Supplement to "Learning in network games"

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A. Additional material: Sample information

We provide some information about our participants. Our sample consists mostly of undergraduate students: 90% of our participants range in age between 18 to 32 years. The oldest participant is 51 years old (Table S1). Figure S1 (left panel) shows the age distribution of our participants across the nine main treatments. Participants come from a range of different countries, with the vast majority (84%) being from Europe. There are about an equal number of women and men: the share of female participants ranges from 38% (N-1, M-3) to 66% (M-2).

We also elicited a coarse measure of risk aversion in the postexperimental questionnaire based on seven (nonincentivized) choices between a lottery and various sure outcomes. The risk aversion index reported in Table S1 takes the value 1 if the participant takes the most risky option each time (least risk averse) and takes the value 7 if the participant takes the safest option each time (most risk averse). Figure S1 shows that the distributions of this risk aversion measure are similar across treatments. Participants in F-3 seem more risk averse than those in M-3, however, in the sense of first-order stochastic dominance. We also asked participants about how important a number of things are for them and the mean answers to these questions are reported in Table S1.

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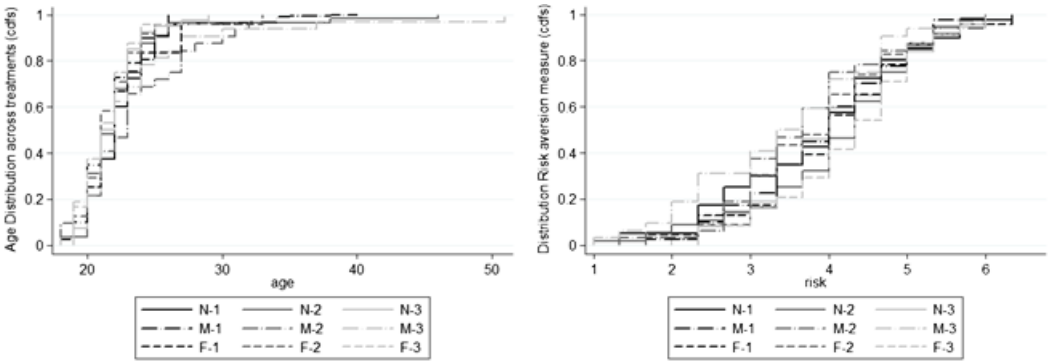


(a) Age (b) Risk aversion measure

FIGURE S1. Age distribution and distribution of risk aversion measure (cumulative distribution functions (c.d.f.s)) across treatments.

TABLE S1. Some sample characteristics: mean (range).

	N-1	N-2	N-3	M-1	M-2	M-3	F-1	F-2	F-3
Age	22.12	22.26	21.87	22.25	21.87	21.54	22.16	23.34	23.43
	[19, 26]	[18, 46]	[19, 29]	[19, 29]	[19, 33]	[19, 29]	[19, 40]	[18, 34]	[18, 51]
Gender	0.38	0.46	0.65	0.46	0.66	0.38	0.48	0.53	0.47
	[0, 1]	[0, 1]	[0, 1]	[0, 1]	[0, 1]	[0, 1]	[0, 1]	[0, 1]	[0, 1]
Risk aversion	3.85	4.07	4	4.04	3.85	4.25	3.92	3.69	3.42
measure	[1.33,6.33]	[1, 6]	[2, 6]	[2.33,6.33]	[1.66,6]	[2.33,6]	[1.66,6.33]	[1.33,6]	[1, 6]
	On a scale from 0 (not at all important), 1, 2, 3 (very important) how important is ... to you?								
Work	2.23	2.27	1.91	2.21	2.43	2.42	2.28	2.75	
	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[2, 3]
Family	2.72	2.67	2.83	2.73	2.79	2.82	2.75	2.87	3
	[1, 3]	[0, 3]	[1, 3]	[1, 3]	[2, 3]	[2, 3]	[1, 3]	[2, 3]	[3, 3]
Friends	2.75	2.62	2.81	2.78	2.66	2.65	2.70	2.81	2.78
	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[2, 3]	[2, 3]	[2, 3]	[2, 3]	[2, 3]
Leisure	2.47	2.58	2.40	2.47	2.33	2.34	2.65	2.75	2.47
	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[1, 3]	[2, 3]	[1, 3]
Politics	1.92	1.76	1.35	1.52	1.58	1.39	1.70	2.03	1.62
	[0, 3]	[0, 3]	[0, 3]	[0, 3]	[1, 3]	[0, 3]	[0, 3]	[0, 3]	[0, 3]
Religion	1.00	1.12	0.75	0.73	0.71	0.91	0.38	0.50	0.66
	[0, 3]	[0, 3]	[0, 3]	[0, 3]	[0, 2]	[0, 3]	[0, 2]	[0, 2]	[0, 3]

