Cognition and Behavior in Two-Person Guessing Games

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This paper reports experiments that elicit subjects' initial responses to a series of dominance-solvable two-person guessing games, relatives of those studied by Nagel (*AER* '95) and Ho, Camerer, and Weigelt (*AER* '98; "HCW")

The design presents the games to subjects with hidden but freely accessible payoff parameters that vary across players and games, to study subjects' cognition via their information search

The goal is to identify more precisely and document more convincingly how subjects' initial responses are determined, and ultimately to develop a structural alternative to Nash equilibrium as a model of initial responses to games

The alternative model should both explain why equilibrium is often a reliable model of initial responses to simple games and predict the systematic deviations that arise in complex games

Such a model would inform many applications that now rely on equilibrium in complex games without clear precedents: e.g. entry, bargaining, auctions, incentives and mechanism design

Accurately modeling initial responses is essential even in applications where people can learn to play an equilibrium, to predict comparative statics or selection among multiple equilibria

It would also help identify the structure of learning, distinguishing reinforcement from beliefs-based and more sophisticated rules

Previous work on guessing and other games

Nagel's and HCW's guessing or "beauty contest" games were inspired by the famous passage in chapter 12 of Keynes' *General Theory*, in which he likened professional investment

> . . . to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view.

● *n* (15-18 in Nagel, 3-7 in HCW) subjects guess between *limits* ([0,100] in Nagel, [0,100] or [100,200] in HCW)

● The subject whose guess is closest to a *target* (*p* = 1/2, 2/3, or 4/3 in Nagel, *p* = 0.7, 0.9, 1.1, or 1.3 in HCW) times the group average wins a prize, with ties broken randomly

● The structure is public knowledge

● Subjects played the games repeatedly, but we can view initial responses as "one-shot" if they treated their own influences on future partners' guesses as negligible; plausible in these groups

(These games capture salient features of Keynes' example, but they are not quite the same; compare Van Huyck et al. *QJE* '91, Mehta et al. *AER* '94, and Rubinstein, Tversky, and Heller '96)

The [0, 100] games with $p < 1$ are dominance-solvable in infinite numbers of rounds, with "all-0" the unique equilibrium (if $p > 1$ and $n > 2p$ there are equilibria at all-0 and all-100 but no dominance)

The [100, 200] games are dominance-solvable in finite numbers of rounds, with all-100 the unique equilibrium when $p < 1$ and all-200 the unique equilibrium when $p > 1$

Thus equilibrium predictions of initial responses to these games depend "only" on iterated knowledge of rationality, not of beliefs

Yet Nagel's subjects never played their equilibrium strategies, and HCW's seldom did; instead their initial responses were heterogeneous, most respecting 0 to 3 rounds of dominance

As Keynes concluded,

> . . . It is not a case of choosing those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees.

Note that Keynes' wording suggests finite iteration of best responses, initially anchored by players' true preferences

Non-equilibrium responses like those in Nagel's and HCW's experiments are often modeled as "equilibrium plus noise" or "equilibrium taking noise into account" (e.g. McKelvey and Palfrey's *GEB* '95 quantal response equilibrium or "QRE")

But, even adjusting for the equilibrium being on the boundary, Nagel's and HCW's data resemble neither "noisy Nash" nor QRE for any of the standard distributions

The data do suggest that the deviations from equilibrium have a coherent, non-random, but individually heterogeneous structure

In the [0,100] games, for example, spikes are clearly visible (amid the noise) at $50p^k$ for target p and k = 1,2,3—like spectrograph peaks that suggest discrete chemical elements

Similar patterns of heterogeneous but structured strategic behavior have been found in initial responses to matrix games by Stahl and Wilson (*GEB* '95; "SW") and Costa-Gomes et al. (*EMT* '01; "CGCB"), to alternating-offers bargaining games by Camerer, Johnson et al. ('93, *JET* '02; "CJ"), and to other games

● Subjects' initial responses are often "strategic" and they make undominated decisions 85-95% of the time

● Subjects are less likely to rely on dominance for others (Beard and Beil, *MS* '94), and reliance on iterated dominance stops at 1-3 rounds (a strategic "constant of nature"?)

● Subjects play equilibrium strategies less often in games where they differ from strategies suggested by certain alternative rules

Strategic decision rules or "types"

The data from these experiments have been analyzed using certain general decision rules or "types," chosen as plausible descriptions of subjects' behavior, and for theoretical interest

● SW's *L1* (CGCB's *Naïve*) best responds to a uniform prior over its partner's decisions (and so respects one round of dominance); *L1* has a perfect model of the game but a naïve (or at least diffuse) model of others' decisions

● CGCB's *L2* (*L3*) best responds to *L1* (*L2*); *L2* (*L3*) has a perfect model of the game and a less naïve model of others

Lk anchors its beliefs with a naïve prior and adjusts them via thought-experiments involving iterated best responses

Lk is rational in that it chooses a best response to its beliefs; but those beliefs are based on simplified models of others that don't "close the loop" as equilibrium does

This yields a workable model of others' responses to incentives while avoiding the cognitive complexity of equilibrium analysis

In the words of Selten (*EER* ’98):

"Basic concepts in game theory are often circular in the sense that they are based on definitions by implicit properties…. Boundedly rational strategic reasoning seems to avoid circular concepts. It directly results in a procedure by which a problem solution is found. Each step of the procedure is simple, even if many case distinctions by simple criteria may have to be made."

Another set of types is closer to how theorists analyze games:

● CGCB's *D1* does one round of dominance and then best responds to a uniform prior over its partner's remaining decisions

● *D2* does two rounds of dominance and then best responds to a uniform prior over its partner's remaining decisions

Dk starts with iterated knowledge of rationality and then invokes a naïve prior; by standard measures its cognitive requirements are close to *Lk+1*'s, and both respond similarly to dominance

In Nagel's [0, 100] games with $p < 1$, *Dk*'s and *Lk+1*'s guesses are perfectly confounded: *Dk* guesses $([0+100p^k]/2)p$ and *Lk+1* guesses $[(0+100)/2]p^{k+1}$; thus both match the spikes

In HCW's [100,200] games and CGCB's matrix games, *Dk* is weakly separated from *Lk+1* and the results are inconclusive

In this paper separating them was an important design goal, and we find that *Dk* subjects are far less frequent than *Lk+1* subjects

Two other types are important in our analysis

● *Equilibrium* makes equilibrium decisions

● *Sophisticated* best responds to the probability distributions of others' decisions (estimated from the observed frequencies), the behavioral game theory ideal, included to learn if any subjects have an understanding of others that transcends mechanical rules (we find little evidence of this, but some of *Equilibrium*)

New guessing design

In our Baseline treatment, game-theoretically naïve subjects played a series of 16 different two-person guessing games; subjects were anonymously, randomly paired with no feedback during play to suppress learning and repeated-game effects

(Our design builds on SW and CGCB in eliciting initial responses to a series of games, and on CJ and CGCB in presenting the games with hidden, freely accessible payoff parameters to study cognition by monitoring subjects' information searches; but it is the first to do either of these things with guessing games)

● In each game, two players make simultaneous guesses

● Each player has a lower and an upper limit, both positive (so with finite dominance-solvability as in HCW's [100, 200] games)

● But players are not required to guess between their limits: instead guesses outside the limits are *automatically* adjusted up to the lower limit or down to the upper limit as needed

(Payoffs are quasiconcave, so a subject can enter his *ideal* guess, ignoring his limits, and know without checking his limits that his *adjusted* guess will be optimal; this separates types' search implications, particularly *L1*'s, more than in other designs)

