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The effect of opponent type on human performance in a three-alternative choice task

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ABSTRACT

Adult participants played computerised games of "Paper Scissors Rock". Participants in one group were told that they were playing against the computer, and those in the other group were told that they were playing against another participant in the adjacent room. The participant who won the most games would receive a $50 prize. For both groups however, the opponent's responses (paper, scissors, or rock) were generated by the computer, and the distribution of these responses was varied across four blocks of 126 trials. Results were analysed using the generalised matching law for the three possible pairs of alternatives (paper vs. scissors, paper vs. rock, and scissors vs. rock) across all participants in each group. Overall, significantly higher estimates of sensitivity to the distribution of opponent's responses were obtained from participants who were told their opponent was a computer compared to participants who were told their opponent was another participant. While adding to the existing literature showing that the generalised matching law is an adequate descriptor of human three-alternative choice behaviour, these findings show that external factors such as perceived opponent type can affect the efficacy of reinforcer contingencies on human behaviour. This suggests that generalising the results from tasks performed against a computer to real-life human-to-human interactions warrants some caution.

1. Introduction

Choice is a widely studied topic in the area of behaviour analysis, and the simplest way to look at choice behaviour is by presenting a subject with two response alternatives, for example, two response keys or levers. When each alternative is associated with its own schedule of reinforcement (e.g., concurrent variable-interval [VI] VI schedules), then the relative frequency of reinforcement and relative rates of responding are almost equal (Herrnstein, 1961); this has become known as the matching law. Noting two kinds of deviation from strict matching, Baum (1974) proposed a generalised form of Herrnstein's matching law, known as the generalised matching law (GML):

$$\log\left(\frac{B_1}{B_2}\right) = a\log\left(\frac{R_1}{R_2}\right) + \log c \qquad (1)$$

where B_1 and B_2 represent the numbers of responses made on alternatives 1 and 2 respectively, and R_1 and R_2 represent the numbers of reinforcers obtained from making B_1 and B_2 responses respectively. The parameter a is a measure of the sensitivity of a subject's behaviour to the reinforcer distributions; in other words, it measures the extent that changes in the relative rates of reinforcement change the subject's relative rates of behaviour. When relative rates of reinforcement and behaviour are equal, then $a = 1$. When the relative rates of behaviour are less extreme than the relative rates of reinforcement, then $a < 1$; this is known as undermatching. Log c is a measure of any inherent bias that the subject has for responding more on one alternative over the other, irrespective of changes in the reinforcer distributions (Baum, 1974, 1979).

1.1. Two-alternative choice

Choice with two alternatives has been studied using both non-human and human subjects, using a variety of procedures. Typically, non-human subjects show slight undermatching with estimates of a around 0.8–0.9 (see Baum, 1979; Davison and McCarthy, 1988). Human subjects however, are more variable in their performance in two-alternative choice situations. For example, Pierce and Epling (1983) reviewed 16 studies where two concurrent schedules of reinforcement were available to human participants. They found that 13 of those provided results that were consistent with the GML, and that those that were found to be inconsistent had questionable validity or conflicting results. Kollins et al. (1997) also reviewed findings from human participants in two-alternative choice situations, and compared these to findings

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from non-human participants. They found that sensitivity values from human participants were more variable than those obtained from non-human participants, and overall, humans were less sensitive to changes in reinforcement contingencies (median a of around 0.7 across the studies reviewed). However, when human subjects were tested in more naturalistic settings, they were found to show stronger matching and results more similar to those obtained by non-human animals, suggesting that methodological issues may be the primary reason behind the differences between human and non-human performance.

Recently, Kennelly and Fantino (2007) and Fantino and Kennelly (2009) studied human choice from a different perspective, looking at the allocation of resources. Participants in their studies played a "sharing game", where they were given the choice between pairs of unequal money amounts, for example, \$7/\$9 vs. \$5/\$3, across a number of trials. On each trial, the participant received the first amount out of the pair they selected (e.g., \$7 in the first pair) while their opponent received the second amount (e.g., \$9 in the first pair). In this example, the optimal choice for the participant would be the first pair, as the participant would receive the most money for him/herself; however, this option would give their opponent a greater amount than the participant. The competitive choice would then be the second pair, as the participant would receive more money (\$5) than their opponent (\$3), but both would receive less money overall when compared to the first pair.

