The mother glances toward the two children in the same graceful pace as she continues to speak.</p>
	<p>The mother establishes visual contact with what is happening with the two children by direct gaze and slightly turning her head and shoulders. The younger child continues moving into the space as he raises the phone. The older child tracks the younger child's movements, turning his head and shoulders and looking at what the younger brother is showing.</p>
	<p>The older child relinquishes the action to the mother by dropping his eyes and turning back into the interview space. The three never stop moving together as the younger child is ushered in, and included in the envelope of activity. The younger child uses the same shared pace established by mother's hands and voice, and the older child's body movements. The mother engages with both children, turning her</p>

	head and eyes toward their movements and the children's hands.
	<p>As the mother tracks the children, she turns her head back toward the interviewer, keeping the same pace. Her backchannel "...uhm..." keeps her explanation going while she brings the younger child into the shared envelope of activity. The older child smoothly guides the younger into the family's shared space by maintaining contact between his hand and the younger brother's hand. He matches the mother's return to the interview space, turning his gaze and torso in the same direction as hers, following the same pace.</p>
	<p>Without interrupting her speech or gestures, the mother disengages from the youngest child as the older one gracefully ushers him back out of the room with a gentle sweep of his arm, torso, and face.</p>

child's need and harmoniously floating him off and back out of the interview

without an interruption to the mother's explanation, which happened to be, simultaneously, a report of the family's intergenerational Family-in-Community Collaboration.

In less than a second, shown in Figure 7-a, the group changed its rhythmic form to accommodate the inclusion of the youngest child. The microsecond movements handled the younger child's involvement in a way that contributed to group harmony, without interruption of the mother's explanation. She explained that the overgrowth is because "we lost my grandfather about three years ago, ...uhm..." a statement that spans



Figure 7. The family manages an interruption. Here, in Figure 7-a, the family coordinates the inclusion of the younger child.


The younger child used the same shared pace established with mother's hands and voice throughout the time he was physically in the same room as the rest of the family. This harmonious triadic movement occurred as the mother and the older child described the interpersonal relations involved in maintaining the Grandma's land and navigating to the creek.

The mother's statement, "once they get to a certain age, they just quit taking care of properties like that," spans Figure 7. The mother invoked the kinship group's shared responsibility for maintaining Tribal land, as she explained why the land was overgrown – "once they get to a certain age, they just quit taking care of properties like that." (A Cherokee grandfather's passing sometimes leads to the land that he had previously cared for being deliberately left to rest for a certain period of time out of respect.)

During her statement, the older boy ushered the younger brother out, while maintaining the shared conversational frame with the mother's placeholder, 'uhhh,' holding the rhythm of the conversation, and using the body positions of both mother and son.

Figure 7-b. The family re-situates during the exit of the youngest child

	<p>"Once they get to a certain age..."</p> <p>The older child continues to track the younger child with his head and shoulder movement as the younger child assumes a faster, bounding pace and leaves the room. In this frame, the 3 people are not all following the same pace.</p>
	<p>"...they just quit taking care of properties like that."</p> <p>The older child is still monitoring his little brother leaving, as he reconnects to the now dyadic shared reference space by turning back toward the mother,</p>

	slightly lowering his head and shoulders to match hers.
	Completing their resumption of focus on the interview, both mother and child simultaneously hunch toward each other and the shared reference space in perfect synch with the uninterrupted shared rhythm already established prior to the younger child's introduction into the space.

While the microsecond events highlighting inclusive, harmonious intergenerational relations occurred, the family was also referencing millennial values and practices of Cherokee families that prioritize inclusive, intergenerational relations. The mother's description referenced how the family comes together to use and maintain Tribal land, in shared extended family responsibilities for land. It showed Cherokee Family-in-Community Collaboration, in a Fluid notion of leadership, flexible use of time and space, and extended notion of intergenerational kin working together for a shared purpose in a longer timeframe than individual lifetimes.

In her statements, the mother was referring to the longstanding relations of herself and her children and her whole extended family collectively caring for this land, in a mutual process, as an unbroken chain of Cherokee inclusive, shared caring, for generations. Referring to Grandma's place in this context is a regional idiom for "our families' land," which is collectively owned and maintained by her extended family and recognized as such by the other kin groups in the broader Cherokee community. The intergenerational process of organizing to take care of the land has probably continued on this specific piece of land since at least 1907-1917 (the allotment era; for some families this time period is much longer, extending back to about 1811-17; Purdue, 1998).

Discussion of Fractal Analysis 1: Simultaneous micro and cultural/historical Cherokee collaboration

This very brief event illustrates the fractal nature of interaction. The clip is an example of intergenerational fluid collaboration occurring at multiple time scales simultaneously. In this interaction, we see the moment-by-moment fluid, harmonious movements as well as elements of collaborative organization that have persisted for millennia.

The form of fluid collaboration that we can see in microanalysis of the participants' moment-by-moment interactions embodies Cherokee elders' statements of how things are to be done that specify that such inclusive, fluid ways of engaging are how to engage together – and their community enactment in longstanding Cherokee practices. Both micro and millennial Cherokee practices embody a knowledge system that is holistic and relational. In Cherokee communities, learning is enacted through an oral process that includes overt Elder teachings in addition to intergenerational contact in community contexts to practice life in-relation to family, community, and the natural world. Traditional Cherokee practices have persisted through colonization and teach responsible action within a “framework of moral and ethical relationships” (Bastien, 2016, p. 15).

The principles specified in the Cherokee elders' statements apply at one and the same time to the microsecond scale involved in interpersonal interactions and the years-and-centuries scale of longstanding ways of organizing communities. These scales are reflected in Facet 1 and Facet 3 of the LOPI prism, dealing fractally with inclusive harmonious multigenerational organization of the community and inclusive harmonious multigenerational processes of interaction among individuals. During the

The Indigenous worldview is fundamentally relational -- the process of maintaining harmony forms a shared reality (Medin & Bang, 2014; Mejía-Arauz, Rogoff, Dayton, & Henne-Ochoa, 2018). The natural world is seen as an ongoing process of dynamic “connections and relationships” based upon maintaining “accountability to these relationships” (Wilson, 2008, pp. 73-74; pp. 70-71). In this conception, ideas are not transcendent, but emerge from embodied and enacted relational processes. These are developed through the careful maintenance of relationships and lose meaning out of context.

The Cherokee approach to maintaining these relational processes has been referred to as the Harmony Ethic (Thomas, 1958). Cherokee Community Values ensure that human-beings enact their place within these interdependent relational alliances. This approach situates learning as an act of accountability to others in a dynamic web of interdependencies within which human-beings are responsible for maintaining harmony in all of their actions. Fractal Analysis 2 provides some clues to how the Cherokee intergenerational, harmonious, situated/improvisational values are evidenced, supported, and learned.

Fractal Analysis 2. Fractal microanalytic and cultural/historic perspective on pairs of children collaborating in piloting a game

Fractal Analysis 2 presents several episodes that support the idea that the Cherokee emphasis on intergenerational, harmonious approaches is shown in every aspect of every interaction, and almost always includes everyone present. The episodes help to show what is meant by harmony in social interaction across generations. The participants coordinated together at a microscale during scripted moments of piloting the researchers’ game and equally during ‘cracks’ of the overall

agenda, in unscripted moments, both during times in which the game design invites ‘cooperation’ and when it invites ‘competition.’

These moment-by-moment views of intergenerational harmony occur at the same time as harmony that is evident in the episodes that involve years and generations, even millennia. In particular, the children’s involvement in the game was accompanied by the guidance of an Elder and the harmonious form of guidance that he used in helping the children and the researchers in the activity. This guidance supported the children’s involvement in a harmonious way, and at the same time the participants contributed to the millennial cultural/historical process in their moment-to-moment continuance of millennial values and practices regarding intergenerational, harmonious engagement.

Fractal Analysis 2 examines children’s Fluid Collaboration in fractions of seconds, using videos of several pilot sessions that took place to develop the protocol for the dissertation study. As the children tried out our game task, their teacher consulted on how he would recruit the children to an empty classroom at their school during free play time and how to situate the activity within the school day.