B. ADDITIONAL MATERIAL: EXPERIMENTAL INSTRUCTIONS (TREATMENTS N-1, N-2, AND N-3)

Welcome and thanks for participating in this experiment. Please read these instructions carefully. They are identical for all the participants with whom you will interact during this experiment.

If you have any questions please raise your hand. One of the experimenters will come to you and answer your questions. From now on communication with other participants

is not allowed. If you do not conform to these rules we are sorry to have to exclude you from the experiment. Please do also switch off your mobile phone at this moment.

For your participation you will receive 2 euros. During the experiment you can earn more. How much depends on your behavior and the behavior of the other participants. During the experiment we will use ECU (experimental currency units) and at the end we will pay you in euros according to the exchange rate 1 euro = 75 ECU. All your decisions will be treated confidentially.

THE EXPERIMENT

In the experiment you are linked up with some other participants in this room, which we will call your neighbors. You will play a game with your neighbors that we will describe below. Your neighbors in turn are of course linked up with you, but (possibly) also with other participants in the room. And their neighbors again are linked up with other participants and so on...

Note that your neighbors are not necessarily the participants who are located to your left and right in the physical layout of the computer laboratory.

During the experiment, you will be able to find out how many neighbors you have as well as their experimental label, but not who they really are. This also means, of course, that your neighbors will not know your real label.

The experiment lasts for 20 periods. In each period you play a game with each of your neighbors. Your payoff in each period is the average payoffs obtained in all the games with your neighbors.

Each period consists of three stages, which we will describe in detail below. Here is a summary:

1. In the first stage, you choose an action in the game. Note that you have to choose the same action for all your neighbors.

2. In the second stage, you can request information about your neighbors, your neighbors' neighbors, etc.—the actions they chose in the past period and the payoff they obtained in the past period—as well as about your own payoff.

3. In the third stage, the information you requested is displayed on the computer screen.

We will now describe the different stages in more detail.

Stage 1 (Action Choice)

In the first stage you have to choose one action in the game, which is described by the following table, which will be shown to you every time you choose an action.

	A	*B*	*C*	*D*
A	20, 20	40, 70	10, 60	20, 30
B	70, 40	10, 10	30, 30	10, 30
C	60, 10	30, 30	10, 10	30, 40
D	30, 20	30, 10	40, 30	20, 20

In the table your actions and payoffs are given in dark grey and your neighbor's actions and payoffs in light grey. The table is read as follows (dark payoffs):

—If you choose A and your neighbor A, you receive 20
—If you choose A and your neighbor B, you receive 40
—If you choose A and your neighbor C, you receive 10
—If you choose A and your neighbor D, you receive 20
—If you choose B and your neighbor A, you receive 70
—If you choose B and your neighbor B, you receive 10
—If you choose B and your neighbor C, you receive 30
—If you choose B and your neighbor D, you receive 10
—If you choose C and your neighbor A, you receive 60
—If you choose C and your neighbor B, you receive 30
—If you choose C and your neighbor C, you receive 10
—If you choose C and your neighbor D, you receive 30
—If you choose D and your neighbor A, you receive 30
—If you choose D and your neighbor B, you receive 30
—If you choose D and your neighbor C, you receive 40
—If you choose D and your neighbor D, you receive 20

Note that your neighbor (light payoffs) is in the same situation as you are. This means that for your neighbor:

—If your neighbor chooses A and you A, your neighbor receives 20
—If your neighbor chooses A and you B, your neighbor receives 40
—If your neighbor chooses A and you C, your neighbor receives 10
—If your neighbor chooses A and you D, your neighbor receives 20
—If your neighbor chooses B and you A, your neighbor receives 70
—If your neighbor chooses B and you B, your neighbor receives 10
—If your neighbor chooses B and you C, your neighbor receives 30
—If your neighbor chooses B and you D, your neighbor receives 10
—If your neighbor chooses C and you A, your neighbor receives 60
—If your neighbor chooses C and you B, your neighbor receives 30
—If your neighbor chooses C and you C, your neighbor receives 10
—If your neighbor chooses C and you D, your neighbor receives 30
—If your neighbor chooses D and you A, your neighbor receives 30
—If your neighbor chooses D and you B, your neighbor receives 30
—If your neighbor chooses D and you C, your neighbor receives 40
—If your neighbor chooses D and you D, your neighbor receives 20

