

Simulating Baboon Behavior using Stata

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Since this presentation is rather different from my usual methodology presentations please feel free to ask questions at any point during the presentation.

In the mid 1970s I spent two years studying baboon behavior at two research sites in Tanzania.

Site 1: Mikumia National Park - open savannah populated with yellow baboons (*Papio cynocephalus*).

Site 2: Gombe Primate Research Centre - forested hills populated with olive baboons (*Papio anubis*).

Papio cynocephalus



Papio anubis



Target or focal individuals within the troop were selected randomly and followed for two hour observation periods.

Individuals were selected from four classes of baboons: 1) Adult males, 2) adult females, 3) adolescent males, and 4) adolescent females.

Each of the classes of baboons were counterbalanced for time-of-day observation: 1) morning, 2) midday, 3) afternoon.

Recording the data

Data were recorded manually on ledger type sheets of paper. Columns were for the various behaviors. Each row was for a 5 minute observation period. There were 24 rows for a 2 hours of data.

Observers carried electronic timers that emitted a beep once every 5 minutes.

Some behaviors were recorded on-the-moment (OTM) while some recored thru-the-moment (TTM).

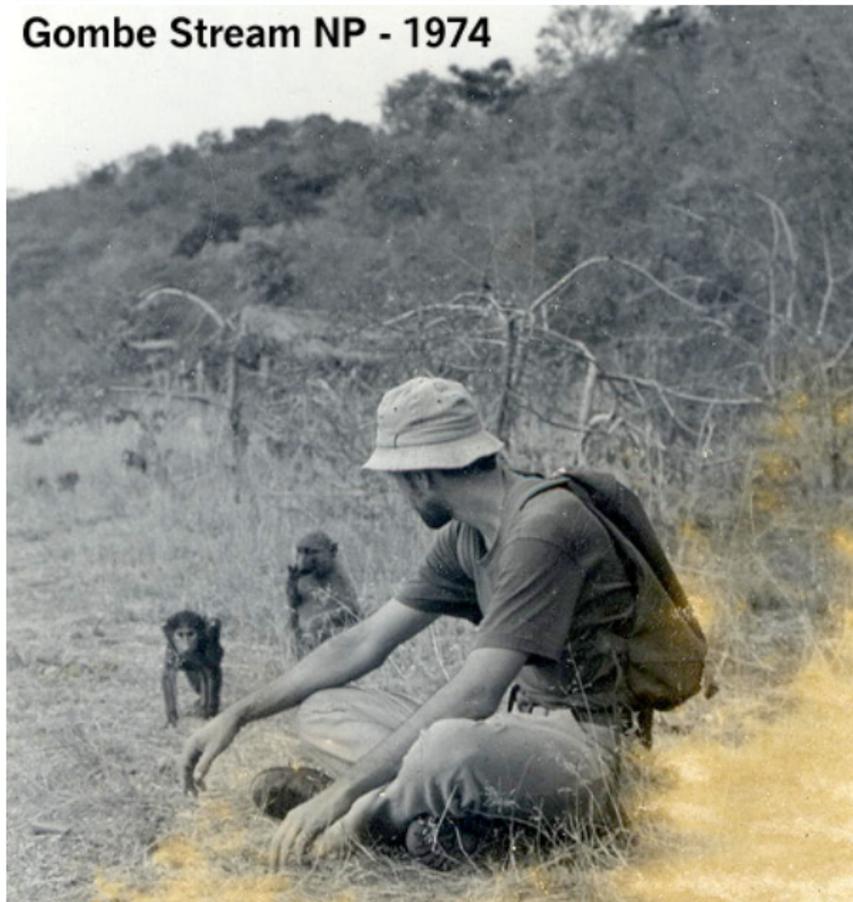
OTM Behaviors were marked if the behavior was occurring when the beep sounded.

TTM Behaviors were marked one time if the behavior occurred anytime within the 5 minute interval.

Target animals are frequently lost to observation due various causes. The most common reasons were ...

- * Thick vegetation obscuring target animal
- * Target animal not visible in tree
- * Baboons can move faster than people on foot
- * Elephants
- * Cape Buffalo
- * Lions
- * Rhinos

Gombe Stream NP - 1974



Another Gombe Photo



Criticism of Behavior Sampling

At the time there was considerable criticism of the behavior-time sampling approach.

Behavior-time sampling was thought to be unreliable and did not actually measure the "true" count or "true" duration of behaviors.

This, of course, cried out for a simulation study comparing behavior-time sampling methods and "true" or actual frequency (count) and duration.

An inconvenient truth

The truth is that in field research, it is virtually impossible to collect with absolute certainty the true count or frequency of a behavior let alone its true duration.

The First Simulation Study

So, in 1979 I wrote a simulation program in FORTRAN IV which ran on an IBM 360 Model 60. It took several weeks to write and debug since nonpriority jobs had to run in the evening and overnight which limited me to an about of one run per day.

The program involved the use many arrays and numerous DO-loops.

Along with the primatologist Ramon J. Rhine the simulation study was published in the American Journal of Primatology in 1983.

I thought wouldn't it be fun to replicate the simulation using Stata?

The Stata Simulation

I could have just translated the FORTRAN code into Mata. But, that wouldn't take advantage of the many time and code saving features built into Stata. Besides, I couldn't locate the original FORTRAN source code.

The end result is today's presentation in which the behavioral sampling simulation is written in simple straight forward Stata. It was written and debugged in a single morning.

