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The emergence of salience: an experimental investigation

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Abstract
In this experiment, individuals recurrently play coordination games that are similar to, but not identical with, one another. Initially, subjects are no more successful than if they had acted at random, but coordination rates gradually increase to levels similar to those found in one-shot games with “obvious” focal points. Subjects seem to coordinate by choosing actions that are similar to ones that have previously been successful. This leads to the emergence of different similarity conventions – interpretable as different conceptions of salience – in different groups of players. We present a simple model of learning which organizes our main findings.

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The emergence of salience: an experimental investigation*

Many economic and social interactions are coordination problems that do not fit easily into the standard game-theoretic taxonomy of one-shot and repeated games. Think of the problem faced by individuals independently choosing what to wear at some social occasion, each preferring to dress with the same degree of formality as the others. Although people repeatedly attend events of this general class, no such occasion is quite the same as another. For example, the degree of formality with which people dress varies according to who is expected to attend; and the range of relevant dress options, and hence the ways in which different degrees of formality are expressed, change with fashion and the seasons. As a result, this is not a repeated game in the standard theoretical sense, and game-theoretic models of learning such as replicator dynamics or fictitious play, where a single, welldefined game is played recurrently within a population of players, cannot be directly applied. Equally, it is not exactly a one-shot game because individuals have experience of *similar* problems involving different types of occasion and dress options that could be used to predict other people's behavior. The point of this example is that conventions based on similarity relationships may emerge and reproduce themselves in recurrent play of games that are similar to, but not identical with, one another. Such a process is the subject of our paper.

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The online appendix is provided at
http://www.uea.ac.uk/ssf/cbess/working_papers/Appendix+-+Alberti,+Hargreaves+Heap+and+Sugden+(2011)

There have been some theoretical discussions of this issue but, perhaps because similarity relationships are difficult to model formally, this literature remains sparse.[1] In this paper, we take an experimental approach. We report an experimental investigation of recurrent play of "families" of pure coordination games: these share a common payoff matrix with strategies described to players using labels that are similar but not identical across games. We investigate whether subjects learn rules that facilitate coordination in these families of games and, if so, what kinds of rules these are and how they are learned.

As far as we know, this class of *recurrently similar* coordination games has not been studied experimentally before.[2] Among the reasons why the investigation of such games is important is that it may help to explain how people solve what appear to be one-shot pure coordination games, of the kind first studied by Thomas Schelling (1960). In such games, players are often remarkably successful in reaching Pareto-efficient Nash equilibria. For example, American and British players achieve high rates of coordination in 2×2 pure coordination games where the strategies are labelled "heads" and "tails"; they do so by favouring "heads" (Schelling, 1960, pp. 54–58; Judith Mehta et al., 1994). Any theory that is to explain and rationalize such "focal points" has to explain how, using only the content of the labels by which strategies are described, a player is able to infer which strategy her opponent is most likely to choose. Although some progress has been made in explaining focal points, the features that make particular labels focal are still not well understood.[3] One possible explanatory strategy starts from David Lewis's (1969, pp. 36–38) suggestion that the perception of focal points in one-shot games is closely related to the recognition of patterns in the play of recurrently similar coordination games. When players find focal points in what appear to be one-shot games, they may be drawing on previous experiences of coordination in other interactions that they perceive as in some degree similar.

[1] See, for example, Schlicht (1988), Cubitt and Sugden (2003) and Sugden (2004, 2010). There are also some analyses of the use of similarity relationships in individual decision-making, for example Rubinstein (1988) and Gilboa and Schmeidler (1995).

[2] Hargreaves Heap and Varoufakis (2002) report an experimental investigation of the emergence of conventions in a recurrent coordination game with *constant* labels.

[3] See, for example, Mehta et al (1994a, 1994b), Sugden (1995), Bacharach and Bernasconi (1997), Bacharach and Stahl (2000), Casajus (2001), Janssen (2001), Bacharach (2006), Crawford et al (2008) and Bardsley et al (2010).

Because the games that we study are not usually discussed in the literature, we begin by explaining their nature and how we generated a set of such games where, plausibly, there are no obvious prior cues that could be used to coordinate behavior (Section I). We consider possible learning mechanisms that the players of such games might use to coordinate their strategy choices, and what each would entail for players' behavior (Section II). We then describe our experiment in detail (Section III). Our results (presented in Section IV) establish that players *do* learn to coordinate and that the pattern of learning is consistent with the principle of choosing actions that are similar to ones that have been successful in the past. In Section V, we sketch a simple model of this learning mechanism and show that it can account for the main features of our data. In the final Section, we draw some more general conclusions. In particular, we suggest that what we have observed in our experiment can be interpreted as the emergence and reproduction of salience.

I. Experimental design: fundamentals

In our experiment, subjects are paired anonymously and play a series of coordination games. We keep player pairings fixed, rather than randomly re-matching subjects, because our aim is to investigate the mechanisms by which people learn to coordinate their choices. Fixed pairings make this learning problem less difficult and allow conventions to emerge more quickly.

The series of games played by each pair of subjects is subdivided into blocks of recurrently similar games; all games within a block belong to the same family. In each game in a block, each of the two subjects is separately shown the same four *images* and is instructed to choose one of them. If they both choose the same image, each is credited with a positive monetary reward (the same whichever image is chosen); otherwise, both earn nothing. Each subject is informed of the other's decision before going on to the next task.

We begin by describing one family of games which we call *abstract*. Four images for two typical abstract games are shown in the two rows of Figure 1.

[Figure 1 near here]

Each image is a chequered pattern of colored squares, reminiscent of a simple fabric design or a tiled floor. More formally, each image is a 16×16 array of squares that can be subdivided into 8×8 identical *cells*. Each cell consists of the same 2×2 array of four squares in three colors. Two *fixed colors*, and the locations of these colors in the cell, are held constant over all four images, inducing a general resemblance between the images; the third *variable color* differs between images. Images were constructed by means of a computer program that initially created the cell for one image by randomly selecting three distinct colors from a set of 48 colors and assigning these colors to the four squares of the cell (the top right and bottom left squares being given the same color). One of the three colors was then pulled out at random and successively replaced by three new random colors to form the cells for the other three images. By repeated use of this procedure, we constructed 20 games, each with a unique set of four images. In an obvious sense, all 20 games are similar to, but not identical with, one another.

Considered in isolation, these games seem to lack obvious focal points. In almost all the games that have been used in previous experimental investigations of focal points, labels have been pre-selected by the experimenters, often with the intention of making one particular label appear as salient.[4] Clearly, this is not the case for our randomly-generated images. Further, our sets of images seem to offer few "clues" that could be used to identify focal points. Although the general appearance of the images may evoke associations of ideas with phenomena outside the laboratory, the differences between images within a task have little cultural resonance. In these respects, our design is an unusually severe test of individuals' ability to solve coordination problems. However, the fact that these games are difficult to solve in a one-shot setting is an essential feature of our design. Our aim is to investigate whether, and if so how, conventions *emerge* in recurrent play of similar games. It would defeat our object if subjects were able to achieve a high degree of coordination without making use of the experience or feedback provided by the experiment itself.

Nevertheless, the design allows a rich array of concepts that could be used to differentiate one image from another and so underpin a learning process. For example, individual colors can be located on the red/yellow/blue/violet spectrum and on the unsaturated/saturated dimension; this can allow one image to be perceived as, say, the 'reddest' or 'palest'. Other visual properties such as harmony and contrast are induced by relationships between the three colors in an image. More subjective aesthetic properties, such as 'attractive', 'vibrant' and 'dull', might also be perceived. There seems to be no shortage of rules (such as 'Choose the palest image' or 'Choose the most vibrant image') that could in principle be used to identify focal points.

[4] The 'nondescript pure coordination games' investigated by Bardsley et al (2010) are an exception.

Our abstract games differ in at least two ways from the coordination games that have featured in most previous experiments: the labels are visual images, the most salient properties of which are aesthetic; and these labels seem to lack social or cultural content. At the design stage of our experiment, we met some skepticism from fellow-economists who doubted whether we would find any systematic coordination in such abstract games, even after feedback. We decided that it would be useful to include in the experiment some families of recurrently similar coordination games using visual images with more cultural content. We call these families *culture-laden*. We included these games for two main reasons. The first was to ensure that, even if there was no systematic coordination in the abstract games, our experiment would generate *some* data about learning in recurrently similar games. (By using several different culture-laden families, we hedged our bets still further.) The second was to provide a benchmark against which to measure the degree of success with which subjects learned to coordinate in the abstract games. Our prior expectation was that subjects would be more successful in games with more cultural content.

