Subsistence and cooperation

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Part I: Subsistence

Economic production

Subsistence: the strategies used to acquire necessary resources

- Can also use the term “livelihood” to avoid connotations of “hand-to-mouth” or of a pure “subsistence economy”
- Has important cultural, identity dimensions as well as being about the acquisition of necessary resources[1]
- Focus in anthropology on non-market economies
- Premise of evolutionary approaches is that we can use mathematical models to generate hypotheses about people’s behavior (vs. Sahlin’s fallacy)

[1] Steward, J. 1955. *Theory of culture change: The methodology of multilinear evolution* (Chapter 2). Urbana: University of Indiana Press.

Modeling decision-making

Foraging theory provides one means of generating testable hypotheses about why organisms use resources in particular ways (e.g., why eat some foods and not others)[2]

- Uses optimization analysis to predict behavior, given an objective (e.g., getting sufficient calories in a minimum amount of time)
- Does NOT imply organisms are "optimal"
- Reductionist: prioritizes simplicity and clear specification of relationships between variables
- Deliberately brittle: Failures of a model highlight that model assumptions are wrong (models themselves are never proven or disproven, they just may not be a useful representation of the real world)
- Major weakness: organisms are making decisions over a wide range of problems simultaneously

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2 Smith, E.A. and Winterhalder, B. 1992. Natural Selection and decision-making: Some fundamental principles. In: *Evolutionary Ecology and Human Behavior.* New York: Aldine de Gruyter.

Modeling decision-making

Components of an optimization model:

- **Actor:** the organism (see Smith and Winterhalder on methodological individualism)
- **Strategy set:** what behaviors are available to the actor (e.g., to play Hawk or Dove; to choose a subset of food items from the environment)
- **Currency:** what is the actor's objective? (Ultimately, to maximize fitness, but we often work with proximate objectives, such as calories)
- **Constraints:** relevant variables not under the actor's control
    - *Extrinsic:* environmental conditions (e.g., the size of prey)
    - *Intrinsic:* the actor's abilities (e.g., walking speed) and requirements (e.g., minimal calories per day)

The prey choice model

The most well-known foraging model is the **prey choice** or **diet breadth** model,[3] which predicts which resources an organism should choose to eat as it searches through a fine-grained environment (i.e., where resources are randomly distributed)

Model components:

- **Actor:** an organism travelling through a landscape
- **Strategy set:** any combination of potential prey items
- **Currency:** assume goal is to maximize calories per time spent foraging
- **Constraints:** *Organism searches for all prey simultaneously but must stop search in order to handle a prey.*

[3] MacArthur, R.H. and Pianka, E.R. 1966. *The American Naturalist* 100: 603-609.

The prey choice model

Post-encounter return rate of a prey item: $e/h =$ energy of item/handling time

Overall foraging return rate: $E/T =$ Total energy acquired/foraging time, ($T = (s + h)$, $s =$ search time)

Key prediction:

If $e/h > E/T$ then take the item on encounter, otherwise pass over.

To maximize the total energy intake rate, the organism should only stop to handle items that provide a *post-encounter return rate* higher than the overall return rate provided by waiting to encounter a more profitable item.

The prey choice model

On average, you expect to find and pick up 1 quarter and 5 dimes per minute spent foraging for coins on the street. It takes you 1 second to pick up any size coin. Should you also pick up pennies?

Overall rate of quarters and dimes = 0.75¢/min or 1.25¢/second

Handling rate of pennies = 1¢/s

If however you expect to find and pick up 1 quarter and 3 dimes per minute, how much money would you earn per minute? Should you then pick up pennies?

55¢/min $<$ 1¢/s

What would happen if pennies were predictably always encountered in pairs?

The prey choice model

Key implications:

- Inclusion of a prey type doesn't depend on how abundant it is but on how abundant higher-ranked prey are
- Lower-ranked prey ignored unless higher-prey are more scarce (this lowers average return rate so lower-rank prey will improve energy capture rate)
- Diet breadth will respond to ecological conditions: decrease with "better" conditions (more high-ranked prey), increase with "poor" conditions (high-ranked prey depleted)

Suggested exercise: Read Chap 1. of Bettinger[4] and complete the problem set.

