

Robert Axelrod

Professor of Political Science and Public Policy at U Michigan, Ann Arbor

First paper on cooperation published in 1980.

Book (left) published in 1984 to wide acclaim.

Best known for this and related work; still active in this area and publishing new research.

http://www-personal.umich.edu/~axe/

## Iterated Prisoner's Dilemma

Two players

Prisoner's Dilemma played repeatedly

History of previous interactions remembered by each player

No other outside knowledge



## Contest #1

Call for entries to game theorists

All entrants told of preliminary experiments

15 strategies = 14 entries + 1 RANDOM

Round-robin tournament against all other players and "twin"

Each game 200 iterations

Games run 5 times against each strategy

Scores averaged over all games

Anatol Rapoport	4	504.5
Nicholas Tideman & Paula Chieruzzi	41	500.4
Rudy Nydegger	23	485.5
Bernard Grofman	8	481.9
Martin Schubik	16	480.7
William Stein & Amnon Rapoport	13	477.8
James Friedman	13	473.4
Morton Davis	6	471.8
James Graaskamp	63	400.7
Leslia Downing 1	33	390.6
Scott Feld	6	327.6
Johann Joss	5	304.4
Gordon Tullock	18	300.5
Name withheld	77	282.2
RANDOM	5	276.3

## And, the winner is...

### TIT FOR TAT

"Cooperate on first move, thereafter reciprocate opponent's previous action"

Shortest program submitted

By psychologist, Anatol Rapoport

#### Oxford English Dictionary

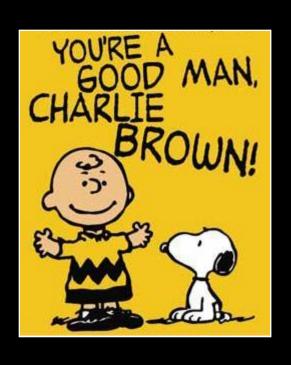
1. In phr. tit for tat [app. a variation of tip for tap, known a century earlier: see  $\underline{TAP}$   $n.^2$ ,  $\underline{TIP}$   $n.^2$ , and cf. prec. But perh. wholly or partly onomatopæic.] One blow or stroke in return for another; an equivalent given in return (usually in the way of injury, rarely of benefit); retaliation. Also used as rhyming slang for 'hat'. Cf.  $\underline{TITFER}$ .

The whole phrase is used sometimes as a n, sometimes as adj, or adv, also, elliptically or as int.

1556 J. HEYWOOD Spider & F. XXXVII. 26 That is tit for tat in this altricacion. 1586 J. HOOKER Hist. Irel. in Holinshed II. 94/1 That they would not sticke to set his servants at libertie, so he would redeliuer them the youth of the citie, which was nothing else in effect, but tit for tat. 1710 ADDISON Tatler No. 229 3, I was threatened to be answered Weekly Tit for Tat. 1809 J. QUINCY in Life 181, I shall give what politicians call a Rowland for their Oliver, and what the ladies term tit for tat. 1881 SAINTSBURY Dryden iv. 80 A fair literary tit-for-tat in return for the Rehearsal. 1891 Daily News 16 July 5/1 Fair Traders, Reciprocity men, or believers in the tit-for-tat plan of dealing with other nations. 1905 H. A. VACHELL The Hill viii, Tit for tat. If I do this for you, will you do something for me? 1925 FRASER & GIBBONS Soldier & Sailor Words & Phrases 285 Tit for tat, hat. (Rhyming slang). 1930, 1937 [see TITFER].

## Analysis: "Nice" Guys Finish First

### Top 8 strategies never defect first.



Anatol Rapoport	4	504.5
Nicholas Tideman & Paula Chieruzzi	41	500.4
Rudy Nydegger	23	485.5
Bernard Grofman	8	481.9
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# Other Interesting Strategies

### TIT FOR TWO TATS

- Retaliate only if previous two are D's
- Could have won tournament, if entered

### NICE DOWNING

- Like DOWNING, but start with C's
- Could have won tournament, if entered

### Variations on TIT FOR TAT

Did well, but none beat TIT FOR TAT

## Contest #2

Same set up as Contest #1, except...