The experiment included four families of culture-laden games, each consisting of a block of five games. In two of these families, the images were fabric designs; in the other two, they were paintings. In each game in a given family, each of the four images is an example of a different *style*. For fabrics, styles represent particular periods in the history of fashion in western society;[5] for paintings, they correspond with particular artists.[6] The same four styles appear in each game in a family, but different families have different sets of styles. Figure 2 shows two games from a fabric family; Figure 3 shows two games from a painting family. (In these figures, images with the same style appear above one another, but in the experiment the locations of the images were randomized independently for each subject.)

[Figures 2 and 3 near here]

This feature of our design was intended to help subjects find common concepts of similarity between images in different culture-laden games. Of course, we could not be sure that players would perceive style-based similarities; but, for our purposes, that perception is

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[5] Examples include 'late Victorian' and 'Retro'. We used the classification provided by the website http://www.reproductionfabrics.com.

[6] As far as possible, we tried to ensure that the four paintings in a given game had similar subjects, thus steering subjects towards aesthetic rather than subject-based rules.

not essential. The experiment is designed so that the main questions we are investigating can be answered without any need for specific hypotheses about the aesthetic determinants of subjects' choices. Style is just one aesthetic property that might be used as a coordination device in culture-laden tasks, but it is not the only possibility. In fact, as we show in Section IV.C, our subjects revealed some ability to recognize style-based similarities.

II. Mechanisms that might induce coordination

We now consider four mechanisms by which subjects might succeed in coordinating, and how the operation of these mechanisms might be detected in the data that our experimental design generates. The observable implications of each mechanism are italicized for this purpose.

We say that two co-players *match* in a given game if they choose the same image. If the choices are random, the probability of matching in a four-image game is 0.25. We call the actual proportion of matches the *matching frequency*. If there is any systematic tendency for the matching frequency to be greater than 0.25, there must be at least some pairs where each co-player, consciously or unconsciously, is following some *rule of selection* that picks out an image in each game and where these two rules *mesh* – that is, have some tendency to select the same image.[7] (Two rules may have different descriptions, as understood by the respective players, and yet still mesh. For example, suppose one player's rule is "Choose the reddest image" and the other's is "Choose the image I like best" when their favourite color is red.)

A. Pre-experimental inclination

As Schelling's classic experiments show, meshing rules are often used in one-shot coordination games. For example, when the Heads and Tails game is played in a one-shot form, there seems to be a strong tendency for players to follow the rule "Choose the more important thing" and to perceive "heads" as more important than "tails". Clearly, this rule is not learned from any feedback received during the experiment (there is no such feedback); players' inclinations to use it are *pre-experimental*. Analogously, players in our experiment might have pre-experimental inclinations to follow particular rules, and those rules might

[7] The concept of a rule of selection is due to Schelling (1960, p. 94).

mesh. If a mechanism of this kind were at work, it would tend *to induce matching frequencies greater than 0.25 in the first tasks that pairs of co-players face*.

In designing the experiment, we conjectured that many subjects would have a pre-experimental inclination to choose either the image that they themselves most liked or the image that they expected their co-player to most like. This conjecture is supported by the evidence that judgements about "favoriteness" are good predictors of behavior in many coordination games (Nicholas Bardsley et al., 2010). The aesthetic nature of the images in our games might be expected to make "liking" a particularly salient concept for our subjects. With this conjecture in mind, we elicited subjects' own likings of images, and their beliefs about other subjects' likings, before coordination games were played (see Section III).

B. Feedback-independent learning

Even without any feedback about other players' behavior, the experience of thinking about coordination games may improve subjects' skills in new games – particularly if they are similar to previous ones. For example, after a subject has seen several different abstract tasks, it might occur to him that in each task there is a palest image, and that choosing the palest image might be a sensible rule of selection. By this route, two players might independently arrive at meshing rules. In our design, this kind of learning *will induce an increasing trend in the frequency of matching over a sequence of games of the same family, independent of the feedback that subjects receive*.

C. Feedback-dependent learning

After completing each game, subjects are informed about their co-player's choice. If subjects can recognize rules of selection that apply across tasks, this feedback might facilitate matching in subsequent tasks. But, since different pairs of co-players can be expected to receive somewhat different feedback, any learning of meshing rules of this kind will have a *pair-specific* component. This means there will be a tendency for each subject's rate of matching with her *actual* co-player to be greater than the hypothetical matching rate she would have achieved, had her choice in each game been paired with the choice of another subject drawn at random from the set of subjects who played the same task under the same conditions. Hence, as feedback is the only feature of the experiment that is specific to pairs, *evidence of pair-specific matching in this sense is an unambiguous indication of some kind of feedback-dependent learning*.[8]

Particular kinds of feedback-dependent learning mechanisms will have further implications for behavior. We consider two broad types. One is *asymmetric rationalization*. This requires one player to act as "leader" and the other as "follower". The follower looks for the most obvious rule, accessible to both players, that rationalizes the leader's behavior, and follows that rule; the leader does not adapt to the follower's decisions (but might try to impose a consistent pattern on her own choices that will be easy for the follower to rationalize). For this to work, the players must first coordinate on which role each is to play. Such coordination is not easy to achieve if, as in our design, the players have no common information (for example about one another's age or gender) that could discriminate between them. In fact, we found no evidence of the within-pair asymmetries of behavior that would indicate asymmetric rationalization.[9] For this reason, we do not discuss this mechanism any further.

The other is *symmetric rationalization*. After a pair of co-players has matched in one game, each co-player looks for the most obvious rule, accessible to both of them, that rationalizes the previous match, and then applies that rule in (at least) the following game. Because both players are adapting their behavior to a common cue, one should expect this mechanism to favour the formation of meshing rules.[10] If players' initial inclinations are to choose the images they like most, this mechanism *will induce a downward trend in the frequency with which "favorites" are chosen, at the same time as an upward trend in the frequency of matching.*

In addition, because the symmetric rationalization mechanism is activated by previous matches, it will show itself in *a tendency for matching in one task from a given*

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[8] The converse does not hold. If the feedback received by different pairs is positively correlated, feedback-contingent learning can also produce matching which is *not* pair-specific. Later in this subsection we discuss a specific effect of this kind.

[9] We found that most players' initial inclination was to choose the image they most liked (see Section IV.D). So if learning was by asymmetric rationalization, leaders would continue to choose the images they liked, while followers would tend to match their co-players' likings.

[10] Crawford and Haller (1990) analyse a similar learning mechanism, but in the context of repeated play of a pure coordination games in which labels are held constant. In this case, players whose strategies have led to coordination in one game can simply repeat those strategies in subsequent games.

family to be followed by matching in the next.[11] In culture-laden tasks, there is a further potential indicator of symmetric rationalization. Subjects who are using this mechanism and who recognize styles may try to repeat previous matches by repeating the styles of the images on which they matched. Thus, in such a case, *the frequency with which a subject chooses the same style in successive tasks will be greater if there was a match on the earlier task*.

Symmetric rationalization can be expected to work only with considerable error, both because a given decision can typically be rationalized by more than one rule and because the implication of a given rule for a new game can be ambiguous. However, some rules may be more *salient* that others – that is, be more likely to be perceived as credible rationalizations. Other things being equal, more salient rules are more likely to be learned. In addition, some rules may be more *reliable* than others – that is, be less vulnerable to differences of interpretation when applied to new games. Other things being equal, more reliable rules are more likely to be successful when applied to new games. Thus, if players learn by symmetric rationalization, there will be a long-run tendency for them to converge on salient and reliable rules.[12] To the extent that salience and reliability are population-wide rather than pair-specific properties of rules, there will be some long-run tendency for different pairs to learn *the same* rules, even though learning is mediated by feedback. In consequence, *symmetric rationalization might be expected to induce an upward trend in matching that has both pair-specific and non-pair-specific components.*

D. Learning how to learn

The symmetric rationalization mechanism is cognitively quite demanding. However, once both players are using it and succeeding, it is a mechanism that can be applied in *any* family of recurrently similar games, and not only the particular family where it was first learned. If this form of higher-level learning (or 'learning how to learn') occurs then it might be expected *to induce a long-run upward trend in matching over the whole course of the*

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[11] The asymmetric rationalization mechanism does not have the same tendency. Players who use this mechanism as followers try to replicate leaders' previous choices, irrespective of whether those choices led to matching.