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[4] Bettinger, R.L. 2009. *Hunter-gatherer foraging: Five simple models* Clinton Corners, NY: Eliot Werner Publications.

The prey choice model

Ethnographic "tests" of the prey choice model have been generally successful[5]

- E.g., seed collecting falls out of Alyawara (Australian aboriginal) diet when flour introduced[6]
- Data collection is challenging...

But, almost all cases yield some deviations from model predictions

- These "failures" usually reveal something important
- E.g., gender differences in foraging choices

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5 Hawkes, K., Hill, K. and O'Connell, J.F. 1991. *American Ethnologist* 9: 379–398.

6 O'Connell, J.F. and Hawkes, K. 1981. Alyawara plant use and optimal foraging theory. In: *Hunter-gatherer foraging strategies: Ethnographic and archaeological analysis.* Chicago: University of Chicago Press.

Other foraging models

Getting "patchy" resources: the Marginal Value Theorem[7]

Getting things and bringing them home again: Central Place Foraging[8]

Choosing a home base: the Ideal Free Distribution[9]

Models for other problems such as crop planting, herd management,[10] as well as reproductive investment, technological investment, etc. are not substantively different.

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[7] Charnov, E.L. 1976. *Theoretical Population Biology* 9: 129–136.

[8] Orians, G. H. and Pearson, N. E. 1979. On the theory of central place foraging. In *Analysis of ecological systems*. Columbus: Ohio State University Press.
Metcalfe, D. and Barlow, K.R. 1992. A model for exploring the optimal trade-off between field processing and transport. *American Anthropologist* 94: 340–356.

[9] Fretwell, S.D. 1969. *Acta Biotheoretica* 19(1): 45–52

[10] Mace, R. 1993. *Behavioral Ecology and Sociobiology* 33: 329–334.

End Part I

These models are tools not truths. You can always build a model to suit your problem!

Interlude: Dealing with risk

Dealing with risk

Many basic foraging models assume that maximizing long-term return rate (i.e., expectation) is a fitness-maximizing objective.

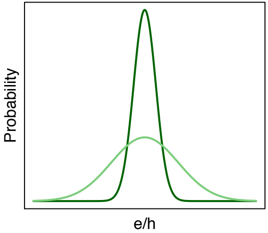
- This can work very well in archaeological contexts!
- But at finer time scales, encounters with prey are probabilistic
- Organisms may have competing objectives (e.g., minimum calories per day, predator avoidance)

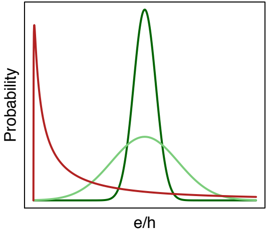
When the environment is stochastic and the relationship between the amount of a resource (currency) and utility for the organism is non-linear, organisms may be *risk-sensitive*

What is risk?

Risk: the probability distribution of outcomes (usually use variance as measure of magnitude of risk). Even if risk is known, specific failures are unpredictable (stochastic).[11]

Uncertainty: a lack of knowledge about that probability distributions. Uncertainty can be often be reduced through learning (social or non-social).



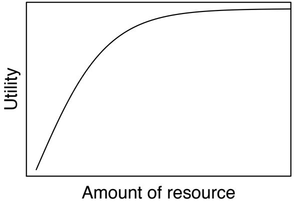


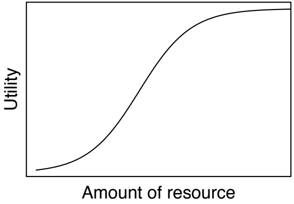
[11] Winterhalder, B., Lu, F. and Tucker, B. 1999. *Journal of Archaeological Research* 7: 301–348.