For the correlational version of the study, we had planned to focus on what happened between pairs of children in a cooperative/competitive game that had been used by prior researchers in the 1980s in the same communities. We planned to focus in at a microscale to see fluid collaboration or alternatives to fluid collaboration. The prior study (Brown, 1980) only analyzed children’s scores in the game and did not analyze the children’s actions (though Brown commented on the children’s behavior in her discussion).

Our analysis here shifted from the correlational plan, to a microscale analysis of the children's fluid collaboration. This shift also draws attention to the connection with community practices and values as the teacher (a community Elder) guided the children's collaboration in a harmonious, fluid collaboration that embodies Cherokee principles that have been handed down for centuries, including making the effort to involve everyone present and to do so in a thoughtful, harmonious, and gentle way (Benny Smith via Ryan Mackey, 2009).

We present Fractal Analysis 2 (like Fractal Analysis 1) at multiple timescales simultaneously to emphasize the pattern rather than the timescale. The fractal analysis attempts to convey the fluid collaboration between 2 pairs of children at the same time as the fluid collaboration involved in an Elder's guidance in enacting harmony, and the children's harmonious interactions at times in the piloting that are between the moments that are structured by the researchers' game script ("between the cracks").

Fractal Analysis 2 examines two pilot sessions to show evidence for the argument that a fractal analysis of events reveals Cherokee fluid collaboration at scales ranging from micro to millennia.

Fractal Analysis 2, Session 1 -- *Children Helping Conduct the Session*. Two boys play the game in a fluid, collaborative way in both the trials that are designed to elicit cooperation and those designed to invite competition. They engage in "mock competitiveness" through fluid collaboration both within and between trials. Their collaboration illustrates the Cherokee values regarding working together and maintaining harmony.

Fractal Analysis 2, Session 2 -- *Teacher/Elder Joining and Guiding the Session*. As two girls play the game, we widen the analysis to include their coordination and that of a Cherokee teacher/Elder, who provides guidance (in playing the game and in Cherokee language instruction) in a way that also involves fluid

collaboration. He uses subtle ways of guiding, without invoking a didactic or controlling mode which might be common for teachers in some other communities. Between trials, the girls, like the boys in Session 1, engage in “mock competitiveness” through fluid collaboration and coordinate with the actions of the adults. The engagement with the Elder illustrates a broader cultural/historical view bringing in not only Cherokee values regarding working together and maintaining harmony, but also nonintervention of guidance practices.

Participants

Our description of the participants already involves recognition of the intergenerational, relational aspects of the interactions on which we focus. This recognition is in line with Cherokee community values and with Indigenous research methodologies (Wilson, 2008). Participants in the two pilot sessions that we analyze here include two pairs of fourth-grade children, age 9-11, working with the first author (who is operating the camera, the audible game timer, and occasionally interacting) and the research assistant, a 16-year-old community member (and daughter of the first author). A respected community elder and elementary school master teacher who is familiar to the first author’s family was looking on, freely offering guiding comments to all of the children and the research team. The second author was virtually and asynchronously present, as she viewed and commented on the procedure between pilot sessions.

The first author had gotten permission to use a spare room at the school as a potential area to run the dissertation. The Superintendent and fourth-grade classroom teachers agreed to help, because the researcher’s 9-year-old daughter was a student at the school. (The research assistant who was training to run the game, is her older sister.) As we set up to do a “dry run” with live cameras to test the procedure, Mr. Tim, a well-respected classroom teacher and Cherokee first-language speaking Elder,

noticed us setting up and asked about the work. He offered to help run the pilot sessions and to bring pairs of students to play the game. We gladly accepted his unprompted offer of help, and he participated in the piloting session over the next 2 hours or so. The participant children volunteered to help Mr. Tim and “Chloe’s Dad and big sister” rather than play outside for recess.

The setting is a school in which Cherokee community values are explicitly taught, in the Cherokee language, and the children’s family members are contributing participants. The piloting in this particular school and the relations of the people present contribute to an environment involving layers of trust and safety, surrounded by familiar Elders and community members. The teachers are Elders who are all first-language Cherokee speakers and experienced and credentialed classroom teachers. The children have been attending this school for nearly 8 years.

The game procedure

The game is adapted from the cooperation/competition board developed by Madsen (1967) and used by Brown (1980) in Cherokee communities in Oklahoma (see Figure 8). This game has historic importance in research finding more cooperation among pairs of Indigenous children than among children of some other backgrounds. (As an interesting convergence, during piloting we learned that the teacher/Elder was a member of the community where Brown, 1980, found more cooperation among Cherokee children.)

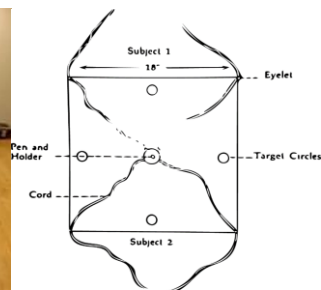


DIAGRAM 1. Madsen Cooperation Board (Top View)

Figure 8-a. The setup with 2 children holding a string in each hand to pull the upright pen, in fluid collaboration, with the Research Assistant timing the game, their teacher/Elder guiding them, the first author running the camera, and the second author 'present' via the camera. These are the people involved in Session 2, below.

Figure 8-b. Schematic of the game board from Brown (1980), designed to work only if the children cooperate in moving the pen and holder around the four target circles (even in the 'competition' trials).

The game involves pairs of children moving a pen by pulling two strings (one with each hand) around a board set on a tabletop. The pen leaves a record of their actions in ink on white paper marked with 4 target circles. In order to win prizes, the children must move the pen to mark target circles drawn on the board, within a 30-second time limit. (See the gameboard schematic in Figure 8-b.)

To move the pen, the children must physically work together – if both children are not involved, the pen cannot reach certain target circles. (The eyelets that the strings pass through limit the children's ability to reach some of the target circles.) Thus, any move they make is dyadic, whether collaborative or not. The game has two phases, which the originators of the game designed to elicit either cooperation or competition.

"Cooperation" trials. In the first phase of two trials, the game structure is designed to elicit cooperation – the pair earns a point (toward prizes) each time they move the pen all the way around the four circles in a specified order. Thus the game is designed so that points are scored collectively can only be won when the pair works together.

"Competition" trials. In the next two trials, the rules shift to individual ownership of circles (designed by Madsen, Brown, and colleagues to prompt competitive efforts). Instead of points going to the team, each child is designated as 'owner' of two of the target circles, and they earn points individually each time the

pen passes through one of “their” target circles. However, cooperation still maximizes reward. If the children pulls against each other, the pen cannot reach either of the child’s target circles. Therefore, the shift at the third trial, as the rules change and the children try to win points, is designed to show the pair choosing to compete or cooperate.

Defining fluid collaboration

Before we piloted with Cherokee children, in the videos we analyze here, we had developed a coding scheme to focus at a microscale on the ways that dyads move together as a cohesive unit while operating this game board. We had piloted with children and adults in Santa Cruz, and created a coding scheme based on other studies of fluid collaboration (especially Alcalá et al, 2018; Chavajay & Rogoff, 2002; Dayton et al, 2002; Mejía-Arauz et al., 2007; Ruvalcaba & Rogoff, 2002).

Our original coding scheme (see Appendix B) made distinctions between 5 ways of approaching the game, coded in time segments of 200 milliseconds, as in Dayton et al. (2022). The most important to us is *Fluid Collaboration* – a single rhythmic system involving both children mutually, in mutual rhythmic coupling, creating sort of an impromptu choreography. (See Figure 9.) We wanted to distinguish whether the two children were dancing together, separately, or not at all.



Figure 9. *Fluid Collaboration*. In the video that this photo is clipped from, the 2 children’s feet and torsos move at the same time and the same direction, and their arm movements coordinate with each other to loosen and tighten the strings together to create a single rhythmic system. The pen moves smoothly across the board in the same direction and speed as the children move -- it is part of the envelope of activity formed by the children’s actions. (These are people involved in Session 1, below.)

The original coding scheme was designed to contrast several alternatives to fluid collaboration. The most important are *Oscillation/negotiation*, in which two separate rhythmic systems “influence” or “read” each other, but they are not joined together, and *Competition/resistance*, in which two separate rhythmic systems work against each other (see Figure 10). We also had categories for the times that children’s engagement was One-way (one child directs and the other follows or one does not engage with the other, who observes) or Disengaged (one or both children are off task).