[12] Compare Sugden's (2004, pp. 49–54, 103–107, 187–190) evolutionary game-theoretic explanation of why evolution by trial-and-error learning favours those putative conventions that are most salient.

experiment – even between games belonging to different culture-laden families, and between abstract and culture-laden games.

III. Experimental design: details

We recruited 118 subjects from the general student population of [name of institution removed]. Each subject participated in one of nine experimental sessions. Each session had 12, 14 or 16 participants. Each subject was paired with a randomly-selected anonymous co-player throughout the experiment. The experiment was computerized.[13] Subjects were not able to communicate with one another, other than through the decisions they made in the coordination games and through the feedback they received about their co-players' decisions.

Written instructions were given on each subject's computer screen. This text was also read out by the experimenter, to ensure that the instructions were common knowledge and to make it easier for subjects to ask questions of clarification. The instructions and representative screen shots are given in the Online Appendix.

Each pair of subjects played 40 coordination games as described in Section I. Games were of two *types* – abstract and culture-laden. In the *abstract-first* treatment (five sessions with a total of 64 subjects), the first 20 tasks (the *first part* of the experiment) were abstract and the second 20 (the *second part* of the experiment) were culture-laden; in the *culture-first* treatment (four sessions with a total of 54 subjects), this order was reversed. Each sequence of 20 tasks was subdivided into four *blocks* of five games each; because payoffs were calculated separately for each block, the breaks between blocks were salient to subjects (see later). In the case of the culture-laden games, the games in each block comprised a distinct family, defined by a set of four styles. In two blocks, the images were paintings; in the other two, they were fabric designs. In the case of the abstract games, all 20 games were constructed using the same random mechanism. In this sense, the subdivision of abstract games into blocks was arbitrary. However, this subdivision served two purposes. First, it allowed the presentation of tasks to be standardized across the whole experiment, simplifying the experiment for subjects. Second, we conjectured that the break between blocks might have a 're-start effect'. (For example, if a pair of subjects has repeatedly failed to coordinate, the start of a new block might be perceived as the right time for one or both of

[13] The program was written by Kei Tsutsui, using Perl and CGI.

them to try a different approach.) Thus, comparability between the two types of task required both to have the same block structure.

All pairs of co-players faced the same 40 games with the same subdivision into blocks. For the purposes of exposition and analysis, we identify games by their sets of images. We use the labels A1–A20 for the abstract games; the four blocks of these games are A1–A5 , A6–A10, A11–A15 and A16–A20. Similarly, the blocks of culture-laden games are labelled C1–C5 (fabrics), C6–C10 (fabrics), C11–C15 (paintings) and C16–C20 (paintings); we also refer to these as culture-laden blocks 1, 2, 3 and 4 respectively. The images used in each game are shown in Figures 1.1–1.4 and 2.1–2.4 of the Online Appendix. For each type of game, the order in which the four blocks were presented to co-players was randomized, as was the order of games within each block. For reasons that will become clear from the discussion of the questionnaire below, the first and fifth games in each block were randomized separately from the second, third and fourth. (Thus, for example, game A1 always appeared as either the first or the fifth game in its block; game A2 always appeared either second, third or fourth.)

In each game, the four images from which a choice had to be made were presented in a 2×2 array on the computer screen, with a radio button below each image. The relative positions of the images were randomized independently for each subject (and subjects knew this), so that position could not be used as a coordination device. Each co-player selected an image by clicking on its button, and then submitted this choice by clicking on a "submit" button at the bottom of the screen. After both co-players had submitted their decisions, each of them was shown the four images again, but now with information about which image had been chosen by their co-player. Unless the game was the last in a block, the two co-players moved immediately to the next game. At the end of each block, co-players were reminded of the number of times they had matched in the five games of that block, and told how much they had earned from those games. For each block, all the subjects in a session shared a pool of £1.25 multiplied by the number of subjects. This pool was divided between subjects in proportion to the number of points each had scored.[14] At the end of the session, each subject was paid her total earnings in cash.

[14] For this purpose, the first "block" comprised the first five games faced by each pair of co-players in the session, and so on; because the order of games was randomized, this set of games was different for different pairs. This payment mechanism was chosen because it gives each pair of co-players an

In addition to playing the 40 coordination games, each subject was required to complete four “questionnaires”. (There were no specific incentives for these responses, but completing the questionnaires was a condition for receiving any payment from the experiment.) Two questionnaires related to the abstract images, two to the culture-laden images. The questionnaires were placed before and after the 20 games of the corresponding type. Thus, in the abstract-first treatment, each subject proceeded through the following sequence of tasks: the “before” questionnaire about abstract images; four blocks of abstract games; the “after” questionnaire about abstract images; the “before” questionnaire about culture-laden images; four blocks of culture-laden games; and the “after” questionnaire about culture-laden images. The “before” and “after” questionnaires contained exactly the same questions, but were addressed to respondents with different degrees of experience: the “after” questionnaire allowed subjects to draw on their experience of playing the games and discovering their co-players’ choices.

Each questionnaire comprised eight tasks, each asking two questions in relation to a set of four images. Although subjects were not told this, these were the sets of images used in the first and last game in each block of the relevant type. (Thus, the questionnaires relating to abstract images used the sets of images from games A1, A5, A6, A10, A11, A15, A16 and A20.) The order of questionnaire tasks was the same for all subjects. In each task, the subject was shown the four relevant images, each identified by a number. She was required to record (separately) the image she “liked most” and the one she “thought the person whom she was paired with liked most”.

We recognize that by asking questions about “liking” we may be imparting a bias towards the use of liking-based rules of selection. However, the objective of our experiment was not to investigate the relative strength of subjects’ pre-experimental inclinations towards different rules of selection; it was to investigate within-experiment learning. For the purposes of such an investigation, subjects’ pre-experimental inclinations serve only as a datum. The findings of Bardsley et al (2010) gave us reason to expect that subjects would initially be inclined to choose the images that they liked best, or that they expected their co-players to like best. If this proved to be the case (and whether or not this inclination had been partially induced by the questionnaires), having individual-level data on likings would

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incentive to score as many points as possible, while giving no incentive for subjects to make collusive agreements before entering the experiment (when they do not know whom they will be paired with).

enable us to investigate whether, over a sequence of coordination games, subjects' choices moved away from likings towards other rules of selection.

IV. Results

A. Trends in matching frequencies

Figures 4a–4d give an overview of the data generated by the experiment. For the present, we discuss only the "actual" graphs in these figures; the "predicted" graphs will be explained later. Figure 4a shows how the matching frequency varied over the sequence of 20 abstract games when these were played in the first part of the experiment. This frequency is calculated for each *round*, "round 1" being the first abstract game faced by each pair of co-players. Figures 4b, 4c and 4d provide the same information for abstract games in the second part of the experiment, and for culture-laden games in each part.

[Figures 4a, 4b, 4c and 4d near here]

Because the order of games was randomized independently for each pair of co-players, the observed matching frequency for any given round averages across a mix of the 20 games (a "game" being defined by its set of labels). Since each observation is generated by only 32 or 27 pairs of co-players (in the abstract-first and culture-first treatments respectively), these data are subject to considerable noise. Nevertheless, matching frequencies seem to increase progressively over the course of the experiment, as shown both in the upward trends of the graphs and in the fact that for each type of game (but more obviously for abstract games) matching frequencies are higher in the second part of the experiment than in the first. Interestingly, and contrary to our prior expectations, experienced players are more successful in coordinating in abstract games than in culture-laden ones.

