The Power of Focal Points is Strong: Coordination Games with Labels and Payoffs

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3 August 2020

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Abstract: *People's ability to coordinate on salient labels has been widely reported since Schelling. However, it is not known how players behave when label salience conflicts with payoff dominance. We consider such games by independently varying the two elements, focusing especially on cases where the two criteria conflict. We also introduce a new form of the game, in which players choose labeled strategies in response to a stimulus. In games with no reference stimulus, behavior is consistent with a simple model, according to which strategic players assume their naïve counterparts choose the higher payoff. In games with a reference stimulus, behavior is consistent with a model in which strategic players assume their naïve counterparts choose the label that is more salient to them, except perhaps where the two labels' salience are very similar, in which case the higher payoff is chosen. A key finding is that in the presence of a stimulus, play is best explained by a model in which players choose according to label salience, even against the combination of payoff and risk dominance.*

Introduction

Coordination games are a type of game with multiple equilibriums and in which players' incentives are aligned. They are widely studied and are considered as capturing important aspects of many economic activities. The strategic uncertainty in coordination games results from their simplicity, there being no obvious rational basis on which a strategic player can anticipate his/her partner's choice (Colman 2003).

Research on focal points, beginning with Schelling (1960) , has demonstrated that when strategies are associated with common knowledge labels, players may utilize the information conveyed by the labels to facilitate coordination. To each individual, one of the labels may be "salient", and this may influence the player's choices. For example, if there are two strategies with identical payoffs and one is labeled "Blue" and the other "Green", a higher than random fraction of p layers will choose the strategy labeled "Blue", thereby increasing the coordination rate (Mehta, Starmer et al. 1994).

A second stream of research has explored the influence of payoffs. When there is a payoff-dominant solution, it is widely assumed that each player will do his/her part by choosing the corresponding strategy (Harsanyi and Selten 1988), which results in a Pareto efficient outcome.

In this paper, we consider games in which label salience and payoff-dominance clash. In particular, we consider games with symmetric payoffs, in which one strategy is payoff dominant and a different strategy is associated with a more salient label. An example is shown in Figure 1. Assuming that the label "Blue" is more salient than "Green" among a population of players – Mehta et al. found that it is – then label salience and payoff salience recommend different strategies. This paper addresses the question of how players will behave in such a game.

Figure 1 Coordination Game with Strategies Characterized by Payoffs and Labels

		Column Player	
		Blue	Green
Row Player	Blue	5, 5	0, 0
	Green	0, 0	10, 10

It is difficult to make any a priori prediction. Both criteria – payoff dominance and focal points -- lie outside the scope of orthodox game theory (Colman 2003), though formal theories have been proposed for both (Sugden 1995; Colman and Bacharach 1997; Jannsen 2001). Indeed, Harsany and Selten (1988) propose that payoff dominance *is* a kind of focal point, making it still more difficult to predict which criteria, if any, will be preferred. Furthermore, empirical research shows that both criteria are inconsistent and/or sensitive to details of the game. For example, payoff dominance fails when it conflicts with risk-dominance (Harsanyi and Selten 1988), and even when it doesn't (Cooper, DeJong et al. 1990), while label salience fails to guarantee coordination in games with asymmetric payoffs (Crawford, Gneezy et al. 2008). Since the games we consider involve two conflicting, unorthodox, and inconsistent criteria, it is difficult to make a priori predictions.

Moreover, existing theoretical approaches to focal points require extension or elaboration before they can be applied to the games considered here. There are two main theoretical approaches to salience and focal points (Mehta, Starmer et al. 1994) – (1) cognitive hierarchy (Stahl and Wilson 1995; Camerer, Ho et al. 2004; Bardsley, Mehta et al. 2009) and (2) team-reasoning (Bacharach 1993; Sugden 1995).Our primary focus in this paper is on cognitive hierarchy. We extend it to make predictions in the game we study, and explore how results may be interpreted within that framework. A concluding discussion briefly considers what the observed behavior might mean under team reasoning, but this is not our main focus.

In order to address the game we study, we augment cognitive hierarchy in a number of ways. One significant innovation of our paper is that we introduce and formalize a notion of degree of label salience at the level of an individual. Most prior research has considered label salience as a population-level phenomenon, meaning that for each individual, only one label is salient, with the degree of label salience being defined only at the population level, as the proportion of individuals for which it is the salient one (Bardsley, Mehta et al. 2009). Here, we model an individual-level effect of label salience, which means that a label has a degree of salience to each individual.

A second innovation within the hierarchical framework is that we consider variable as well as fixed effects, for both payoffs and labels. A fixed effect means that the individual chooses the strategy with higher payoff or more salient label, with a fixed probability that is higher than random. A variable effect is that the individual chooses the strategy with higher payoff or more salient label, with a probability that corresponds to the magnitude of the difference in payoffs or salience. Regarding payoffs, this is a shift from prior work, which has considered only a fixed payoff bias (Crawford, Gneezy et al. 2008). Regarding labels, this is also new. A variable effect, whereby an individual's behavior depends on the degree of label salience, was not possible under the prevailing models that have defined a label's degree of salience as something that emerges at the level of the population. But because we model degree of label salience as an individual level phenomenon, we are also able to investigate variable effects of label salience.

The concept of individual-level degrees of salience leads, in turn, to methodological innovations. Bardsley et al. introduced the idea of picking and guessing tasks as a way of illuminating the factors driving players' choices. In their picking tasks, players were simply asked to pick one label, irrespective of any other players; and in their guessing task, players were asked to guess what label was mostly commonly picked by guessers. We adapt these treatments to suit our theoretical framework in which *each label has a degree of salience to each individua*l. In particular, in lieu of a picking task we have an “assessing” task in which each subject assigns a probability to each label, and a “guessing” task in which each subject guesses the average of those assessments. Using behavior in these treatments as a reference, we make predictions regarding the proportion of players in a coordinating treatment that will choose each strategy under the various proposed models being compared.

An additional innovation – and one that is not specific to cognitive hierarchy -- is that we study two variants of the game, one of which is newly proposed. In the familiar version depicted in Figure 1, subjects are asked to choose a label a propos of nothing, e.g. “Choose a date” (Mehta, Starmer et al. 1994) or “Choose one of these words”. The other variant, which we introduce, is the same except that players choose a labeled strategy in response to a reference stimulus. For example, players may be shown an image with respect to which they choose labels, i.e. labeled strategies. This variant is motivated by the observation that a contextual stimulus is present in many if not most settings for which coordination games are offered as providing relevant insights. This is a point to which we will return in section 5 where we introduce that game. We examine and interpret behavior in both versions of the game.

We find support for simple models of behavior. Specifically, in the absence of reference stimuli, we find that players coordinate on the higher payoff, with label salience playing almost no perceptible role in players’ choice of strategies. In the presence of reference stimuli, results are very different. Here, the data is predicted well by a simple model in which each player chooses the strategy associated with the more salient (to him/her) label. Somewhat better predictions are made by refining that to a model in which players do consider payoffs, but only when the two labels’ salience levels (to him/her) are within about 13% of one another. To summarize, without reference stimuli, payoffs determine players’ choices, and with reference stimuli, labels dominate players’ choices. Both results are convincing in the sense that they handily out-perform all the other models that we consider.

The most important and surprising result is that in the presence of a reference stimulus, behavior is explained by the focal points, even against the combination of payoff and risk dominance. This result can be modeled within a cognitive hierarchy approach as we have done, but is much more difficult to explain within a team-reasoning framework.

1 Theoretical Development

1.1 Preliminaries

We study symmetric, one-shot coordination games for two players. For reasons to be elaborated below, we restrict our attention to games with only two strategies for each player to choose from; a discussion section briefly considers the case of games with more choices. Described in normal form using the notation from Bardsley et al., player *i* (*i*=1..2) chooses between strategies s_{ij} (*j*=1..2). If, for a given *j,* the two players choose strategies s_{1j} and s_{2j} respectively, they each earn U_j. In addition, there exists a set of labels $L = \{L_1, L_2\}$, and for a given *j* (*j*=1..2), strategies s_{1j} and s_{2j} are associated with label L_j. Due to the game's complete symmetry, for convenience we may drop the first subscript and write simply of "strategy s_j" as being associated with label L_j and coordinating payoff U_j. In addition, due to the association between strategies and labels, we write "choose L_j" as shorthand for "choose the strategy associated with label L_j". Labels are meaningful in the sense of being recognizable words or symbols in the players' language or culture (Bardsley, Mehta et al. 2009), and which may therefore facilitate coordination through the emergence of focal points.

Within classical game theory, which ignores the labels, the game has two symmetric pure strategy equilibriums, as well as one mixed strategy equilibrium. Equilibrium refinements predict that players will choose the payoff dominant strategy if it exists, i.e. if $U_1 \neq U_2$. Where $U_1 = U_2$, classical game theory does not make definitive predictions about which strategy players will choose. The theory of focal points has been developed to address games of this type, i.e. coordination games with meaningful common knowledge labels and equal payoffs, i.e. $U_i = U_j$ for all *i,j*.

Our reason for restricting our attention to games with two strategies for each player is that we focus on cognitive hierarchy not team reasoning. As noted by Bardsley et al., the two frameworks may coincide, as when a player sees no better selection rule than "follow secondary salience". As our main interest is in hierarchical models, we prefer games in which the two frameworks coincide in this manner. We view this as being more likely in games that have only two choices, where the principle of insufficient reason is more likely to apply (to both) because there cannot be an "odd man out". Indeed, we know of no empirical work within the team reasoning framework that studies games with two choices. This is our reason for restricting our attention to games with two strategies. A discussion section returns to this point.

We begin by reviewing Bardsley et al.'s cognitive hierarchy theory, which we adopt as a baseline that we then modify and build upon. In Bardsley et al.'s theory, Level-0 players do not act strategically but simply pick a label according to a probability distribution p^0. Probability p_j^0 of label *j*'s being picked in such a task is called that label's *degree of primary salience* in their framework. A level 1 player, in turn, is defined to have beliefs about which label would be chosen by the largest number of level-0 players, i.e. to guess the mode of p^0. If these beliefs are aggregated across all level players at level 1 and higher, the result is a probability distribution denoted p^1.

Similar reasoning may be used to define level-2 players, whom we model as believing their partners are level 1. Two differing simplifying assumptions appear in the literature. Bardsley et al. assume that each level *n* $(n \geq 2)$ player envisions all players at level *n-1* as have the same beliefs that they do, so that the beliefs of higher level players follow the same distribution as level 1 players. This allows treating all levels *n* $(n \geq 1)$ identically. Crawford et al. (2008), by contrast, assume perfect knowledge among level 2 players, meaning that they know the distribution of choices made by level 1 players. This approach requires accounting for level 2 players separately from level 1. We will make predictions and show results under both assumptions. We do not model beyond level 2.

Our theoretical framework builds upon Bardsley et al.'s cognitive hierarchy, but modifies and extends it in the following three ways: (1) It considers an individual level degree of label salience; (2) it considers payoffs; (3) it allows both fixed and variable effects for both labels and payoffs.

2 Theoretical Framework

The various models that we will propose – and test empirically – are all defined within the extended hierarchical framework we develop, which we call cognitive hierarchy with individual-level label salience and payoffs. The first innovation of this framework is the introduction of an individual level degree of label salience. This element will be formalized following a preliminary discussion.

2.1 Cognitive Hierarchy with Individual-level Label Salience

We depart from prior work in considering that labels may affect an individual player's choice in proportion to its relative salience to that individual. It is not new that a label may be salient to one individual and not to another; this is largely assumed in the focal point literature. Similarly, it is not new that in the aggregate, each label has its own probability of being salient (to a random individual); this is utilized in Bardsley et al.'s framework[1]. What is new in our paper is that we consider that each label has a degree of salience *to each individual*, not just in the aggregate.

This idea has some basis in the literature, though to our knowledge it has not been previously incorporated into a formal model. Mehta et al. (1994) allow a related idea that the process that brings one label to mind might be stochastic, such that various labels might come to one's mind with different probabilities, with the distribution differing between individuals. Ho and Chen (2009) take this one step further, specifying a frequency-based interpretation of such a probability, according to which, for each player, each label occurs with a certain frequency. These conceptualizations still retain the idea that ultimately, a single label enters one's mind on any given occasion, except that a stochastic process chooses which one. As an alternative, we might conceive of all labels as entering an individual's mind to varying degrees that may differ across individuals. In such a conceptualization, when an individual is forced to make a single choice, a stochastic process chooses one of the labels, with probabilities that reflect the degree to which each label had occupied his/her mind. In our framework, any of the above conceptualizations is valid. Our approach will only assume that for each individual, each label has a degree of primary salience that defines the probability that *that individual* will select it in a picking task. A label's *degree of salience* may be viewed as probability of entering one's mind – in which case, in a picking task, the individual chooses *the one* that's in his/her mind. Or, a label's degree of salience may be viewed as the extent to which it occupies one's mind – in which case, in a picking task, this extent defines the probability that that individual will pick that label. Our model applies equally to these conceptualizations.

For each level 0 individual *i* in the game defined in section 1.1, we define p_{ij}^0 as the probability with which player *i* would pick label *j*. This represents label *j*'s degree of salience for individual *i*. The probability $p_{\cdot j}^0$ denotes the average degree of salience of label *j* across players. Finally, $p_{\cdot}^0$ denotes the distribution comprised of $p_{\cdot j}^0$ for all labels *j*.