Entries from first-round contestants as well as open call in magazine

63 strategies = 62 entries + 1 RANDOM

Each game iterated an uncertain number of iterations, with probability 0.00346 of ending

The Contestants					
Rank	Name	Country (if not U.S.)	Discipline (if faculty)	I anguage (FORTRAN or BASIC)	Length of Program*
1	Anatol Rapoport	Canada	Psychology	F	5
2	Danny C. Champion			F	16
3 4	Otto Börufsen Rob Cave	Norway		F F	77 20
5	William Adams			В	22
6	Jim Graaskamp & Ken Katzen			ř	23
7	Herb Weiner			F	31
8	Paul D. Harrington	,		F	112
9	T. Nicolaus Tideman & P. Chieruzzi		Economics	F	38
10	Charles Kluepfel			В	59
11	Abraham Getzler	Contractors		ŀ	9
12	François Leyvraz Edward White, Jr.	Switzerland		B F	29 16
14	Graham Eatherley	Canada		F	12
15	Paul E. Black	- 21000		F	22
16	Richard Hufford			i-	45
17	Brian Yamauchi			В	32
18	John W. Colbert			F	63
19 20	I-red Mauk Ray Mikkelson		Physics	I. B	63 27
21	Glenn Rowsam		Physics	l·	36
22	Scott Appold			F	41
23	Gail Grisett			В	10
24	J. Maynard Smith	United Kingdom	Biology	Ŀ	9
25	Tom Almy				142
26	D. Ambuelh & K. Kickey			Į-	23
27	Craig I eathers			В	48
28	Bernard Grofman		Pol. Science	F	27
29	Johann Joss	Switzerland	Mathematics	В	74
30 31	Jonathan Pinkley			F	64 23
32	Rudy Nydegger Robert Pebley		Psychology	1: B	13
33	Roger Falk &			В	117
34	James Langsted Nelson Weiderman		C	i. 1.	18
35	Robert Adams		Computer Sci	i. 1 <sup>.</sup> B	43
36	Robert Adams Robert M. Dawes &		Psychology	Ĕ	29
	Mark Batell		,		
37	George Lefevre			В	10
38	Stanley F. Quayle			F	44
39	R. D. Anderson		Psychology	F	44 33
40 41	Leslie Downing George Zimmerman		rsychology	F	36
42	Steve Newman			F	51
43	Martyn Jones	New Zealand		В	152
44	E. E.H. Shurmann			В	32
45	Henry Nussbacher			B F	52 28
46	David Gladstein			F	30
47 48	Mark F. Batell David A. Smith			В	23
49	Robert Leyland	New Zealand		В	52
50	Micharl F. McGurrin			F	78
51	Howard R. Hollander			F	16
52	James W. Friedman		Economics 5 4 1	F	9
53	George Hufford			F F	41 6
54	Rik Smoody		Sociology	F	50
55 56	Scott Feld Gene Snodgrass		Sociology	F	90
57	George Duisman			В	6
58	W. H. Robertson			F	54
59	Harold Rabbie			F	52
60	James E. Hall			F	31 84
61	Edward Friedland RANDOM			F	(4)

# And, the winner is...



TIT FOR TAT, again!

(Again, by Anatol Rapoport)

## Analysis: Contest #1 Lessons Validated

14 of top 15 strategies never defect first.

14 of bottom 15 strategies were not "nice".

Forgiveness important.