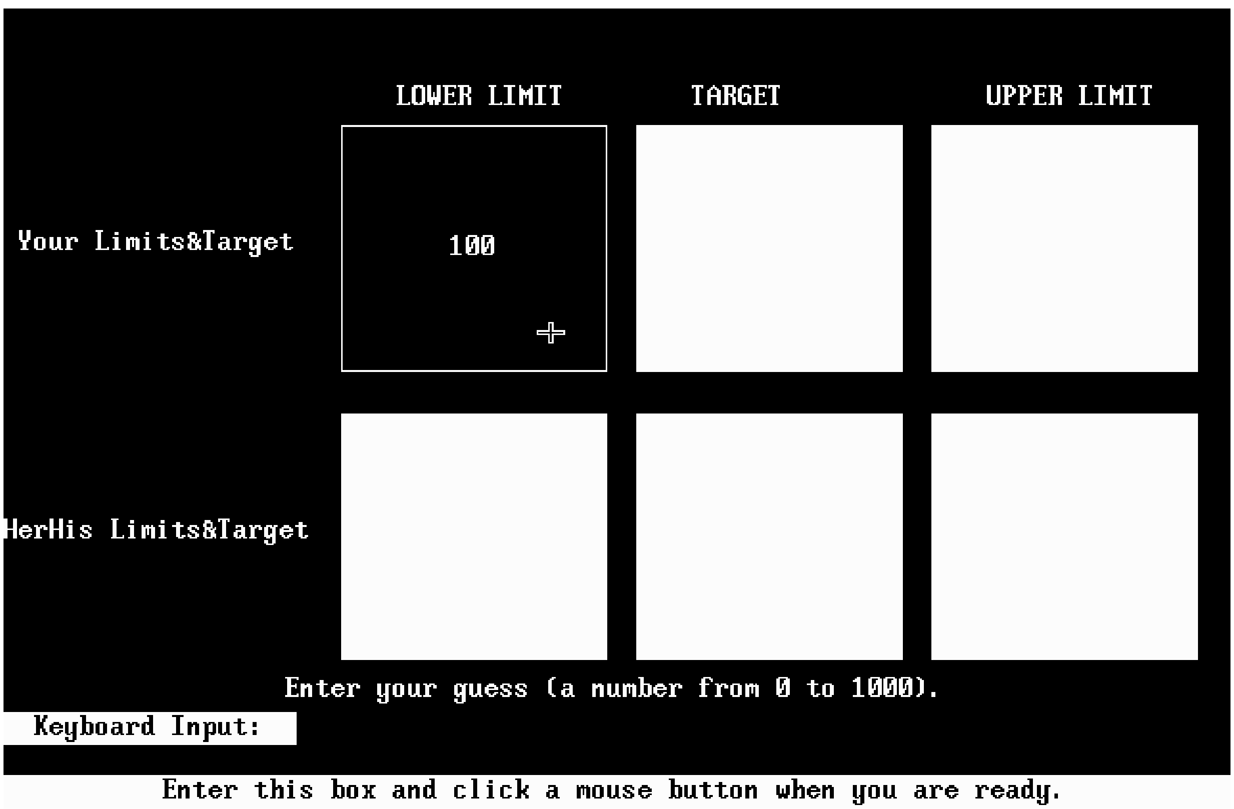
● Each player has a target, and his payoff increases with the closeness of his adjusted guess to his target times the other's adjusted guess (thus players' guesses determine continuous payoffs rather than who wins an all-or-nothing prize, and payoffs depend on a partner's rather than the group average guess)

● The targets and limits vary independently across players and games, with the targets both less than one, both greater than one, or mixed (in previous guessing experiments the targets and limits were always the same for both players within a treatment)

● Because the targets and limits vary, subjects don't know them

● We use a MouseLab interface to present the games with targets and limits hidden, giving subjects free access to them *game by game*, publicly announcing all other aspects of the structure (including the fact that subjects have free access)

● Low search costs then make the games' structures effectively public knowledge, so that (with the suppression of learning and repeated-game effects) our design induces a series of 16 independent complete-information games



The games have a balanced mix of targets, limits, and strategic structures, dominance-solvable in from 2-52 rounds (there are eight *player-symmetric* pairs and one pair of symmetric games)

Table II. Strategic Structures

Game *i j*	Order Played	Targets	Equilibrium	Rounds of Dominance	Pattern of Dominance	Dominance at Both ends
α2β1	6	Low	Low	4	A	No
β1α2	15	Low	Low	3	A	No
β1γ2	14	Low	Low	3	A	Yes
γ2β1	10	Low	Low	2	A	No
γ4δ3	9	High	High	2	S	No
δ3γ4	2	High	High	3	S	Yes
δ3δ3	12	High	High	5	S	No
δ3δ3	3	High	High	5	S	No
β1α4	16	Mixed	Low	9	S/A	No
α4β1	11	Mixed	Low	10	S/A	No
δ2β3	4	Mixed	Low	17	S/A	No
β3δ2	13	Mixed	Low	18	S/A	No
γ2β4	8	Mixed	High	22	A	No
β4γ2	1	Mixed	High	23	A	Yes
α2α4	7	Mixed	High	52	S/A	No
α4α2	5	Mixed	High	51	S/A	No

Limits: (α) 100,500; (β) 100,900; (γ) 300,500; δ) 300,900
Targets: (1) 0.5; (2) 0.7; (3) 1.3; (4) 1.5
Pattern of Dominance: A ≡ Alternating; S ≡ Simultaneous;
S/A ≡ Alternating in first round, then Simultaneous

The games have essentially unique equilibria determined (not always directly) by players' lower (upper) limits when the product of targets is less (greater) than one ("essentially" only because guesses that lead to the same adjusted guess are equivalent)

E.g. game γ2β4: Targets are 0.7 and 1.5, product is 1.05 > 1 so the equilibrium is High; in it the γ2 player guesses his upper limit 500, but the β4 player guesses 750, below his upper limit 900

The discontinuity of the equilibrium correspondence when the product of targets equals one enhances separation of equilibrium from boundedly rational rules; games like δ2β3 and γ2β4 differ mainly in whether the product is slightly below or above one; equilibrium responds much more strongly to this than other rules

Open Boxes and Robot/Trained Subjects Treatments

The Open Boxes ("OB") treatment was identical to the Baseline, but with targets and limits continually visible; we find insignificant differences between Baseline and OB subjects' guesses, suggesting that decisions are not distorted by looking up payoffs

There were six Robot/Trained Subjects ("R/TS") treatments, each identical to the Baseline except that an R/TS subject was trained to identify the guesses implied by a type (*L1*, *L2*, *L3*, *D1*, *D2*, or *Equilibrium*) and told that he was playing with a robot (framed as "the computer"), which would choose its guesses in the way that justified his assigned type's beliefs

R/TS results provide a benchmark by which to judge the model of cognition and search we use to analyze Baseline results

The R/TS results show that with training, most (though not all) subjects are *capable* of identifying the types' guesses, so if Baseline subjects' don't make equilibrium guesses, it cannot be attributed entirely to the cognitive difficulty of identifying equilibria

The R/TS results also suggest that *Lk* types are much easier than *Equilibrium*, which may be easier in turn than *Dk* types

Advantages of the design

● Tracking behavior within subjects across 16 games with large strategy spaces and varying payoff parameters greatly enhances separation of equilibrium and alternative rules' guesses, yielding sharper identification; e.g. *L2* and *D1* are much better separated