Risk-sensitive foraging

Risk-sensitive foraging also requires a non-linear relationship between currency and utility

- Can take any shape but most often we think of *diminishing returns*
- There may be multiple inflections (e.g., a sigmoidal curve)[12]





[12] Kuznar, L.A. 2001. *Current Anthropology* 42: 432–440.

Risk-sensitive foraging

Among human hunter-gatherers, high return resources also tend to be high variance, often with a high failure rate[13]

How can people manage risk?

- **Diversification:** widening the diet, mixed cropping, field scattering
- **Mobility:** average over space
- **Technological investment, esp. storage:** better tools might reduce variance (but external storage poses problem of defense)
- **Sharing:** risk pooling through exchange (intra- vs. inter-group)

Effective strategies depend on the temporal and spatial scales of variability, as well as its predictability.

[13] Bird, D.W., Bliege Bird, R. and Codding, B.F. 2009. *American Antiquity* 74: 3–29.

Risk and cooperation

In ethnographically observed hunter-gatherers, sharing of food, especially large game, is nearly ubiquitous

But sharing also carries the risk that your partners might cheat or free-ride…

Why do hunter-gatherers share?

Why is sharing (and other forms of cooperation) so common in human societies?

Inuit collecting shares of beluga whale

Part II: Cooperation

Why help?

A "puzzle" from an evolutionary perspective is why should an individual pay a (fitness) cost to help others?

Evolutionary theorists posit some sort of benefit to helping (altruism is not really altruistic), generally at the individual level[14]

[14] Group selection (once considered implausible) now more widely accepted

Kin selection

Kin selection: helping your genetic relatives helps your genes, because genes are shared among ("inclusive fitness")

Humans (and many other animals) do tend to help their kin more than non-kin, but whether it is actually kin selection is extremely difficult to test!

Hamilton's rule: Help if the cost to you is less than the benefit to the recipient, discounted by their relatedness to you[15]

$$rB > C$$

[15] Hamilton, W.D. 1964. *Journal of Theoretical Biology* 7: 1–52.

Reciprocal "altruism"

Benefit of helping may be that others help you

- cost of giving when you have a resource should be less than the benefit of receiving a share later
- accounts do not have to be balanced to maintain helping (marginal utility)
- can pool risk in stochastic environments: **sharing as insurance**

BUT temptation to defect (to receive help without giving it).

- Evolutionary Game Theory usually used to examine this problem, especially the (iterated) Prisoner's Dilemma (a form of the Hawk-Dove game)
- need mechanisms to maintain cooperation

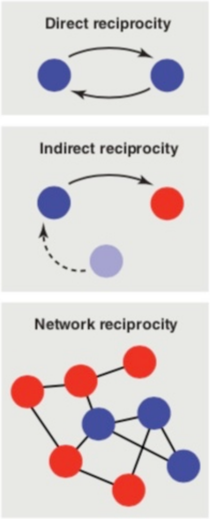
Reciprocal altruism

Mechanisms that can sustain reciprocity depend on the structure of interactions:[16]

Direct reciprocity: repeated pairwise interactions. Individuals can punish past offenders (e.g., through "tit-for-tat")

Indirect reciprocity: sharing not pairwise but distributed among all. Offenders can be excluded using reputations

Network reciprocity: clumpiness of cooperators lets benefits outweigh the costs



[16] Axelrod, R. and Hamilton, W.D. 1981. *Science* 211: 1390–1396. Nowak, M.A. 2006. *Science* 314: 1560–1563

Problem of non-excludability

Cooperation often involves provisioning **common goods** or **public goods**

- for both, cannot exclude non-cooperators ("non-excludability")
- common goods can be depleted while public goods cannot ("non-subtractable")[17]
- e.g., fish stocks (common good) or street lighting (public good)

In hunter-gatherer societies, large game is often treated like a common good. Why should someone pay the cost of providing that good?[18]

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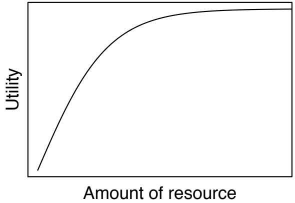
[17] Ostrom, E. et al. 1999. **Science** 284: 272–282.
[18] Hawkes, K. 1993. *Current Anthropology* 34: 341–361 .