Figure 10. These two alternatives to fluid collaboration both involve children not engaged in the same rhythmic system. In *Oscillation/negotiation*, on the left, the children act separately – each one is trying to institute their own idea of how to play, so they have stopped the game to negotiate how to proceed. In this moment, they are not rhythmically coupled – their body movements do not match each other. They attempt to divide the activity, negotiating over the game. In *Competition/resistance*, on the right, both children attempt to forcibly pull the pen to their own target circle, and actively work against each other -- in this frame, they break the string. (After the string broke, these two shifted to collaborating, with the 3 remaining strings, in a harmonious final 3 seconds of the trial.)

Analysis of Fractal Analysis 2, Session 1 - Children Helping Conduct the Session

The two boys that we focus on in Fractal Analysis 2, Session 1 – *Children Helping Conduct the Session* played together while harmoniously contributing to the adults’ pace and agenda. Even before the actual session began, the children showed skill in coordinating with everyone present. They monitored the shifting attention of the adults and “read” the apparent expectations of the scripted pilot set-up. Through the use of fluid, harmonious collaboration unfolding within the first minute of arrival

in this novel situation, this pair formed a harmonious, dyadic mutual ensemble. They contribute to a millennial process unfolding at a timescale spanning generations (within this very event) as well as centuries and well beyond. This fractal process of continual, mutual contribution can be seen in each of the four sequences analyzed below.

During the first two trials, designed for cooperation, the two boys that we focus on in Pilot Session 1 evidenced fluid collaboration throughout (see Figure 9). They worked together, moving their feet and arms in mutual, dynamic synchrony to move the pen smoothly around the board.

Between trials, in the ‘cracks,’ the participants also showed fluid collaboration. For example, during the preparation for the second “Cooperation” trial, both children smoothly and fluidly engaged to help the researchers reset the game board for the next timed trial. All four people in this brief engagement were mutually engaged in a shared pace, rhythm, and purpose. (See Figure 11.)



Figure 11. Four people and four hands smoothly engage in this momentary activity. ‘One organism, many limbs’ (Dayton et al., 2022). While the research team mildly struggles to reset the game board between trials, the boy in blue reaches down and holds the corner of the paper on the board, without being prompted, while the researcher tears off the corners to fit the paper to the board. While they are doing this, the research assistant holds the stylus above the board to keep the strings out of the way, and the boy in red is attuned to the shared activity by the orientation of his head and torso as well as by his sharing in the pace and direction of the group with his movements.

Between the second and third trials, while the adults tried to fix a problem with the procedure, the children evidenced skillful and helpful fluid collaboration in this ‘crack’ in the procedure. They moved together and coordinated with each other to track and coordinate with the adults in the room, contributing to the flow and direction of the piloting session in which they were participating. The children helpfully exchanged the available pen while coordinating their visual contact with the researchers and one another, while the researcher looked for a missing second pen. (See Figure 12.)



Figure 12. The children coordinate their shared attention with the research team. While the boy in red follows instructions to write his name on the gameboard, the boy in blue tracks the researcher. At the exact instant that the boy in red hands the pen to the other child, he fluidly turns his head completely to track the researcher, seamlessly taking up the job of watching the adult as the pair aids in moving the game agenda forward.

After the children collaborated through the “Cooperation” trials, they continued to collaborate as they introduced a side activity of playing ‘silly battle’ by exaggerating the postures and movements of ‘fierce competition’ in the “Competition” trials. (See Figure 13.)

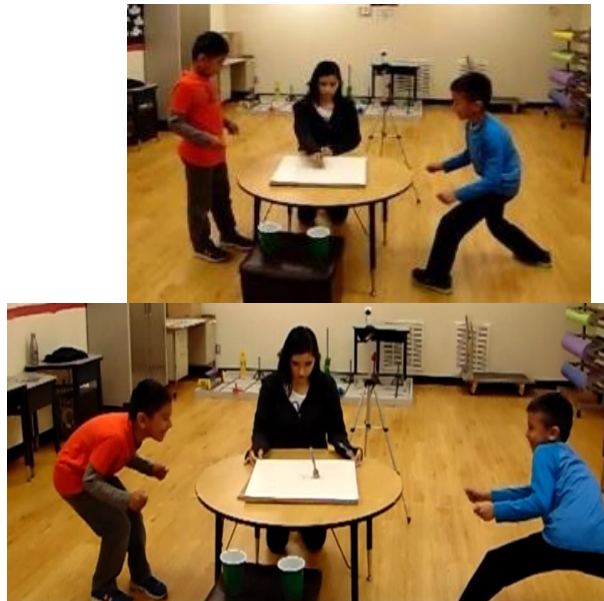


Figure 13. The child in blue assumes an exaggerated posture as if he were about to put a lot of force on the string, while the research assistant prepares for the second ‘Competition’ trial. When the trial begins, the child in the red shirt also assumes a cartoonish mock-competitive posture.

The game is designed for the strings to break if the children pull them too hard. These two children maintained enough tension on the strings to keep the strings from breaking; they skillfully acted out competitive behavior while maintaining constant, coordinated pressure on the strings. Their mock-fight was a well synchronized collaboration, as their impromptu choreography involved coordination to stage a fight over the game, together.

Note that their mock fight results in a score of zero for the trial, which would be coded as competition according to Madsen and Brown. The children were responsive to the ‘competitive’ design of Trial 4, but instead of competing with each other, they subverted the invitation to compete (in the game design). They gracefully turned the event into a playful and sophisticated commentary on cooperation and competition, evidencing fluid collaboration to do so.

Throughout the session, including in the ‘cracks’ between trials, the two boys showed fluid collaboration with everyone in the room. In an inclusive form of

collaboration, they integrate their actions into the shared purpose and pace of the overall activity, coordinating with everyone present, analyzed below in 2 ‘episodes’ – children helping while ‘playing in the cracks,’ and ‘handling the chime.’

Playing in the Cracks Episode. As the research team set up the game and checked the camera angles between trials, the boys engaged together in an elaborate back-and-forth playful dance in the ‘cracks’ of the overall event. They gracefully synchronized with everyone else in the room, in their private game of acting “silly” when nobody is looking, then appearing focused and ready whenever either of the adults glanced toward either of them.




As the researchers focused on re-setting the game board for the second “Competition” trial, the children were attuned to the shifting attention of one another as well as the adults. Their impromptu choreography seems to involve them working together to dance and act silly when neither adult is paying attention to them, then to ‘snap back ‘in place if one or the other adult might see them. Both children quickly ‘snapped back’ when the game board was set, anticipating the adults’ moves that showed readiness for the next trial. This playful impromptu choreography is an example of the children using fluid collaboration to skillfully blend their agendas with everyone present by playing within the rhythmic, spatial, and temporal ‘cracks’ in the pilot procedure, detecting opportunities for spontaneity in the moments between those calling for their specific actions.


The episode that we describe below shows the children’s interstitial dance, as they played in the ‘cracks’ in the overall agenda without interrupting the harmonious flow of the adults’ loosely scripted overall activity. They coordinated with the actions

of the adults, monitoring the pace of the overall activity while they engaged with fluid collaboration in their side ‘dance battle.’

Figure 14. Cherokee children playing during the cracks of the pilot script, coordinating with the adults in piloting. “Red” is the boy on the left; “Blue” is the boy on the right.