Table 1 reports a random-effects probit regression analysis of the determinants of matching frequencies. The data set consists of one observation for each pair for each game, giving 59×40 = 2360 observations. The estimation procedure takes account of correlation of observations within pairs in addition to variance within and between pairs. We report estimates of two models, in each of which the dependent variable (*match*) takes the value 1 if the co-players choose the same image and 0 otherwise. We use the following five non-interactive independent variables: *match–1* takes the value 1 if the game is not the first of its type (i.e. abstract or culture-laden) and if the co-players matched in the previous game, and 0 otherwise; *block* (which takes the values 1, ..., 5) is the position of the game in its block; *round* (which takes the values 1, ..., 20) is the position of the game in the sequence of 20 games of its type; *second* takes the value 1 if the game is played in the second part of the experiment and 0 if it is played in the first part; *culture* takes the value 1 if the game is culture-laden and 0 if it is abstract.

[Table 1 near here]

Model 1 has no interaction terms. The coefficients for *block*, *round* and *second* are all significant at the 10 per cent level or better, indicating that, over the course of the experiment, co-players changed their behavior in ways that increased the probability of coordination. Such learning occurred within five-game blocks, within 20-game sequences of games of the same type, and from the first part of the experiment (when games were of one type) to the second part (when they were of the other type). The coefficient for *match–1* is positive and overwhelmingly significant. This is a particularly important result, as it is evidence for the hypothesis that symmetric rationalization underpins the increasing success in coordinating.[15]

Model 2 includes interaction terms between *match–1* and the dummy variables *culture* and *second*.[16] The coefficients for *block*, *round* and *second* remain positive and significant at the 10 per cent level or better, again indicating general upward trends in matching. The coefficient for *match–1* is no longer significant, but there are highly significant interactions between *match–1* and the dummy variables. The implication of the estimated model is that for abstract games, matching on the previous game has no significant effect in the first part of the experiment but a very strong positive effect in the second; for culture-laden games, matching on the previous game has a more modest positive effect in both parts of the experiment. In other words, it seems that players are unable to learn by symmetric rationalization in abstract games until they have had experience of culture-laden games; but for sufficiently experienced players, this form of learning is *more* effective in

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[15] On its own, this evidence is not conclusive. Even if there were no feedback-dependent learning, there could be positive autocorrelation between the choices made by individual subjects in different rounds. (For example, some subjects might always choose the reddest image, and others might always choose the bluest.) Such autocorrelation could induce a positive *match–1* coefficient. Further evidence of symmetric convergence is presented in Section VI.B.

[16] We experimented with other interaction terms but none of these proved to be statistically significant.

abstract games than in culture-laden ones. We postpone discussion of this intriguing result to Section V.

Table 2 shows the matching frequencies in the first and last games of each block, as predicted by Model 2. (The predictions of this model are also plotted as the "predicted" graphs in Figures 1a, 1b, 1c and 1d.) The predicted matching frequencies for the first game played in the first part of the experiment (0.298 for abstract games, 0.259 for culture-laden games) are only slightly greater than the 0.25 that would be expected from random play; the observed differences from 0.25 are not statistically significant.[17] The implication is that our subjects' overall success in matching is not attributable to pre-experimental inclinations; it is the product of learning within the experiment.

[Table 2 near here]

At the opposite extreme, the predicted matching frequencies for the last game played in the second part of the experiment are 0.529 for abstract games and 0.439 for culture-laden games. To get a feel for what these numbers signify, consider the following thought experiment. Denote the four images in a game A, B, C and D, and suppose that each player chooses A with probability p and each of B, C and D with probability $(1 – p)/3$. This implies an expected matching frequency of $p^2 + (1 – p)^2/3$. Thus, values of p of 0.40, 0.50, 0.60, 0.65 and 0.70 imply expected matching frequencies of 0.28, 0.33, 0.41, 0.46 and 0.52 respectively. Putting this the other way round, a matching frequency of about 0.40 could be induced by a 60: 14: 13: 13 distribution of each co-player's choices over images, while a matching frequency of about 0.50 could be induced by a 70: 10: 10: 10 distribution. A complementary benchmark is provided by the matching frequencies found in classic one-shot Schelling coordination games where strategies are identified by culturally-resonant labels. Bardsley et al (2010) report eight such games in which subjects choose one of four labelled strategies. Averaging over these games, the distributions of individuals' strategy choices imply an expected matching rate of 0.41; the highest expected matching rate in any of these games (induced by the predominant choice of "frog" from the set {"frog", "leopard", "panther", "tiger"}) is 0.55.

These comparisons imply that experienced players of our recurrently similar abstract games achieve matching frequencies similar to those typically found in classic one-shot

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[17] Using the delta method, a test of the hypothesis that the matching frequency for part 1, round 1 abstract games is greater than 0.25 gives a t-statistic of 1.457.

Schelling games. In other words, over the course of the experiment, pairs of co-players learn rules of selection that can be applied to new members of the family of abstract games with much the same degree of success as when co-players use focal points in one-shot Schelling games.

B. Is matching pair-specific?

Our analysis uses the concept of the *coordination index* (Mehta et al, 1994). Consider a given coordination game in which each player chooses from a set of n strategies, identified by the labels $l_1, ..., l_n$. Suppose we observe the choice made by each member of a population of N players of the game. For each label l_j, let m_j be the number of individuals who choose it. Then the coordination index is $\sum_j m_j(m_j - 1) / [N(N - 1)]$. This index measures the probability that two distinct individuals, chosen at random from the set of N individuals, choose the same strategy. It takes the value 1 if all individuals choose the same strategy, and 0 if everyone chooses a different strategy. If strategies are chosen at random, the expected value of the index is $1/n$. For any given game, we will say that the distribution of players' choices is *more concentrated* (or, equivalently, *less dispersed*), the higher the value of the coordination index.

For each game in our experiment, we can calculate the coordination index for the population of all 118 subjects. This index can be interpreted as the expected matching frequency under the counterfactual assumption that subjects were randomly reassigned to new pairings, but made the same choices as they had done in their actual pairs. Averaging across all 20 games of a given type, this calculation produces the coordination indices shown in the "CI" columns of row 1 of Table 3. These can be compared with the actual matching frequencies shown in the "MF" columns of that row, and with the benchmark frequency of 0.25 implied by random choice. Coordination indices are much lower than actual matching frequencies; for each type of game, the hypothesis that these differences are due to random variation is rejected in a one-tail bootstrap test ($p < 0.01$).[18] Because each of the families of culture-laden games has its own unique features, we also report matching frequencies and coordination indices separately for each block of these games (rows 2 to 5).

[18] We repeatedly reassigned subjects to pairs at random and calculated the number of matches per subject implied by subjects' actual choices. Confidence intervals were then calculated for the simulated distribution of 'matches per subject'.

[Table 3 near here]

The large differences between matching frequencies and coordination indices recorded in rows 1 to 5, and (with the possible exception of block 1 of the culture-laden games) the closeness of those coordination indices to 0.25, suggest that most of the systematic matching that occurred in the experiment was pair-specific. That would have two implications: first, that learning was predominantly feedback-dependent, and second, that there was at most only a weak tendency for such learning by different pairs of players to induce convergence on common rules. Before reaching these conclusions, however, it is useful to compare matching frequencies and coordination indices for different breakdowns of the sets of abstract and culture-laden games.

The statistics in rows 1 to 5 aggregate across games played at different positions in the sequence of 40 games that made up the experiment. An ideal test for pair-specific matching would compare matching frequencies and coordination indices separately for each <game, position> combination, but we have far too few observations for this to be feasible. Even if all learning were feedback-independent, an upward trend in matching frequencies over the course of the experiment would produce "all-games" matching frequencies that were greater than the corresponding coordination indices.[19] As a partial check for this possibility, we calculate matching frequencies and coordination indices separately for games played in the first and second parts of the experiment (rows 6 and 7), and for games played in rounds 1–10 and in rounds 11–20 (rows 8 and 9). For each of these breakdowns, the coordination index is fairly close to 0.25, confirming the conclusion that most learning is feedback-dependent. Given that all 20 abstract games belong to the same family, the fact that coordination indices remain low even in the later rounds of these games suggests that there was relatively little convergence on common rules.