Level 1 players are modeled as having beliefs about level 0 players. Our models depart significantly from Bardsley et al., where "p^1 is not a belief that can be attributed to any player, or to players in general". In

[1] One can interpret that Bardsley et al. conceive that for each individual, one of the labels has primary salience. This would be consistent with – but not implied by – their model. Even with this addition, however, a label's *degree* of primary salience would still be defined only at the level of the population, as the probability that it is chosen by a random draw from p^0.

our different approach, for a player *i* at cognitive level 1 or above, we define p_{ij}^1 as player *i*'s belief regarding the degree of salience of label *j* to level-0 players. We adopt a homogeneity assumption, according to which level 1 players view level 0 players as homogenous. Accordingly, beliefs p_{ij}^1 that are held by a level-1 player *i* reflect his/her beliefs about the degree of salience of label *j* to every level 0 player, not (merely) to level 0 players on average, i.e. not (merely) his/her beliefs about $p_{\cdot j}^0$. Distribution p_i^1 denotes player *i*'s distribution of such beliefs about all labels. As we will develop in the next section, predictions about the distribution of choices made by level 1 players depend on the fraction of level 1 players *i* whose beliefs p_i^1 satisfy some property. It suffices here to note that we have no need for estimates of the average beliefs among level 1 players. Rather, predictions for the coordination game will require estimates of the fractions of level 1 players whose beliefs satisfy various properties. Figure 2 gives an example of the above definitions.

Figure 2 Example Calculation

Degree of salience of each of two labels to three level 0 players

		Label A	Label B
Level-0 individual	1	.75	.25
	2	.50	.50
	3	.60	.40
		$p_{\cdot j}^0 = avg(.75,.5,.6) = .62$	$p_{\cdot j}^0 = avg(.25,.5,.4) = .38$
		$p_{\cdot}^0 = (.62,.38)$	

Beliefs of three level-1 players about degrees of salience to level 0 players

		Label A	Label B	
Level-1 individual	1	.70	.30	$p_1^1 = (.7,.3)$
	2	.80	.20	$p_2^1 = (.8,.2)$
	3	.55	.45	$p_3^1 = (.55,.45)$

2.2 Cognitive Hierarchy with Payoffs

Our framework also incorporates payoffs. For utility maximizing level 1 players, incorporating payoffs is straightforward: their choices are determined by comparing the products of an appropriate probabilistic belief – the various models we will develop within our framework differ on what probability that is -- and the numerical value of the payoff.

Regarding level 0 players, no new "machinery" is needed for payoffs as it was for labels, except for the stipulation that players think of the game as we have described it in section 1.1, with strategies having associated labels, and separately from that, associated coordinating payoffs. In particular, players treat payoffs as distinct from labels, and understand their significance as numerical payoffs that confer utility. The significance of this becomes clear when we consider the alternative: Bardsley et al. propose that level 0 players are "completely unaware of the significance of payoffs" (ibid. p. 50) or that they respond to a higher payoff with a more positive affect, "in the same sense that … <<Porsche>> is a more attractive label then <<Volkswagen>>". If we interpret this to mean that players actually treat payoffs as additional labels, then the approach seems unworkable in our setting. The reason is that strategies in our game are characterized by both labels and payoffs, and if payoffs are not distinguished from labels, we face the dubious prospect of modeling level 0 players as somehow responding to pairs of labels, such as {"Blue" "5"} versus {"Green" "10"}. This does not seem to us a promising direction, and none of our proposed models involve this sort of reasoning. Instead, our framework assumes that players treat payoffs as distinct from labels. In addition, it assumes that payoffs are different from labels in having an objective meaning, so that unlike for labels, we do not model how level 0 individuals vary in their response to payoffs.

2.3 Fixed and Variable Effects

The third and final category of additions that distinguish our framework is the possibility of variable as well as fixed effects. This section introduces these modeling elements.

2.3.1 Fixed and Variable Effect of Payoffs

It seems straightforward enough to consider that players – especially level 0 players within a cognitive hierarchy framework -- might prefer (i.e. be more inclined to choose) a strategy in relation to the magnitude of its payoff. Yet prior literature has not taken this approach. For example, Crawford et al. modeled a fixed bias towards the higher payoff, rather than a variable effect. Similarly, Bardsley et al. quoted above seem to take this one step further, by offering a psychological theory whereby players respond to payoffs as to labels. By contrast, in our model players treat numbers separately from payoffs, and as the numbers that they are. Within those assumptions, our framework allows modeling that a fixed effect in which (all) players favor the higher payoff with the same fixed bias, or a variable effect in which (all) players favor payoffs in accordance with their magnitude.

When a fixed payoff p_U bias is in effect, it means that (all) level 0 players choose the strategy with the higher payoff with a probability $(.5 + p_U)$ and the other strategy with probability $(.5 - p_U)$. A variable payoff bias means that all level 0 players choose each strategy s_j with probability $\frac{U_j}{U_j+U_k}$.

2.3.2 Fixed and Variable Effect of Labels

A fixed bias in favor of (the strategy associated with) label L_j means that the level 0 player chooses the associated strategy s_j with a higher than random probability. We denote such a bias as p_L to indicate a labels bias, and its effect is that a level 0 player chooses the strategy whose associated label is more salient (to him/her) with a probability $(.5 + p_L)$ and the other strategy with probability $(.5 - p_L)$. Variable effects mean that the magnitude of the bias depends on the magnitude of the difference in payoffs or salience. A variable labels bias means that a level 0 player *i* chooses each strategy s_j with probability p_{ij}^0. The possibility of a variable labels bias is made possible by the introduction of the individual-level degree of salience, p_{ij}^0.

3 Models and Predictions

We adopt the following general principles in all the models we will explore within our extended hierarchical framework: (1) level 0 players are assumed to have zero frequency in the population (Crawford, Gneezy et al. 2008), even though their imagined behavior drives the models. (2) Level 1 players assume that level 0 players are homogeneous. (3) When utility-maximizing level 1 players are faced with two equal expected values, they choose randomly between them.

We propose three alternate structures for the modeling of level 0 players, whose behavior drives that of strategic higher-order players. We will develop predictions under each structure, and compare them empirically. The three structures are:

Structure A: A level 0 player favors the higher payoff with a fixed or variable bias, unless its associated label salience is x_1% lower than other choice, in which case he/she favors the more salient label with a fixed or variable bias.

> Put another way, when the two labels' salience levels differ by more than x_1%, a level 0 player favors the more salient label; otherwise the player favors the higher payoff. This treats payoffs as a tie-breaker for when label salience is similar.

Structure B: A level 0 player favors the more salient label with a fixed or variable bias, unless its associated payoff is $x_2\%$ lower than other choice, in which case he/she favors the higher payoff with a fixed or variable bias.

> Put another way, when the two strategies' payoffs differ by more than x_2%, a level 0 player favors the higher payoff; otherwise the player favors the mode salient label. This treats label salience as a tie-breaker for when payoffs are similar.

Structure C: Level 0 player considers label salience and payoffs equally, choosing according to the "product" of label salience and payoff.

A few observations are in order. First, structures A and B each represents a family of four different specific models, depending on whether the payoff and label effects are modeled as fixed or variable. These possibilities are elaborated below, but turn out to have only minor impact, so it is appropriate to emphasize the main structure over those differences. Second, structures A and B have parameters x_1 and x_2, respectively, that govern whether labels and payoffs, respectively, are sufficiently different that they come into play. Third, where structures A and B include a fixed effect, there is an additional parameter that defines the magnitude of the bias, p_L for a fixed labels bias and p_U for a fixed payoff bias, as introduced in section 2.3.3. Lastly, there are a few special cases that relate the models to one another. We will note these special cases after presentation of the models.

3.1 Structure A

In the first family of models we explore, any level 0 player is biased towards the strategy with higher payoff, unless that choice's label is x_1% less salient (to him/her) than the other, in which case he/she is biased towards the more salient label. Put another way, as long as the two labels' salience levels are within x_1% of each other, a level 0 player is biased towards the higher payoff, otherwise the player is biased towards the more salient label. It remains to model whether the payoff and labels biases are fixed or variable.

3.1.1 Model A1: Fixed payoff bias, fixed salience bias

We first consider a model we call A1, with a fixed bias p_U towards the higher payoff, and a fixed bias p_L towards the mode salient label, when label salience comes into play. In this model, a level 0 player prefers the higher payoff with fixed bias p_U, unless that choice's label is x_1% less salient (to him/her) than the other, in which case he/she chooses the more salient label with fixed bias p_L. The detailed behavior of level 0 players is shown in Figure 3.

Figure 3: Level 0 players in Model A1

Condition on payoffs	Condition on salience	Probability chooses sj
$U_j > U_k$	$p_{ij}^0 \geq \frac{p_{ik}^0}{(1+x_1\%)}$	$(.5+p_U)$
	$p_{ij}^0 < \frac{p_{ik}^0}{(1+x_1\%)}$	$(.5-p_L)$
$U_j < U_k$	$p_{ij}^0 > p_{ik}^0(1+x_1\%)$	$(.5+p_L)$
	$p_{ij}^0 \leq p_{ik}^0(1+x_1\%)$	0
$U_j = U_k$	$\frac{p_{ik}^0}{(1+x_1\%)} \leq p_{ij}^0 \leq p_{ik}^0(1+x_1\%)$	.5
	$p_{ij}^0 < \frac{p_{ik}^0}{(1+x_1\%)}$	$(.5-p_L)$
	$p_{ij}^0 > p_{ik}^0(1+x_1\%)$	$(.5+p_L)$

From these, we derive the proportion of level 1 players choosing strategy s_j.

If $U_j > U_k$ and his/her beliefs satisfy $p_{ij}^1 \geq \frac{p_{ik}^1}{(1+x_1\%)}$ then the player will choose s_j

If $U_j \geq U_k$ and $p_{ij}^1 < \frac{p_{ik}^1}{(1+x_1\%)}$ then the player will choose s_j if $(.5-p_L)U_j > (.5+p_L)U_k$

If $U_j \leq U_k$ and $p_{ij}^1 > p_{ik}^1(1+x_1\%)$ then the player will choose s_j if $(.5+p_L)U_j > (.5-p_L)U_k$

If $U_j \leq U_k$ and $p_{ij}^1 < p_{ik}^1(1+x_1\%)$ then the player will not choose s_j

If $U_j = U_k$ and $\frac{p_{ik}^1}{(1+x_1\%)} \leq p_{ij}^1 \leq p_{ik}^1(1+x_1\%)$ then the player will choose s_j with probability .5

3.1.2 Model A2: Variable payoff bias, fixed salience bias

Next, we consider a similar model but replace the fixed payoffs bias with a variable payoffs bias. The behavior of level 0 players is thus changed from model A1 only in the first condition of Figure 3, whose probability of choosing s_j is changed from $(.5 + p_U)$ to p_{ij}^0. The behavior of level 1 players is not changed at all, and remains identical to model A1.

3.1.3 Model A3: Fixed payoff bias, variable salience bias

An alternative that does result in a slightly different model, is to model replace the fixed label bias (when it comes into play) with a variable effect. Details of level 0 behavior are shown in Figure 4.

Figure 4: Level 0 players in model A3

Condition on payoffs	Condition on salience	Probability chooses sj
$U_j > U_k$	$p_{ij}^0 \geq \frac{p_{ik}^0}{(1 + x_1\%)}$	$(.5 + p_U)$
	$p_{ij}^0 < \frac{p_{ik}^0}{(1 + x_1\%)}$	p_{ij}^0
$U_j < U_k$	$p_{ij}^0 > p_{ik}^0(1 + x_1\%)$	p_{ij}^0
	$p_{ij}^0 \leq p_{ik}^0(1 + x_1\%)$	0
$U_j = U_k$	$\frac{p_{ik}^0}{(1+x_1\%)} \leq p_{ij}^0 \leq p_{ik}^0(1 + x_1\%)$	.5
	$p_{ij}^0 < \frac{p_{ik}^0}{(1 + x_1\%)}$	p_{ij}^0
	$p_{ij}^0 > p_{ik}^0(1 + x_1\%)$	p_{ij}^0

From these, we derive the proportion of level 1 players choosing strategy s_j. A level 1 player *i* will choose s_j as follows:

if $U_j > U_k$ and his/her beliefs satisfy $p_{ij}^1 \geq \frac{p_{ik}^1}{(1+x_1\%)}$

if $U_j \geq U_k$ and /her beliefs satisfy $p_{ij}^1 < \frac{p_{ik}^1}{(1+x_1\%)}$ and $p_{ij}^1 U_j > p_{ik}^1 U_k$

if $U_j \leq U_k$ and /her beliefs satisfy $p_{ij}^1 > p_{ik}^1(1 + x_1\%)$ and $p_{ij}^1 U_j > p_{ik}^1 U_k$

if $U_j \leq U_k$ and /her beliefs satisfy $p_{ij}^1 \leq p_{ik}^1(1 + x_1\%)$ then the player will not choose s_j

if $U_j = U_k$ and beliefs satisfy $\frac{p_{ik}^1}{(1+x_1\%)} \leq p_{ij}^1 \leq p_{ik}^1(1 + x_1\%)$ then player will choose sj with probability .5;

3.1.4 Model A4: Variable payoff bias, variable salience bias

The behavior of level 0 players is thus changed from model A3 only in the first condition of Figure 4, whose probability of choosing s_j is changed from $(.5 + p_U)$ to p_{ij}^0. The behavior of level 1 players is not changed at all, and remains identical to model A3.

