Making TRACS: The Diagrammatic Design of a Double-Sided Deck

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Abstract. TRACS: Tool for Research on Adaptive Cognitive Strategies, is a new family of card games played with a special deck. Each card in the deck is a double-sided diagram, where the back gives a clue to the front. Compared to standard card games, this clue/truth structure makes TRACS more tractable to theoretical investigations in the lab and more typical of practical situations in the world. Here I present the design of the deck and discuss some research results.

1 Introduction

Card games are useful for studying human judgment and decision making because they simulate the probabilistic and dynamic conditions of "naturalistic" (real world) situations. Unfortunately, with a standard deck of 52 cards, most games are too complex for analytical or numerical solution, and this makes it difficult to establish normative benchmarks for cognitive performance. Furthermore, with no information on one side (back) and all information on the other side (front), standard playing cards fail to capture the clue/truth structure of many real world problems.

TRACS (Tool for Research on Adaptive Cognitive Strategies) [1] is a new family of games played with a special deck of double-sided cards (Fig. 1). The deck has a non-uniform distribution of six clue/truth (back/front) card types, and this structure allows players to infer the likely truth (front) from a given clue (back).

Compared to standard games played with single-sided cards, TRACS offers advantages of theoretical rigor and practical relevance. With respect to rigor, the backs of the cards provide partial information to constrain the possible game states, and this makes the games more tractable to mathematical analysis of optimal solutions. For example, a face down card in a standard deck can be any one of 52 cards; but in TRACS the card can be one of only six types, and the front (truth) is further constrained by the back (clue). With respect to relevance, the back/front (clue/truth) structure of the TRACS cards simplistically simulates the practical problem of inferring naturalistic truths from probabilistic clues. This is a basic problem in many applications, such as military intelligence (target identification from radar image) and medical diagnosis (tissue identification from x-ray image).

With this novel structure of the deck, TRACS offers a useful blend of rigor and relevance for research on human judgment and decision making. Below I provide examples of a rigorous investigation and a relevant application.

2 Discussion

The basic problem in playing TRACS is that the probabilistic distribution of card types (Fig. 1) changes in a dynamic fashion as cards are turned over to reveal their fronts. This is similar to the problem posed by standard card games like Blackjack, except that with standard cards the backs of the cards provide no information to help one make a decision, e.g., to draw a card (or not), or to choose one card over another.

Many games can be played with the TRACS cards [1]. The simplest is a solitaire game called Straight TRACS, where on each turn the player is presented with a face-up card (color) flanked by two face-down cards (black shapes). The object is to turn over the black shape (left or right card) that is most likely to match the color of the card in the middle. The challenge is to count cards and update odds as the deck is depleted in play. For example, at the start of the game (with a full deck), a triangle is more likely than a circle to turn out Red, i.e., by odds of 3:2 as illustrated by the diagram on the front of each Red card (Fig. 1). But later in the game, after some triangles and circles have been turned over and removed from play, a circle may be more likely than a triangle to turn out Red.

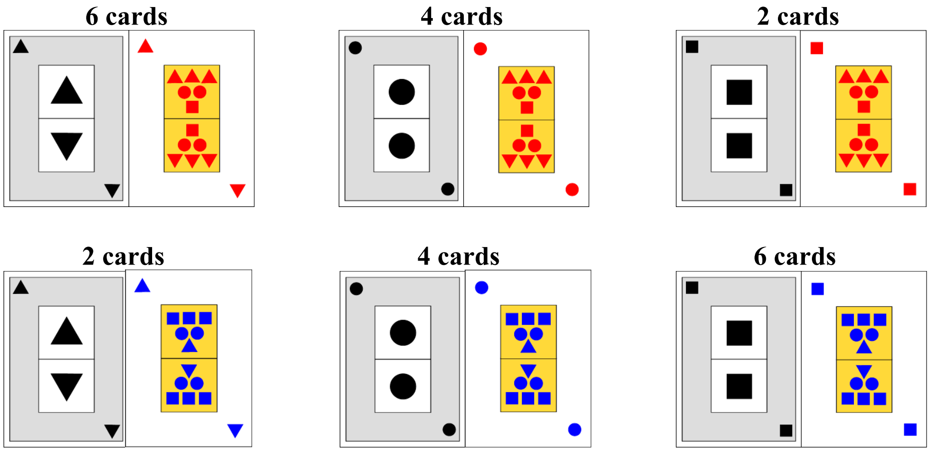

Fig. 1. The TRACS cards (Copyright 2002 by K. Burns). The double-sided deck contains 24 clue/truth (back/front) cards. The front of each card (Red or Blue) illustrates the distribution.

Initial experiments on Straight TRACS [2], [3] showed that human subjects are quite limited in their ability to count cards and update odds, even after much practice in the task. For example, Fig. 2 plots the probabilistic judgments reported by subjects (N=45) for one card type (squares) in one game (11 turns). The plot shows that subjects are “anchored” to the baseline (initial) odds and they make rather sluggish “adjustments” compared to the actual odds. The plot also shows the results of a computational (probabilistic) model [4] that simulates this anchoring and adjustment behavior. The model compares well to the data, both in mean response (line) and standard deviation (bars). This is an example of how TRACS offers rigor – in laboratory investigations to model human judgment and decision making.

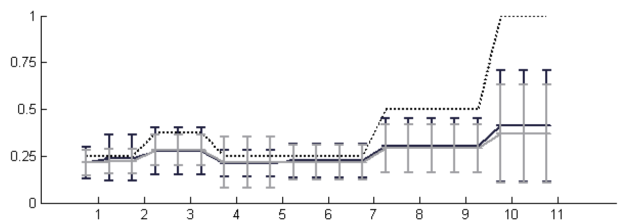

Fig. 2. Probability (% Red) vs. turn (#) for one card type (squares). Model (gray) against data (black). Lines show mean; bars show standard deviation. Dotted line shows actual probability.

Subsequent experiments were performed on a game called Spy TRACS [5], which is similar to Straight TRACS except that the player does not have to count cards. Instead, the player is given the "deck odds" for each turn, along with "spy odds" from an independent source (i.e., a simulated spy). The object is to combine the deck odds and spy odds (in a task of Bayesian inference) to estimate the "final odds" as a basis for choosing a card to turn. Experiments on Spy TRACS offer insight into cognitive "conservatism" in Bayesian inference [6], and this insight was used to design a diagram called "Bayesian Boxes" that helps correct conservatism [5]. This is an example of how TRACS offers relevance – for practical applications to improve human judgment and decision making.

Additional experiments are currently being planned for a multi-player game called Poker TRACS [1]. In this game, the diagnoses are more complex because information is conveyed by intentional actions (when bets are made and raised) as well as physical events (when cards are dealt and turned). Similarly, the decisions are more complex because they involve chips (in betting) as well as cards (in drawing), and because they require projections of future game states as well as assessments of current game states. These cognitive challenges make the game relevant to practical problems in the world [7], and the double-sided deck makes the game tractable for rigorous research in the lab.

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