Types' guesses in the 16 games, in (randomized) order played

	L1	***L2***	***L3***	***D1***	***D2***	***Eq.***	***Sop.***
1	600	525	630	600	611.25	750	630
2	520	650	650	617.5	650	650	650
3	780	900	900	838.5	900	900	900
4	350	546	318.5	451.5	423.15	300	420
5	450	315	472.5	337.5	341.25	500	375
6	350	105	122.5	122.5	122.5	100	122
7	210	315	220.5	227.5	227.5	350	262
8	350	420	367.5	420	420	500	420
9	500	500	500	500	500	500	500
10	350	300	300	300	300	300	300
11	500	225	375	262.5	262.5	150	300
12	780	900	900	838.5	900	900	900
13	780	455	709.8	604.5	604.5	390	695
14	200	175	150	200	150	150	162
15	150	175	100	150	100	100	132
16	150	250	112.5	162.5	131.25	100	187

Table IV. Numbers of games in which types' guesses are separated*

	L1	***L2***	***L3***	***D1***	***D2***	***Eq.***	***Sop.***
L1	-	15,13	15,12	12,10	15,12	15,15	15,14
L2	15,13	-	11,9	13,9	10,8	11,9	10,8
L3	15,12	11,9	-	13,12	8,5	9,6	9,8
D1	12,10	13,9	13,12	-	9,7	14,13	12,10
D2	15,12	10,8	8,5	9,7	-	9,8	9,6
Eq.	15,15	11,9	9,6	14,13	9,8	-	11,9
Sop.	15,14	10,8	9,8	12,10	9,6	11,9	-

*By more than 0 (or 0.5), by more than 25

● Two-person guessing games focus sharply on the central strategic problem of predicting the decisions of others who view themselves as a non-negligible part of one's own environment

● Although our games are not zero-sum and have more than two possible payoffs, like other guessing games they limit the effects of altruism, spite, and (by design of payoff function) risk aversion

● Varying the targets and limits within a common structure greatly enhances separation of types' search implications and makes monitoring search a powerful tool for studying cognition

● It also makes each type's search implications independent of the game (with one minor exception), which often allows us to read a subject's type directly from his information search pattern

● As in other guessing games, the intuitive common structure reduces the noisiness typical of initial responses to games

● It also makes mental models of others easy to express as functions of the targets and limits, which seems to encourage subjects to articulate such models to themselves; this enhances the clarity of the results, but might also distort subjects' guesses

Studying cognition via guesses and information search

"The look-ups are the windows of the strategic soul."
—folk saying of the MouseLab people

We link guesses and search by assuming each subject has a single, pure type, which determines them in the 16 games

The types *L1*, *L2*, *L3*, *D1*, *D2*, *Equilibrium*, and *Sophisticated* were chosen for appropriateness as possible descriptions of behavior, from general principles that have played important roles in the literature (CGCB's *Altruistic*, *Optimistic*, and *Pessimistic* have limited relevance in these games)

A priori specification seems necessary because a type's search implications depend not only on what it guesses, but why

These types provide a kind of basis for the enormous space of possible guesses and searches, imposing enough structure to make it meaningful to ask if they are related in a coherent way

Table VI summarizes our characterization of types' ideal guesses (which determine their adjusted guesses via the automatic adjustment function *R*( )) and search implications

Table VI: Types' Ideal Guesses and Relevant Look-ups

Type	Ideal guess	Search implications
L1	$p^i [a^j+b^j]/2$	$\{[a^j,b^j],p^i\} \equiv \{[4, 6], 2\}$
L2	$p^i R(a^j,b^j; p^j[a^i+b^i]/2)$	$\{([a^i,b^i],p^j),a^j,b^j,p^i\} \equiv \{([1, 3], 5), 4, 6, 2\}$
L3	$p^i R(a^j,b^j; p^j R(a^i,b^i; p^i[a^j+b^j]/2))$	$\{([a^j,b^j],p^i),a^i,b^i,p^j\} \equiv \{([4, 6], 2), 1, 3, 5\}$
D1	$p^i(\max\{a^j,p^j a^i\} + \min\{p^j b^i,b^j\})/2$	$\{(a^j,[p^j,a^i]),(b^j,[p^j,b^i]),p^i\} \equiv \{(4,[5,1]),(6,[5,3]),2\}$
D2	$p^i[\max\{\max\{a^j,p^j a^i\},p^j \max\{a^i,p^i a^j\}\}$ $+\min\{p^j \min\{p^i b^j,b^i\},\min\{p^j b^i,b^j\}\}]/2$	$\{(a^i,[p^i,a^j]),(b^i,[p^i, b^j]),(a^j,[p^j,a^i]),(b^j,[p^j,b^i]),p^j,p^i\}$ $\equiv \{(1,[2,4]),(3,[2,6]),(4,[5,1]),(6,[5,3]),5,2\}$
Eq.	$p^i a^j$ if $p^i p^j < 1$ or $p^i b^j$ if $p^i p^j > 1$	$\{[p^i,p^j],a^j\} \equiv \{[2, 5], 4\}$ if $p^i p^j < 1$ or $\{[p^i,p^j],b^j\} \equiv \{[2, 5], 6\}$ if $p^i p^j > 1$
Sop.	[no closed-form expression; search implications are the same as *D2*'s]	$\{(a^i,[p^i,a^j]),(b^i,[p^i, b^j]),(a^j,[p^j,a^i]),(b^j,[p^j,b^i]),p^j,p^i\}$ $\equiv \{(1,[2,4]),(3,[2,6]),(4,[5,1]),(6,[5,3]),5,2\}$

p is a target; *a* (*b*) is a lower (upper) limit; *i* and *j* are the player and his partner; and *R*( ) is the automatic adjustment function. *Basic* operations—the innermost operations in the formulas on the left side, in square brackets on the right—must be associated with adjacent look-ups, which can appear in any order but can't be separated; other operations, in parentheses or curly brackets on the right side, can appear in any order, and can be separated. The table gives the order that seems most natural when there is one, but we do not insist on this order.

Derivation of types' ideal guesses

Subjects are paid for their points in 5/16 randomly selected games, so if a subject maximizes the expected utility of his money payment, and guesses have known consequences, he will maximize his point payoff in any given game

Because equilibrium always implies unique, known adjusted guesses, risk preferences do not affect *Equilibrium* guesses

Our payoff function makes best responses to uniform priors on intervals certainty-equivalent (due to symmetry of the function), so risk preferences do not affect *Lk* or *Dk* guesses either

But risk preferences might affect *Sophisticated* guesses, and for it we assume risk-neutrality for simplicity

Each of our types implies a unique, pure ideal guess in each game (*Sophisticated* only generically)

Certainty-equivalence and our characterization of equilibrium immediately yield types' ideal guesses, except *Sophisticated*'s, which we compute from the data

Derivation of types' search implications

Standard assumptions imply that a type will look up all freely available information that might affect its guess

Each type is naturally associated with algorithms that describe how to process this information into a guess

We use a type's algorithms as models of cognition, and derive the search implications of those algorithms under conservative assumptions about how cognition affects search

(Assumptions are needed because if a subject memorized parameters, look-up order could be unrelated to cognition; our assumptions are corroborated by our R/TS treatments)

Because a subject can enter his ideal guess and know that his *adjusted* guess will be optimal, and we seek *minimal* search implications, we derive them from ideal guesses