3.2 Structure B

In this alternative structure, which represents a sort of "opposite" approach to structure A, a level 0 player prefers the label that is more salient to him/her, unless that choice's payoff is x_2% lower than the other, in which case payoffs come into play. Put another way, as long the two strategies' payoffs are within x_2% of each other, a level 0 player prefers the more salient label, otherwise he/she prefers the higher payoff. It remains to model whether the labels and payoffs biases are fixed or variable.

3.2.1 B1: Fixed Label bias, Fixed Payoffs bias

First, consider a fixed bias for labels and for when payoffs come into play. Assume without loss of generality that for a given level 0 player *i*, $p_{ij}^0 > p_{ik}^0$. Then if $U_j > \frac{U_k}{(1+x_2)}$ level 0 player *i* prefers s_j with probability $(.5 - p_L)$. Otherwise, he/she chooses the higher payoff with probability equal to $(.5 + p_U)$. The detailed behavior of a level 0 player in this model is shown in Figure 5.

Figure 5: Level 0 players for model B1

Condition on salience	Condition on payoffs	Probability chooses sj
$p_{ij}^0 > p_{ik}^0$	$U_j \geq \frac{U_k}{(1 + x_2\%)}$	$(.5 + p_L)$
	$U_j < \frac{U_k}{(1 + x_2\%)}$	$(.5 - p_U)$

$p_{ij}^0 < p_{ik}^0$	$U_j > U_k(1 + x_2\%)$	$(.5 + p_U)$
	$U_j \le U_k(1 + x_2\%)$	0
$p_{ij}^0 = p_{ik}^0$	$\frac{U_k}{(1+x_2\%)} \le U_j \le U_k(1 + x_2\%)$	.5
	$U_j < \frac{U_k}{(1 + x_2\%)}$	$(.5 - p_U)$
	$U_j > U_k(1 + x_2\%)$	$(.5 + p_U)$

From these, we derive the proportion of level 1 players choosing strategy s_j.

If $p_{ij}^1 > p_{ik}^1$ and $U_j \ge \frac{U_k}{(1+x_2\%)}$ then the player will choose sj if $(.5 + p_L)U_j > (.5 - p_L)U_k$

If $p_{ij}^1 \ge p_{ik}^1$ and $U_j < \frac{U_k}{(1+x_2\%)}$ then the player will choose sj if $(.5 - p_U)U_j > (.5 + p_U)U_k$

If $p_{ij}^1 \le p_{ik}^1$ and $U_j > U_k(1 + x_2\%)$ then the player will choose sj if $(.5 + p_U)U_j > (.5 - p_U)U_k$

If $p_{ij}^1 \le p_{ik}^1$ and $U_j \le U_k(1 + x_2\%)$ then the player will not choose s_j

If $p_{ij}^1 = p_{ik}^1$ and $\frac{U_k}{(1+x_2\%)} \le U_j \le U_k(1 + x_2\%)$ then the player will choose s_j with probability .5

3.2.2 B2: Fixed Label bias, Variable Payoffs bias

Next, consider a variable bias when payoffs come into play. Assume without loss of generality the for a given level 0 player *i*, $p_{ij}^0 > p_{ik}^0$. Then if $U_j > \frac{U_k}{(1+x_2)}$ level 0 player *i* prefers s_j with a fixed bias. Otherwise, he/she chooses sj with probability equal to $\frac{U_j}{U_j+U_k}$. Figure 6 presents details.

Figure 6: Level 0 players for Model B2

Condition on salience	Condition on payoffs	Probability chooses s_j
$p_{ij}^0 > p_{ik}^0$	$U_j \geq \frac{U_k}{(1 + x_2\%)}$	$(.5 + p_L)$
	$U_j < \frac{U_k}{(1 + x_2\%)}$	$\frac{U_j}{U_j + U_k}$
$p_{ij}^0 < p_{ik}^0$	$U_j > U_k(1 + x_2\%)$	$\frac{U_j}{U_j + U_k}$
	$U_j \leq U_k(1 + x_2\%)$	0
$p_{ij}^0 = p_{ik}^0$	$\frac{U_k}{(1+x_2\%)} \leq U_j \leq U_k(1 + x_2\%)$	$.5$
	$U_j < \frac{U_k}{(1 + x_2\%)}$	$\frac{U_j}{U_j + U_k}$
	$U_j > U_k(1 + x_2\%)$	$\frac{U_j}{U_j + U_k}$

The proportion of level 1 players choosing strategy s_j in this version is then derived.

If $p_{ij}^1 > p_{ik}^1$ and his/her beliefs satisfy $U_j \geq \frac{U_k}{(1+x_2\%)}$ then the player will choose s_j if $(.5 + p_L)U_j > (.5 - p_L)U_k$

If $p_{ij}^1 \geq p_{ik}^1$ and $U_j < \frac{U_k}{(1+x_2\%)}$ then the player will choose sj if $\frac{U_j}{U_j+U_k} U_j > \frac{U_k}{U_j+U_k} U_k$

If $p_{ij}^1 \leq p_{ik}^1$ and $U_j > U_k(1 + x_2\%)$ then the player will choose sj if $\frac{U_j}{U_j+U_k} U_j > \frac{U_k}{U_j+U_k} U_k$

If $p_{ij}^1 \leq p_{ik}^1$ and $U_j \leq U_k(1 + x_2\%)$ then the player will not choose s_j

If $p_{ij}^1 = p_{ik}^1$ and $\frac{U_k}{(1+x_2\%)} \leq U_j \leq U_k(1 + x_2\%)$ then the player will choose sj with probability .5

3.2.3 B3: Variable Label bias, Fixed Payoffs bias

Model B3 posits a variable salience bias and a fixed payoffs bias. This model differs from model B1 only in the first condition of Figure 5 whose probability is changed from $(.5 + p_L)$ to p_{ij}^0. Level 1 players' behavior is also identical to Model B1, except for the first condition which becomes: If $p_{ij}^1 > p_{ik}^1$ and his/her beliefs satisfy $U_j \geq \frac{U_k}{(1+x_2\%)}$ then the player will choose sj if $p_{ij}^1 U_j > p_{ik}^1 U_k$.

3.2.4 B4: Variable Label bias, Variable Payoffs bias

Finally, consider model B4 with variable salience bias and a variable payoffs bias. This model differs from model B2 only in the first condition of Figure 6 whose probability is changed from $(.5 + p_L)$ to p_{ij}^0. Level 1 players' behavior is also identical to Model B2, except for the first condition which becomes: If $p_{ij}^1 > p_{ik}^1$ and his/her beliefs satisfy $U_j \geq \frac{U_k}{(1+x_2\%)}$ then the player will choose sj if $p_{ij}^1 U_j > p_{ik}^1 U_k$.

3.3 Structure C: Payoffs and Labels considered jointly

Finally, we consider a structure in which level 0 players respond simultaneously to both labels and probabilities, with neither of them having logical primacy over the other. In these models, level 0 players are guided by the "product" of label salience and the corresponding payoff.

3.3.1 C1: Fixed effect of "Product" of Payoff and Label Salience

The first of two models we consider has a fixed effect, whereby a level 0 player *i* favors strategy s_j with a fixed bias p_{UL} if $p_{ij}^0 U_j > p_{ik}^0 U_k$. Level 1 players then choose s_j if their beliefs satisfy $p_{ij}^1 U_j > p_{ik}^1 U_k$, and the fraction of such players is is estimated by the fraction of guessers whose guesses satisfy $g(p_{\cdot j}^0) U_j > g(p_{\cdot k}^0) U_k$ as usual. We also allow a free parameter for this model. With this free parameter *k*, level 0 player *i* chooses strategy s_1 if $\frac{p_{ij}^0}{p_{ik}^0} > k \frac{U_k}{U_j}$.

3.3.2 C2: Variable effect of "Product" of Payoff and Label Salience

In the second variation, the level 0 player chooses strategy s_j with a probability equal to the relative magnitude of the product of its label salience and payoff, i.e. $\frac{p_{ij}^0 U_j}{p_{ij}^0 U_j + p_{ik}^0 U_k}$. In this case, level 1 players choose s_j if their beliefs satisfy $\frac{p_{ij}^1 U_j}{p_{ij}^1 U_j + p_{ik}^1 U_k} U_j > \frac{p_{ik}^1 U_k}{p_{ij}^1 U_j + p_{ik}^1 U_k} U_k$, with the fraction of such level 1 players estimated in the usual manner. In models C1 and C2, payoffs have significant weight, first influencing the naïve choices attributed to level 0 players, and then again influencing the utility-maximizing choices made by level 1 players, *given* level 0 choices.

3.4 Special Cases

When structure A's parameter x_1 is set sufficiently high –as high as the greatest percentage difference that any subject assigns to any pair of labels – the result is a special case in which level 0 players are biased towards the higher payoff exclusively. Similarly, when structure B's parameter x_2 is set sufficiently high – as high as the greatest percentage difference that any subject assigns to any pair of labels – the result is a special case in which level 0 players are biased towards the more salient label. These are the only truly reduced special cases. The logic of the models when $x_1 = 0$ or $x_2 = 0$ is presented in Table 1

Table 1: Intuition of Special Cases

	Level 0	**Level 1**
Structure A's x_1 sufficiently high	Choose higher payoff	Choose higher payoff
Structure B's x_2 sufficiently high	Choose more salient label	Choose more salient label
$x_1 = 0$:	If higher payoff and more salient, invoke a (positive) payoffs bias; If higher payoff and less salient, invoke a (negative) labels bias; If lower payoff and more salient, invoke a (positive) labels bias; If lower payoff and less salient, forget it	If higher payoff and more salient, choose it; If higher payoff and less salient, consider the (negative) labels bias; If lower payoff and more salient, consider the (positive) labels bias; If lower payoff and less salient, forget it
$x_2 = 0$:	If more salient and higher payoff, invoke a (positive) labels bias; If more salient and lower payoff, invoke a (negative) payoff bias;	If more salient and higher payoff, choose it; If more salient and lower payoff, consider the (negative) payoff bias;

	If lower salience and higher payoff, invoke a (positive) payoff bias; If lower payoff and less salient, forget it	If lower salience and higher payoff, consider the (positive) payoff bias; If lower payoff and less salient, forget it

3.5 Estimating the models' predictions

The models' predictions depend on the proportions of level 1 players whose beliefs satisfy various conditions. As these probabilities are unknown, we follow Bardsley et al. in formulating testable predictions that relate behavior in a coordination game to the behavior of subjects in guessing treatments, patterned after Bardsley et al.'s picking and guessing treatments. In Bardsley et al.'s picking treatment, subjects were asked to pick one of a set of labels. Adapting this treatment to our purposes, we rename it as an "assessing" treatment, and ask players to state, for each label, the probability of their selecting it. In Bardsley et al.'s guessing treatment, subjects were asked to guess which label was most frequently picked by pickers. Adapting this treatment to our purposes, our guessers are asked to guess, for each label, the average probability assigned by assessors. We will denote the guess made by subject *i* in a guessing treatment about average probability $p_{\cdot j}^{0}$ among level 0 players, as $g_i\left(p_{\cdot j}^{0}\right)$.

The proportions of level 1 players whose beliefs satisfy the various conditions are estimated by using guessing players' $g\left(p_{\cdot j}^{0}\right)$ and $g\left(p_{\cdot k}^{0}\right)$ in lieu of p_{ij}^{1} and p_{ik}^{1} in the stated conditions. For example, the proportion of level 1 players whose beliefs satisfy $p_{ij}^{1} \geq \frac{p_{ik}^{1}}{(1+x_1\%)}$ -- a condition that arises in structure A -- is estimated by the proportion of subjects in a guessing treatment[2] whose guesses satisfy $g\left(p_{\cdot j}^{0}\right) \geq \frac{g\left(p_{\cdot k}^{0}\right)}{(1+x_1\%)}$.

[2] Hypothetically, if a guesser imagines a skewed distribution, it is possible that he/she could think that one label had higher average salience but that the other label had higher salience to a larger fraction of assessors. In this sense, a more perfect treatment to estimate this fraction would be to ask subjects to guess which label had higher salience to a larger fraction of assessors. For many reasons, we chose to neglect this possibility. First, because for structure C we need the guesses of average salience, which information is lost if we ask which label had higher salience to a larger fraction of assessors. We could have run multiple versions of the guessing treatment, but we deemed it unnecessary, first because the possibility of a guesser having in mind a distribution that is skewed in that way seemed likely pertain to only a small minority if any guessers, second because it does not affect our data analysis in a *systematic* way, and third since we anyhow adopt a homogeneity assumption for level 1 players

Finally, there are two approaches to modeling level 2 players. Under one possible simplifying assumption, the distribution of their beliefs is identical to the distribution at level 1, so no separate account is needed. In an alternative that we will also allow, level 2 players know the distribution of level 1 behavior and respond perfectly. This approach requires that we take separate account of level 2 players. Let r^1 denote the proportion of level 1 players satisfying these conditions and therefore choosing s_j under a given model. Then the proportion of higher-order players who choose s_j under that model is 100% if $r^1 U_j > (1 - r^1) U_k$, 0% otherwise. We will make predictions under the first approach and label it as $q = 1$ meaning that all players are level 1, and under the latter assumption we will make predictions for $q = .7$

4 Experiments

We ran two separate sets of experiments, for games with and without stimuli. Study 1 reports results of the game with no stimuli, which is the game in the familiar form presented in Figure 1. The meaning of games with stimuli is presented in section 5 below. Much of the methodology is common to both studies, but the differences are sufficiently prominent that we opt to present the two separately.