		The Contest	tants		
Rank	Name	Country (if not U.S.)	Discipline (if faculty)	I anguage (FORTRAN or BASIC)	Length of Program*
1	Anatol Rapoport	Canada	Psychology	F	5
3	Dunny C. Champion Otto Porulsen	Manuau		F	16 - · 77
4	Poo Cave	Norway		F F	20
5	William Adams			В	22
6	Jim Graaskamp &			F	23
	Ken Katzen				
7	Herb Weiner	,		F	31
9	Paul D. Harrington		E	F F	112
9	T. Nicolaus Tideman & P. Chieruzzi		Economics	r.	38
10	Charles Kluepfel			В	59
11	Abraham Getzler			Ĭ.	9
12	François Leyvraz	Switzerland		В	29
13	Edward White, Jr.			F	16
14	Graham Eatherley	Canada		F	12
15	Paul E. Black			F	22
16 17	Richard Hufford Brian Yamauchi			Į. B	45 32
18	John W. Coibert			I/	63
19	I-red Mauk			į,	63
20	Ray Mikkelson		Physics	В	27
21	Glenn Rowsam			l·	36
22	Scott Appold			F	41
23 24	Gail Grisetl J. Maynard Smith	Heired Wiesder	Distance.	B. I:	10
25	Tom Almy	United Kingdom	Biology	i ,	142
26	D. Acabuelh &			i.	23
	K. Kickey				
27	Craig I eathers			В	48
28	Bernard Grofman		Pol. Science	F	27
29 30	Johann Joss	Switzerland	Mathematics	B. F	74 64
31	Jonathan Pinkley Rudy Nydegger		Psychology	1	23
32	Robert Pebley		rsychology	В	13
33	Roger Falk &			В	117
	James Langsted				
34	Nelson Weiderman		Computer S	i 1·	18
35 36	Robert Adams Robert M. Dawes &		Psychology	F	43 29
30	hark Batell		rsychology		2.7
37	George Lefevre			В	10
38	Stanley F. Quayle			F	44
39	R. D. Anderson			F	44
40	Leslie Downing		Psychology	F	33 36
41 42	George Zimmerman - Steve Newman			F	51
43	Martyn Jones	New Zealand		в	152
44	E. E.H. Shurmann			В	32
45	Henry Nussbacher			В	52
46	David Gladstein			F	28
47	Mark F. Batell			F	30
48	David A. Smith			В	23
49	Robert Leyland	New Zealand		B F	52 78
50	Micharl F. McGurrin			F	16
51 52	Howard R. Hollander James W. Friedman		Economics	F	9
53	George Hufford		LICONOMINO	F	41
54	Rik Smoody			F	6
55	Scott Feld		Sociology	F	50
36	Gene Snodgrass			F	90
57	George Duisman			В	6 54
58	W. H. Robertson			F F	52
59 60	Harold Rabbie James E. Hall			E	31
61	Edward Frienland		_	F	84
62	RANDOM			F	(4)

## Analysis: Be Retaliatory

Some entrees tried to take advantage of "nice" strategies:

TRANQUILIZER – cooperate first, if other cooperates, too, throw in a few defections.

TESTER – defect first, if other doesn't retaliate, cooperate twice, then alternate defection and cooperation. If other ever defects, do TIT FOR TAT.

Strategies that were unresponsive to defections get taken advantage of.

Top strategies retaliate quickly.

# Analysis: Sneakiness Doesn't Pay

Entrees that try to take advantage of "nice" strategies, don't gain as much as they lose.

TRANQUILIZER – 27<sup>th</sup> place in tournament.

TESTER – 46<sup>th</sup> place in tournament (out of 63).