We assume that *basic* operations are associated with adjacent look-ups, which can appear in any order but cannot be separated; other operations can appear in any order, and can be separated; the table gives the order that seems most natural when there is one, but we do not insist on this order

In the econometric analysis we summarize a subject's compliance with a type's search implications in a game, under these assumptions, by the density of the type's look-up sequence in the subject's observed look-up sequence

L1, *L2*, *L3*, *D1*, *D2* search implications are easy to derive

Equilibrium can use any workable method to find its ideal guess, which equals its target times its partner's lower (upper) limit when the product of targets is < (>) 1

In particular it can conjecture and check guesses for consistency with equilibrium, which is less demanding than other methods and determines minimal search implications, but requires more luck than our subjects appeared to have

Using our characterization of equilibrium yields the same look-up requirements but requires targets to be adjacent; we take this to determine *Equilibrium*'s search implications

Note that unlike in CGCB's design, *Equilibrium*'s minimal search implications are as simple as *L1*'s, and simpler than other boundedly rational types'

We assume that *Sophisticated*, like a good behavioral game theorist, must deduce its beliefs from the game's structure, including its equilibrium and dominance relationships

But we ignore more than two rounds of dominance as impractical, and take *Sophisticated*'s search implications as the union of *Equilibrium*'s and *D2*'s; because *D2*'s include *Equilibrium*'s, *Sophisticated*'s implications reduce to *D2*'s

Results for Baseline and OB subjects' guesses

On average 90% of Baseline and OB subjects' guesses respected simple dominance, much more than random (~60% here) and typical of initial responses to games

All but 12 respected dominance in 13 or more games (80%), suggesting that they understood the games and maximized self-interested expected payoffs, given coherent beliefs

43 of 88 subjects made 7-16 of some type's exact (within 0.5) guesses: far more than could occur by chance, given the strong separation of types' guesses and the fact that guesses could take from 200 to 800 different rounded values

But 35 of those 43 subjects conformed closely to types other than *Equilibrium*: 20 to *L1*, 12 to *L2*, and 3 to *L3*

Given our type definitions, those subjects' deviations from equilibrium can be confidently ascribed to non-equilibrium beliefs rather than altruism, spite, confusion, or irrationality

The results for guesses also favor CGCB's noiseless definition of *Lk*, *k* > 1, over SW's, which best responds to a noisy *Lk-1*; and provide evidence against types that depend on estimated population parameters, such as SW's *Worldly*

Table IX gives subject by subject maximum likelihood type estimates based on guesses for a spike-logit error structure, in which a subject of a given type has probability $1 – \varepsilon$ of making his type's guess exactly (within 0.5) in a game, and his guess otherwise has a logit distribution with precision λ

Point type estimates assign 43 subjects to *L1*, 20 to *L2*, 3 to *L3*, 5 to D1, 14 to *Equilibrium*, and 3 to *Sophisticated*

Subjects make exact guesses so often that the spike is needed for 81 (83) of our 88 subjects at the 1% (5%) level

Spike-logit does significantly better than a spike-uniform error structure for only 21 (34) subjects at the 1% (5%) level

All but 10 subjects' estimated types do significantly better than a completely random model of guesses; the estimated types that fail this test are marked "†" in the table

Table IX. Type Estimates Based on Guesses Only, Search Only, and Guesses and Search

		Guesses only				**Search only**				**Guesses and search**							
ID	**dom.**	**ln L**	***k***	**exact**	***λ***	**ln L**	k_s	ζ_H	ζ_M	$\ln L_t$	$\ln L_g$	$\ln L_s$	k_s	**exact**	***λ***	ζ_H	ζ_M
513	0	0.00	*L1*	16	-	-	-	-	-	-	-	-	-	-	-	-	-
118	0	-9.62	*L1*	15	1.85	-7.41	$L1_e$	0.88	0.06	-17.03	-9.62	-7.41	$L1_e$	15	1.85	0.88	0.06
101	1	-10.27	*L1*	15	0.55	-9.94	$L1_e$‡	0.69	0.31	-20.21	-10.27	-9.94	$L1_e$‡‡	15	0.55	0.69	0.31
104	0	-16.63	*L1*	14	2.20*	-3.74	$L1_e$	0.00	0.94	-20.37	-16.63	-3.74	$L1_e$	14	2.20	0.00	0.94
413	0	-17.81	*L1*	14	0.88	-6.03	$L1_l$	0.13	0.88	-23.84	-17.81	-6.03	$L1_l$	14	0.88	0.13	0.88
207	0	-17.96	*L1*	14	0.42	0.00	$L1_e$	1.00	0.00	-17.96	-17.96	0.00	$L1_e$	14	0.42	1.00	0.00
216	1	-25.41	*L1*	13	1.06	-11.25	$L3_e$	0.75	0.19	-38.69	-25.41	-13.29	$L1_e$	13	1.06	0.31	0.63
402	0	-30.93	*L1*	12	5.65*	-9.00	$L1_e$	0.00	0.75	-39.93	-30.93	-9.00	$L1_e$	12	5.65	0.00	0.75
418	0	-42.23	*L1*	10	21.22**	-7.41	$L2_e$	0.88	0.06	-52.16	-42.23	-9.94	$L1_e$	10	21.22	0.00	0.69
301	1	-45.84	*L1*[D]	10	0.00	-3.74	$L1_e$	0.06	0.94	-49.58	-45.84	-3.74	$L1_e$	10	0.00	0.06	0.94
508	0	-46.19	*L1*[D]	10	2.05	-	-	-	-	-	-	-	-	-	-	-	-
308	3	-47.34	*L1*	10	0.00	-9.63	$L3_e$	0.81	0.13	-60.65	-47.34	-13.30	$L1_{el}$	10	0.00	0.19	0.69
102	4	-47.63	*L1*	10	0.00	-9.63	$L2_e$	0.81	0.06	-57.57	-47.63	-9.94	$L1_e$	10	0.00	0.00	0.69
415	1	-53.64	*L1*	9	0.88	-16.38	$D1_e$	0.31	0.50	-107.28	-90.90	-16.38	$D1_e$	2	0.76	0.31	0.50
504	1	-56.97	*L1*	8	1.68**	-	-	-	-	-	-	-	-	-	-	-	-
208	6	-61.62	*L1*	8	0.00	-3.74	$L1_l$	0.06	0.94	-65.37	-61.62	-3.74	$L1_l$	8	0.00	0.06	0.94
318	0	-62.61	*L1*	7	3.18*	-3.74	$L1_e$‡	0.00	0.94	-66.36	-62.61	-3.74	$L1_e$	7	3.18	0.00	0.94
512	0	-63.33	*L1*	7	1.56	-	-	-	-	-	-	-	-	-	-	-	-
502	1	-64.55	*L1*	7	1.01	-	-	-	-	-	-	-	-	-	-	-	-
516	1	-64.93	*L1*[C]	7	1.10*	-	-	-	-	-	-	-	-	-	-	-	-
409	0	-73.59	*L1*[E]	4	9.90**	-10.59	$L1_l$	0.00	0.38	-84.18	-73.59	-10.59	$L1_l$	4	9.90	0.00	0.38
106	0	-75.82	*L1*	5	1.19	-7.72	Eq_e	0.00	0.19	-85.75	-75.82	-9.94	$L1_l$	5	1.19	0.00	0.31
305	3	-79.89	*L1*	5	0.37	-6.03	$L1_e$	0.88	0.13	-85.92	-79.89	-6.03	$L1_e$	5	0.37	0.88	0.13
411	1	-80.58	*L1*	4	1.45**	0.00	$L3_e$	1.00	0.00	-86.61	-80.58	-6.03	$L1_e$	4	1.45	0.13	0.88
509	1	-81.81	*L1*	4	0.86	-	-	-	-	-	-	-	-	-	-	-	-
203	4	-83.90	*L1*	4	0.00	-9.94	Eq_e	0.00	0.31	-94.49	-83.90	-10.59	$L1_e$	4	0.00	0.00	0.63
505	4	-84.13	*L1*	4	0.43	-	-	-	-	-	-	-	-	-	-	-	-
317	3	-86.58	*L1*	3	0.92*	-3.74	$L1_e$	0.94	0.06	-90.32	-86.58	-3.74	$L1_e$	3	0.92	0.94	0.06
416	1	-86.74	*L1*†	1	4.48**	-3.74	$L1_e$‡	0.00	0.94	-90.48	-86.74	-3.74	$L1_e$	1	4.48	0.00	0.94