4.1 Study 1: No Stimuli

4.1.1 Methodology

The experimental design is patterned after Bardsley et al. (2008), who devised three experimental treatments: picking, guessing, and coordinating. Our picking treatment, which we rename as "assessing", asks players to provide a percentage value for each label, not just to choose one. More specifically, the instructions asked the subject to state the probability that they would pick each label from among the two choices, with the two percentages totaling 100%. The instructions given to guessers quoted the instructions had been given to pickers, and asked them (the guessers) to guess the mean of the probabilities that they believe would have been assigned by the pickers. Twenty-five assessors provided responses for the full set of thirty-one label pairs. Their responses were used (only) as the basis to reward the group of thirty-seven subjects in a guessing treatment. Thirty-eight subjects participated in a coordination game treatment. In all treatments, the two labels in each pair were

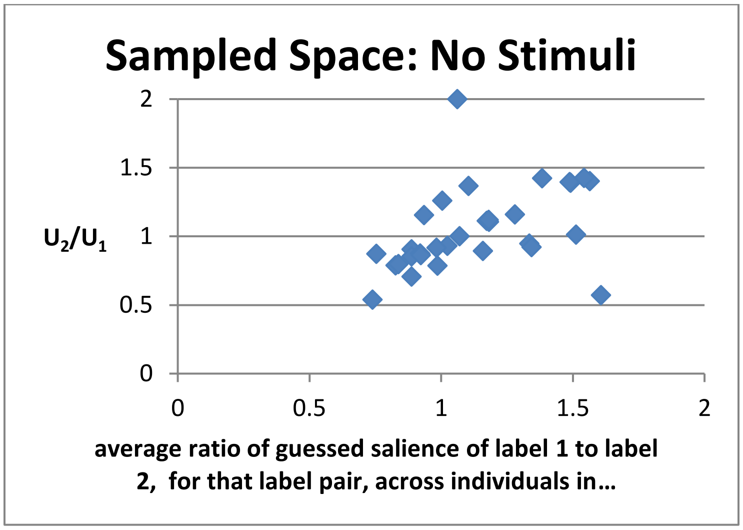
whereby they view level 0 players as homogenous, and this assumption, if applied also to guessers, rules out any such effect (less restrictive assumptions can also rule it out).

presented in a random order to each subject, and subjects were made aware of this so that they would not attempt coordination on the basis of label position.

Each game in the experiment could be done on the basis of any pair of labels, as the theory is not sensitive to their meaning, nature, probabilities, etc. The origin of the particular label pairs used in both Study 1 and Study 2, is a focus group that was shown a series of thirty-one pictures and was asked to list labels that come to mind in response to each one. The researchers then chose two of the generated labels from each image, to form a pair. The images are the very same ones that are used in Study 2, so for that study, both labels have some meaning with respect to the image. But no harm is done by using the same set of label pairs in Study 1 where the image has been removed. The benefit of using the same label pairs is that it provides some commonality between the two admittedly different studies, to allow possible comparisons and interpretation. Experiments were conducted in the leading national university of a non-US country, and the labels used were in the country's native language. The Appendix and various figures show labels in translation to English, but subjects saw them only in their native language.

After running the guessing treatment, the researchers set up the coordinating treatment by setting, for each strategy s_j, a payoff U_j that was imperfectly inversely proportional to the average of the ratio of salience values guessed by guessers. The coordinating payoffs were chosen such that the ratio $\overline{\left(\frac{g(p_{\cdot 1}^0)}{g(p_{\cdot 2}^0)}\right)} : \frac{U_2}{U_1}$ was distributed around 1, where $\overline{\left(\frac{g(p_{\cdot 1}^0)}{g(p_{\cdot 2}^0)}\right)}$ denotes the average ratio (slightly different from the ratio of averages) of guesses regarding the label salience of labels L_1 and L_2 across individuals in the guessing treatment. Figure 7 presents the sampled part of the space. It is a noisy swath around the line $\overline{\left(\frac{g(p_{\cdot 1}^0)}{g(p_{\cdot 2}^0)}\right)} = \frac{U_2}{U_1}$. The coordinating payoffs were calibrated to range from about 50-150 points. An Appendix shows the full set of label pairs, together with the average guesses of their salience by subjects in a guessing treatment, and the payoff for coordinating on each label. A second appendix shows screenshots of instructions given to subjects.

Figure 7: sampled pairs of average relative salience versus relative payoff



Regarding incentives, subjects in the *assessing* treatment received a fixed payment for their participation. They were asked to assign a percentage to each label. The importance of their honest assessments to the research was stressed. These responses were used only as a basis for rewarding subjects in the *guessing treatment* described next. Subjects in the *guessing* treatment received a payment that increased with the accuracy of their estimations. For each label they guessed the average of the probabilities that were assigned by subjects in the assessment task, and received for that guess a number of points equaling 100% minus the absolute difference between their guess and the true average. At the conclusion of the session, guessing subjects' final payoff in real money was calculated according to the formula: $\left(\frac{Y_i}{\bar{Y}}\right)M$ where Y_i denotes player *i*'s total accumulated points for all guesses, $\bar{Y}$ is the average points accumulated across players, and *M* is a parameter set by the researcher to approximately USD $20. Subjects in the coordination game treatment described next, similarly received payments according to that same formula, again with an average payment of USD $20. All sessions lasted less than one hour.

Figure 8 shows an example of how coordination-game predictions were made for various models, based on individual-level data from the guessing treatment. There are two strategies, s_j (arbitrarily named) which is associated with the label L_j "Europe" and a coordinating payoff $U_j = 87$, and s_k which is associated with the label L_j "Nightime" and a coordinating payoff $U_k = 108$. The figure shows the guessing treatment data for three guessers, and the coordination-game predictions that would be made by models A1 if there were just these three guessing treatment subjects, for free parameter values of $x_1 = 30\%$ and p_L=.1.

Figure 8: Example calculation

Guessing Treatment Subject	Label	Average Salience Guess (%)	Coordinating Payoff set for coordinating treatment, in light of guessing results	Model A1 calculation element: Do this individual's guesses satisfy $U_j < U_k$ and $g(p_{\cdot j}^0) \geq g(p_{\cdot k}^0)(1+x_1\%)$ when $x_1 = 30\%$?	Model B1 calculation element: Do this individual's guesses satisfy $g(p_{ij}^0) > g(p_{ik}^0)$ with $U_j \geq \frac{U_k}{(1+x_2\%)}$, when $x_2 = 30\%$?
1	Europe s_j	.7	87	1	1
1	Nighttime s_k	.3	108		
2	Europe s_j	.85	87	1	1
2	Nighttime s_k	.15	108		
3	Europe s_j	.60	87	0	1
3	Nighttime s_k	.40	108		

Based on just these three guessers, one would predict according to model A1 for the given parameter values that 2/3 of level 1 players would choose strategy s_j if $(.5 + p_L)U_j > (.5 - p_L)U_k$, which is true here if $p_L > .055$, while for model B1, 100% would choose s_j under the same condition. From such percentages, we also derive the percentages of higher-order players choosing s_j. Finally, based on all the above, we derive the percentage of players that is predicted by each model to choose each strategy in a coordination game under various parameter settings. These predictions are then compared with the actual percentages choosing each label in the coordination game treatment.

Figure 9 shows a label pair, sample data showing the average label salience values given by assessors and guessers for the two labels in this particular pair, coordinating payoffs set by the researchers for the coordination game, the coordinating treatment predictions for this image made for Model s A1 and B1 on the basis of the fictitious example data from Figure 8 (in the real data analysis, these predictions are based on the full guessers data set), and the actual observed behavior of coordinators, for this one label pair among thirty-one. The predictive ability of the various models was evaluated in this manner, based on the full set of thirty-one label pairs. While previous research often reports a coordination index

(Bardsley, Mehta et al. 2009), in our context it is important and more informative to report which choice players make in what proportions; to the extent coordination rates would be of interest, these could of course be directly derived. The statistical measure of predictive ability is the correlation or R-square between the percentage choosing an (arbitrarily chosen) reference label from each pair, and the percentage predicted by the model in question. AIC values do not add any information about model fit beyond the simple R-square or correlation.

Figure 9: Example of Predictions and Actual choices

	Payoff set by researchers for coordinating on that label in coordination treatment	% coordination players predicted by Model A1 to choose this label assuming *q* = 1 (or .7) with $x_1 = 30\%$ and p_L=.1	% coordination players predicted by Model B1 to choose this label assuming *q* = 1 (or .7%) with $x_2 = 30\%$ and p_L=.1	% coordination subjects choosing this label
Label 1: Europe	87	66.6% (77%)	100% (100%)	6%
Label 2: Nighttime	109	33.3% (23%)	0% (0%)	94%

4.1.2 Results of Study 1 with no Stimuli

A first session of a coordinating treatment was conducted with eighteen subjects, the first batch from a total of thirty-eight subjects. Results were consistent and extreme, with almost every subject choosing the strategy with higher payoff in almost each case of the thirty-one. This corresponds to proposed models A1-A2 with x_1 set sufficiently high, and to B1-B4 with parameter x_2 set to 0. Structure C performed reasonably well, but not nearly as well as models that considered only payoffs. It will be recalled that structure C places significant weight on payoffs, though with a different logic than models in structures A-B.

Results are summarized in Table 2. For structures A and B, we show results when x_1 or x_2 take extreme values, and one moderate value, as sample points to help illuminate behavior.

Table 2: Results of First set of Coordinating Data testing models

Scenario	Model	Free Parameter Values	R-square when q=1 (q=.7)	Comments about level 1 players
1	A1-A4	$x_1 = 200\%$	.86 (.86)	Optimal parameter values for Structure A; Reduces to payoffs only
2	A1-A2	$x_1 = 40\%, p_L = .2$	.32 (.49)	Choose higher payoff unless labels differ by >40%, in which case bias towards salient label
3	A3-A4	$x_1 = 40\%, p_L = .2$	.45 (.57)	
4	B1-B2	$x_2 = 100\%$	Negative Correlation -.38	Fixed Labels bias only
5	B3-B4	$x_2 = 100\%$	Negative Correlation -.24	Variable Labels bias only
6	B1-B2	$x_2 = 40\%, p_U = .2$	0 (0)	
7	B3-B4	$x_2 = 40\%$ $p_U = .2$	.05 (.02)	
8	B1-B4	$x_2 = 0$	.86 (.86)	Optimal parameter values for Structure B;
9	C1	$k = 1$	.08 (.15)	
10	C1	$k = .5$	0	
11	C2	No free parameters	.52 (.49)	Optimal model within Structure C

It can be clearly seen that the best models by far are those in which level 0 players are assumed to choose the higher payoff. Note that the high values chosen for parameters x_1, x_2 in scenarios 1, 4, 5 have no particular theoretical meaning; rather, their meaning is simply that in our particular data set, $x_1 = 200\%$ is sufficiently high to reduce that model to considering payoffs only because 200% was the largest relative difference in salience assigned by any guessing player to a pair of labels. Similarly for payoffs, the largest payoff differential was 100%.

As a result of the consistency of these first results, it was decided that for the second batch of twenty subjects, researchers would re-calibrate the payoff differential so that the strategy (say s_1) with the less salient label (on average) was assigned a payoff that was only very slightly higher, so that the sampled space satisfied $\overline{\left(\frac{G_1}{G_2}\right)} \ll \frac{U_2}{U_1}$ rather than $\overline{\left(\frac{G_1}{G_2}\right)} = \frac{U_2}{U_1}$. The idea was to ascertain if even small payoff advantage was sufficient to serve as a focal point even in the face of a significant disadvantage in label salience. A second set of twenty subjects played in a coordination treatment with these new payoffs, and here, although results were less extreme, the best models still focused exclusively on payoffs. The highest R-squares, .7 (.67) with q=1 (q=.7), were again achieved when with $x_1 = 8$ and $x_2 = 0$, reducing the models to considering payoffs only. Model C2 performed less well here, with an R-square of .16.

4.1.3 Study 1: Discussion

There was no evidence of across-game learning. Figures 13a-13b plot the coordination index (Bardsley, Mehta et al. 2009) – a measure of coordination rates that removes the accidental effect of random partnering -- against the order in which the image was presented to subjects. There is no upward statistically significant trend over time. Players in the coordination game appear to have chosen from the outset to always choose the higher payoff, regardless of label salience.