Tolerated theft

If resources come in large packages, sharing may be a byproduct of the marginal valuation of the resource[19]

- one unit of resource has a high value to someone with nothing (they might be willing to fight for it)
- for the resource holder, cost of defending an additional share may exceed the benefit of keeping it



[19] Blurton Jones, N.G. 1984. *Ethology and Sociobiology* 5: 1–3. Winterhalder, B. 1996. *Ethology and Sociobiology* 17: 37–53.

Costly signaling

Another proposed solution to the free-rider problem is via **signaling**[20]

- **signals** are traits that communicate hidden information about the signaller to the receiver (in a way that benefits that signaller)
- **costly signals** are kept honest because "low quality" individuals cannot produce them (handicap principle)

Sharing as a "prosocial" signal that communicates information (e.g., hunting ability, generosity, commitment to the group) that impacts how people subsequently treat them (e.g,. mate choice)

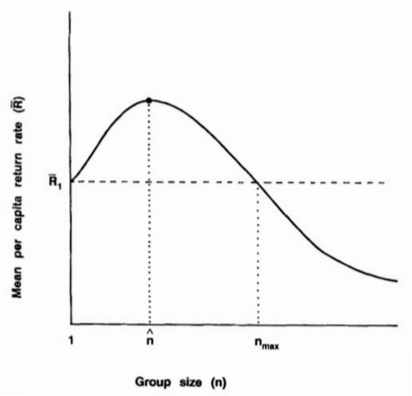
[20] Bliege Bird, B. and Smith, E.A. 2005. *Current Anthropology* 46: 221–248.

Not all cooperation problems provide an incentive to free-ride

Sometimes, actors do have common interests!

- coordination problems, (e.g., the stag hunt game)
- problem shifts to communication about intent and/or exclusion (e.g., joiner's rule[21])

Again, models are just tools. Important to think carefully about the real structure of the problems people face.



[21] Smith, E.A. 1984. *Inuit Studies* 8(1): 65–88.

Current research in the field[22]

- Livelihoods in "transitioning" economies
- Risk-reduction and climate change
- Learning how to forage
- Cooperation, signaling and social capital

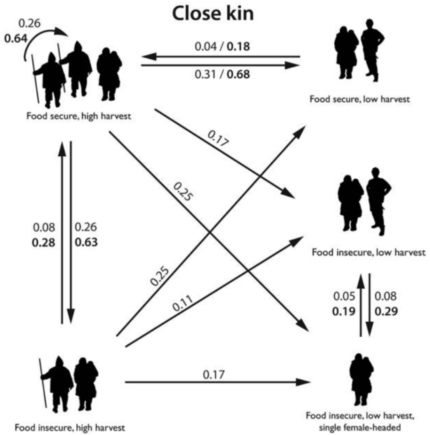
Conflict and coalition networks among Tsimane men

[22] ...and in the HBEC department!

My research

Why do Inuit continue to hunt and share food?

How do people respond to changed ecological and social environments? What encourages the persistence of traditional cultural forms?



Probabilities of food sharing ties between Inuit households[23]

[23] Ready, E. and Power, E.A. 2018. *Current Anthropology* 79: 74–97.

Up next

Today: Static approaches to micro-level decision-making (about resource acquisition and cooperation)

Tomorrow & Friday lectures: Dynamics of systems over time (Bret and Laurel)

For tomorrow afternoon's discussion:

Bird, D.W., Bliege Bird, R. and Codding, B.F. 2009. In pursuit of mobile prey: Martu hunting strategies and archaeofaunal interpretation. *American Antiquity* 74: 3–29.

Suggested exercises:

Problem set from Bettinger (2009), Chap 1.