217	3	-87.12	*L1*	3	0.68	-10.59	$L1_e$	0.00	0.38	-97.71	-87.12	-10.59	$L1_e$	3	0.68	0.00	0.38
219	3	-87.32	$L1^{+}$	3	0.89^{*}	-7.72	$L1_e$	0.00	0.81	-95.04	-87.32	-7.72	$L1_e$	3	0.89	0.00	0.81
501	1	-87.93	$L1^{\dagger}$	0	4.38^{**}	-	-	-	-	-	-	-	-	-	-	-	-
410	3	-89.18	*L1*	2	1.53^{**}	-7.72	$L1_{el}^{\ddagger}$	0.00	0.19	-96.90	-89.18	-7.72	$L1_{el}$	2	1.53	0.00	0.19
510	5	-89.60	*L1*	3	0.00	-	-	-	-	-	-	-	-	-	-	-	-
420	2	-89.68	$L1^{+}$	2	1.25^{**}	-3.74	Eq_l	0.00	0.06	-94.26	-90.52	-3.74	Eq_l	3	0.19	0.00	0.06
408	2	-89.71	$L1^{+}$	2	1.09^{*}	-6.03	$L1_e$	0.00	0.88	-95.74	-89.71	-6.03	$L1_e$	2	1.09	0.00	0.88
201	3	-90.26	$L1^{+}$	2	1.21^{**}	-3.74	$L1_e^{\ddagger}$	0.00	0.94	-94.00	-90.26	-3.74	$L1_e$	2	1.21	0.00	0.94
105	2	-90.58	$L1^{+}$	2	1.29^{**}	-9.00	Eq_e	0.25	0.75	-102.56	-93.56	-9.00	Eq_e	2	0.11	0.25	0.75
103	3	-90.61	$L1^{+}$	2	1.12^{*}	-6.03	$L1_e$	0.00	0.13	-96.63	-90.61	-6.03	$L1_e$	2	1.12	0.00	0.13
213	2	-95.57	$L1^{\dagger+}$	0	1.19^{*}	-3.74	$L2_e$	0.94	0.00	-100.34	-96.60	-3.74	$L2_e$	0	0.62	0.94	0.00
515	4	-95.68	$L1^{\dagger+}$	1	0.60	-	-	-	-	-	-	-	-	-	-	-	-
113	5	-96.61	$L1^{\dagger+}$	1	0.07	-9.63	$L3_{el}^{\ddagger}$	0.81	0.06	-108.49	-98.86	-9.63	$L3_{el}$	4	0	0.81	0.06
109	8	-97.31	$L1^{\dagger+}$	1	0.00	-	-	-	-	-	-	-	-	-	-	-	-
309	0	0.00	*L2*	16	-	-9.94	$L2_{el}^{\ddagger}$	0.69	0.00	-9.94	0.00	-9.94	$L2_{el}$	16	0.00	0.69	0.00
405	0	0.00	*L2*	16	-	-13.30	$L3_e$	0.69	0.13	-14.40	0.00	-14.40	$L2_e$	16	0.00	0.63	0.25
206	0	-10.07	*L2*	15	0.79	-7.41	$L2_e$	0.88	0.06	-17.49	-10.07	-7.41	$L2_e$	15	0.79	0.88	0.06
209	0	-25.51	*L2*	13	0.96	-9.00	$L1_e$	0.00	0.75	-35.45	-25.51	-9.94	$L2_l$	13	0.96	0.69	0.31
108	0	-25.88	*L2*	13	0.45^{*}	0.00	$L2_e^{\ddagger}$	1.00	0.00	-25.88	-25.88	0.00	$L2_e$	13	0.45	1.00	0.00
214	2	-35.30	*L2*	11	2.73^{**}	-3.74	$L1_e$	0.00	0.94	-41.33	-35.30	-6.03	$L2_e$	11	2.73	0.88	0.13
307	1	-38.88	*L2*	11	1.04^{*}	-7.72	Eq_e	0.00	0.19	-48.51	-38.88	-9.63	$L2_l$	11	1.04	0.81	0.13
218	0	-40.54	*L2*	11	0.60	-7.72	$L1_e$	0.00	0.81	-53.84	-40.54	-13.30	$L2_l$	11	0.60	0.69	0.19
422	2	-55.79	*L2*	9	0.22	0.00	$L1_e$	0.00	1.00	-61.82	-55.79	-6.03	$L2_e$	9	0.22	0.88	0.13
316	1	-58.43	*L2*	8	0.73	-10.97	$Eq_e^{\ddagger}$	0.00	0.44	-72.26	-58.43	-13.84	$L2_l$	8	0.73	0.06	0.38
407	0	-60.98	$L2^{C}$	8	0.44	-6.03	$L2_e^{\ddagger}$	0.88	0.13	-67.00	-60.98	-6.03	$L2_e$	8	0.44	0.88	0.13
306	2	-68.48	*L2*	7	0.18	-3.74	$L1_l$	0.00	0.06	-75.68	-71.94	-3.74	$L1_l$	6	0.71	0.00	0.06
412	0	-69.43	*L2*	6	1.05^{**}	0.00	$L2_e^{\ddagger}$	1.00	0.00	-69.43	-69.43	0.00	$L2_e$	6	1.05	1.00	0.00
205	0	-72.81	*L2*	6	0.01	0.00	$L1_e$	0.00	1.00	-75.80	-75.80	0.00	$L1_e$	4	3.27	0.00	1.00
220	1	-72.96	*L2*	6	0.32	0.00	$L1_e$	0.00	1.00	-76.70	-72.96	-3.74	$L2_e$	6	0.32	0.94	0.06
403	0	-73.60	*L2*	6	0.50	-6.03	$Eq_l^{\ddagger}$	0.00	0.13	-86.91	-80.88	-6.03	Eq_l	4	0.84	0.00	0.13
517	0	-73.70	*L2*	5	0.98^{**}	-	-	-	-	-	-	-	-	-	-	-	-
503	3	-88.21	$L2^{+}$	3	0.00	-	-	-	-	-	-	-	-	-	-	-	-