Figure 10a Coordination index by order of games, set 1

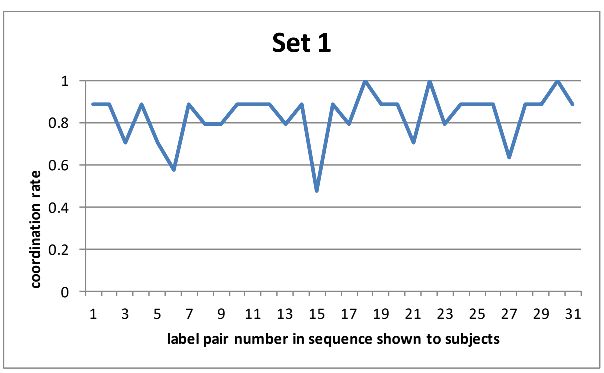
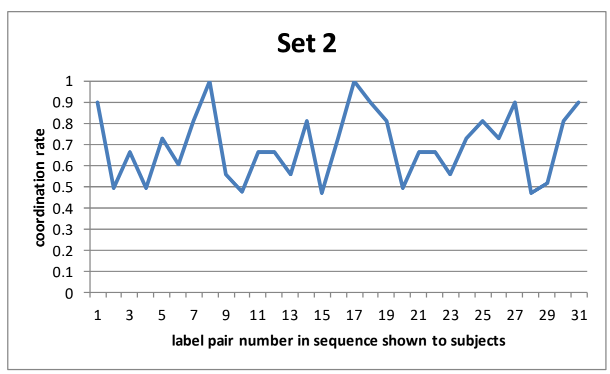


Figure 10b Coordination index by order of games, set 2



For thirty-eight subjects on thirty-one label pairs, results consistently point to a near exclusive focus on payoffs. There were also significant differences in performance between the fixed and variable effects versions of structures A and B. In particular, results were better for models with a variable effect of labels. However, these differences are limited to the sub-optimal ranges of parameter values, and are therefore less meaningful. The main result is the simple reliance on payoffs for coordination.

Within cognitive hierarchy, these results are easily explained and perhaps expected, because payoffs are visible, concrete numbers, while label salience is an abstraction. This difference leads level 0 players to respond exclusively to the payoffs. Beyond that, our results complement those of Crawford et al. (2008) who found that level 0 players are conceived (by strategic players) as having a slight fixed bias to the higher payoff. This had left open the question of whether labels play any role at all in their game. Our results support an interpretation of behavior in their game to mean that level 0 players as giving a slight fixed bias to the higher payoff *and as completely ignoring label salience*. This is because we do not see any basis within cognitive hierarchy for theorizing that level 0 players assign no role to labels in our game where strategies have different payoffs, but do assign a role to labels in their game where players have different payoffs.

The simplicity of results for Study 1 makes it seem unnecessary to have explored such a variety of possible models. As we will see in the following section, however, behavior in games with reference stimuli is different and more complex, and the variety of models helps to illuminate behavior.

5 Study 2: Coordination games with reference stimulus

This section introduces the second version of the game and reports experimental results.

5.1 Motivation

In this version, strategies are chosen with respect to a stimulus. To make this concrete, Figures 14a-b show screenshots of the game with and without a reference stimulus. In this section, we explain and motivate our interest in this version of the game, and specifically, in modeling how players respond to the combination of payoffs and label salience.

Figure 11a Screen Layout, games with no stimulus

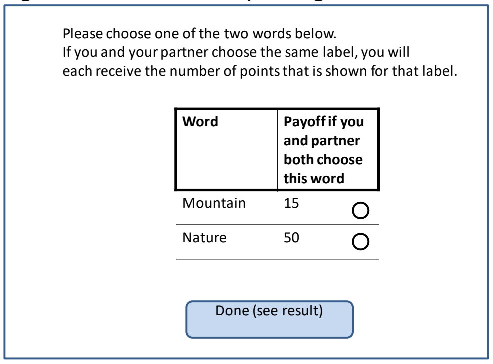
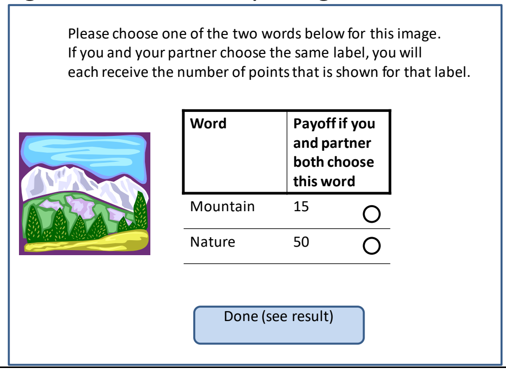


Figure 11b Screen Layout, games with stimulus



Research on coordination games is frequently motivated as characterizing economic activity in many settings (Cooper, DeJong et al. 1990; Goyal and Janssen 1996; Young 1996). Experimental work on focal points, which explores people's ability to coordinate in such games, has employed a variety of tasks, all of which require subjects to choose one among many labeled strategies. In most cases, the research design enumerates a number of labeled strategies from which subjects are asked to choose, as in Mehta et al.'s (1994) questions 11-20. In other cases, especially in earlier work, the strategies and their labels are not enumerated, as when subjects are asked to "Choose a Location", or "Choose a Date" in Mehta et al.'s questions 1-10. But what is common to all experimental tasks of which we are aware, is that the choice is being made without reference to any stimulus, context, or story that conveys to subjects the purpose for which they are making the choice.

We are motivated by the observation that in most situations, there is a context or stimulus, in the sense that the players wish to coordinate not for the sake of coordination per se, but for a contextual purpose. Consider a classic coordination game from Ochs (1990) in which buyers and sellers choose which location to go to. Coordination is achieved when buyers and sellers divide themselves among the various locations with the same proportions. An example might be Apple's introduction of an iPhone to a new market. Interested consumers attempt to anticipate where they have the best chances of obtaining the device, while Apple tries to anticipate the volume to supply to each location. Modeled as a focal point game, the two sides might be choosing between labeled store locations such as (say) "5th Avenue", "Soho", and so on. Players in such a setting are not choosing a place to "meet" per se, but a place to meet in order to make an iPhone transaction. If players were choosing a place to meet in order to go to dinner, then surely those same labels would have different degrees of salience. The one situation we can identify in which people wish to coordinate per se, but not for any reason, are situations in which two people have lost each other – in an amusement park, say -- and wish to re-unite. In almost every other economic or other setting we can conceive of, players wish to coordinate for an extrinsic reason, which provides a context from/within which labels derive their salience.

Electronic commerce represents an increasing proportion of all retail activity (Winters, Davie et al. 2011). Much economic activity on the World Wide Web can be characterized quite literally as a coordination game with meaningful labels, and here, too, the presence of reference stimuli is clear. Many searchers – whether for information or for products -- use search engines, which operate on the basis of matching the query words submitted by the searcher against a database of words called descriptors that represent various websites. It is a coordination game, because both sides choose words with the aim of matching one another. It is clear that searchers choose search words. As for websites, their descriptors are determined in one of two ways, both of which are also the result of active – and possibly strategic choices made by its owners. The first way is keyword ads, in which a website's owners contract with a search engine to display its ad whenever a searcher's query includes the specified word. The other way that websites get descriptors is via their organic text. Search engines assign every word that appears in a website as a descriptor for that website. Whether through keyword ads or organic text, website owners directly or indirectly determine the descriptors that are ultimately compared against users' query words. The result is a coordination game in which searchers and relevant websites choose query words and descriptors, respectively, with both sides preferring to choose the same term, as this will enable them to encounter each other. Moreover, it is established that both searchers (Spink and Saracevic 1997) and vendors (Lohr 2006; Clifford 2009) choose words strategically, as envisioned in the cognitive hierarchy framework. In this economic setting, coordination games with meaningful common knowledge labels are not just a valid metaphor for describing the interactions, but are a literal description, because the participants actually choose among strategies that are identified with words. Moreover, the players in this setting do not choose words a propos of nothing. Rather, the information or product being sought or sold represents a contextual stimulus with respect to which players on both sides choose labels, and with respect to which labels draw their salience.

This setting has also given rise to a concrete practical application of exactly the games considered here, where strategies are characterized by payoffs as well as labels, and in the clear presence of a reference stimulus. The practical problem arises because while search engines can easily assign descriptors to text by extracting words from a website, it cannot easily assign labels to images, which computers cannot “see”. The ESP game (von Ahn and Dabbish 2004) is a coordination game that was designed to address this practical problem, and was deployed by Google as “Google Image Labeler” from 2006 until 2011. In the game, two players each see an image and are asked to suggest labels for it, with the players receiving points if – and only if -- they choose the same term. The ESP game is designed to be sufficiently fun that players will play it voluntarily, with the benefit to the search engine that the images will thereby be labeled with meaningful descriptors. A limitation of the game was that – for reasons that are clear in light of focal point theories -- players tended to choose only the terms that are most “obvious” in some sense, and thus of least benefit to the search engine seeking to exploit human intelligence. Ongoing research in computer science aims to invent payoff schemes that reward players for choosing less obvious labels that may have a lower chance of resulting in coordination (Weber, Robertson et al. 2008). The problem facing game designers is that essentially nothing is known about how players behave in such a game, with higher payoffs for matching less salient words. This is precisely the sort of game we consider here.

A question arises regarding the meaning of degree of label probabilities in the presence of a reference stimulus. As discussed in section 2.3.2, the literature on focal points with no reference stimulus supports a number of possible conceptualizations of individual-level degrees of label salience, including the extent, probability, or relative frequency with which a label enters one’s mind, while for games *with* a reference stimulus, Ho and Chen (2009) conceive of it as the probability or relative frequency with which the label is expected to co-occur with the stimulus in the same context (e.g. webpage).

Based on the totality of the above literature, three aspects emerge regarding the nature of the connection between the stimulus and the values that may be assigned to labels: (a) the extent or probability to which the label might enter one’s mind in response to the image; (b) the extent to which it seems an appropriate description of the image; (c) the probability one would expect to see the label in the same context as the image. Although conceptually distinct, these three aspects all regard the strength of association between the stimulus and the label.

In this section, we have motivated our interest in coordination games in the presence of reference stimuli, with respect to which players are choosing among labeled strategies. The formal models being tested are identical to the two games, except that for Study 2, all probabilities are understood to be conditioned on the given reference stimulus. It is of course possible to also develop theory that explicitly accounts for this extra structure; in this paper, we do not advance such a theory.

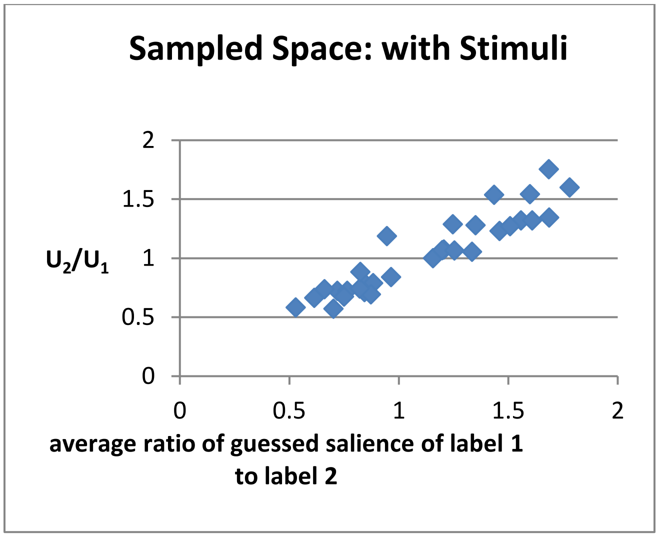
5.2 Experiments

5.2.1 Methodology

As discussed in section 5.1, there are a number of overlapping meanings to the degree of label salience in the presence of a reference stimulus. A preliminary experiment indicated that the three aspects are highly correlated. In light of this, and because of the nature of our research purpose and the lack of any specific theoretical guidance on this point, we deemed it sufficient to consider all three aspects in combination. This means that subjects in our assessing and guessing treatments were instructed to think of the values they assign in terms of all three aspects enumerated above (see Appendix). In addition, unlike the game with no reference stimulus, here our assessing (and guessing) subjects were instructed that when assigning numbers to each of two labels for a given image, they should treat each number separately and the numbers did not need to sum to 100. If we denote the raw numbers thus elicited as v_{ij}^{0}, we computed the necessary probabilities p_{ij}^{0} as $p_{ij}^{0} = \frac{v_{ij}^{0}}{v_{ij}^{0}+v_{ik}^{0}}$, $p_{ik}^{0} = \frac{v_{ik}^{0}}{v_{ij}^{0}+v_{ik}^{0}}$. Our reason for instructing subjects to enter the two values separately in this study is that in the presence of a reference stimulus, there is meaning to the value assigned to a given label, while the meaning of a relative value is less straightforward. For example, one of the meanings supported in the literature is the probability that the label will be observed to co-occur with the stimulus. It would be odd to require that subjects convert those values into relative proportions (the probability that the label co-occurs with the stimulus, relative to the probability that the other label co-occurs with the stimulus?). This is opposite from an assessing task with no stimuli, where indeed the only straightforward meaning is relative, i.e. the probability that the subject would select the label from among the two; there is no other conceivable value to elicit (the value of the label per se). In this manner, the presence of a stimulus affects the meaning of the probabilities that describe level 0 players' behavior.