The Contestants					
Rank	Name	Country (if not U.S.)	(if faculty)	I anguage (FORTRAN or BASIC)	Length of Program*
1	Anatol Rapoport	Canada	Psychology	F.	5
2	Danny C. Champion Otto Börulsen	Norway		F F	16 - · 77
4	Rob Cave	11011111		ř	20
5	William Adams			В	22
6	Jim Graaskamp &			F	23
7	Ken Katzen Herb Weiner			F	31
, B	Paul D. Harrington	,		F	112
9	T. Nicolaus Tideman		Economics	F.	38
	& P. Chieruzzi				
10	Charles Kluepfel Abraham Getzler			B I-	59 9
12	François Leyvraz	Switzerland		В	29
13	Edward White, Jr.	C) TELEVISION		F	16
14	Graham Eatherley	Canada		F	12
15	Paul E. Black			F	22
16	Richard Hufford			Į.	45
17 18	Brian Yamauchi John W. Colbert			I. B	32 63
19	Fred Mauk			į.	63
20	Ray Mikkelson		Physics	В	27
21	Glenn Rowsam			1.	36
22	Scott Appold			F	41
23 24	Gail Grisell J. Maynard Smith	United Kingdom	Biology	B	10 9
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27 28	Craig Feathers Bernard Grofman		Pol. Science	B 1:	48 27
29	Johann Joss	Switzerland	Mathematics	В	74
30	Jonathan Pinkley			F	64
31	Rudy Nydegger		Psychology	1-	23
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34	Nelson Weiderman		Computer Sci	. 1·	18
35	Robert Adams			В	43
36	Robyn M. Dawes &		Psychology	F	29
37	Mark Batell George Lefevre			8	10
38	Stanley F. Quayle			F	44
39	R. D. Anderson			F	44
40			December 1 mans		33
	Leslie Downing		Psychology	F	
41	George Zimmerman		rsychology	F	36
42	George Zimmerman Steve Newman	New Zealand	Psychology	F F B	
	George Zimmerman	New Zealand	rsychology	F F B	36 51 152 32
42 43 44 45	George Zimmerman Steve Newman Martyn Jones E. E. H. Shurmann Henry Nussbacher	New Zealand	rsychology	F B B	36 51 152 32 52
42 43 44 45	George Zimmerman Steve Newman Martyn Jones E. E. H. Shurmann Henry Nussbacher David Gladstein	New Zealand	Psychology	F B B B	36 51 152 32 52
42 43 44 45 46 47	George Zimmerman Steve Newman Martyn Jones E. E. H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell	New Zealand	rsychology	F B B	36 51 152 32 52
42 43 44 45	George Zimmerman Steve Newman Martyn Jones E. E. H. Shurmann Henry Nussbacher David Gladstein	New Zealand New Zealand	rsychology	F B B B F F B	36 51 152 32 52 28 30 23 52
42 43 44 45 46 47 48	George Zimmerman Steve Newman Martyn Jones E. E.H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell David A. Smith		rsychology	F B B B F B B	36 51 152 32 52 28 30 23 52 78
42 43 44 45 46 47 48 49 50 51	George Zimmerman Steve Newman Martyn Jones E. E. H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell David A. Smith Robert Leyland Micharl F. McGurrin Howard R. Hollander			F B B F F B B F	36 51 152 32 52 28 30 23 52 78 16
42 43 44 45 46 47 48 49 50 51 52	George Zimmerman Steve Newman Martyn Jones E. E.H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell David A. Smith Robert Leyland Micharl F. McGurrin Howard R. Hollander James W. Friedman		Economics	F B B B B F F F	36 51 152 32 52 28 30 23 52 78 16 9
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42 43 44 45 46 47 48 49 50 51 52 53 54 55 56	George Zimmerman Steve Newman Martyn Jones E. E.H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell David A. Smith Robert Leyland Micharl F. McGurrin Howard R. Hollander James W. Friedman George Hufford Rik Smoody Scott Feld Gene Snodgrass George Duisman		Economics	F	36 51 152 32 52 28 30 23 52 78 16 9 41 6 50 90 6
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58	George Zimmerman Steve Newman Martyn Jones E. E.H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell David A. Smith Robert Leyland Micharl F. McGurrin Howard R. Hollander James W. Friedman George Hufford Rik Smoody Scott Feld Gene Snodgrass George Duisman W. H. Robertson		Economics	F	36 51 152 32 52 28 30 23 52 78 16 9 41 6 50 90 6 54
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59	George Zimmerman Steve Newman Martyn Jones E. E. H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell David A. Smith Robert Leyland Micharl F. McGurrin Howard R. Hollander James W. Friedman George Hufford Rik Smoody Scott Feld Gene Snodgrass George Duisman W. H. Robertson Harold Rabbie		Economics	F F B B B F F F F F F B F F	36 51 152 32 52 28 30 23 52 78 16 9 41 6 50 90 6 54 52
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58	George Zimmerman Steve Newman Martyn Jones E. E.H. Shurmann Henry Nussbacher David Gladstein Mark F. Batell David A. Smith Robert Leyland Micharl F. McGurrin Howard R. Hollander James W. Friedman George Hufford Rik Smoody Scott Feld Gene Snodgrass George Duisman W. H. Robertson		Economics	F	36 51 152 32 52 28 30 23 52 78 16 9 41 6 50 90 6 54

## General Lessons

### Be nice. (Don't defect first.)

The best way to do well is to cooperate with others who are also nice.

### Retaliate swiftly.

Or, others will take advantage.

### Forgive.

Feuds are costly. Defections shouldn't prevent cooperation later on.

### Don't be too clever.

Too much cleverness looks RANDOM.

## TIT FOR TAT and Ethics

#### Mahabharata (~3000 BC)

"One should not behave towards others in a way which is disagreeable to oneself. This is the essence of morality. All other activities are due to selfish desire."

#### Hammurabi's Code (~1750 BC)

"If a man put out the eye of another man, his eye shall be put out. If he break another man's bone, his bone shall be broken."

#### The Golden Rule (~30 AD)

"Do unto others as you would have them do unto you."

#### Kant's Categorical Imperative

"Act so that the maxim of action may be capable of becoming a universal law."

# Garrett Hardin ("The Tragedy of the Commons", 1968) "Conscience is self-eliminating."

# Thank you!