<p>3:46</p>		<p>The children attend to the researchers’ delay in setting up the game board.</p> <p>Blue begins to drum his fingers rhythmically on the underside of the table that builds into what playfully becomes an imaginary “force” that he sends to the child in red.</p>
<p>3:51</p>		<p>Red takes up the game as Blue hunches down and leans toward him, intensifying the drumming. Red responds to the increase in “force” created by Blue’s intensifying finger drumming and hunched, effortful posture by pretending to be “pushed” back.</p> <p>Meanwhile, Blue is shifting his gaze to the researcher.</p>
<p>3:53</p>		<p>Blue continues to scan the room,</p> <p>Meanwhile, he “releases” the force by removing his hands from under the table, standing up straight, and flicking his hands surreptitiously toward Red, who breaks in to an expressive, playful dance, while</p> <p>Blue monitors the researcher. The children continue to pass an imaginary “wave” through</p>

	<p>the physical space between them.</p>
<p>4:04</p> 	<p>Blue assumes a “ready posture,” perhaps in response to a glance from the researcher or maybe to provide cover for Red to continue his dance. Blue stands up quickly and cartoonishly, with his back straight, his hands tucked behind his back while looking where he is “expected to be looking” displaying an ‘attentive’ posture common in this school.</p>
<p>4:07-4:08</p> 	<p>Red moves his dancing back toward the table, smoothly “sending” the force back to Blue, who “receives” the force, as if the imaginary force arrives in his midsection, timed to how an actual force would travel in the shared dance, and breaks into his dance move. Together, the children fluidly send a “wave” back and forth between them as each child continues to do his own dance simultaneously.</p>
<p>4:09-4:12</p> 	<p>Red returns to the game frame, lowering his gaze to the game board, straightening his torso and legs straighten up, and pointing toward the board, while he continues his movement in coordination with Blue.</p> <p>In coordination with Red’s changing posture, gaze, and pace, Blue moves his own gaze to the game board, beginning to wind down the side activity, as Red moves in toward the</p>

	<p>game board, dropping his hands and preparing to assume the “ready” posture, as the researcher completes the preparations for the next trial.</p>
<p>4:15</p> 	<p>Red shows the “ready posture” as the researcher steps away from the table. Blue joins Red in turning to the game piloting, reaching down toward the strings while assuming an attentive game posture.</p>




The children playfully helped with the adults’ agenda, helping keep the pace and focus of the piloting activity on track. Connecting with longstanding Cherokee value systems about helping out, and also Facet 1 and 3 of the LOPI prism, these children showed fluid collaboration using mutual engagement with everyone present to accomplish a task together with shared, mutual purpose.





In line with the longstanding Cherokee value systems, these children chose to maintain group harmony in the direction and pace of the shared purpose of the group, not focusing on the supposed ‘goal’ of the game – to win points. Rather than cooperating to win points or competing with one another, these children seemed to focus on the process of mutual engagement in piloting the game – engagement that included coordinating with the adults and the research procedure, as well as playful peer engagement. They interlaced their engagement within and through the game script without attempting to score points.

Handling the Chime Episode. Between the first and second trial, the pair worked together to help the researchers with what would otherwise be a problem during another crack in the agenda. The chime that marked the end of the first timed

trial needed to be turned off; for some reason, it repeated, loudly, with nobody near it to turn it off. Within about 15 seconds the researcher and both children worked together to turn off the chime and get back to the scripted activity. Like in other moments during the session, the boys turned an unscripted, somewhat annoying interruption of the scripted flow into a playful way to contribute to the activity. The children and the researchers managed to correct the problem without disengaging from one another, the shared purpose and direction of the activity, or the harmonious pace and rhythm already established within the overall pilot session. (See Figure 15.)

Figure 15. The children pitched in to assist in running the pilot session.

<p>1:20</p> 	<p>While the researcher and the research assistant prepare the board for the next trial, with their hands full, the chime that signaled the end of the previous timed trial goes off across the room. The sound draws the gaze of both children away from the board and toward the chime.</p> <p>Blue maintains the “ready posture” throughout this sequence, while turning his head and body to track aspects of the overall activity. Red is turning toward moving toward the chime.</p>
<p>1:22</p> 	<p>As the researcher continues to work on the game board, Red leaves the game space and dance-walks toward the chime, in the rhythm of the chime. Notably, the chime is in the work station that the researcher has set up with expensive equipment – a space that might be considered out of bounds for a child to approach.</p>
<p>1:25</p> 	<p>Blue signals to Red to stop the annoying chime from sounding, by surreptitiously making a button press gesture and indicating “ssshh!!” with finger to lips. He immediately returns to the “posture of attentiveness” before the researcher begins his turn away from the game space and toward the chime.</p>

<p>1:26</p> 	<p>Blue maintains the “posture of attentiveness” while he pivots to look at the action at the chime, while the researcher goes to help Red stop the chime.</p> <p>While this is occurring, the research assistant fluidly finishes setting up the game board, fluidly continuing the overall game activity.</p>
<p>1:28</p> 	<p>A secondary camera shows Red seated at the researcher’s workstation. The researcher points to one of the devices and says “You got it? It’s right...there....Thanks.”</p> <p>When Red finds the button on the cellphone to stop the chime, the researcher says “there it is” and then the chime stops mid-tone.</p> <p>Blue has never left the “ready posture,” standing straight with his hands behind his back, while watching the events at the chime.</p> <p>Meanwhile, the research assistant places the strings back in front of each child’s position at the board. This proceeds at a smooth, steady unhurried pace over the 7 seconds.</p>
<p>1:35</p> 	<p>Blue completes his reach down to pick up the two strings the research assistant has placed in front of him at the precise moment the research assistant completes standing up from leaning over the board. The completion of both of these movements is perfectly synchronized, even though neither of them is looking directly at the other.</p>
<p>1:37</p> 	<p>Red dashes back to the table to arrive just in time to pick up his strings in synchrony with the other child, arriving 2 seconds after he turned off the chime. This occurs before Blue has even completed standing up after grabbing his strings, showing Red’s coordination in the overall activity even while dealing with the interruption from the chime.</p>

The two children precisely synchronized with everyone in the room even when they themselves focused on other events, working together to help the adults keep the game activity on-script. The overall group stayed cohesive even as one or two of the participants took care of an unexpected event. Both children continually attended to what was occurring around them and successfully anticipated the next events.

The two children solved the problem of the chime with no need for the researcher to assist them during preparations for the next trial (the first “Competition” trial), when the timer went off again. The children turned off the chime by themselves before the researcher had begun to stand up (taking 5 seconds, for what took the group 15 seconds to solve the first time), helping to keep the entire activity closer to the “scripted” pace that the research team was attempting and that the pilot script called for. (See Figure 16.)



Figure 16. As the chime goes off again, Red bursts over to the work station. Blue follows him, helping, watching how Red stops the timer. The children return to the game table in pace with the adults’ setting up the game board.

In keeping with longstanding Cherokee values regarding harmony and attentive collaboration, these children contributed to the adults' agenda through the use of harmonious, fluid collaboration. Their collaboration occurred both as a mutually engaged dyadic ensemble and as contributors to the overall shared pace and direction of everyone present. This smooth harmonious, mutual engagement included everyone present at all times and continued throughout the entire pilot session

This analysis offers visible evidence at microscale of Cherokee children and families smoothly maintaining the pace and direction of the group, blending agendas while attending to everyone present with mutual care and harmonious, attentive contribution to the overall activity. This evidence of fluid collaboration among Cherokee community members is central to our overall claim that this kind of micro engagement simultaneously and directly contributes to maintaining and innovating millennial patterns of harmonious collaboration.

Analysis of Fractal Analysis 2, Session 2 – Teacher/Elder Guiding the Session

This session of Fractal Analysis 2 illustrates not only Cherokee values regarding working together and maintaining harmony, but also Cherokee values regarding respectful and subtle ways of guiding one another. The research team, the teacher, and a different pair of Cherokee children together maintained a harmonious flow of the overall activity. They all fluidly collaborated as an overall group and as dynamically shifting dyads and triads to manage the scripted transitions between trials. This smooth pace continued from the moment the children were introduced into the space by the teacher to the moment they were ushered back out of the room.

This pilot session provides a view of nonintervention in guidance practices, as the teacher/Elder aids the two children in the game in a manner that maintains and promotes harmony, in intergenerational fluid collaboration. He used subtle ways of guiding using his voice and body movements, without invoking a didactic or controlling mode which might be common for teachers in some other communities. His form of guidance is widely recognized in the literature on Indigenous ways that adults support children's learning (Barnhardt, unpublished; Battiste, 2002; Erickson & Mohatt; Scollon & Scollon). He keenly attended to the children, the game and the overall activity while freely and fluidly moving around the room, providing the children with collaborative verbal and nonverbal pointers for playing the game (and also subtly giving Cherokee language instruction).