As with Study 1 with no stimuli, following elicitation of these guesses, preparations were made for a coordinating treatment by setting each strategy's payoff to be roughly inversely proportional to the relative salience of its label in the guessing treatment. The sampled space is depicted in Figure 12. As shown above in Figure 11b, instructions for the coordinating treatment were to choose a label to represent the image, with the payoff depending only on whether the two players chose the same label. Each player was shown the two labels in a random order, and this design element was disclosed to players so that they would not think to attempt coordination on the basis of label position. An Appendix shows the full set of images and associated label pairs, together with the average guesses of their salience by subjects in a guessing treatment, and the payoff for coordinating on each label.

Figure 12 Sampled space for Study 2



5.2.2 Results

Table 3 presents a summary of results, highlighting the conditions under which each model performs well or not. We choose a sample of points from the space of free-parameter values. For structures A and B, we show results when x_1 or x_2 respectively are set sufficiently high to reduce the models to labels only or payoffs only. We also show a mid-range value, and the optimal parameter settings under each structure.

Table 3: Results for Study 2

Scenario	Model	Free Parameter Values	R-square when q=1 (q=.7)	Comments – level 1 behavior described
1	A1-A4	$x_1 \geq 8$	Negative correlation -.58	Payoffs bias only
2	A1-A2	$x_1 = 13\%$, $p_L \geq .14$	.62 (.53)	Optimal parameter values for A; prefer higher payoff unless labels differ by 13%, in which case 14% bias towards more salient label
3	A3-A4	$x_1 = 13\%$	0	Same as scenario 2, with variable labels bias

4	A1-A2	$x_1 = 0$, $p_L \geq .14$	.57 (.6)	If more salient label and higher payoff, choose it; if less salient and lower payoff, forget it if less salient and higher payoff, or vice versa, labels bias
5	A3-A4	$x_1 = 0$	.03 (0)	
6	B1-B2	$x_2 \geq .8, p_L \geq .14$	.56 (.51)	Fixed labels bias only
7	B3-B4	$x_2 \geq .8, p_L \geq .14$	.29 (.17)	Variable labels bias only
8	B1-B4	$x_2 = 0$	Negative correlation -.58	If more salient label and higher payoff, favorable bias; if less salient and lower payoff, forget it; if less salient and higher payoff, or vice versa, payoffs bias
9	C1	$k = 1$	.03	
10	C1	$k = .5$	0	
11	C2	No free parameters	Negative correlation -.54	

The overall optimum is scenario 2, in which level 0 players are biased towards labels with a bias of 14%, whenever label salience differs by 13% or more, in effect treating payoffs as a tie-breaker only when labels have comparable salience. The next best are scenarios 4 and 6, in which level 0 players choose according to label salience with or without regard to payoffs respectively, with a fixed bias of 14% towards the more salient label. Models placing emphasis on payoffs did poorly. As between fixed and variable biases, fixed biases consistently out-performed comparable variables-bias models, including on optimal parameter settings.

Figures 13-17 depict the scatterplots of predicted vs. observed, for optimal parameter values under each model as well as other specified values. The left column is with q=1, the right column with q=.7. For consistency, we also show a scatterplot even when a model makes binary predictions. The statistical correlation and associated R-square are the appropriate basis for comparing models' predictions, even for models whose predictions are binary, as a phi coefficient yields the same result as a Pearson product moment correlation.

Figure 13a Scenario 1 with q=1

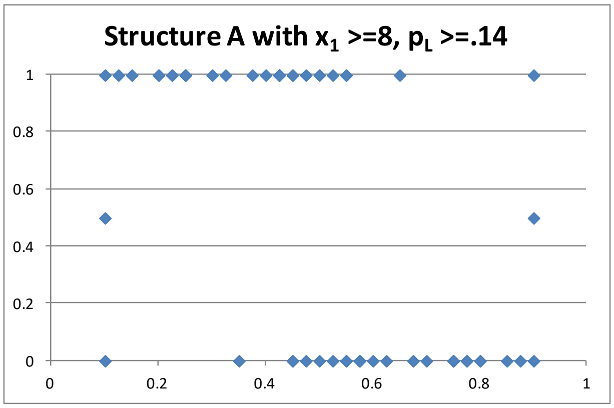


Figure 13b Scenarion 1 with q=.7

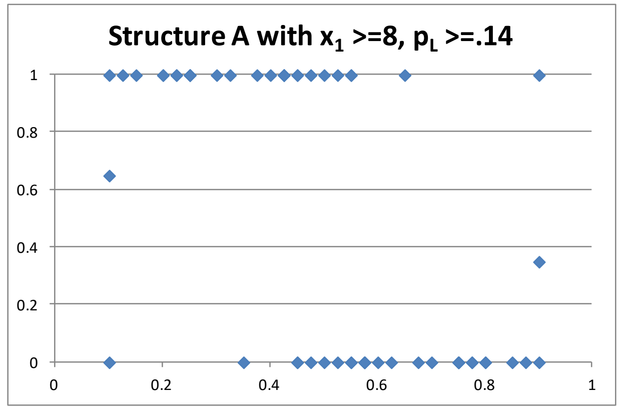


Figure 14a Scenario 2 with q=1

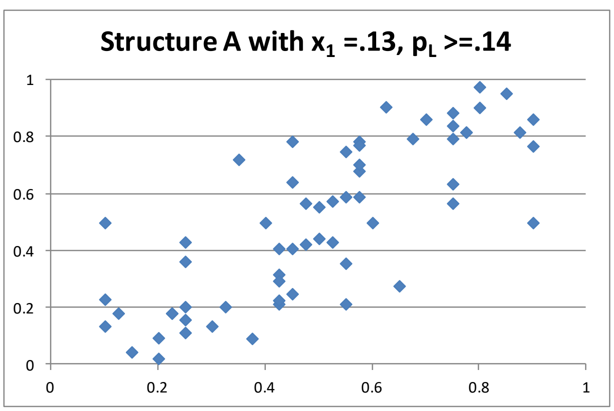


Figure 14b Scenario 2 with q=.7

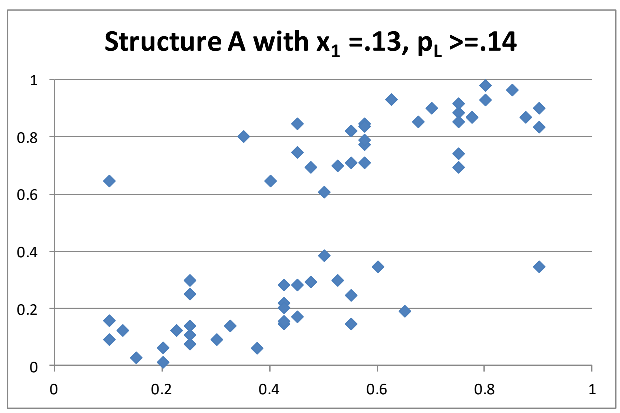


Figure 15a Scenario 4 with q=1

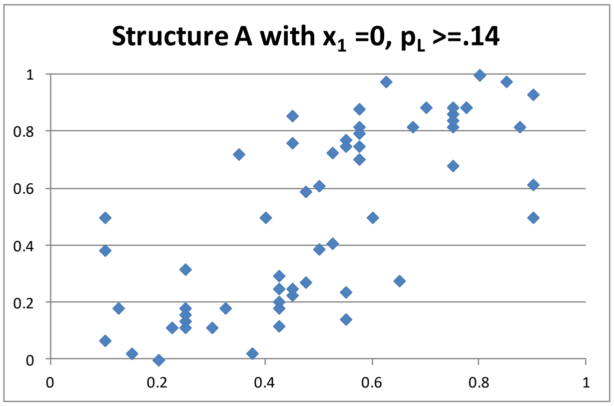


Figure 15b Scenario 4 with q=.7

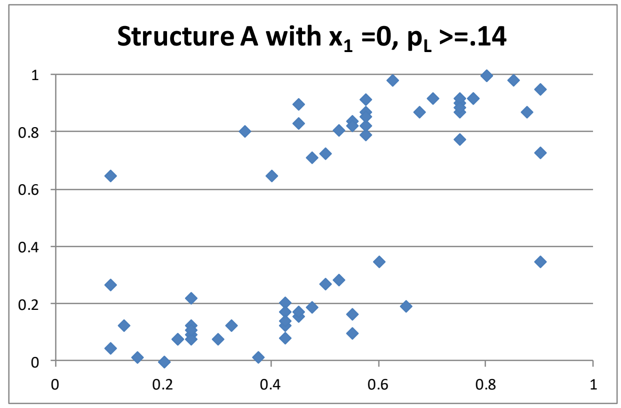


Figure 16a Scenario 6 with q=1

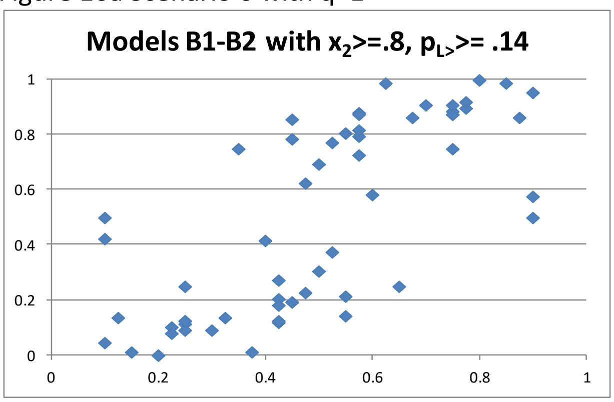


Figure 16b Scenario 6 with q=.7

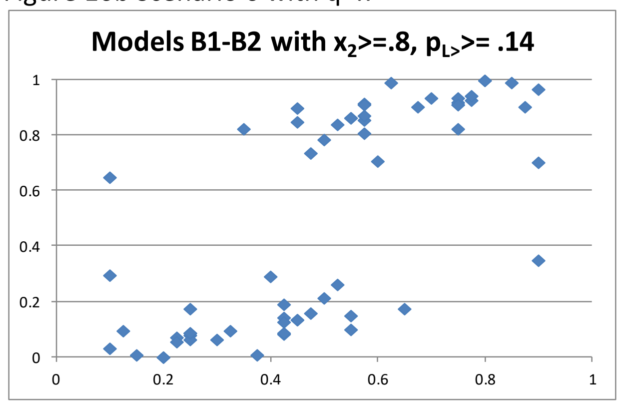


Figure 17a Scenario 7 with q=1

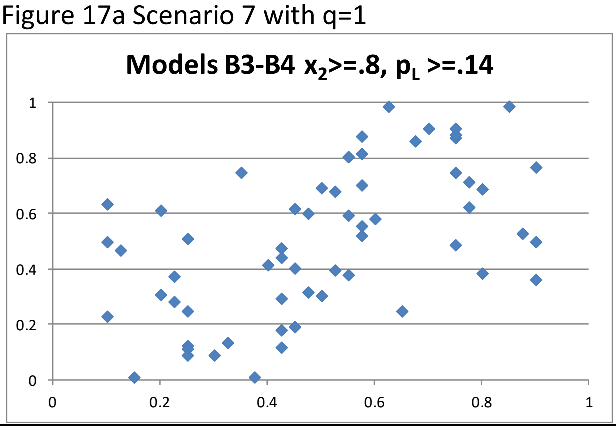
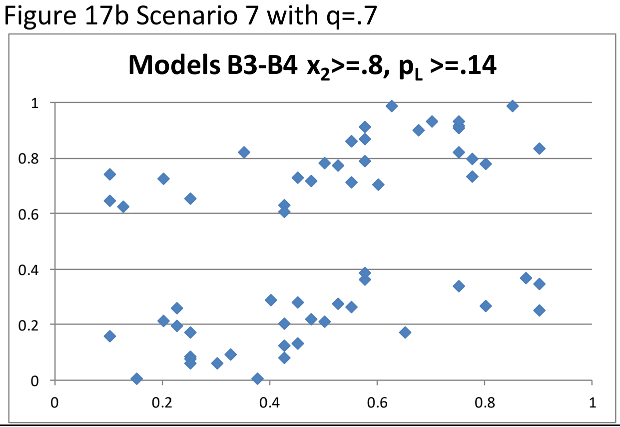


Figure 17b Scenario 7 with q=.7



All models' predictions were better under the assumption that all players were level 1, without higher order players. This is an artifact of the modeling approach in which, under the assumption that the distribution of beliefs of level 2 players differs from that of level 1, they are assumed to all have perfect knowledge of level 1 behavior and therefore they act in unison to further bi-polarize (narrow) the distribution of strategy choices.

5.2.3 Study 2: Discussion

The prominent result from this study is that in the presence of the reference stimulus, the data is explained by a model in which players choose according to labels, even against the combination of payoff and risk dominance.

There was no evidence of across-game learning. Figure 18 plots the coordination index against the order in which the image was presented to subjects. There is no upward trend over time. Figure 19 refines this by separately showing the percentage choosing the higher payoff and the percentage choosing the higher (on average) salience label. It is also clear from this figure that labels play an important role in determining choices, and apparently a more important role than payoffs.