However, coordination indices calculated by pooling all subjects might conceal differences in behavior between faster-learning and slower-learning (or perhaps non-

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[19] For example, consider an experiment with just two coordination games, each with four images, played in random order. Assume that in each game, one image is 'focal'. Every subject chooses at random in the first game she plays, and chooses the focal image in the second. Clearly, matching is not pair-specific. The expected number of actual matches per game is (1/4 + 1)/2 = 0.63. But holding constant each subject's choice in each game and randomly reassigning subjects to pairs, the expected number of hypothetical matches per game (i.e. the 'all games' coordination index) is only 7/16 = 0.44.

learning) pairs. In considering the hypothesis that learning leads to convergence on common rules, it is relevant to ask whether there was greater convergence for those pairs that were most successful in matching. We therefore calculate matching frequencies and coordination indices separately for *better-performing* and *worse-performing* pairs (rows 10 and 11). Better-performing pairs are defined as those whose matching frequencies are greater than or equal than the average matching frequency in the relevant set of 20 (abstract or culture-laden) tasks; worse-performing pairs are those whose matching frequencies are less than the average. For the better-performing pairs there is *some* evidence of convergence, but matching frequencies are *much* higher than coordination indices. Again, the implication is that systematic matching was predominantly pair-specific.

C. Styles as rules of selection in culture-laden games

In the families of culture-laden games, the four styles can be thought of as pre-defined rules of selection, which players might (but need not) use. In general, these families of games do not seem to have particular styles that were perceived as salient prior to the experiment. (Recall that our estimated model predicts a matching frequency of only 0.259 when culture-laden games are played at the very start of the experiment.) This makes it particularly interesting to investigate whether players *learn* to use styles as a means of matching.

As a first step, we analyse the relationship between the behavior of individual players in each round $r = 1, ..., 4$ of each block of culture-laden games and their behavior in the following round. Table 4 presents data on this relationship for each block of culture-laden games. In each case, the data are shown as a 2×2 contingency table, specified in terms of whether a player chose the same image as her co-player in round r ('match') and whether the image she chose in round $r + 1$ had the same style as the image chosen in round r ('same'). The entries in the cells are frequencies summed over the four relevant rounds r.

[Table 4 near here]

It is immediately obvious that in each case there is a strong positive association between "match" and "same"; the association is particularly strong in block 2.[20] These

[20] Because the observations are not independent, a chi-squared test of the aggregated data in each contingency table would be inappropriate. If a separate chi-squared test is carried out for each round r in each block, there is a significant positive association ($p < 0.05$) for $r = 1$ in block 1, for $r = 2$, 3 and 4 in block 2, for $r = 1$ in block 3 and for $r = 4$ in block 4.

regularities strongly suggest that players of the culture-laden games used the symmetric rationalization mechanism and that when they rationalized previous matches, they did so in terms of the style of the image on which they had coordinated. Thus, even though individual styles did not have pre-experimental salience, at least some players recognized styles and learned to coordinate on style-based rules of selection.

Given that styles were used in this way, it is relevant to look at the distributions of choices across styles. The first five columns of Table 5 describe these distributions aggregating over all rounds in a block, and separately for first and last rounds. (Notice that, because of the way the order of games was randomized, for any given block the data for the first and last rounds aggregates across the same two games. For example, the distributions for "block 1, round 1" and "block 1, round 5" both aggregate over games 1 and 5.) For each distribution in which the observations are independent, the sixth column reports a χ^2 test of the hypothesis that style choices were non-random. For each block, the final column reports a χ^2 test of the hypothesis that style choices differed between the first and last rounds.

[Table 5 near here]

These data show no firm evidence that feedback-dependent learning induced convergence of style-based rules. In none of the blocks is there a significant difference between the distributions of style choices in the first and last round.[21] Although, in general, style choices are not completely random, the distributions are rather dispersed; this may account for the low coordination indices found for culture-laden games. (Notice that the block with the least dispersed distributions of style choices, block 1, is also the block with the highest coordination index.) Overall, it seems that matching by styles was pair-specific: different pairs learned to use different styles. Although styles were certainly used as coordination devices, we cannot rule out the possibility that some pairs coordinated by using other rules of selection (such as rules based on the predominant color in each image); but whatever rules were used, it is clear that most matching was pair-specific.

D. The relationship between liking and choosing

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[21] However, it may be worth noting that the difference between first and last round distributions is greatest in block 2, the block for which the evidence of symmetric rationalization is strongest. In this case, there is perhaps some tendency for convergence on style 2. Our intuition is that this is a particularly distinctive style.

We now consider the data generated by the questionnaires. We will be primarily concerned with subjects' responses to the two questionnaires that were placed *before* the relevant coordination games but, as a preface, we note two features of the questionnaires placed *after* the games. There was a very strong positive correlation between subjects' pre-game and post-game responses to questions about the images that they most liked. There was also a very strong positive correlation between subjects' post-game responses to questions about the images they thought their co-players most liked and the choices actually made by those co-players in the corresponding games. These correlations contribute to the evidence that questionnaire responses were not arbitrary, but they imply that the post-game responses have little information content additional to that of the pre-game ones.

Table 6 presents some statistics about responses to the pre-game questionnaires, separately for abstract and culture-laden games. The first three rows provide information about the degree of concentration in the responses of subjects, taken together. The first row shows the average coordination indices for responses to the questions about subjects' own likings. The values of these indices are only slightly greater than 0.25, indicating a wide dispersion of likings in the subject population. It is not surprising, therefore, that subjects were unable to predict with any accuracy which images were most liked by other subjects. As the second row of the table shows, responses to the question about the co-player's likings were even more dispersed than responses about own likings. The *cross-coordination* indices in the third row show the probability that, for two individuals drawn from the population at random and without replacement, one individual's "belief about the other's liking" matches the other's "own liking". These indices too are close to 0.25. Interestingly, an individual's beliefs about other players' likings are slightly *worse* predictors of those likings than the first individual's own likings. The implication of all this is that neither subjects' own likings, nor their pre-play beliefs about other subjects' likings, would induce successful coordination if used as a rule of selection.[22]

[Table 6 near here]

[22] This implication is in marked contrast to the findings of Bardsley et al (2010, Table 2), who studied games with more culturally-resonant labels. A questionnaire which elicited subjects' 'favourite' labels for Bardsley et al's two sets of coordination games found normalized coordination indices (i.e. coordination indices multiplied by *n*) of 1.345 and 1.756 respectively. Our data imply normalized coordination indices of only 1.156 for abstract games and 1.148 for culture-laden games.

The remaining rows of Table 6 provide information about the degree to which a subject's response to one question about a given game predicts *her own* response to another question about the same game, or predicts *her own* choice in that game. The most important data are in the penultimate row. In 59.3 per cent of cases, a subject's actual choice in the first abstract game she played was the image that, in the pre-game questionnaire, she had said she most liked. The corresponding proportion for the first culture-laden game is 68.6 per cent. These high numbers strongly suggest that, in the first round of each part of the experiment, most subjects used the rule of selection "Choose the image you like most".

One might perhaps have expected that, in preference to that rule, most subjects would use the rule "Choose the image you believe your co-player likes most". The final row of the table shows that this was not the case. The fact that "*i*'s belief about *j*'s liking" has considerable predictive success for "*i*'s round 1 choice" is mainly attributable to the strong positive correlation between a subject's own likings and her beliefs about her co-player's likings, which is evident in the fourth row of the table.

We now have a proximate explanation of the low matching frequencies observed in the early rounds of each type of game: subjects chose according to their own likings, and the distributions of those likings were very dispersed. Since we know that matching frequencies increased over the course of the experiment, there must have been a corresponding decline in the tendency for subjects to choose according to their own likings. Nevertheless, the graphs of this decline, as shown in Figure 5, are illuminating. For each type of game, the graph of the frequency with which players choose their most-liked image has a "ratchet" pattern around an underlying downward trend. This frequency declines between the first and last game of each block, but then increases between the last game in one block and the first game in the next; this re-start effect is strongest at the end of the first block and becomes progressively weaker after successive blocks. The implication of the re-start effect seems to be that 'Choose the image that you most like' is used as a default rule of selection. The systematic pattern of movement away from this default rule as more relevant feedback is received is consistent with symmetric rationalization.