The teacher/Elder used his posture, movements, and voice to pitch in at times as well as to maintain the harmonious pace and tone of the entire session, and to teach everyone involved. One striking tool he employed to guide the children and to guide the entire session is "the ready posture" (see Figure 17). His guidance using the ready posture (and other means) did more than organizing the piloting as it fit into the school structure and smoothly transitioning children through the procedure. It also guided the children and the researchers in Cherokee ways of harmoniously managing interaction. His role as Elder showed the researchers how to conduct a research project in a Cherokee school, providing research training for the doctoral student (and the research supervisor) in how to manage the frustrations and uncertainty of piloting a study in a Cherokee way. This is intergenerational harmonious, subtle guidance – Family-in-Community-Collaboration – in line with the ways of learning involved in Indigenous Ways of Knowing.



Figure 17. The Teacher/Elder assumes the “ready posture,” with his back straight, his hands tucked behind his back, while directing his gaze and posture in the direction that he (and everyone else in the room) is “expected to be looking.”

The teacher/Elder appeared to use this posture as well as his movements to indicate how and where to be paying attention. Throughout the session, he assumed this posture as he circulated around the activity, at times that aided the children and the researchers in making transitions. At the moment caught on the left in Figure 17, his switch to the ready posture aided the researcher in transitioning to the timed trial script from awkward conversational banter at the beginning of the session. He guided without pushing or taking over.

Indeed, the Elder’s way of teaching the researcher is one that an Elder provides a junior – Mr. Tim assumed the ready posture and moved right into the workspace (near the camera) where the researcher would stand in order to transition into the script, and then Mr. Tim backed out, conducting the researcher into the script’s next move. The researcher immediately stepped right into the space that the teacher/Elder indicated. The Elder broke the researcher’s awkwardness with his move, and circled out of guiding the researcher to guiding the children as the researcher got back onto the script. He used the ready posture and orientation to shift the group’s attention to the researcher. As the researcher finished preparing the game board and explained the game to the children, the teacher/Elder assumed a “side by side” orientation with the researcher, and conducted the group into the beginning of the game.



The use of the ready posture appears to be a mode of deliberate attention and pace modeling, as the teacher/Elder did not always stand this way. This posture also seems to establish his role as Elder, with the responsibility of managing the event. He demonstrates that “we” are focusing on the researcher’s activity by prominently assuming this posture. All of the children and the teacher in the set of pilot sessions assumed this posture during key times in the activity, using the posture of active attention at moments of transition as a way of helping move the group into focusing on the next aspect of the activity.



Each of the two episodes that follow offer visible evidence at microscale of Cherokee children and their teacher smoothly maintaining the pace and direction of the group, blending agendas while attending to everyone present with harmonious, attentive, mutual contribution to the overall activity. In both episodes, the teacher/Elder collaborates in helping the children do their part in the overall event. For their part, the two girls smoothly and fluidly collaborated throughout the pilot session. During the “Competition” trials, they continued to use the same cooperative strategy they used in the “Cooperation” trials. Between trials, the girls, like the boys in Fractal Analysis 2, engaged in mock competition through fluid collaboration while simultaneously coordinating with the actions of the adults. They included the teacher in their mock competition by ribbing him too, between trials.

Teacher/Elder Guiding the Session – Elder Leads by Joining Episode. At this point in the pilot, the girls had already completed the first “Cooperation” trial and had struggled to operate the stylus and pen. During that previous trial, the teacher had remained behind the camera and had not yet directly joined the activity. The

following sequence (Figure 18) describes the first instance in which the teacher gets directly involved in the script, as the whole group navigates the second trial.

Figure 18. The teacher guides the children by joining with their pace.

<p>0:41</p> 	<p>As Orange struggles to move the pen to the next target circle, Burgundy gently attempts to guide her with subtle simultaneous gestures with her hand and lips, light tugs on the strings, and movement cues of her body.</p> <p>Simultaneously, the teacher steps into the activity, coordinating his subtle guidance moves with the rhythm of movement established by the children. He uses his body and voice in concert with the movements of Burgundy, but starting with the rhythm of Orange, which appears to guide Orange into the desired actions for the game. He counts in a rhythmic sing-song in Cherokee, matching the children's movements, subtly and harmoniously guiding the activity by moving in the same direction and pace as the pen.</p>
<p>0:42</p> 	<p>The girls begin to smoothly move the pen together to the next target circle, dancing together in perfect synchrony. They move back and forth on their knees in unison, matching their body movements to their heads, arms, and hands.</p> <p>During the children's movements, the teacher continues to circle the board in the same pace and direction as the children and the pen. When the pen movement goes from moving from right-to-left after passing the target circle in front</p>

	<p>of Orange, the teacher also changes direction, matching the new direction of the pen with the same pace and fluidness as the girls' movements and those of the pen.</p>
<p>0:45</p> 	<p>As Orange seems to struggle a bit to hit the target circle in front of her, the teacher positions himself behind Burgundy and sways on his feet, directly matching the rhythmic sway of both children. He continues to count in Cherokee using this same rhythm. He remains in this position for around 1 second. His swaying rhythm directly synchronizes with Burgundy's swaying on her knees as well as the oscillating effort of Orange's hand movements. All three of these oscillating movements share the same smooth rhythmic 'pulse'.</p>
<p>0:46</p> 	<p>As Orange and Burgundy successfully keeps the pen moving... The teacher continues to count while still tracking the direction and speed of the pen with his gait as he walks out of the game space and continues to monitor the children's actions.</p>

The teacher/Elder and his students worked together to operate the game while subtly assisting one of them. This assistance was fluidly and harmoniously embedded into the activity itself while maintaining the smooth mutual engagement of everyone present. The entire group continued to engage in a single, shared, cohesive purpose with fluid, mutual synchrony, simultaneously managing multiple scales, including the game moves (of the pen) and working together to keep the scripted pilot procedure on track. In addition, the teacher/Elder guided not only this small group – he was




simultaneously tracking the activity of his class on the playground and the needs of his teaching team in two other classrooms (as senior teacher), as he helped guide the piloting through 3 pairs of children. His subtle guidance epitomizes Cherokee values regarding mutuality, inclusion, and harmony.

Teacher/Elder Guiding the Session – Elder Conducts the Conclusion

Episode. The teacher conducted the ending of this piloting session by incorporating play with the children in the concluding part of the session – getting their prizes, and then moving his body toward the door. This simultaneously modeled for the researcher which aspect of the event to be attending to, and how to manage it. The research team had begun to transition the game space for the next session with a new pair of children, without paying attention to giving the children their prizes (for points). The teacher/Elder contributed to this as-yet-unscripted portion of the session – how to move the children to pick up their ‘prize’ candy and move out of the room – in his role as lead teacher, managing the session to keep to the tight piloting schedule during the school’s recess period.

In the following sequence (Figure 19), in helping to end the session, the teacher/Elder turned the children’s attention to the prizes by playfully suggesting that he was going to take the candy in the cups (the “prizes for points”), and engaging with the girls in playful teasing “mock competition.” The children blocked him from the cups, as they also continually monitored the overall activity.

Figure 19. The teacher conducts an unscripted portion of the piloting.