Figure 18: Coordination index in order of games played

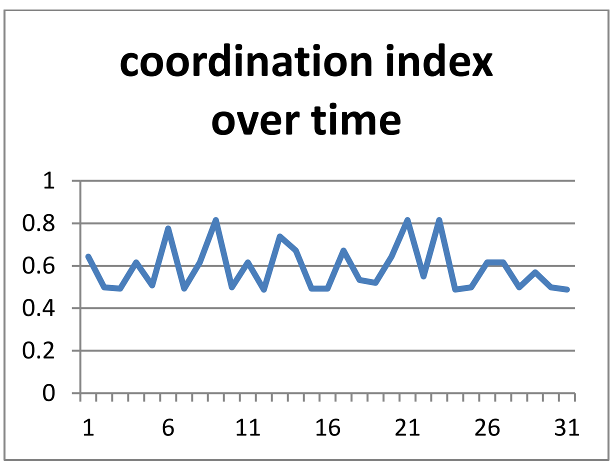
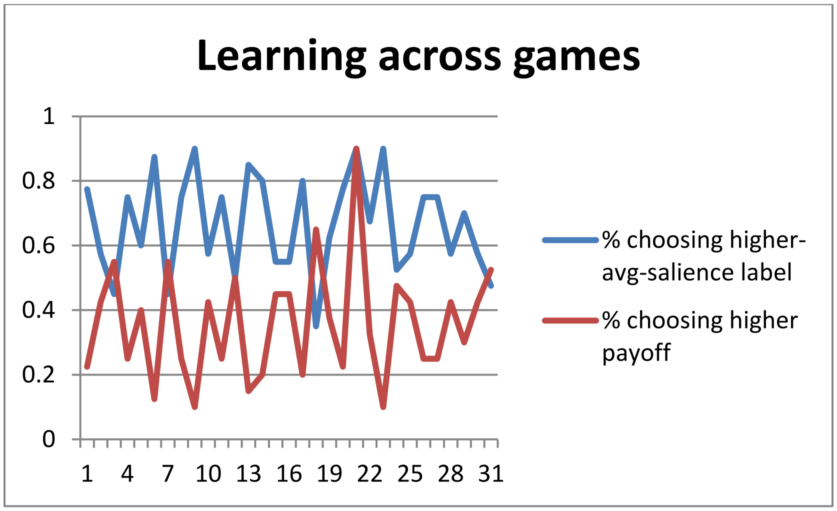


Figure 19: Choice of higher payoff or salient label in order of games played



One might think to challenge our interpretation of results in terms of cognitive hierarchy, on the grounds that players will be trying to choose a good or correct label for the image rather than actually play a coordination game. It is important to clarify a few points. First, it was clear to all players that their reward depended solely on whether they matched their partner in choosing the same labeled strategy. Second, players at hierarchical level 1 and above are strategic, and in that sense it is their beliefs about the behavior of level 0 players that drives the model. Regarding level 0 players, the extent to which they consider the meaning of words and stimuli – including the fit between the word and the stimulus -- is precisely part of the research question being addressed here. Even naïve players are aware that strategies are associated with payoffs as well as labels, and if players' choices are partly or primarily influenced by the labels and stimuli and not only payoffs, this answers our research question. Bardsley et al. were able to argue – not investigate -- that the behavior of level 0 players can be identified with the behavior of players who "just pick a label". But in our case, it cannot be assumed that level 0 players "just pick a label for the image". The difference is that in Bardsley et al.'s games, payoffs were identical in all coordinating outcomes. The point of our research is to investigate the behavior of level 0 players (as strategic players imagine it) when they "just pick" strategies that are associated with both labels and payoffs, or, in our Study 2, with both labels-for-the-stimulus and payoffs. We have found that when just picking strategies that are associated with both labels and payoffs, they pick based on payoffs, and when just picking strategies that are associated with both labels-for-the-stimulus and payoffs, they pick based on labels, except when the labels have (to them) comparable degrees of salience.

6 General Discussion

We have seen that in games with no stimuli, players coordinate on labels, whereas in games with stimuli, the best predictors are models in which players prefer the strategy with more salient label, at least when the degrees of label salience are significantly different. This latter result means that with a reference stimulus, players choose according to labels even against the combination of payoff and risk dominance. This appears to be an important and unexpected result.

Although not our main focus, this result also has implications for the relative merits of cognitive hierarchy versus team reasoning. Results of study 1 may be interpreted as indicating that “choose the higher payoff” is chosen as a decision rule over “choose the more salient label”. Within Bacharach’s variable frame theory (Bacharach 1993; Bacharach and Bernasconi 1997), payoffs may be viewed as more conspicuous than salience because payoffs are visible and therefore more likely to occur to one’s partner. If players frame the choice in this way, then the higher payoff will be chosen due to the theory’s rules of symmetry disqualification and payoff dominance. But it is not clear that Bacharach intends that payoffs themselves can be considered as a “family” of concepts that may be used to frame the problem in the first place. Sugden’s (1995) theory is more explicit on this point, as it defines a player’s private description of the game to include both labels and payoffs, and a player chooses a decision rule that is defined in terms of his private description. The remaining trick is to specify why “choose the higher payoff” is preferred to “choose the more salient label”. This is achieved within Sugden’s theory of collective rationality if we model that players know that individuals differ in their label salience. That would make the payoffs-based rule to be the collectively rational one, since it guarantees coordination in our games while the labels-based rule doesn’t.

It is more difficult to explain results of study 2 in terms of team reasoning. Certainly, it is difficult to construct frames or decision rules that include – let alone recommend -- the contingent rule that is optimal in our data, viz. “choose the more salient label unless the two labels’ salience is within x1% of one another”. Even if we restrict ourselves to the simpler rule of choosing the more salient label, this is not payoff dominant, which violates a rule in Bacharach’s theory. Even within Sugden’s theory, it is difficult to see how the less reliable salience rule can be preferred to a payoffs-based rule. Team reasoning is not our focus in this paper, but it appears that results of Study 2 favor hierarchical models.

6.1 Relation to Other Work

Dugar and Shahriar (2009) consider games in which one strategy is payoff dominant and another is risk dominant. It is well known that players often fail to coordinate on the payoff dominant strategy, and coordinate instead on the Pareto inferior risk-dominant strategy. Dugar and Shahriar investigate whether label salience is sufficient to facilitate coordination on the Pareto efficient, payoff-dominant strategy. They find that it can be, depending on what they term the relative salience of the two labels. They implicitly define relative salience of one label L_1 versus another L_2 as the percentage of players choosing L_1 in a coordinating treatment. Our work complements theirs, but is not directly related. In their games, higher payoffs correspond with label salience, whereas in our case they are inversely related. In addition, their work is not developed within a cognitive-hierarchical framework, and related to that, their notion of relative salience is different from the one used here, and even from the one implied by Bardsley et al. and other work within the cognitive hierarchical framework, where it is defined not as the probability of being chosen in a coordination game, but the probability of being chosen in a picking task.

Crawford et al. (2008) studied coordination games with common knowledge labels and non-symmetric payoffs, i.e. where one player receives a higher payoff in one coordination outcome, and the other player receives a correspondingly higher payoff in the other. In their X-Y games for which a cognitive hierarchy framework was considered more appropriate than team reasoning, they found that (level 1 players believe that) level 0 players have a small, fixed bias towards a higher payoff, which wipes out any discernible effect of focal points. Their result shows a case where focal point behavior is not in evidence, but their work leaves open the question of what role, if any, is played by labels in such games. Their model does not explicitly assign any role to label salience, and the only label pair they considered was literally "X" and "Y", so their work offers neither theoretical nor empirical evidence about what role labels might play. Our work picks up a related point. We ask what role, if any, labels play in the face of payoff differences, except instead of studying asymmetric payoffs as in Crawford et al., our games have symmetric payoffs that differ between coordinating outcomes. We have shown that in this case, labels actually play no role whatever, at least in games with no stimuli. It remains an open question whether labels play any role in games with asymmetric payoffs such as Crawford et al.'s X-Y games.

Summary and Conclusions

We set out to shed light on how players behave in coordination games whose strategies are characterized by both payoffs and meaningful, common knowledge labels. The general question follows directly from previous work, but little was previously known about how players will behave in such a game. We expected that both payoffs and labels would play a role, but lacking any theoretical basis for proposing any particular model a priori, we explored a variety of models to see which would best fit the data. We adopted and extended a hierarchical framework to include an individual level degree of label salience, payoffs, and fixed and variable effects for both.

In coordination games with two strategies, one of which has higher label salience and one of which has higher payoff, level 0 players in the games with no stimuli were found to simply choose the strategy with higher coordinating payoff. In games with stimuli, level 0 players were found to choose the strategy with higher label salience whenever there was a 13% or more difference in the two labels' salience to that individual, relying on payoffs as a tie-breaker when label saliences are similar. A simpler rule with almost the same predictive ability is that level 0 players always choose the strategy with the more salient (to them) label. Along the way, we have constructed a cognitive hierarchical framework with an individual-level notion of degrees of label salience, with payoffs as well as labels, and variable and fixed effects for each. We attach particular significance to the formalization of an individual level degree of salience. Label salience is an individual-level phenomenon, and has been described as such throughout the literature, but this basic element has not to our knowledge been previously formalized. Finally, we have introduced a coordination game with reference stimulus, as being more representative of coordination games as they arise in realistic economic settings.

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Appendix: Screen Layouts of Instructions in all treatments, Studies 1 and 2 (in English translation)

Study 1, Assessing Treatment, Instructions Screen 1

In this experiment, you will be shown a series
of word pairs, one pair after another.
For each word, please assign the probability
that you would choose that word,
if asked to choose one of the two.
The two numbers must sum to 100.

Continue to Example

Study 1, Assessing Treatment, Instructions Screen 2

For example, suppose we present the two labels
“mountain” and “nature” as seen below.

You might feel that if asked to choose
one of these two words,
there is a 75% chance that you’d choose “mountains”
and a 25% chance you’d choose “nature”.
In this case, you’d fill in 75 and 25
in the appropriate spaces below

Label	Probability
mountain	? [%]
nature	? [%]

Continue Instructions

Study 1, Assessing Treatment, Instructions Screen 3

THIS IS A TRIAL RUN FOR PRACTICE

For each of the two words, please assign a
Probability between 0 %and 100% that describes the
chance you’d pick that word, if asked to choose one.
The two numbers must sum to 100%

Label	Probability
Flying car	[%]
Cartoon	[%]

Done (go to next image)

Any Questions?

Please wait for Instructor
Before proceeding

Begin

Study 1, Guessing Treatment, Instructions Screen 1

In this experiment, you will be shown a series
of word pairs, one pair after another.

In a previous experiment, we asked subjects what is the
probability 0%-100% they would choose each word, if asked to
choose one of them. The sum of the two numbers had to equal 100%

Your task is to guess the average probability that was assigned to
each word by subjects in that other experiments.

Your payment for this experiment will depend on how accurate
your guesses are.

Continue to Example

Study 1, Guessing Treatment, Instructions Screen 2

For example, consider the word pair below.
In a previous experiment, we asked each subject the probability 0%-100%
that he/she would choose “mountain”, and the probability he/she would
choose “nature”, if asked to choose one of them.
The two numbers had to sum to 100%.
Your job is to guess what was the average probability that was given by
the subjects in that other experiment for each word, with the two
guesses summing to 100% .
For example, you might guess that on average, people would assign a
probability or weight of 75% to “mountain” and a probability of 25% to
“nature”. So, you would enter the numbers “75%” and “25%”
in the table below

Label	Probability
mountain	? [%]
nature	? [%]

Continue Instructions

Study 1, Guessing Treatment, Instructions Screen 3

After you make your guesses, the computer will show you how accurate your guesses were. For each label, your guess will be judged according to the absolute difference between your guess and the actual average value assigned to that word by the subjects in the previous experiment. Your total score for each image depends on the accuracy of the two separate guesses. An example is shown below.

Label	probability you guessed was assigned by others	Actual probability assigned by others	Absolute Difference
mountain	75%	80%	|75 – 80| = 5
nature	25%	20%	| 25 – 20| = 5
Total error			10
Your points for this image			100-10 = 90 points for this round

Continue Instructions

Study 1, Guessing Treatment, Instructions Screen 4

THIS IS A TRIAL RUN FOR PRACTICE

For each of the two words, please guess what probability between 0% and 100% was assigned by subjects in a previous experiment, on average, as the probability that they would choose that word if asked to choose between the two. The two numbers you enter must sum to 100%, just as theirs did.

Label	Probability
Flying Car	20 [%]
Cartoon	80 [%]

Done (see how accurate I was)

Study 1, Guessing Treatment, Instructions Screen 5 Example

THIS IS A TRIAL RUN FOR PRACTICE

Label	probability you guessed was assigned by others	Actual probability assigned by others	Absolute Difference
Flying Car	20 %	35 %	15
Cartoon	80 %	65 %	15
Total error			30
Your points for this image			100-30 = 70 points for this round

Done (go to next word pair)

Study 1, Guessing Treatment, Instructions Screen 6

Any Questions?

Please wait for Instructor
Before proceeding

Begin

Study 1, Coordinating Treatment, Instructions Screen 1

In this experiment, you will be shown a series of word pairs, one after another.
You will be asked to choose one of the two words.
You will be assigned to a random partner, one of the other people in the room, who is facing the same choice.
If you and your partner choose the same word, you will each receive the number of points that is shown for that label, for that round of play.
If you and your partner choose different words, you will each receive 0 points for that round.
Your final payment for this experiment depends on how many points you accumulate throughout the whole session.

Continue to Example

Study 1, Coordinating Treatment, Instructions Screen 2

For example, consider the choice of words "mountain" and "nature" as seen below.
If you and your partner both choose the word "mountain", you will each receive 50 points.
If you and your partner both choose the word "nature", you will each receive 20 points.
If you and your partner choose different words from each other, you will both receive 0 points for that round.