414	4	-89.00	*L2*	2	0.78^{*}	-7.72	$L1_e$	0.00	0.19	-102.56	-92.62	-9.94	Eq_e	2	0.36	0.00	0.31
110	3	-92.51	$L2^{+}$	2	0.00	-9.00	$L1_l$	0.00	0.75	-107.03	-98.03	-9.00	$L1_l$	0	0.56	0.00	0.75
210	0	-51.13	$L3^{B}$	9	0.92^{*}	-10.59	$L1_e$	0.00	0.38	-68.44	-51.13	-17.32	$L3_e$	9	0.92	0.38	0.25
302	0	-61.46	$L3^{B}$	7	1.11^{**}	-6.03	Eq_e	0.00	0.13	-71.14	-65.12	-6.03	Eq_e	7	1.11	0.00	0.13
507	0	-63.23	*L3*	7	0.94^{**}	-	-	-	-	-	-	-	-	-	-	-	-
313	0	-79.12	$D1^{E}$	2	2.68^{**}	-6.03	$L1_e^{\ddagger}$	0.00	0.88	-90.93	-84.90	-6.03	$L1_e^{\ddagger\ddagger}$	2	3.28	0.00	0.88
312	0	-80.45	$D1^{\dagger}$	3	5.85^{**}	-3.74	$L2_e^{\ddagger}$	0.94	0.06	-84.74	-81.00	-3.74	$L2_e$	3	1.37	0.94	0.06
204	2	-84.86	$D1^{E}$	2	1.22^{**}	0.00	$L1_e^{\ddagger}$	0.00	1.00	-88.47	-88.47	0.00	$L1_e$	2	1.59	0.00	1.00
115	1	-86.10	*D1*	2	1.74^{**}	-9.94	Eq_e	0.00	0.31	-107.99	-98.05	-9.94	Eq_e	0	0.39	0.00	0.31
401	2	-91.99	$D1^{\dagger}$	0	1.58^{**}	-6.03	Eq_l	0.00	0.13	-104.35	-98.32	-6.03	Eq_l	0	0.32	0.00	0.13
310	0	-41.69	Eq^{A}	11	0.00	-9.94	$L1_l$	0.00	0.31	-56.84	-41.69	-15.15	Eq_{el}	11	0.00	0.13	0.31
315	0	-41.80	*Eq*	11	0.00	0.00	$L3_e^{\ddagger}$	1.00	0.00	-50.80	-41.80	-9.00	Eq_e	11	0.00	0.00	0.75
404	1	-54.69	*Eq*	9	0.03	-9.00	$Eq_e^{\ddagger}$	0.00	0.75	-63.69	-54.69	-9.00	Eq_e	9	0.03	0.00	0.75
303	0	-59.93	*Eq*	8	0.41	-3.74	$Eq_e^{\ddagger}$	0.00	0.06	-63.68	-59.93	-3.74	Eq_e	8	0.41	0.00	0.06
417	0	-60.52	Eq^{A}	8	0.30	-10.97	$L1_e$	0.00	0.44	-73.80	-60.52	-13.29	Eq_e	8	0.30	0.31	0.63
202	0	-60.78	Eq^{A}	8	0.10	-9.94	Eq_e	0.00	0.31	-70.72	-60.78	-9.94	Eq_e	8	0.10	0.00	0.31
518	0	-66.38	*Eq*	7	0.61	-	-	-	-	-	-	-	-	-	-	-	-
112	2	-66.39	*Eq*	7	0.00	-16.64	$L2_e$	0.25	0.25	-106.23	-89.60	-16.64	$L2_e$	3	0	0.25	0.25
215	0	-73.85	*Eq*	6	0.55	-3.74	$L1_e$	0.00	0.06	-81.57	-73.85	-7.72	Eq_e	6	0.55	0.00	0.19
314	5	-78.06	*Eq*	5	0.52	-9.94	Eq_e	0.00	0.69	-87.99	-78.06	-9.94	Eq_e	5	0.52	0.00	0.69
211	3	-79.14	*Eq*	5	0.00	-7.72	Eq_e	0.00	0.19	-86.86	-79.14	-7.72	Eq_e	5	0.00	0.00	0.19
514	8	-85.98	*Eq*	2	0.00	-	-	-	-	-	-	-	-	-	-	-	-
406	2	-86.73	*Eq*	3	0.59	-6.03	$L1_l$	0.00	0.13	-99.17	-86.73	-12.44	Eq_l	3	0.59	0.06	0.25
212	5	-96.62	$Eq^{\dagger}$	1	0.00	-6.03	$L1_e$	0.00	0.88	-104.34	-96.62	-7.72	Eq_e	1	0.00	0.00	0.81
506	0	-82.10	*So*	3	1.26^{**}	-	-	-	-	-	-	-	-	-	-	-	-
304	5	-93.29	So^{+}	2	0.25	0.00	Eq_e	0.00	1.00	-97.31	-97.31	0.00	Eq_e	1	0	0.00	1.00
421	4	-96.78	$So^{\dagger}$	1	0.31	-10.59	Eq_e	0.00	0.38	-109.34	-98.38	-10.97	$L1_e$	0	0.43	0.00	0.56

Specification test and analysis

For some subjects these estimates leave room for doubt about whether our a priori specification of types omits relevant types and/or overfits by including irrelevant types

We conduct a subject by subject specification test that compares the likelihood of the subject's type estimate with those of estimates based on 88 *pseudotypes*, each constructed from one of our subject's guesses in the games

With regard to overfitting, for a subject's type estimate to be credible it should have higher likelihood than at least as many pseudotypes as at random: 87/8 ≈ 11 with i.i.d. likelihoods; estimated types that fail this test are marked "+" in Table IX

Now imagine that we had omitted a relevant type, say *L2*; the pseudotypes of subjects now estimated to be *L2* would then outperform the non-*L2* types estimated for them, and would also make approximately the same (*L2*) guesses

Finding such a *cluster* we would diagnose an omitted type, and studying what its subjects' guesses have in common might help to reveal its decision rule; in Table IX possible clusters are identified by superscript letters A, B, C, D, or E

The next tables (from Appendix F) collect the guesses of the cluster candidates and summarize the games' structures; 310 and 409 are included as potential members of cluster A or E, respectively, despite some failures of the likelihood criteria

Game Structures, Types' Guesses, and Guesses of Cluster Candidates A, B, and C

Game	ai	bi	pi	aj	bj	pj	L1	L2	L3	D1	D2	E	S	202	417	(310)	210	302	407	516
1	100	900	1.5	300	500	0.7	600	525	630	600	611.25	750	630	675	600	500	630	630	600	600
2	300	900	1.3	300	500	1.5	520	650	650	617.5	650	650	650	650	650	650	650	650	520	520
3	300	900	1.3	300	900	1.3	780	900	900	838.5	900	900	900	900	900	900	900	900	700	780
4	300	900	0.7	100	900	1.3	350	546	318.5	451.5	423.15	300	420	500	333.87	630	380	430	609	565
5	100	500	1.5	100	500	0.7	450	315	472.5	337.5	341.25	500	375	425	450	500	450	479	450	450
6	100	500	0.7	100	900	0.5	350	105	122.5	122.5	122.5	100	122	100	100	100	100	100	360	350
7	100	500	0.7	100	500	1.5	210	315	220.5	227.5	227.5	350	262	215	173.91	200	350	340	210	210
8	300	500	0.7	100	900	1.5	350	420	367.5	420	420	500	420	370	315	500/630	420	400	420	500
9	300	500	1.5	300	900	1.3	500	500	500	500	500	500	500	500	500	500	500	500/999	500	500
10	300	500	0.7	100	900	0.5	350	300	300	300	300	300	300	300	300	300	300	300	300	490
11	100	500	1.5	100	900	0.5	500	225	375	262.5	262.5	150	300	310	300	500	375	370	225	225
12	300	900	1.3	300	900	1.3	780	900	900	838.5	900	900	900	900	900	900	900	900/999	900	692
13	100	900	1.3	300	900	0.7	780	455	709.8	604.5	604.5	390	695	600	520	400	550	555	455	455
14	100	900	0.5	300	500	0.7	200	175	150	200	150	150	162	150	150	150	150	160	210	175
15	100	900	0.5	100	500	0.7	150	175	100	150	100	100	132	100	100	100	100	100	175	175
16	100	900	0.5	100	500	1.5	150	250	112.5	162.5	131.25	100	187	240	227	100	187.5	218.75	250	375