Remember that you have to choose the same action for all your neighbors. Your gross payoffs in each period are given by the sum of payoffs you have obtained in all games against your neighbors divided by the number of neighbors you have.

Stage 2 (Information Request)

In the second stage you can indicate which of the following pieces of information you would like to obtain:

—The experimental label of your neighbors
—The experimental label of your neighbors' neighbors (second-order neighbors)
—The experimental label of your neighbors' neighbors' neighbors (third-order neighbors)
—The experimental label of your neighbours' neighbor's neighbors' neighbors (fourth-order neighbors)

Note that who is a neighbor of you does not change during the experiment. Hence once you have asked for this information in some period, it will be displayed in all future periods. Note also that in order to receive information about your neighbors' neighbors you first need to request information about your neighbors, etc. The cost of requesting each of these pieces of information is 10. You only have to pay this cost once. In addition you can request information about the following items which (in principle) can change in every period.

—The actions chosen by your neighbors
—The actions chosen by your neighbors' neighbors
—The actions chosen by your neighbors' neighbors' neighbors
—The actions chosen by your neighbors' neighbor's neighbors' neighbors
—The payoffs obtained by your neighbors
—The payoffs obtained by your neighbors' neighbors
—The payoffs obtained by your neighbors' neighbors' neighbors
—The payoffs obtained by your neighbors' neighbor's neighbors' neighbors
—Your own payoffs

Obviously, in order to receive information about your neighbors' (or neighbors' neighbors') actions or payoffs you first need to request information about the experimental label of your neighbors (neighbors' neighbors), etc. The cost of requesting each of these pieces of information is 1 and you have to pay it each time you request this information anew. Your net payoffs in a period are your gross payoffs minus the cost of the information you requested.

Stage 3 (Information Display)

The information you have requested in Stage 2 is displayed on the screen for 40 seconds.

Control Questions

Before we start the experiment please answer the following control questions on your screen.

1. Assume you have only one neighbor. She chooses action B and you action D. Which gross payoff will you get in this period?

2. Assume you have three neighbors and they choose action A, B, and A. You choose action D. Which gross payoff will you get in this period?

3. True or False: My neighbors change in every period of the game.

4. True or False: My neighbors face the same payoff table as I do.

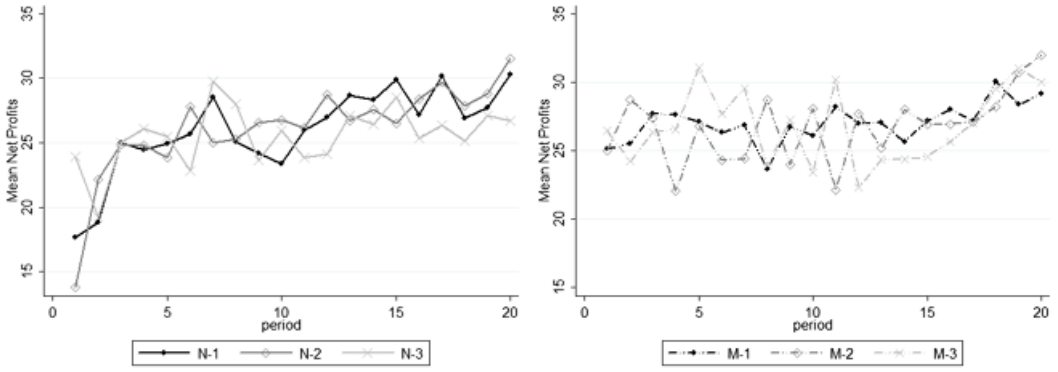
5. True or False: My neighbors are those sitting in the cubicles to my left and right.