Kennelly and Fantino (2007) found that, across all conditions, participants only chose the optimal pair on 49% of trials, and that participants playing for real money were more likely to make optimal choices than participants who played for hypothetical money. This finding was then replicated using a within-subjects design by Fantino and Kennelly (2009). Furthermore, and of particular relevance to the present study, both Kennelly and Fantino (2007) and Fantino and Kennelly (2009) found that participants did not respond differently when they were told their opponent was a computer or another person (when in fact, in both instances, the participants were playing the computer). This effect was found even when the monetary amounts earned were real; that is, it appeared that the drive to respond competitively was the same, regardless of whether the participant's opponent was identified as being a person or a computer.

Kennelly and Fantino's (2007) and Fantino and Kennelly's (2009) findings are consistent with the CASA (Computers Are Social Actors) model (Nass et al., 1994). The model proposes that the rules one applies to interact with a computer are the same as those applied to social interactions with other humans. The model was based on work by Nass et al. (1994) where participants engaged in various two-way interactions with the computers. Nass et al. found that individuals applied social norms and social rules such as politeness, praise, and gender stereotypes to computers, as well as concepts such as "self" and "other". Other studies (for review see Nass and Moon, 2000) looking at other aspects such as ethnicity and reciprocity have also provided support for this model by demonstrating that humans show ethopoeia; that is, they directly respond to a non-human entity as if it were a human while having awareness that it is not. In other words, despite knowing that computers are not people, humans still "mindlessly" respond to computers as if they were (Nass and Moon, 2000).

1.2. Multiple-alternative choice

Compared to studies of two-alternative choice, studies of choice when there are three (or more) concurrently available alternatives are less common in the behaviour analysis literature. Because situations in which organisms have to choose between more than two options commonly occur outside the laboratory, it is important for any model of choice to also be able to describe multi-alternative choice behaviour. The few studies that have examined choice with more than two alternatives have found the GML to be a satisfactory descriptor of choice behaviour (although see Elliffe and Davison, 2009, for issues with the constant-ratio rule). For example, Pliskoff and Brown (1976) looked at three-alternative choice behaviour with pigeons in a changeover key procedure. Pecks to the left (change-over) key allowed the pigeons to choose between three different VI schedules of reinforcement (signalled by key colour changes) on the right key. Pliskoff and Brown found that both the relative time spent on each schedule, as well as relative response rates on each schedule, matched the relative reinforcement rates. Similarly, Miller and Loveland (1974) looked at pigeons' choice behaviour in a five-key concurrent-schedule procedure, and found that relative time and relative responses matched the relative rates of reinforcement for three out of four of their subjects. These studies, along with a number of others (e.g., Davison and Hunter, 1976; Elsmore and McBride, 1994; Graft et al., 1977; Hunter and Davison, 1978), support the extension of the GML to multi-alternative situations with non-human subjects.

More recently, Kangas et al. (2009) looked at three-alternative choice performance with human participants in a simulated Paper, Scissors, Rock (PSR) game. The standard rules of play applied: paper beats rock, rock beats scissors, and scissors beats paper. Participants were told that the participant who received the highest overall score at the end of the study would be awarded a \$50 gift certificate. Each participant played a number of rounds (i.e., trials), where they chose to play either paper, scissors, or rock against the computer by clicking on the corresponding option on the computer screen. The computer's choice was then presented after the participant had made theirs. The winner of each round (i.e., the participant or the computer) received 5 points, while ties and losses resulted in no change to the overall scores. Within the session, the participant completed 10 blocks of 100 trials. For each block, the probability of the computer playing paper (P), scissors (S), or rock (R) varied. In the first block, these probabilities were equal (i.e., .33, .33, .33 for P, S, and R respectively). Across the other nine blocks, the probabilities for each option varied from .05 to .85. The GML captured the relation between response allocation and probability of 'winning' well by accounting for between 88 and 92% of the variance in the data.

In a second experiment, Kangas et al. (2009) examined the effect of providing the participants with information about the computer's response probabilities. These participants ran through a similar procedure as Experiment 1, but were told at the start of each block what the probabilities were that the computer would be playing the various response options. Under these conditions, five of six participants responded almost exclusively to the most probable option, which led to significantly higher game scores for participants in Experiment 2 compared to those in Experiment 1. Kangas et al. suggested that the additional instructions in Experiment 2 allowed participants to adjust quickly to the reinforcement contingencies in place for each block, and they surmised that if Experiment 1 participants had had more exposure to the contingencies, then their performance may have been similar to that of the participants in Experiment 2. The researchers also noted that both receiving points when winning a round, and competing against a computer, were both likely to be reinforcing for participants. They also suggested that using a game that was so familiar to participants enhanced the control by the contingencies. Kangas et al. concluded that the GML provides a good description of how human participants allocate responses in a three-alternative concurrent choice scenario.

1.3. The present study

In the present study, human participants played a game of Paper, Scissors, Rock, similar to Kangas et al.'s (2009) procedure. However,