Game Structures, Types' Guesses, and Guesses of Cluster Candidates D and E

Game	ai	bi	pi	aj	bj	pj	L1	L2	L3	D1	D2	E	S	301	508	204	313	(409)
1	100	900	1.5	300	500	0.7	600	525	630	600	611.25	750	630	600	600	600	600	600
2	300	900	1.3	300	500	1.5	520	650	650	617.5	650	650	650	520	520	500	550	520
3	300	900	1.3	300	900	1.3	780	900	900	838.5	900	900	900	780	780	645	645	645
4	300	900	0.7	100	900	1.3	350	546	318.5	451.5	423.15	300	420	350	490	645	510	465
5	100	500	1.5	100	500	0.7	450	315	472.5	337.5	341.25	500	375	210	300	225	250	325
6	100	500	0.7	100	900	0.5	350	105	122.5	122.5	122.5	100	122	300	300	175	175	325
7	100	500	0.7	100	500	1.5	210	315	220.5	227.5	227.5	350	262	210	210	175	250	225
8	300	500	0.7	100	900	1.5	350	420	367.5	420	420	500	420	500	350	500/600	475	400
9	300	500	1.5	300	900	1.3	500	500	500	500	500	500	500	500/520	500	500	475	475
10	300	500	0.7	100	900	0.5	350	300	300	300	300	300	300	300	300	300	300	400
11	100	500	1.5	100	900	0.5	500	225	375	262.5	262.5	150	300	150	340	150	200	325
12	300	900	1.3	300	900	1.3	780	900	900	838.5	900	900	900	780	780	645	645	645
13	100	900	1.3	300	900	0.7	780	455	709.8	604.5	604.5	390	695	350	430	645	510	645
14	100	900	0.5	300	500	0.7	200	175	150	200	150	150	162	200	200	300	200	200
15	100	900	0.5	100	500	0.7	150	175	100	150	100	100	132	150	150	175	175	150
16	100	900	0.5	100	500	1.5	150	250	112.5	162.5	131.25	100	187	150	150	175	175	175

A. Subjects 202, 310, and 417, all estimated *Equilibrium*: All made equilibrium guesses in exactly our 8/16 games without mixed targets, and 310 also did so in 3 games with mixed targets; 202's and 417's deviations were always in the same direction but to different guesses, as were all but one of 310's (there is no pattern with respect to other aspects of structure)

We judge 202's and 417's guesses similar enough to meet the definition of a cluster, but we provisionally accept 310's identification as *Equilibrium*, which fits 310's guesses much better than 202's and 417's pseudotypes, despite similarities

However, the standard methods for identifying equilibrium guesses all work equally well with mixed targets, and only one of 29 *Equilibrium* R/TS subjects came close to 202's and 417's pattern; they may just have been using "homemade" rules that mimic *Equilibrium* in games without mixed targets

B. Subjects 210 and 302, both estimated *L3* with *Equilibrium* a fairly close second: Both deviate from *L3* in 7 games, 6 with mixed targets; and 302 also has minor deviations in 2 games, one with mixed targets (there is no other structural pattern)

6/7 of their common deviations are in the same direction, and all are to similar guesses; and both make exactly the equilibrium guess in game 6, the only game without mixed targets in which *L3* and *Equilibrium* are separated

We judge these subjects' guesses similar enough for a cluster, but we cannot tell how they were determined; they may come from rules that are hybrids of *L3* and *Equilibrium*

C. Subjects 407, estimated *L2*; and 516, *L1*: Both make *L1* guesses in most (5 or 7) of the first 9 games and *L2* guesses in most (6 or 4) of the last 7 (no other structural pattern)

These subjects' guesses are similar enough for a cluster, but we do not believe they followed an omitted type: the time pattern of deviations and the fact that most later guesses are more sophisticated suggest introspective learning; there are weak indications of an *L1*-*L2* switch for a few other subjects

(By contrast, 108 made *L2* guesses except for *L1* guesses in games 2, 10, and 16; most *L1* guesses are later and *L2* fits her/his guesses significantly better than any pseudotype)

D. Subjects 301 and 508, both estimated *L1*: Each of these subject's pseudotype is the only one with higher likelihood than the other's estimated type; they have five common deviations from *L1*, all downward but most to different guesses, and each also has one lone, upward deviation (no apparent structural pattern, but both lone deviations seem due to forgetting to multiply by own target, and some common deviations also seem due to cognitive errors such as forgetting or interchanging targets or limits)

These subjects' guesses are similar enough for a cluster, but we are not sure that they followed an omitted type; they may be sloppy *L1*s whose errors tended to fall in the same games

E. Subjects 204, estimated *Equilibrium*, 313, estimated *L1*, and 409, estimated *L1*: These subjects all made similar guesses, with 645s inexplicable by our types in (symmetric) games 3 and 12 and, for 204 and 409, in game 13 as well

Their guesses are similar enough for a cluster, but it is plain that they are not following a single omitted type

In their questionnaires all three stated homemade rules that depart from standard decision theory in different ways but, properly interpreted, explain most of their guesses exactly (Subject 409, for instance, says "…I took his/her lower limit and multiplied it by my target. If the resulting number was between my upper and lower limits, I kept that in mind. Otherwise I picked my lower limit. Then I took his/her upper limit and multiplied it by my target. Again, if the resulting number was within my range, I took it. Otherwise I picked the upper limit. Then I found the average of the two numbers." In symbols, 409 guessed $[\max\{a_i, a_j p_i\} + \min\{b_i, b_j p_i\}]/2$. This rule explains her/his guesses exactly in 13/16 games.)

These subjects' homemade rules illustrate what we suspect is a common tendency for subjects to invent rules by which to process the data of games into decisions

To us it is less remarkable that these 3 subjects' rules deviate from standard decision theory than that most other subjects' homemade rules *do* conform to standard decision theory, even though most of them stop short of imposing equilibrium

Summary of results for guesses (only)

Of the 43 subjects whose type estimate is *L1*, 27 are reliably identified as *L1*; the remaining 16 estimates may be spurious

Of the 20 subjects estimated to be *L2*, 17 are reliably identified; the remaining 3 estimates are probably spurious

Of the 3 subjects estimated to be *L3*, only one seems reliably identified; the other two estimates are probably spurious

Of the 5 subjects estimated to be *D1*, only one seems reliably identified; the other 4 estimates are probably spurious

Of the 14 subjects estimated to be *Equilibrium*, 11 seem reliably identified; the other 4 are probably spurious

Of the 3 subjects estimated to be *Sophisticated*, only one seems reliably identified; the other 2 are probably spurious

Thus, considering only guesses, 58 of our 88 subjects appear to be reliably identified as one of our types; almost all of them as *L1*, L2*,* or *Equilibrium*

These results are generally quite close to previous estimates from other kinds of games, except we find more *Equilibrium* subjects than most and no evidence of exotic types that (like SW's *Worldly*) respond to estimated population parameters

Results for R/TS subjects' guesses

Table VII summarizes R/TS subjects' compliance with their assigned type's guesses in 16 games, and the failure rates in our second, type-specific understanding test