C. Additional material: Payoffs and switching

This section contains additional analysis on the evolution of payoffs over time across the different treatments and what this can tell us about how participants learned in the experiment. Figure S2 shows the net payoffs (net of costs for information requests) across the three N treatments over time. It can be seen that net profits are increasing over time. The increase is particularly steep in the first five periods in the N treatments, where most participants request information about the network (which is afterward permanently displayed). In the M treatments, by contrast, where information about the network does not have to be requested, the steepest increase in net payoffs happens after period 12 largely due to the increase in gross profits over those periods.

Table S2 shows ordinary least squares (OLS) regressions of gross payoffs on period across the N treatments. Odd columns consider all rounds. Even columns eliminate the first five rounds. The table shows that gross payoffs are increasing over time in all treatments but in N-3, where the coefficient is rather small and statistically not significant. For the M treatments payoffs are increasing over time in M-1 and M-2, but in M-3 the coefficients are again very small and this time even negative (though again not statistically significant). For the F treatments payoffs are increasing over time in all treatments with bigger and statistically significant coefficients in F-2 and F-3 and positive but statistically not significant coefficients in F-1.

Table S3 shows the expected payoffs for each action $a \in \{A, B, C, D\}$ given the empirical distribution of choices observed across the last 10 periods in all nine treatments.



(a) N treatments (b) M treatments

Figure S2. Net payoffs over time in the N and M treatments.

TABLE S2. OLS regression of gross payoffs on period.

	(1) N-1: 1-20	(2) N-1: 6-20	(3) N-2: 1-20	(4) N-2: 6-20	(5) N-3: 1-20	(6) N-3: 6-20
Period	0.240*	0.218*	0.221**	0.190*	0.069	0.001
	(0.108)	(0.096)	(0.081)	(0.096)	(0.095)	(0.053)
Constant	25.44***	25.74***	26.03***	26.47***	28.25***	27.27***
	(0.932)	(0.871)	(0.761)	(1.480)	(1.182)	(1.212)
Observations	800	600	1120	840	800	600
R-squared	0.026	0.013	0.019	0.009	0.001	0.000
	(1b) M-1: 1-20	(2b) M-1: 6-20	(3b) M-2: 1-20	(4b) M-2: 6-20	(5b) M-3: 1-20	(6b) M-3: 6-20
Period	0.097	0.203**	0.098	0.199	-0.071	0.050
	(0.093)	(0.068)	(0.069)	(0.133)	(0.063)	(0.109)
Constant	26.72***	25.11***	25.99***	24.52***	27.59***	27.20***
	(0.914)	(0.600)	(0.625)	(1.841)	(1.359)	(1.900)
Observations	800	600	640	480	640	480
R-squared	0.004	0.010	0.003	0.007	0.001	0.000
	(1c) N-1: 1-20	(2c) N-1: 6-20	(3c) N-2: 1-20	(4c) N-2: 6-20	(5c) N-3: 1-20	(6c) N-3: 6-20
Period	0.076	0.082	0.179*	0.406**	0.214*	0.413**
	(0.047)	(0.207)	(0.065)	(0.064)	(0.053)	(0.058)
Constant	26.62***	26.58**	26.39***	23.09**	25.07***	22.18***
	(1.033)	(3.885)	(1.172)	(2.872)	(1.184)	(1.390)
Observations	480	360	462	351	480	360
R-squared	0.002	0.002	0.016	0.054	0.016	0.034

Note: Robust standard errors are given in parentheses. ***, $p < 0.01$; **, $p < 0.05$; *, $p < 0.1$.

The table shows that expected payoffs $\pi^e(a)$ are ranked as

$$\pi^e(D) > \pi^e(C) > \pi^e(B) > \pi^e(A)$$

TABLE S3. Expected payoffs for each action given the distribution of choices in the last 10 periods.

	N Treatments			M Treatments			F Treatments		
	Network 1	Network 2	Network 3	Network 1	Network 2	Network 3	Network 1	Network 2	Network 3
A	18.0	16.5	18.0	19.0	21.0	18.8	19.3	16.0	17.5
B	19.6	20.8	20.9	20.1	19.4	22.5	19.6	19.2	21.0
C	24.0	21.9	24.9	25.7	26.9	25.2	24.9	20.8	24.4
D	28.4	29.8	28.7	28.2	27.7	29.2	28.4	29.5	28.6

TABLE S4. Regression of binary variable indicating switch on period.