The Basic Strategy

1. Create variable b (for behavior) with 36,000 zeros (there are 36,000 seconds in a ten hour period).
2. Randomly place the value one in b for the start of each behavior bout.
3. Place a two in b for every second that the behavior bout continues. The duration was randomly generated with a mean and standard deviation compatible with the frequency.
4. Repeat steps 1 thru 3, 500 times for each combination of behavior count and average duration. Save to a file.
5. Import file and analyze using regress.

Behavior Sampling Scheme

1. Behavior sampling intervals were 5 minutes (300 seconds) long.
2. On-the-moment (instantaneous) sampling was done every 5 minutes. If variable *b* was a one or a two then the behavior occurred on-the-moment. All of the on-the-moment bouts were summed for the entire 10 hour (120 5-minute intervals, 36,000 seconds) observation period.
3. Thru-the-moment (one-zero) sampling was coded as a one for an interval if variable *b* was a one or a two at any time during a 5 minute sampling period. All of the thru-the-moment intervals were summed for the entire 10 hour observation period.

Obtaining True Counts and Duration

The true (actual) number of behavior bouts is just the count of the number of values equal to 1.

The true (actual) duration of the behavior was the sum of all the ones and twos.

Sampling Values

1. The number of behavior bouts were specified by the number of times a behavior occurred per hour. The times per hour were .5, 1, 5, 10, and 20. The .5 bouts per hour is equivalent to once every two hours.
2. The average durations used were short (5 or 10 seconds), medium (20 or 30 seconds) and long (60 or 90 seconds).
3. Not every possible combination of frequency and duration makes sense.

The code fragments have numeric constants in them for clarity. The actual program used very few numeric constants but rather used local macros.

Also, to keep things simple I omitted the code that checks for writing beyond 36,000.

Code Fragment 1: Creating Variable b with Behavior Bouts

Code for 20 bouts per hour with average duration 10 seconds

```
forvalues k=1/500 {                                // 500 replicates
  replace b=0                                       // initialize b
  forvalues i=1/200 {                               // 20 per hour for 10 hours
    local s = floor(_N*runiform() + 1) // start
    local s1 = 's' +1
    local d = round(rnormal(10,1))-1 // duration
    local e = 's'+ 'd' // end
    replace b=1 in 's' // start of behavior bout
    replace b=2 in 's1'/'e' if b==0 // continuation of bout
  }
  ...
}
```

Code Fragment 2: Computing Number of Bouts and Duration

```
replace bc=.           // reinitialize bout count variable
count if b==1         // true behavior count
local tc r(N)
count if b!=0         // true behavior duration
local td r(N)
count if b!=0 & mod(36000, 300) // on-the-moment count
local otm r(N)
replace bc=1 if b!=0 // bc=1 everywhere that b!=0
egen ttm=count(bc), by(intervalnumber)
count if ttm!=0 & mod(36000, 300) // thru-the-moment count
local ttm r(N)
```

Why the critics disliked behavioral sampling

times/hour	true_count	true_duration	OTM	TTM
0.5	4.999	124.66	0.412	5.283
1	9.999	249.072	0.89	10.414
2	19.988	495.967	1.68	19.853
3	29.98	741.232	2.447	28.526
5	49.974	1227.87	4.042	43.476
10	99.861	2409.47	8.053	71.324
15	149.702	3554.84	11.896	89.05

But there can also be problems with simulation

Example: count per hour = 1; average duration = 5. No behaviors occurred on-the-moment.

```
regress tc otm
```

Source		SS	df	MS	Number of obs	=	500
-----+-----					F(1, 497)	=	.
Model		0	1	0	Prob > F	=	.
Residual		0	497	0	R-squared	=	.
-----+-----					Adj R-squared	=	.
Total		0	498	0	Root MSE	=	0

tc		Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
-----+-----							
otm		0	(omitted)				
_cons		10

A look at the first 10 observations

	tph	ad	tc	td	otm	ttm
1.	.5	5	5	24	0	5
2.	.5	5	5	25	0	4
3.	.5	5	5	23	0	5
4.	.5	5	5	24	0	5
5.	.5	5	5	27	0	5
6.	.5	5	5	29	0	4
7.	.5	5	5	27	0	5
8.	.5	5	5	26	0	5
9.	.5	5	5	26	0	5
10.	.5	5	5	26	0	5

Simulation Results: R-squared

Table of R-squared

	Behavior Bout Duration		
	Short (5 & 10 sec)	Medium (20 & 30 sec)	Long (60 & 90 sec)
TC<-OTM	0.7536	0.7571	0.8776
TD<-OTM	0.8786	0.8224	0.9421
TC<-TTM	0.7522	0.9672	0.9560
TD<-TTM	0.6594	0.9079	0.9252

TC true count TD true duration
OTM on-the-moment TTM thru-the-moment

R-squared predicted by OTM and TTM

Table of R-squared

	Behavior Bout Duration		
	Short	Medium	Long
	(5 & 10 sec)	(20 & 30 sec)	(60 & 90 sec)
TC	0.8531	0.9678	0.9578
TD	0.9003	0.9315	0.9613

TC true count TD true duration
OTM on-the-moment TTM thru-the-moment

Previous table is misleading

The previous table is misleading because no one would use both on-the-moment (OTM) and thru-the-moment (TTM) sampling to measure the same behavior.

Rhine, R.A. & Ender, P.B. (1983). Comparability of methods used in the sampling of primate behavior. *American Journal of Primatology*, 5, 1-15.

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