V. Discussion

From the data analysis reported in Section IV, we have learned the following about how subjects played our recurrently similar coordination games:

1. Most subjects began by choosing the images they liked most. The distribution of likings in the population was highly dispersed, resulting in very little systematic matching in the early rounds of the experiment (Sections IV.A and IV.D).
2. Over the course of the experiment, substantial learning occurred: matching frequencies increased markedly over the successive rounds of each block of games of a given family, over successive blocks of each type of game, and from the first part of the experiment to the second (Section IV.A).
3. By the end of the experiment, matching frequencies were greater for abstract than for culture-laden games (Section IV.A).
4. Systematic matching was predominantly pair-specific, indicating that (4a) learning was feedback-dependent and (4b) there was at most only a weak tendency for this learning to induce different pairs to converge on the same rules (Sections IV.B and IV.C).
5. Matching showed a pattern of positive autocorrelation that was strongly suggestive of symmetric rationalization. In culture-laden games, subjects tended to repeat the styles used in previous matches (Sections IV.A and IV.C).
6. The autocorrelation of matching was stronger in the second part of the experiment than in the first, indicating that the learning mechanism was itself being learned over the course of the experiment (Section IV.A).
7. For abstract games played in the first part of the experiment, there was no evidence of autocorrelated matching, but when abstract games were played after culture-laden ones, autocorrelation was particularly strong.

We now show that these regularities are consistent with a simple *two-heuristic model* of learning. We do not claim that this model is a prior hypothesis that has been *tested* in our experiment; to the contrary, it has been constructed inductively in the light of our findings. Our aim is merely to suggest possible directions for theoretical development.

As its name suggests, the model is built around two heuristics. At any given point in the experiment, a given subject uses one or other of these heuristics, but she may use one heuristic at one time and the other at another. The first and simplest is the *liking heuristic* – choosing the most-liked image in every game, irrespective of any feedback. The second is the *replication heuristic*. This heuristic has two “settings”. The *default* setting is to choose the most-liked image. The *similarity* setting (which implements symmetric rationalization) is to choose the image that the player judges most similar to the image that she and her co-player chose in the most recent game in which they achieved a match. In the first game in which a player uses this heuristic, the default setting applies. This continues until a match occurs. This triggers the switch to the similarity setting. There is a “re-set” feature that reinstates the default setting after some number of successive failures to match and (perhaps with some probability between 0 and 1) on moving to a new block of games.

For any image *l* belonging to a given family, we define the *replication probability* of *l* as the probability that two randomly-selected co-players will match in a (different) randomly-selected game *g* from the same family if they each choose the image that they judge most similar to *l*. We assume that, on average, this probability is greater than the probability that those co-players would match in *g* by each choosing the image they liked most. (More intuitively, we are assuming that the replication heuristic is a more effective means of coordination than the liking heuristic.) We postulate that over the course of the experiment, there is a tendency for subjects who have been using the liking heuristic to switch to the replication heuristic, and that no switching occurs in the opposite direction. The intuition is that subjects gradually learn that the replication heuristic is more successful.

Such a model induces the effects (1), (2), (4a), (5) and (6). If it is also to induce (3) and (7), two additional assumptions are needed. The first is that similarity probabilities are greater for abstract than for culture-laden games. This implies that, in games in which both players are acting on the similarity setting of the replication heuristic, the probability of matching is higher if the game is abstract. Thus, other things being equal, matching frequencies are greater for abstract games, leading to effect (3).[23] The second assumption is that individuals are more likely to switch from the liking heuristic to the replication heuristic when playing culture-laden games than when playing abstract ones. Thus, subjects in the culture-first treatment tend to make the transition to the replication heuristic earlier in the experiment than subjects in the other treatment, and so achieve more matches in the experiment as a whole. This induces effect (7).

[23] An alternative (or complementary) explanation of effect (3) is that, while the culture-laden games belong to four different families, the abstract games belong to a single family. Thus, the abstract games provide more opportunities for players to learn and apply similarity-based rules. In our model, this opportunity can be realized if players do not reinstate the default setting at the end of blocks of abstract games. In view of this, the strength of the re-start effect for abstract games (see Figure 5) is perhaps surprising.

Are these additional assumptions plausible? With the benefit of hindsight, the postulated difference in similarity probabilities might be explained by the relative simplicity and culture-neutrality of the abstract games. Our conjecture, based on an informal review of the choices of the co-players who were most successful in the abstract games, is that systematic matching was most usually achieved by using simple color-based rules of selection, such as “Choose the bluest image” or “Choose the palest image”. In every abstract game, the four images differ only in a single variable color. Even if subjects are not consciously aware of this property of the images, the overall color balance of each image is influenced by the variable color in a systematic way. (Thus, if one of the variable colors is clearly bluer or paler than the others, the image where it appears will probably be perceived by most subjects as the bluest or palest.) In this context, color-based rules seem to be both salient and reliable, in the senses defined in Section II.C. In contrast, culture-laden games seem to offer many more competing clues that could be used as coordination devices, and many of the more salient rules of selection are likely to be unreliable because of ambiguities of interpretation. Although our subjects seem to have had some sense of the style-based similarities that were built into the design of the culture-laden tasks, we conjecture that different subjects’ judgements of stylistic similarity would be less closely aligned than their judgements about color similarity.

If, as we have suggested, the replication heuristic is more effective in generating coordination in abstract than in culture-laden games, it may seem paradoxical to postulate that individuals are more likely to switch to this heuristic when playing culture-laden games. However, such a switch requires an imaginative leap, a “Eureka moment”: before a player can experience the effectiveness of a new heuristic, she must first *recognize* it as a possible course of action. Just as our fellow-economists were skeptical about the ability of experimental subjects to coordinate in abstract games, so those subjects themselves may have found abstract games perplexing in the absence of previous experience of coordination games with more cultural content. We conjecture that the culture-laden games were more effective in helping players to understand the nature of coordination problems and to recognize methods of solving them.

What about (4b), the apparent absence of convergence on common rules? As we explained in Section II.C, learning by symmetric rationalization can be expected to induce patterns of matching that have both pair-specific and non-pair-specific components. Since the rules that are learned in this way are “seeded” by an initial coincidence of likings, and given that the distributions of likings were very dispersed, it is perhaps not surprising that matching was predominantly pair-specific. Nevertheless, one might have expected different images to have different replication probabilities. (For example, in culture-laden games, some styles might be more distinctive than others; images exhibiting more distinctive styles are likely to have higher replication probabilities.) In order to reconcile (4b) with the two-heuristic model, one must conclude that, in each of our families of games, there were several salient and reliable rules, each inducing different choices but approximately equally effective as means of coordination.

VI. Conclusion

We have reported what we believe to be the first experimental investigation of a type of interaction that does not fit within the usual game theoretic taxonomy of one-shot and repeated games. These interactions are recurrently similar – that is, individuals recurrently play games that are similar to, but not identical with, one another.

We have developed an experimental design using pure coordination games with recurrently similar features. An important feature of this design is that, when people play these games for the first time, and unlike typical one-shot pure coordination games, they are no more successful than if they had chosen their strategies at random. There is no evidence, therefore, that subjects came to the experiment with ideas about how to coordinate that were successful. However, the frequency with which subjects coordinated increased with recurrent play, rising to levels similar to those observed in one-shot coordination games with "obvious" focal points. It is reasonable to infer that subjects learned to make good use in some way of the similarities between the games. Our evidence suggests that they did this by choosing actions that were perceived to be similar in some respect to those that had been successful in previous games. As successful perceived sources of similarity can vary, this learning mechanism can lead to the emergence of different similarity conventions in different groups of players; and this is what we found. We have presented a simple two-heuristic model of learning that can account for this and the other key features of learning revealed in the experiment.

Similarity-based learning mechanisms have occasionally been discussed by decision theorists, but most evolutionary game theory has not taken account of the role of similarity perceptions in the emergence of conventions. Our results suggest that this is an oversight and that recurrently similar coordination games deserve more attention, both theoretically and experimentally.

In particular, it is possible that our analysis points to a way that focal points, rather than being treated as a mysterious and anomalous feature of one-shot games, might be integrated into evolutionary game theory. The concepts of salience that allow focal points to be identified can be thought of as rules of selection or conventions that emerge through learning in, and become applicable across, a wide class of similar but not identical games. In this sense, our experiment has allowed us to observe – and to make some progress in explaining – the emergence of concepts of salience within (two-member) populations of players of recurrently similar games. That different conventions are learned by different pairs of co-players is the experimental analogue of differences between the concepts of salience used in different real-world populations.