 <p data-bbox="393 478 560 556">0:56- 0:57</p>	<p data-bbox="751 155 1284 401">The teacher transitions the children towards leaving the game, stepping in toward the game board and pointing to Burgundy’s cup of candy (in the foreground), with a playful move pretending to attempt to ‘steal’ the candy.</p> <p data-bbox="751 411 1268 737">Burgundy immediately moves from facing the game board, and attends to the cup of candy in an exaggerated, playful way, moving her entire body to the new aspect of the activity. She quickly scans everyone in the room as she covers the top of the cup with her hand.</p> <p data-bbox="751 747 1252 863">Meanwhile the teacher leads toward the door by backing away from the game setup.</p>
 <p data-bbox="393 1180 560 1257">0:58- 0:59</p>	<p data-bbox="751 873 1281 1119">Burgundy then engages Orange (who took off her jacket) with her gaze, and a turn of her head and shoulders. She tells Orange, “Mine” with a playful, exaggerated expression and a playful defiant tipping up of her chin.</p> <p data-bbox="751 1129 1260 1375">Orange joins the impromptu mock competition, rushing entirely into this new frame of shared reference, matching Burgundy’s posture, orientation, and rhythm. She quickly covers her cup,</p> <p data-bbox="751 1386 1278 1501">Meanwhile, Burgundy moves her hand away and stands up, opens the activity back up to the overall event.</p>
	<p data-bbox="751 1505 1263 1709">The children shift their attention to the teacher (off camera, left). They begin to wag their fingers and laugh, playing that he will not be allowed to touch the candy.</p> <p data-bbox="751 1719 1266 1923">Orange now tracks the teacher with gaze and torso orientation, and engages in exaggerated “uh-uu-Uh” and finger-wagging teasing, with a dancing movement. Burgundy erupts into fake</p>

<p style="text-align: center;">1:01- 1:09</p>	<p>laughter, as she is turning toward the teacher. The children treat the teacher familiarly almost as a bad child, wagging their fingers and shaking their heads. Burgundy says, “No, no, Tim!” to Mr. Tim.</p> <p>The children coordinate their finger-wagging and occasionally turn toward the teacher/Elder, while the researcher team continues focusing on changing the game set-up. The children glance at each other and the teacher, teasing him at a pace that fluidly coordinates with each other. The teacher has playfully and subtly moved the children into the last phase of the session, and Burgundy has contributed to the children’s attention to the teacher’s efforts to conduct the end of the session.</p>
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In this second episode, the teacher/Elder was keeping the trains running while simultaneously allowing everyone else the space to work or play, maintaining Cherokee traditional community values. He provided a space and model for how to engage together in shared endeavors while working together and bonding through play. He “modeled” harmonious relations, inclusion, and respect for others’ autonomy, in his direct participation in the overall shared activity. Throughout, the participants’ sub-activities smoothly coalesced, subdivided, and re-connected harmoniously.

Through his involvement in each aspect of the overall shared activity, the teacher guided and conducted the event without pushing, taking over, or demanding attention to himself. In this way, he taught his students as well as the research team about enacting Cherokee values through direct participation, and by guiding the children in how to contribute to and coordinate with community activities with adults.

In these interactions, the teacher and the other participants were contributing to keeping the Cherokee value system alive through their interactions. This notion, of everyday moments contributing directly to a living system, is part of Cherokee philosophy (Mackey, 2014) as well as a central tenet of the idea of mutually constituting process (Rogoff, 1995; 2003).

Discussion of Fractal Analysis 2

Each of the episodes analyzed in Fractal Analysis 2 offers visible evidence at microscale of Cherokee children and families smoothly maintaining the pace and direction of the group, blending agendas while attending to everyone present with mutual care and harmonious, attentive contribution to the overall activity. As in Fractal Analysis 1, Fractal Analysis 2 offers evidence for features of LOPI Facets 1 and 3 in that everyone present is included, and in smooth, harmonious way that respects the shared direction and pace of the group. The participants engaged in harmonious mutual rhythmic systems in their involvement in the game, while smoothly blending their agendas with the overall activity, enacting aspects of millennial Cherokee values in practice. The Cherokee teacher/Elder conducted and guided Session 2 in concert with Cherokee cultural processes that transcend and include everyone present.

In line with longstanding Cherokee value systems, the teacher and his students worked as a cohesive, harmonious group to smoothly and harmoniously pitch in to the work of another Cherokee group (the “family group” comprised of the father/daughter research team who are family of one of their classmates; they have attended school together since they were three years old). The purpose of the activity itself was specifically presented to the children and adults as an opportunity for their

group – the teacher/Elder’s class – to help another group (their classmate’s family). These children volunteered to help with this activity rather than to play on the playground.

The intergenerational Family-in-Community Collaboration documented here is evidence of Cherokee families helping each other in a community setting (the school). They do this by harmoniously sharing time and space engaged together in fluid collaboration, in so doing, contributing to broader and longer-standing Cherokee community value systems.

This evidence of intergenerational fluid collaboration among Cherokee families and community members is central to our overall claim: Harmonious mutual engagement at the microscale is a direct contribution to continuing processes involved in millennial patterns of harmonious collaboration that extend beyond the lifetimes of everyone present, and indeed beyond the historic time period. Millennial Cherokee community values involve pitching in to work together wherever possible, and to do so in harmonious ways. These ideas apply to groups as much as to individuals, and they describe a particularly fluid way of relating to others and the rest of the natural world.

As outlined in the introduction, this form of harmonious engagement is a Cherokee cultural value, and is practiced within families, homes, communities. It is specifically taught -- in the Cherokee language – in the school in which this pilot session occurred. Three of the 13 Cherokee cultural values are especially applicable to Fractal Analysis 2:

ᑭᑭᑭᑭᑭ ᑭᑭᑭᑭᑭᑭᑭᑭ *nudantiyu detsadanvwidisgesdi*
Encourage and instruct one another in a gentle & thoughtful way.
(The teacher does not “take control” but guides using his body and voice.)

rely on an authority to direct and control groups, as well as use of cultural practices that aim to divide resources, time, space, and attention according to rules of fair interaction to negotiate separate individuals (Mejía-Arauz et al., 2018; McDermott & Pea, 2020; Rogoff et al., 2001).

Fractal Analysis 3 involves two groups of middle and high school students at a game station during an “activity day,” where children were free to choose one of the available activities in the common area. (See Figure 20.) The game station with the ‘cooperation/competition’ game, using the game script and the videocamera, was included in the activity day to expose students to research practices to encourage STEM engagement. This was presented to children and staff as an opportunity to help the first author with his research project and to learn how “college works” by helping the researcher with a school assignment.



Figure 20. At the brown table midway up on the right, a group of children gather around the cooperation/competition game, in the multipurpose room during a “STEM activity day” at their school. The students move freely between the eight or so activities, together with anyone they choose, including all the students from first grade to senior in high school, over the course of the whole day, while their teachers attend professional development sessions elsewhere in the school. The first author was hired as a substitute teacher to organize and manage the activity day with the help of two other adult staff members whom the children know.

The students at this boarding school include students from two backgrounds: both students who live at the school who are enrolled Native American community members and students who live near the school but whose family background is not



necessarily Cherokee. The differing socioeconomic and ethnic backgrounds represented at this school have historically been at odds with each other from time to time, in the broader community and in this school, sometimes breaking into altercations between family groups and conflicts between student groups at the school – when the Cherokee community values are not enacted in people’s practice. Indeed, Cherokee discussions of the community values warn that conflict follows when families and communities do not act in accord with these principles (Foley, 1999; Thomas, 1993).

Fractal Analysis 3 contributes to the examination of harmonious fluid collaboration in Cherokee communities by investigating the children’s management of intergroup conflict without upsetting the overall smooth and harmonious pace and flow of the ongoing community activity. The participants in this event reveal the enactment of the Cherokee value system emphasizing harmony, ‘in the wild.’ The students fluidly and flexibly shifted roles as the activity continued through several different configurations of game-play participants; there was never a singular activity leader.


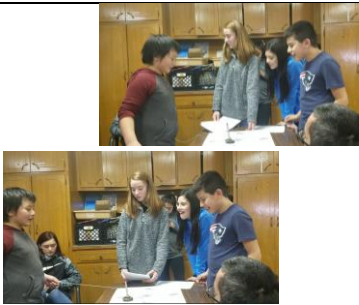

The ways the students in Fractal Analysis 3 manage their complex, potentially conflictual interactions align with Family-in-Community Collaboration, involving flexible use of time and space to engage in shared purposes of fluid groups within the broader multigenerational community. The students do this by employing fluid collaboration in a competitive situation in which individuals and groups of students seek access to the activity. In line with LOPI Facets 1 and 3, they align their movements engaging everyone in their respective groups in especially smooth and harmonious ways.