	(1) N-1	(2) N-2	(3) N-3	(4) M-1	(5) M-2	(6) M-3	(7) F-1	(8) F-2	(9) F-3
Period	−0.024***	−0.026***	−0.025***	−0.026***	−0.030***	−0.014**	−0.028***	−0.033**	−0.030***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)	(0.001)	(0.004)	(0.000)
Constant	0.706***	0.693***	0.692***	0.766***	0.869***	0.728***	0.762***	0.750**	0.761**
	(0.058)	(0.023)	(0.041)	(0.038)	(0.050)	(0.043)	(0.039)	(0.114)	(0.088)
Observations	800	1120	800	800	640	640	480	480	480
R-squared	0.080	0.098	0.089	0.095	0.121	0.027	0.105	0.160	0.128

Note: ***, significant at the 1% level; **, significant at the 5% level; *, significant at the 10% level. Standard errors are clustered at the matching group (network) level. Robust standard errors are given in parentheses. ***, $p < 0.01$; **, $p < 0.05$; *, $p < 0.1$.

in all treatments except for M-2, where the ranking is $\pi^e(D) > \pi^e(C) > \pi^e(A) > \pi^e(B)$. This reflects the fact that participants coordinate on outcomes (D,C) and (C,D) in all treatments. Not only is the ranking of the four payoffs the same in all (except one) treatments, also the payoffs themselves are very similar across treatments: $\pi^e(D)$ ranges between 27.7 and 29.8; $\pi^e(C)$ ranges between 20.8 and 26.9 across treatments; $\pi^e(B)$ ranges between 19.2 and 22.5; $\pi^e(A)$ ranges between 16 and 19 with an outlier of 21 in M-2. In that sense incentives are very comparable across all treatments.

We provide a more detailed analysis of switching behavior, especially in its relation to the amount of information requested by participants. Table S4 shows the results of an OLS regression of the binary variable indicating a switch on period. The regression shows that on average switching decreases by between 1.5 (M-3) and 3.3 (F-2) percentage points per period.

D. Additional material: Screenshots

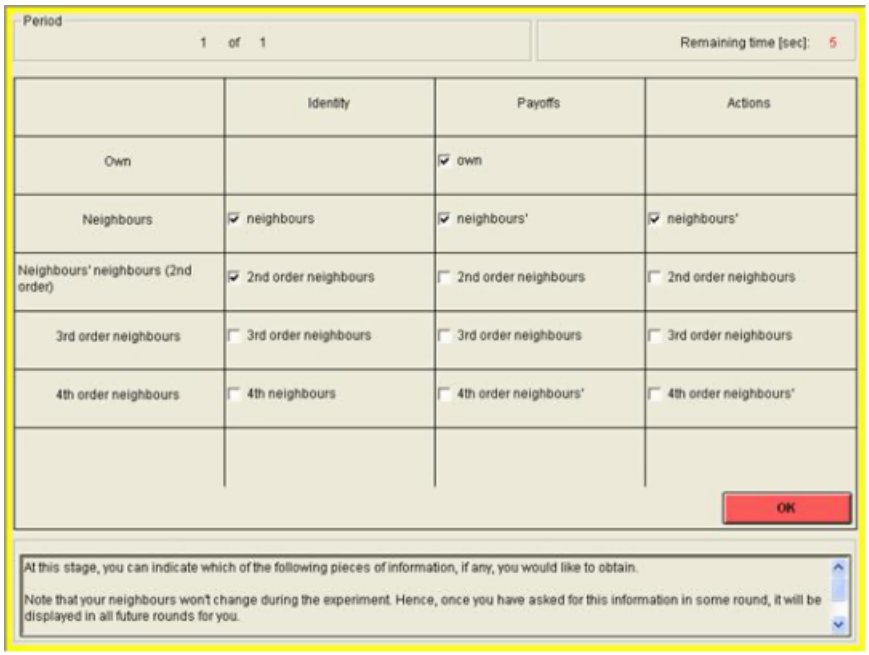


Figure S3. Screen: information requests.