Word	Payoff if match
mountain	50
nature	20

Continue Instructions

Study 1, Coordinating Treatment, Instructions Screen 3

After you and your partner (for that round) both make your choices, the computer will show you what choice your partner made, and how many points you won (if you matched).
In this example, you would each earn 50 points

Candidate Words	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50	mountain	mountain	50 points each
nature	20			

Continue Instructions

Study 1, Coordinating Treatment, Instructions Screen 4

In this example, you would each earn 20 points

Candidate Words	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50			20 points each
nature	20	Nature	Nature	

Continue Instructions

Study 1, Coordinating Treatment, Instructions Screen 5

In this example, you would each earn 0 points because you chose different words

Candidate Words	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50		mountain	0 points
nature	20	nature		

Continue Instructions

Study 1, Coordinating Treatment, Instructions Screen 6

In this example, as well, you would each earn 0 points because you chose different words

Candidate Words	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50	mountain		0 points
nature	20		nature	

Continue Instructions

Study 1, Coordinating Treatment, Instructions Screen 6

THIS IS A TRIAL RUN FOR PRACTICE

Please choose one of the two words below.
If you and your partner choose the same label, you will each receive the number of points that is shown for that label.
Otherwise, you will each earn 0 points for that round.

Word	Payoff if match
Flying Car	10
Cartoon	25

Done (see result)

Study 1, Coordinating Treatment, Instructions Screen 7 Example

THIS IS A TRIAL RUN FOR PRACTICE

Candidate Words	Payoff if match partner on this word	You chose	Your partner chose	You each get
Helmet	10	Flying Car	Flying Car	10 points each
Football	25			

Done

Study 1, Coordinating Treatment, Instructions Screen 7

Important Clarifications:

You will be assigned a new random partner in each round.
Your final payment depends on the total number of points that you accumulate across all rounds.
In each round, your partner may be shown the words in the same order as you see them (e.g. "mountain" on top, "nature" on bottom), or in the opposite order. This is random.

Continue

Study 1, Coordinating Treatment, Instructions Screen 8

Any Questions?

Please wait for Instructor
Before proceeding

Begin

Study 2, Assessing Treatment, Instructions Screen 1

In this experiment, you will be shown a series of images, one after another.

Beside each image, you will see two words.

For each words, please assign a percentage or weight between 0 and 100 for each word, given the image.

Treat each word separately;
the two numbers do not need to sum to 100

Continue to Example

Study 2, Assessing Treatment, Instructions Screen 2

For example, suppose we present the image on the left and the two words "mountain" and "nature" as seen below.
You might decide that the word "mountains" applies with a probability or weight of 65% and the word "nature" applies with a probability or weight of 80%.
Then you'd enter those numbers in the table below

Label	Percentage
mountain	? [%]
nature	? [%]

Continue Instructions

Study 2, Assessing Treatment, Instructions Screen 3

Regarding the percentages,
you can either think of these as
the probability or extent to which the word might enter your mind in response to the image;
the probability or extent to which the word seems an appropriate description of the picture;
or the probability one would expect to see the word in the same context (e.g. webpage, book, etc.) as that word.

Label	Percentage
mountain	65 %
nature	80 %

Begin Trial Run

Study 2, Assessing Treatment, Instructions Screen 4

THIS IS A TRIAL RUN FOR PRACTICE

For each of the two words, please assign a number between 0 and 100 for each word.
The numbers represent
the probability or extent to which the word might enter your mind in response to the image;
the probability or extent to which the word seems an appropriate description of the picture;
or the probability one would expect to see the word in the same context (e.g. webpage, book, etc.) as that word.

Label	Percentage
Flying Car	[%]
Cartoon	[%]

Done (go to next image)

Study 2, Assessing Treatment, Instructions Screen 5

Any Questions?

Please wait for Instructor
Before proceeding

Begin

Study 2, Guessing Treatment, Instructions Screen 1

In this experiment, you will be shown a series of images, one after another.
Beside each image, you will see two words.
In a previous experiment, we asked subjects to assign a percentage0-100 for each words, given the image.
The two weights are treated separately. They do not need to sum to 100.

Your task is to guess what number between 0 and 100 was assigned by other people to each label, given the image.

Your payment for this experiment will depend on how accurate your guesses are.

Continue to Example

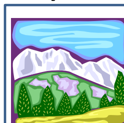
Study 2, Guessing Treatment, Instructions Screen 2

For example, consider the image on the left and the two labels "mountain" and "nature" as seen below.
In a previous experiment, we asked subjects to assign a percentage 0-100 for each label, given the image.
(the two weights did not need to sum to 100).
Your job is to guess what weight or probabilities they assigned to each label. For example, you might guess that given this image, people would assign a probability or weight of 75% to the label "mountain" and a probability of 80% to the label "nature". So, you would enter the numbers "75" and "80" in the table below

Label	Percentages
mountain	? %
nature	? %

Continue Instructions

Study 2, Guessing Treatment, Instructions Screen 3



After you make your guesses, the computer will show you how accurate your guesses were. For each label, your guess will be judged according to the absolute difference between your guess and the actual average value assigned to that word by the subjects in the previous experiment. Your total score for each image will depend on the accuracy of the two separate guesses. An example is shown below.

Label	Percentages you guessed was assigned by others	Actual percentages assigned by others	Absolute Difference
mountain	75 %	80 %	|75 – 80| = 5
nature	80 %	50 %	| 80 – 50| =30
Total error			35
Your points for this image			100-35 = 65 points

Continue Instructions

Study 2, Guessing Treatment, Instructions Screen 4

Regarding the numbers,
subjects in the previous experiment were told to think of these as
the probability or extent to which the word might enter your mind in response to the image;
the probability or extent to which the word seems an appropriate description of the picture;
or the probability one would expect to see the word in the same context (e.g. webpage, book, etc.) as that word.

Label	Percentages
mountain	[%]
nature	[%]

Go to Practice

Study 2, Guessing Treatment, Instructions Screen 5

THIS IS A TRIAL RUN FOR PRACTICE

For each of the two words below, please guess what percentages between 0 and 100 were assigned by other people on average, given the image. The two words are treated separately, i.e. the two numbers do not need to sum to 100.

Label	Percentages
Flying Car	50 %
Cartoon	65 %

Done (see how accurate I was)

Study 2, Guessing Treatment, Instructions Screen 6

THIS IS A TRIAL RUN FOR PRACTICE

Label	Percentages you guessed was assigned by others	Actual percenteages assigned by others	Absolute Difference
Flying Car	50 %	80 %	30
Cartoon	65 %	50 %	15
Total error			45
Your points for this image			100-45 = 55 points this round

Done (go to next image)

Study 2, Guessing Treatment, Instructions Screen 7

Any Questions?

Please wait for Instructor
Before proceeding

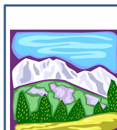
Begin

Study 2, Coordinating Treatment, Instructions Screen 1

In this experiment, you will be shown a series of images, one after another.
Beside each image, you will see two words.
Please choose one of the two words for the image.
If you and your partner choose the same label, you will each receive the number of points that is shown for that round.
Your payment for this experiment depends on how many points you accumulate.

Continue to Example

Study 2, Coordinating Treatment, Instructions Screen 2



For example, consider the image on the left and the two words "mountain" and "nature" as seen below.
If you and your partner both choose the word "mountain", you will each receive 50 points.
If you and your partner both choose the word "nature", you will each receive 20 points.
If you and your partner choose different words, you will each receive 0 points for that round.

Label	Payoff if match
mountain	50
nature	20

Continue Instructions

Study 2, Coordinating Treatment, Instructions Screen 3

After you and your partner both make your choices, the computer will show you what choice your partner made, and how many points you won (if you matched).
In this example, you would both earn 50 points

Candidate Word	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50	mountain	mountain	50 points each
nature	20			

Continue Instructions

Study 2, Coordinating Treatment, Instructions Screen 4

In this example, you would both earn 20 points

Candidate word	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50			20 points each
nature	20	Nature	Nature	

Continue Instructions

Study 2, Coordinating Treatment, Instructions Screen 5

In this example, you would both earn 0 points because you chose different words

Candidate word	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50		mountain	0 points
nature	20	nature		

Continue Instructions

Study 2, Coordinating Treatment, Instructions Screen 5

In this example, you would both earn 0 points because you chose different words

Candidate word	Payoff if match partner on this word	You chose	Your partner chose	You each get
mountain	50	mountain		0 points
nature	20		nature	

Go to Practice

Study 2, Coordinating Treatment, Instructions Screen 6

THIS IS A TRIAL RUN FOR PRACTICE

Please choose one of the two labels for this image. If you and your partner choose the same word, you will each receive the number of points that is shown for that word. Otherwise, you each earn 0 for this round

Label	Payoff if match
Flying Car	25
Cartoon	10

Done (see result)

Study 2, Coordinating Treatment, Instructions Screen 7 Example

THIS IS A TRIAL RUN FOR PRACTICE

Candidate word	Payoff if match partner on this word	You chose	Your partner chose	You each get
Flying Car	25	Flying Car	Flying Car	10 points each
Cartoon	10			

Done (go to next image)

Appendix: All label pairs for Study 1, sets 1 and 2

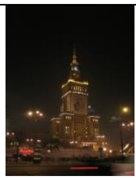
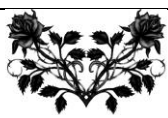
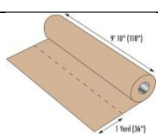
Label pair	Labels	Average Salience of Labels to subjects in Guessing treatment	Set 1 coordinating treatment payoffs for coordinating on this label	Set 2 closer coordinating payoffs

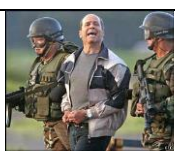
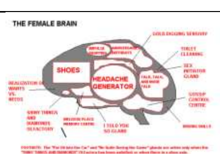
	Night	44	109	90
	Europe	56	87	87
	Checkered pattern	47	69	65
	Doll	53	62	62
	Cook	58	48	48
	Sharp knife	42	55	50
	Black flower	45	52	48
	Black rose	55	47	47
	Black bull	58	77	77
	Bull fallen down	42	78	78
	Blue logo	48	58	58
	Lion	52	65	60
	Roll	46	66	60
	Measurement	54	57	57
	Pray	52	55	55
	Church	48	60	55
	Sneakers	58	49	49
	Pair of shoes	42	77	50
	Egg	46	82	73
	Grass	54	70	70
	Advertisement	44	104	82
	Person	55	82	82

	Red carpet	53	77	77
	Actor	47	88	80
	Present	51	78	40
	Teddy bear	49	39	39
	Building	50	68	68
	Green window	50	68	68
	Soldier	56	71	71
	Arrest	44	101	101
	Person	52	50	56
	t-shirt	48	56	56
	Medical	52	59	59
	Brain	48	75	70
	Cartoon	46	109	81
	Girl	54	77	77
	Corpse	40	107	62
	Surgery	60	60	60
	Knife in sheath	59	77	77
	Knife on fur	41	108	77
	Africa	51	68	55

	Giraffe	49	54	54
	Pirate coin	41	104	76
	Beach	59	73	73
	China	46	58	51
	Dragon	54	50	50
	Fish	51	68	68
	Cup	49	93	69
	Buffet	52	57	57
	Food	48	63	63
	Pink dress	46	58	58
	Party	54	67	60
	Famous painting	52	53	53
	Warrior on a horse	48	57	53
	Yoga	41	67	52
	Woman	59	48	48
	Japanese cartoon	45	63	58
	Girl	55	58	63
	Gray	42	57	41
	Bag	58	52	41

Appendix: All label pairs for Study 2

Image	Labels	Average Salience of Labels to subjects in Guessing treatment	Payoffs
	Night	76	70
	Europe	54	108
	Checkered pattern	59	90
	Doll	70	84
	Cook	83	64
	Sharp knife	44	110
	Black flower	68	78
	Black rose	79	61
	Black bull	62	86
	Bull fallen down	77	76
PEUGEOT	Blue logo	78	68
	Lion	58	101
	Roll	71	47
	Measurement	61	50
	Pray	76	70
	Church	55	97
	Shoes	84	63

	Single shoes	73	80
	Egg	59	90
	Grass	59	90
	Advertisement	77	69
	Person	53	91
	Red carpet	66	81
	Actor	77	76
	Present	68	78
	Teddy bear	45	108
	Building	74	72
	Green window	58	92
	Soldiers	63	85
	Arrest	77	63
	Person	54	99
	t-shirt	80	73
	Medical	51	104
	Brain	75	65

	Cartoon	84	70
	Girl	62	86
	Corpse	65	82
	Surgery	38	140
	Knife in sheath	71	75
	Knife on fur	77	63
	Africa	62	86
	Giraffe	87	56
	Pirate coin	51	104
	Beach	39	150
	China	53	100
	Dragon	85	57
	Fish	51	104
	Cup	85	69
	Buffet	79	67
	Food	54	90
	Pink dress	73	73

	Party	62	94
	Famous painting	73	77
	Warrior on a horse	63	73
	Yoga	54	99
	Woman	75	78
	Japanese cartoon	74	72
	Girl	58	101
	Gray	56	95
	Bag	81	72