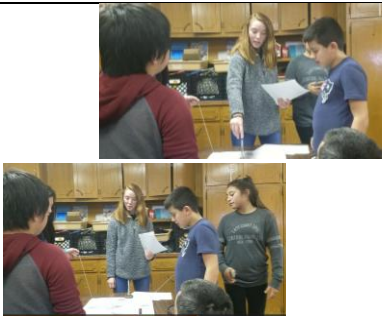
The episode shown in Figure 21 shows the fluid collaboration used by two distinct, competing groups of students to establish and maintain group cohesion while managing potential conflict between groups, as one group takes over the game from the other. The students spontaneously handled the competition over resources (without adult intervention, although the researcher was present) in line with the Cherokee community value system, managing the potential for conflict in a way that maintained harmonious group relations.

Figure 21. Two groups of children manage potential conflict around an activity station by smoothly coordinating without overt conflict. One group moves into the other group’s space, and then the activity itself, by subtly joining the activity. They take over and amplify their engagement within their own group, while managing the competition between groups with fluid collaboration, maintaining (indeed, creating) harmony.

	<p>Group 1 runs the activity – the girl in red runs the script and two girls in grey stand ready to take on that role; the two players are also from Group 1. Several students from Group 2 stand unmoving, looking on; the child in blue observing in the foreground is the only student from Group 2 visible in this screenshot. She stands firmly like a sentinel throughout the episode.</p>
	<p>At the point that one of the waiting girls from Group 1 (“Grey”) takes over running the script, students from Group 2 subtly and playfully move in. Two</p>

	<p>older girls from Group 2 (behind the boy in black) manage the takeover without interrupting the flow as Grey reads the script and demonstrates the strings. The older girls have moved some younger boys from their kin group in as players and they position Grey, along with a girl seated nearby, as the only remaining members of Group 1. The students from Group 2 manage this takeover by using the structure of the script, which they have been watching, and subtle movements to substitute themselves for Group 1 players. The two older girls use exaggerated playful giggling about a cellphone, conveying a good-natured ambience without engaging directly with Group 1.</p>
	<p>Grey steps back from leading the script. The two older Group 2 girls (behind Grey) use a form of “conspicuous ignoring” as a way of moving their Group members’ positions – they appear to focus their attention on timing the game with the phone held by one of them.</p>

	<p>The moments portrayed in the following panes occur smoothly and total only seconds.</p>
	<p>During a crack in the script (Grey stabilizes the board), one of the two older girls from Group 2 (Blue) moves in to take over the entire activity. She engages visually with Red (the boy on the left who is playing the game) as she playfully puts a gum wrapper on the head of the boy in black, who is her brother.</p>
	<p>Blue precisely coordinates with Grey's turn away to get into position between her brother playing the game and Grey. Blue exhibits exaggerated interest in the game, leaning into the space in a way that matches precisely with Red's movement in playing the game.</p>
	<p>Blue pulls out and circles the game space at the moment that Grey returns to reading the script. Blue arrives precisely in time to take over Red's position at the game, with a smooth, effortless handoff of the strings. Blue and Red accomplish the string</p>

	<p>handoff without looking at each other or their hands.</p>
	<p>The Group 2 students have smoothly changed positions while Blue and the two boys all remain mutually engaged with each other and with others from their group who are off camera. None has yet engaged with Grey or the other child from Group 1, still sitting in a chair (behind Blue).</p>
	<p>The other older girl from Group 2 steps up from behind Grey and into the space between Grey and the brother who is playing the game. She does this without looking away from her phone or engaging with Grey, continuing the conspicuous ignoring as a way to manage the conflict without overt aggression. She tunes in to the game play, in a grand exaggerated show of shifting attention from her phone to the Group 2 children playing the game. This move averts potential conflict in a pretense of simply getting involved. Meanwhile, Blue and her brother operate the game like pros.</p>



Then Group 2 crowds around the game station as Grey completes reading the script. Blue, now operating the game on the left, clearly leads everyone's movements.

After completing the game, Group 2 cycles out to the next activity, and another group cycles in to operate the game station.

The Group 2 children assumed control of the activity authoritatively and for as long as they wanted to without pushing or exerting force. They skillfully managed a potentially conflictual situation – vying for their group's time at an activity station – without conflict. They harmoniously managed the relations between each other and between the groups in ways consistent with the Cherokee Cultural Value System. (We also note that the Group 2 students smoothly and skillfully operated the game, casually demonstrating mastery of the game's arbitrary goals. This skillful learning occurred quickly and simultaneously while, similar to the boys of Fractal Analysis 2, they also mastered the game script, skillfully using its timing to cue their own engagements.)

We are not arguing that Cherokee students and groups are always harmonious. In fact, some of their teachers warned the first author, as he prepared to serve as The Substitute, that he would have to be very authoritarian to keep the children from breaking into the fights that these teachers regarded as common among groups of students in this school. However, the first author and his team approached the day with the sort of subtle guidance that Mr. Tim employed in Fractal Analysis 2 – trying

to include everyone in a fluid and harmonious way – and the groups of children maintained harmony throughout the three days of the The Substitute’s responsibility for the school days. We speculate that the difference between the subtle guidance approach and the authoritarian approach urged by some teachers (dividing and controlling groups) made a difference in the children’s approaches – whether to do their part in a Cherokee system of mutuality or to allow things to fall apart (see Pelletier, 1970). Note the parallels in this description with the contrast of LOPI with Assembly-Line Instruction (Rogoff, 2014; Rogoff & Mejía-Arauz, 2022).

The way of approaching potential conflict according to the Cherokee community value system calls for not showing hostility or anger in a public place, to avoid a rupture of the fabric of the community. Instead, individuals are expected to act in the ways described in the Cherokee community value system – to pitch in to work in service of the superordinate community goals and to act in ways that maintain public harmony. (If individuals find themselves unable to enact the values in support of harmony, maintaining a public demeanor and collaborating, they tend to simply withdraw from the situation rather than undermining the group harmony; Thomas, 1993.)

The students in Fractal Analysis 3 act in accord with the Cherokee community value system. Unlike the children of Fractal Analyses 1 and 2, they are unlikely to have been instructed specifically in the Cherokee community values. Their use of ‘philosophy-in-action’ (Matusov & Rogoff, 2002; Rogoff, 2011) fits with the claim that the students’ enactment of the value system is key to the maintenance of the Cherokee community value system. They skillfully enact the practices, whether or

not they would explain their actions using what are referred to as Cherokee community values.

General Discussion:
**How our Fractal Analyses Contribute to Understanding Collaboration
as a Holistic Fractal Process from Microseconds to Millenia**

The three fractal analyses of our study show Cherokee children, families, and community members engaged in harmonious and inclusive relations, both at a microscale of embodied and spoken communication and in enacting the Cherokee value system that calls for people to collaborate in harmonious and inclusive ways. The evidence comes from three different settings: an interview with a mother and children about family-in-community collaboration, a competition/ cooperation piloting session in which pairs of children and their teacher/Elder fluidly collaborated with the research team in carrying out the piloting; and a groups of Cherokee youth using fluid collaboration to maintain harmony while resolving conflicts during a school activity day.

The smooth harmonious, mutual engagement analyzed in this study offers visible evidence at microscale of Cherokee children and families smoothly maintaining the pace and direction of groups, blending agendas, and attending to everyone present with mutual care and harmonious, attentive contribution to the overall activity. We also presented evidence that supports our claim that patterns of harmonious collaboration take form together, at the same time, in engagement at multiple analytic scales, from millennial to micro.

This study contributes to elucidating processes involved with key facets of the LOPI paradigm. In particular, it provides evidence of the simultaneity of the relationship of Indigenous American collaborative organization and process across

cultural/historic and microgenetic scales (Facets 1 and 3 of the LOPI prism, see Figure 1).

In addition, this study addresses a thorny issue in understanding the LOPI approach: How is it that conflict co-exists and is ideally handled in a community where communitywide interpersonal harmony is highly valued and practiced? In Fractal Analysis 3, we showed that the pervasive use of fluid collaboration (shown in Fractal Analyses 1 and 2 as well) can be used as a tool to subtly and peacefully avoid public conflict, even if privately, individuals and groups have good reason to avoid friendly relations. Indeed, there is evidence that Cherokee communities with entrenched intergenerational family disputes often collaborate in public community settings (Warhaftig, 1968).