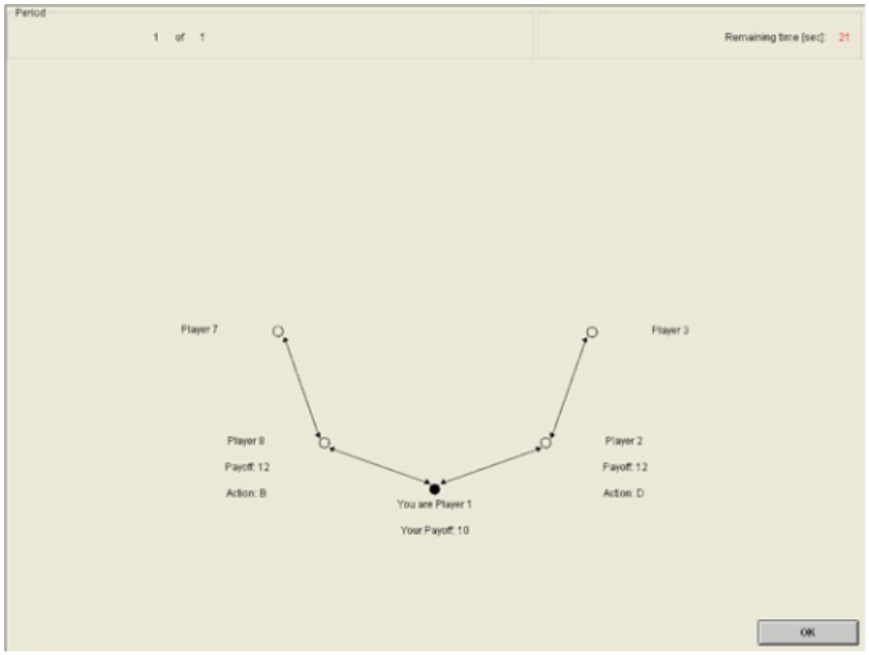


Figure S4. Screen: information display.

E. Additional material: Additional tables

The following tables give additional information regarding estimations in the N treatments. Table S5 shows that the results in N-1 are unchanged if learning rules are eliminated in a different order than that suggested by the algorithm. Table S6 shows the first two iterations of the estimation algorithm for N-2. Table S7 shows that results are robust if rules are eliminated in different order. Table S8 shows the first two iterations of the estimation algorithm for N-3 and Table S9 shows the results for alternative orders of elimination.

Table S5. Alternative order of elimination treatment N-1.

	Learning Types			
Parameters	RL	PBI	MBR	FL
First iteration				
p_k	0.25	0.55	0.20	0
θ_{kZ}	0.04	1	0.07	–
Second iteration				
p_k	0.23	0.54	0.23	
θ_{kZ}	0.04	1	0.07	
Final iteration				
p_k	0.57		0.43	
θ_{kZ}	0.56		0.1	

Table S6. Order of elimination: treatment N-2.

	Learning Types			
Parameters	RL	PBI	MBR	FL
First iteration				
p_k	0.17	0.37	0.19	0.27
θ_{kZ}	0.04	1	0.03	0.99
Second iteration				
p_k	0.21		0.30	0.49
θ_{kZ}	0.08		0.11	0.98
Final iteration				
p_k	0.24		0.76	
θ_{kZ}	0.05		0.47	

TABLE S7. Alternative order of elimination: treatment N-2.

	Learning Types			
Parameters	RL	PBI	MBR	FL
First iteration				
p_k	0.17	0.37	0.19	0.27
θ_{kZ}	0.04	1	0.03	0.99
Second iteration				
p_k	0.19	0.51	0.30	
θ_{kZ}	0.04	0.98	0.11	
Final iteration				
p_k	0.24		0.76	
θ_{kZ}	0.05		0.47	

TABLE S8. Order of elimination: treatment N-3.

	Learning Types			
Parameters	RL	PBI	MBR	FL
First iteration				
p_k	0.15	0.47	0.09	0.29
θ_{kZ}	0.15	1	0.03	0.99
Second iteration				
p_k	0.10		0.22	0.68
θ_{kZ}	1		0.13	0.98
Final iteration				
p_k		0.27	0.73	
θ_{kZ}			0.16	0.97

TABLE S9. Alternative order of elimination: treatment N-3.

	Learning Types			
Parameters	RL	PBI	MBR	FL
First iteration				
p_k	0.15	0.47	0.09	0.29
θ_{kZ}	0.15	1	0.03	0.99
Second iteration				
p_k	0.12	0.72	0.16	
θ_{kZ}	0.15	0.99	0.06	
Final iteration				
p_k	0.46		0.54	
θ_{kZ}	0.94		0.59	

Co-editor Karl Schmedders handled this manuscript.

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