Table 1: Random-effects probit regression results

variable	Model 1	Model 2
match (dependent)	—	—
match–1	0.201 (0.000)	–0.124 (0.273)
block	0.040 (0.041)	0.041 (0.035)
round	0.009 (0.072)	0.008 (0.079)
second	0.169 (0.002)	0.063 (0.567)
culture	–0.070 (0.191)	–0.115 (0.285)
*second*culture*		0.018 (0.918)
*second*match–1*		0.514 (0.001)
*culture*match–1*		0.385 (0.018)
*second*culture*match–1*		–0.501 (0.026)
constant	–0.647 (0.000)	–0.580 (0.000)
log likelihood	–1536.017	–1529.323
no of observations	2360	2360
no of pairs	59	59

p-values shown in parentheses

Table 2: Predicted matching rates

	abstract games		culture-laden games	
round	first part	second part	first part	second part
1	0.298	0.320	0.259	0.286
5	0.350	0.463	0.353	0.400
6	0.297	0.419	0.304	0.339
10	0.373	0.468	0.387	0.423
11	0.314	0.413	0.330	0.370
15	0.392	0.501	0.385	0.440
16	0.327	0.457	0.338	0.370
20	0.397	0.529	0.427	0.439

Table 3: **Pair-specificity of matching**

	average matching frequency (MF) and coordination index (CI) for:			
	abstract games		culture-laden games	
	MF	CI	MF	CI
(1) all games	0.392	0.284	0.369	0.280
(2) culture-laden block 1 (fabrics)			0.356	0.316
(3) culture-laden block 2 (fabrics)			0.407	0.263
(4) culture-laden block 3 (paintings)			0.346	0.280
(5) culture-laden block 4 (paintings)			0.366	0.263
(6) games played in part 1	0.345	0.274	0.350	0.276
(7) games played in part 2	0.446	0.297	0.384	0.290
(8) games played in rounds 1–10	0.361	0.298	0.367	0.282
(9) games played in rounds 11–20	0.423	0.274	0.370	0.281
(10) better-performing pairs	0.530	0.323	0.498	0.310
(11) worse-performing pairs	0.278	0.268	0.267	0.265

Table 4: Effects of previous matching on style choice in culture-laden games

		frequency (proportion) of style choices in round r+1		
		same	different	total
Block 1 (fabrics)				
round r outcome	match	79 (0.45)	97 (0.55)	176 (1.00)
(r = 1, ..., 4)	not match	97 (0.33)	199 (0.67)	296 (1.00)
	total	176 (0.37)	296 (0.63)	472 (1.00)
Block 2 (fabrics)				
round r outcome	match	137 (0.75)	45 (0.25)	182 (1.00)
(r = 1, ..., 4)	not match	101 (0.35)	189 (0.65)	290 (1.00)
	total	238 (0.49)	234 (0.51)	472 (1.00)
Block 3 (paintings)				
round r outcome	match	62 (0.39)	98 (0.61)	160 (1.00)
(r = 1, ..., 4)	not match	84 (0.27)	228 (0.73)	312 (1.00)
	total	146 (0.31)	326 (0.69)	472 (1.00)
Block 4 (paintings)				
round r outcome	match	74 (0.47)	82 (0.53)	156 (1.00)
(r = 1, ..., 4)	not match	103 (0.33)	213 (0.67)	316 (1.00)
	total	177 (0.38)	295 (0.63)	472 (1.00)

Table 5: Style choice frequencies in culture-laden games

	frequency of choice of:					χ^2 statistic for difference between:	
	style 1	style 2	style 3	style 4	total	styles	rounds
block 1: all rounds	116	127	264	83	590		
round 1	30	21	54	13	118	32.03***	
round 5	26	17	53	22	118	26.34***	3.03
block 2: all rounds	117	200	162	111	590		
round 1	24	35	37	22	118	5.86	
round 5	18	48	28	24	118	17.19***	4.23
block 3: all rounds	120	152	128	190	590		
round 1	14	33	27	44	118	15.90***	
round 5	18	30	33	37	118	6.81*	1.85
block 4: all rounds	153	161	136	140	590		
round 1	31	42	27	18	118	10.07**	
round 5	31	36	29	22	118	3.42	0.93

Statistical significance at the 10 percent, 5 percent and 1 percent levels shown by *, ** and *** respectively. All tests have 3 degrees of freedom.

Table 6: Pre-game questionnaire responses

	abstract games	culture-laden games
average coordination index for:		
(i) A's liking	0.289	0.287
(ii) A's belief about B's liking	0.267	0.273
average cross-coordination index between (i) and (ii)	0.274	0.277
predictive power of (i) for (ii) (all rounds)	0.429	0.418
predictive power for A's choice (in round 1) of:		
A's liking	0.593	0.686
A's belief about B's liking	0.398	0.517

Figure 1: Two abstract games

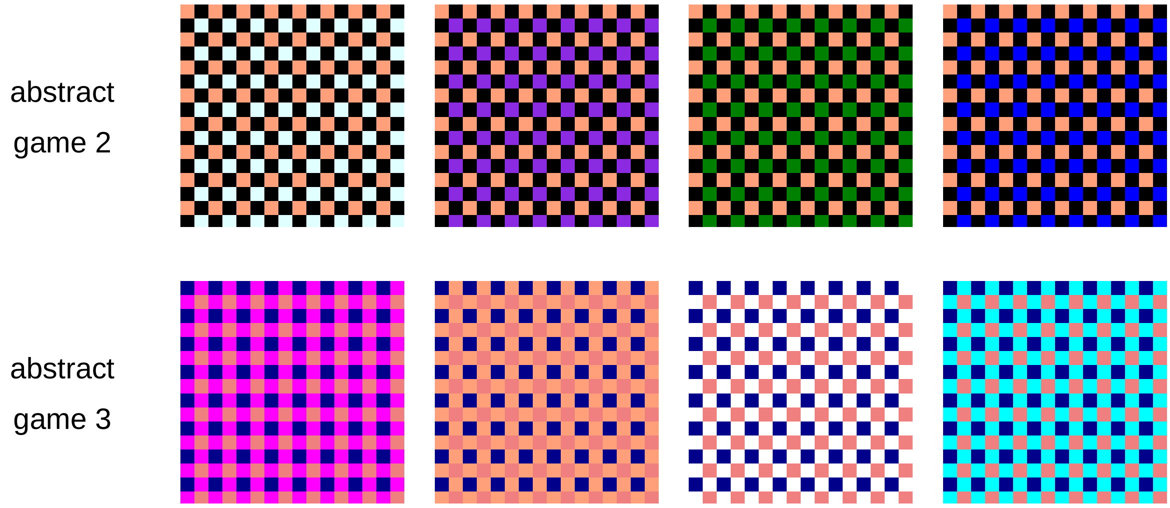


Figure 2: Two culture-laden games using fabric designs

Figure 3: Two culture-laden games using paintings

culture-laden game 17

culture-laden game 19

Figure 4a: Matching frequencies by round: abstract games in first part of experiment

Average matching frequency: 0.345

Predictions derived from Model 2, Table 1

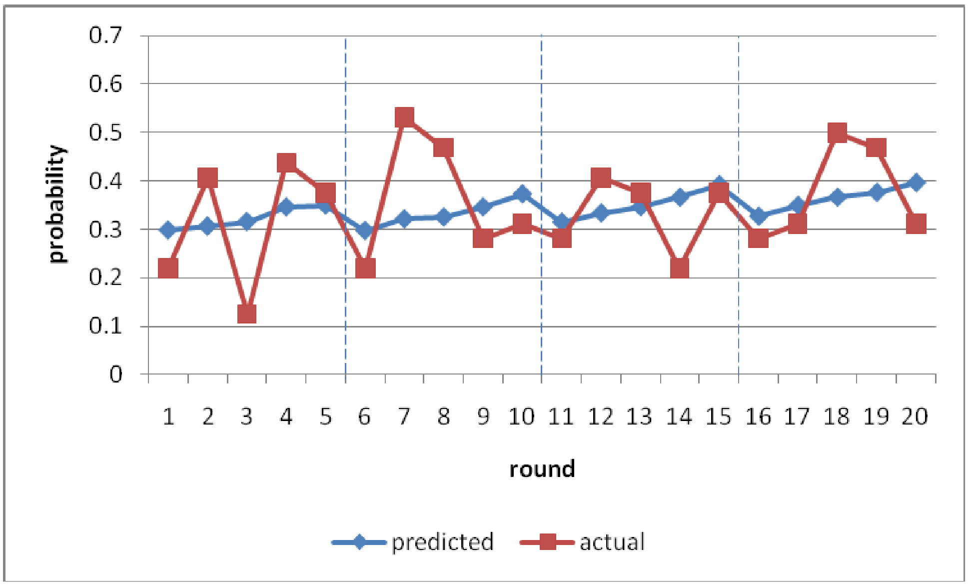


Figure 4b: Matching frequencies by round: abstract games in second part of experiment