Although our account has leaned heavily on statements summarizing Cherokee community values, conveyed in the wampum and in Cherokee Nation statements, we emphasize that these principles are carried in people's actions. People's actions in tiny moments have a *fractal relation* with millennial practices, including formal statements of the Cherokee value system, mutually constituted across time and across people in small scale and longterm actions and systems of action (Rogoff, 1995, 2003). We hope to have demonstrated, in our *fractal analyses*, how individuals' micro interactions are the embodiment and medium of culture, simultaneously occurring over the short term and the long term within a singular process.

Our study provides evidence to elaborate the idea that cultural patterns of practice across time and scale are related fractally, with children's learning and development occurring in the process of their evolving participation in community

endeavors (Dayton et al., 2022; Rogoff, 1995, 1998; 2003). In line with Facet 4 of LOPI, learning is based in people's participation in community endeavors, and the ensuing transformations in their participation (Rogoff, 2014; Rogoff & Mejía-Arauz, 2022).

Our study's evidence supports the treatment of cultural change as a holistic, fractal process (Rogoff, 1995, 2003; Rogoff & Aceves-Azuara, under review; Rosado-May et al., 2020), embedded in patterns of practice and organization that unfold in milliseconds as well as contributing to intergenerational patterns spanning centuries simultaneously and continuously. This contrasts with some other approaches that treat change more mechanically as macro 'influences' on child development and childrearing practices. For example, some accounts attribute large-scale changes and stabilities as well as the apparent rapid changes in small-scale interactions to 'forces' such as 'globalization,' 'modernization,' and the like (as in Garcia & Greenfield, 2015). Rather than presuming that the macro-'level' is a context for the micro-'level' with strong causal asymmetry favoring macro-'level' processes, Rogoff and colleagues' holistic, ecological model of continuity within and across small-scale interaction as well as community organization predicts the kind of fractal patterns investigated in this study. A theoretical need for an extra 'force' to explain dynamic change is rejected in Rogoff's views of mutually constituting processes and transformation of participation.

The relationship of collaborative patterns spanning across timescales shown in the present study supports the idea that mutual engagement itself is a theoretically basic process with a fractal relationship across all developmental timescales

simultaneously and continuously. The study also indicates that as closely as we can examine events, including embodied interactions, cultural processes are salient.

The phenomena observed in this study bring these ideas together with longstanding ideas central to Indigenous Knowledge Systems (IKS), which emphasize holistic approaches to Indigenous ways of collaboration and learning. Our claim that cultural practices that change across generations are built in the moment-to-moment interactions of everyday life is, we believe, consistent with the dynamic, singular holistic process emphasized in IKS (Battiste, 2001; Brayboy, 2005; Tuck, 2011; Wilson, 2008).

Indigenous scholars assert that persistence over millennia is a robust indication of the reliability of these ideas (Battiste, 2002; Cajete, 1999), a proven best way. As Cherokee Elders and scholars note, Cherokee knowledge has been passed on as the essential values and practices embodied in being human and members of Cherokee communities. Whether the generations to follow choose to incorporate the teaching of the essential knowledge of Cherokee Elders into their ongoing practices is a valid, responsible, and well-established way to assess the attainment of shared goals, including knowledge production.

At the same time as claiming the value of millennial practices that persist in their enactment across many generations, we and other scholars argue that many recognized Cherokee practices are adaptations to changing circumstances, such as colonization and globalization (Dayton & Rogoff, 2016; Rosado-May et al., 2020). The process of adaptation itself provides further proof of the value of the core ideas. For example, the Indigenous Knowledge set out in the articulated Cherokee value system to describe this established knowledge, along with the wampum and medicine

societies, have existed at least since 1902 (when the wampum photograph was taken). But they themselves are an adaptive response to outside cultural forces -- even to deliberate efforts at extermination (Mackey, 2014; Mooney, 1902; Teuton, 2012; Wahrhaftig, 1968). Indigenous communities' ways that enact knowledge accumulated over millennia – to remain harmonious in interactions with each other and the natural world, to include everyone and help each other whenever we can and in a careful, loving way, and to avoid anger and violence with each other – are adaptive responses to 'modernization,' not the absence of modernization. Indigenous American communities have the collected and collective knowledge of several iterations of so-called 'modernization' to draw upon, from the Pueblo revolt of 1680 in which a generation passed between Spanish contacts (Wilcox, 2009), to the Cherokees' and Southeast Indians' relationship to the "Mound builders" (Teuton, 2012), to Maya and Aztec periodic epochs in cycles of thousands of years (Chavez, quoted in Christenson, 2001). An important direction for future research is to examine these ideas about the Cherokee community values and about cultural change and persistence with Cherokee elders and first-language speakers.

We offer the analyses as evidence of embodied mutual synchrony, mutual holistic inclusion, and dynamic, embodied rhythmic processes, in fractal relations across timeframes. We relate these theoretical points to philosophy and value systems prevalent in many Indigenous communities of the Americas, where life is regarded as a holistic and relational process. We have situated these theoretical points in micro and millennial moments of ongoing life process, by documenting the ways that the Cherokee participants enacted principles of inclusion, collaboration, and harmony in ways that Elders have taught Cherokee generations to organize and

behave. We hope to have embodied these principles in the methodology of this study as well, with relational accountability, as described by Wilson (2008) in distinguishing Indigenous methodologies from conventional academic methodologies:

Your methodology has to ask different questions: rather than asking about validity or reliability, you are asking how am I fulfilling my role in this relationship? ... This becomes my methodology, an Indigenous methodology, by looking at relational accountability or being accountable to all my relations. (p. 177)

Coda: Future Directions

This discussion has focused on how our findings contribute to Learning by Observing and Pitching In as well as Indigenous Knowledge Systems. In addition, we note here that the findings and the first author's plans for future research connect deeply with dynamical systems concepts related to socio-cognitive development, embodied cognition, and participatory sense making.

My future directions connect the present study with the dynamical systems approaches to social cognition as a dynamic, holistic process that encompasses the entirety of an individual's mental and physical processes. These embodied individual processes are continuously engaged as people connect with others and their environment. Cognitive development is conceptualized as a complex and multifaceted process involving many different areas of the brain and body as well as conceptual cognitive “capacities”, such as affect, perception, attention, memory, language, problem-solving, and decision-making (Spivey, 2007; Thelen & Smith, 1994; Tomasello, 1999; Trevarthan, 1993). In a holistic approach to understanding cognitive development, physical movement is a key aspect of cultural and cognitive processes, as it reflects individual processes, social engagement, and engagement with the environment simultaneously (Dayton et al., 2022; Fantasia, De Jaegher, & Fasulo, 2014; Spivey & Spevak, 2017).

The present study contributes to current directions in cognitive and neuroscience, which have important parallels with the cultural/historical approach of our study. Cognitive scientists call for situating analyses in specific contexts at appropriate timescales to reveal the relation of movement and social cognition across scales (Hutchins, 2011; Spivey & Spevak, 2017). Our fractal analyses embody the investigation of processes that are scale-invariant, self-similar, cyclically iterative, autopoietic (i.e., generative, self-sustaining), and nonlinear. Each spatio-temporal scale is co-constituted by the others. Our study provides evidence that phenomena at any scale are visible from the perspective of any other (as called for in some recent cognitive science, neuroscience, and cultural/historical writings).

Our findings support our claim that fluid collaboration *just is* collaborative community organization – described in different scales (in the language of dynamical systems: rates of iteration and self-creation -- i.e., autopoiesis). As a scholar working

across dynamical systems and cultural/historical approaches, I suggest that the approach we took in this study could lead to quantitative measurements of fractal dynamics in human interaction that bring neurological, individual, and cultural process together as one.

I would like in future to build a team to use these videos and my new depth recordings to develop new representational approaches and quantitative tools to capture contextually embedded fractal engagement dynamics. I have begun such analyses, using the movement rhythms shown in these data to measure “coordinative structures.” This ensemble engagement can be quantified, treating the engagement process as the basic unit. As we demonstrated in the present study, socially shared rhythms are highly culture- and context-dependent (Dayton et al., 2022; Erickson, 2009; Malloch & Trevarthen, 2009; Smith, 1993). My future contributions aim to provide ways to quantify these processes, for advancing theoretical, empirical, and design research.

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