The results suggest that *L1*, *L2*, and *L3* are the easiest types to implement, with lower compliance for *L1* (due, we suspect, to subjects' attempts to outguess the computer)

Next highest in compliance is *Equilibrium*, still high enough that Baseline deviations from equilibrium are unlikely to be due primarily to cognitive limitations

Lowest in compliance are *D1* and *D2*, although *D1* and *D2* failure rates are much lower than *Equilibrium* failure rates

Several *D1* subjects (e.g. 804, with 3 *D1* but 16 *L2* guesses) made many more *L2* than *D1* guesses (after passing a *D1* Understanding Test in which *L2* answers were wrong), reinforcing the impression that *Dk* is less natural than *Lk+1*

Table XIII. R/TS subjects' compliance with assigned type's guesses

	L1	*L2*	*L3*	*D1*	*D2*	*Eq.*
UCSD subjects	7	9	-	11	-	10
% Compliance	77.7	81.3	-	55.1	-	58.1
% Failed UT2	0.0	0.0	-	8.3	-	28.6
York subjects	18	18	18	19	19	19
% Compliance	80.9	95.8	84.4	66.1	55.6	76.6
% Failed UT2	0.0	0.0	0.0	0.0	5.0	13.6
UCSD+York subjects	25	27	18	30	19	29
% Compliance	80.0	91.0	84.7	62.1	55.6	70.3
% Failed UT2	0.0	0.0	0.0	3.2	5.0	19.4

Results for Baseline and R/TS subjects' searches

Tables X and XI give search data for R/TS subjects with high compliance with assigned type's guesses, and for Baseline subjects with high compliance with some type's guesses

R/TS subjects' look-up sequences are rich in their types' relevant sequences, as are the look-up sequences of Baseline subjects whose guesses conform closely to a type

Baseline subject 108, whose guesses switched for *L2*'s to *L1*'s in 3 games, gave no indication of the switches in his look-ups (*L2* search automatically includes *L1* search); and subject 309, whose guesses coincided perfectly with *L2*'s, made enough look-ups to be sure of identifying *L2*'s guess only in games 6-16; he was just lucky in games 1-5

The econometric analysis of search quantifies compliance as the density of a type's relevant look-up sequence in the subject's sequence; Table IX reports estimates of subjects' types based on search only, and on guesses and search

Search-based estimates reaffirm the estimates based on guesses only for 51 of the 58 we argued were reliable; some estimates change because there is a tension between guesses and search; others because the subject did not satisfy the guesses-only type's search requirements

In the end 52 subjects are reliably identified: 27 as *L1*, 13 as *L2*, 10 as *Equilibrium*, and one each as *L3* or *Sophisticated* (the last 2 were OB, and might not survive monitoring search)

Table X. Selected R/TS Subjects' Information Searches and Assigned Types' Search Implications

MouseLab box numbers

	a	*b*	*p*
You (*i*)	1	2	3
S/he (*j*)	4	5	6

Types' Search Implications

L1	{[4,6],2}
L2	{([1,3],5),4,6,2}
L3	{([4,6],2),1,3,5}
D1	{(4,[5,1], (6,[5,3]),2}
D2	{(1,[2,4]),(3,[2,6]),(4,[5,1],(6,[5,3]),5,2}
Eq	{[2,5],4} if pr. tar.<1,{[2,5],6} if > 1

Subject	**904**	**1716**	**1807**	**1607**	**1811**	**2008**	**1001**	**1412**	**805**	**1601**	**804**	**1110**	**1202**	**704**	**1205**	**1408**	**2002**
Type(#rt.)	L1 (16)	L1 (16)	L1 (16)	L2 (16)	L2 (16)	L2 (16)	L3 (16)	L3 (16)	D1 (16)	D1 (16)	D1 (3)	D2 (14)	D2 (15)	Eq (16)	Eq (16)	Eq (16)	Eq (16)
Alt.(#rt.)											L2 (16)						
Est. style	late	often	early	often	early				early								
Game																	
1	123456 4623	146462 134646 23	462513	135462 1313	134446 5213*4 6	111313 131313 5423	462135 21364* 246231 52	146231 564623 1	154356 423213 2642	254514 36231	154346 5213	135464 2646*1 313	246466 135464 641321 342462 422646 124625 5*1224 654646	123456 363256 565365 626365 652651 452262 6526	123456 424652 562525 6352*4 65	123123 456445 632132 11	142536 125365 253616 361454 613451 213452 63
2	123456 4231	462462 13	462132 25	135461 354621 3	134653 125642 313562 52	131313 566622 333	462135 642562 223146 2562*6 2	462462 546231 546231	514535 615364 23	514653 6213	515135 365462 3	135134 642163 451463 211136 414262 135362 *14654 6	123645 132462 426262 241356 462*13 524242 466135 6462	123456 525123 652625 635256 262365 456	123456 244565 565263 212554 146662 654251 44526* 31	123456 456123 643524 1	143625 361425 142523 625656 3

Table XI. Selected Baseline Subjects' Information Searches and Estimated Types' Search Implications

MouseLab box numbers

	a	*b*	*p*
You (*i*)	1	2	3
S/he (*j*)	4	5	6

Types' Search Implications

L1	{[4,6],2}
L2	{([1,3],5),4,6,2}
L3	{([4,6],2),1,3,5}
D1	{(4,[5,1], (6,[5,3]),2}
D2	{(1,[2,4]),(3,[2,6]),(4,[5,1],(6,[5,3]),5,2}
Eq	{[2,5],4} if pr. tar.<1,{[2,5],6} if > 1

Subject	**101**	**118**	**413**	**108**	**206**	**309**	**405**	**210**	**302**	**318**	**417**	**404**	**202**	**310**	**315**
Type(#rt.)	L1 (15)	L1 (15)	L1 (14)	L2 (13)	L2 (15)	L2 (16)	L2 (16)	L3 (9)	L3 (7)	L1 (7)	Eq (8)	Eq (9)	Eq (8)	Eq (11)	Eq (11)
Alt.(#rt.)								Eq (9)	Eq (7)	D1 (5)	L3 (7)	L2 (6)	D2 (7)		
Alt.(#rt.)								D2 (8)			L2 (5)		L3 (7)		
Est. style	early/late	early	late	early	early	early/late	early	early	early	early	early	early	early	early/late	early
Game															
1	146246 213	246134 626241 32*135	123456 545612 3463*	135642	533146 213	1352	144652 313312 546232 12512	123456 123456 213456 254213 654	221135 465645 213213 45456* 541	132456 465252 13242* 1462	252531 464656 446531 641252 462121 3	462135 464655 645515 21354* 135462 426256 356234 131354 645	123456 254613 621342 *525	123126 544121 565421 254362 *21545 4*	213465 624163 564121 325466
2	46213	246262 2131	123564 62213*	135642 3	531462 31	135263 1526*2 *3	132456 253156 456545 463123 156562 62	123456 465562 231654 456*2	213546 566213 545463 21*266 54123	132465 132*46 2	255236 62*365 243563	462461 352524 261315 463562	123456 445613 255462 513565 23	123546 216326 231456 *62	134652 124653 656121 3
3	462*46	246242 466413 *426	264231	135642 53	535164 2231	135263	312456 5231*1 236545 5233** 513	123455 645612 3	265413 232145 563214 563214 523*65 4123	134652 1323*4	521363 641526 5263*6 52	462135 215634 *52	123456 123562 3	123655 463213	132465 544163 *3625