Average matching frequency: 0.446

Predictions derived from Model 2, Table 1

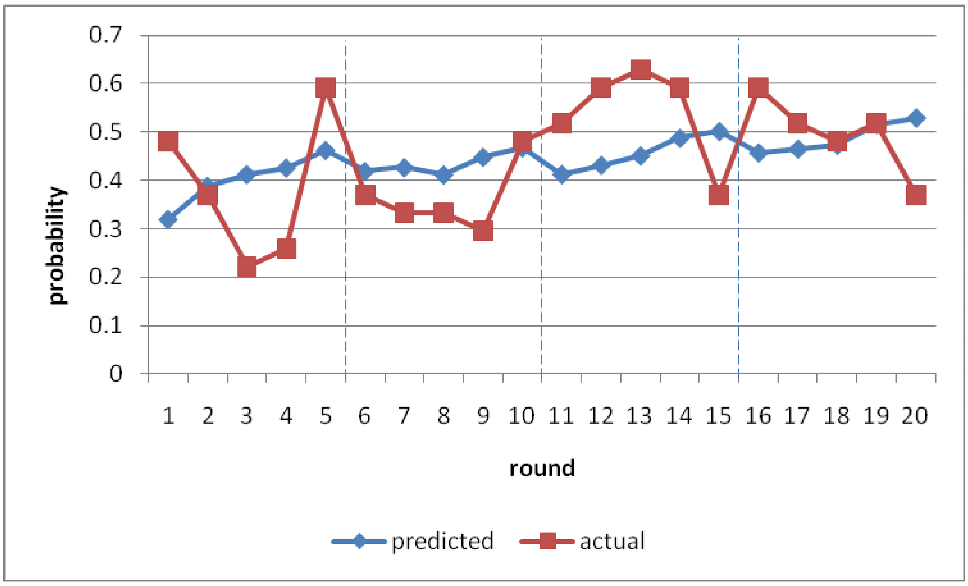


Figure 4c: Matching frequencies by round: culture-laden games in first part of experiment

Average matching frequency: 0.350

Predictions derived from Model 2, Table 1

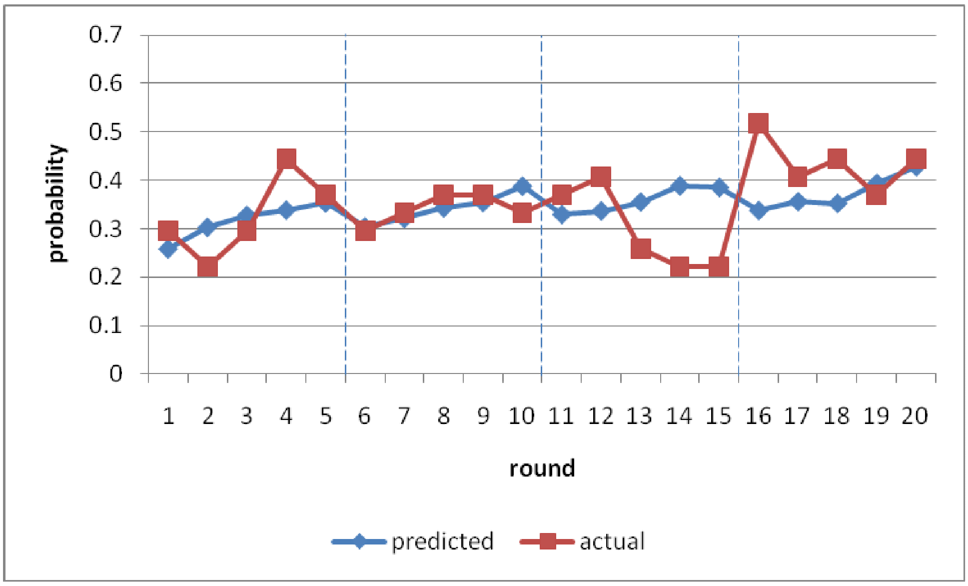


Figure 4d: Matching frequencies by round: culture-laden games in second part of experiment

Average matching frequency: 0.384

Predictions derived from Model 2, Table 1

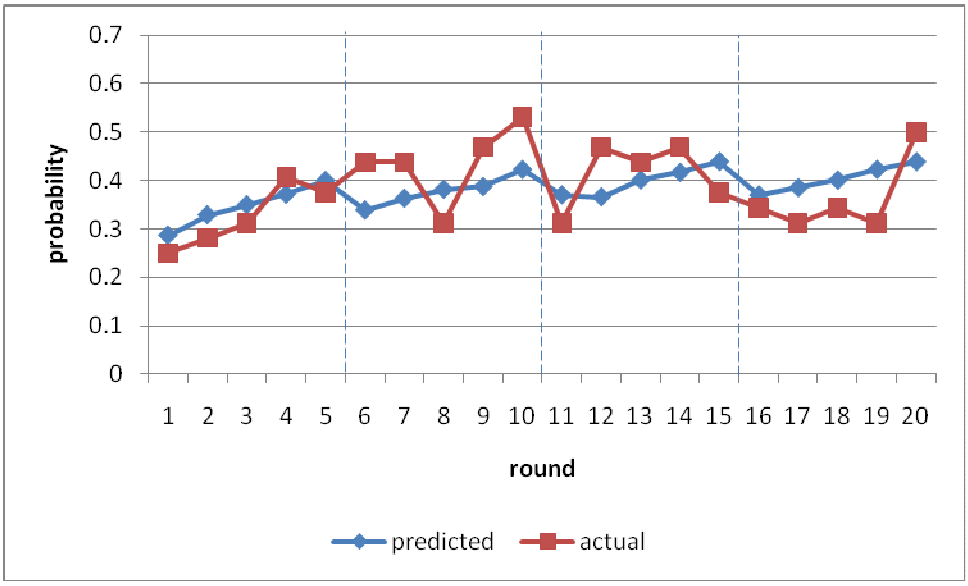
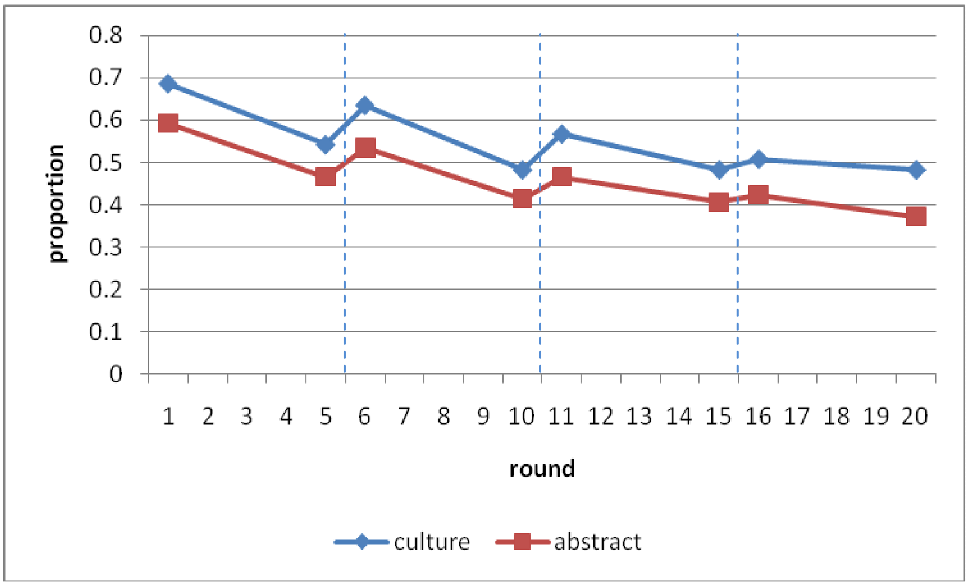


Figure 5: Frequency of choice of 'most liked' image



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