¹ Contingency Judgements

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12   Abstract

13   The purposes of this experiment were to create a simulated version of the Crump et

14   al. (2007) study and additionally to experiment with new theoretical conditions within the

15   simulation. In general, our model was able to replicate several attributes of the in-person

16   study, such as the $\triangle P$ conditions and the outcome densities associated with them, as well

17   as the overall trend of the data. We created a model using RStudio, based on MINERVA 2,

18   which is a simulation model of episodic memory. MINERVA 2 assumes that each

19   experience leaves an individual memory trace (Hintzman, 1986). Our model was presented

20   with six different conditions. Three were high outcome density and three were low outcome

21   density conditions. Low outcome density refers to a trial in which fewer outcomes were

22   presented than cues. High outcome density refers to trials where more outcomes were

23   presented than cues. Four types of trials can be presented to the model. The model can be

24   presented with a cue and no outcome, no cue and no outcome, a cue and an outcome, or no

25   cue and an outcome. Our model was shown all four combinations. It was then asked to

26   predict, based on all of the combinations that it had been presented with, whether an

27   outcome would occur given that cues were presented first with no outcomes. We

28   hypothesized that Just like the human participants in the original study, our computer

29   model also had higher contingency ratings when more outcomes were presented than cues

30   (high outcome density). In contingent conditions ($\triangle P$=.467), contingency ratings were

31   much higher overall than noncontingent conditions ($\triangle P$=0), which, as intended, paralleled

32   the original results. However, it did so with regard to a higher expectation overall than

33   that of the original study. We also presented the model with a negative contingency

34   condition ($\triangle P$=-.467) that was not present in the original study. Our results show that, in

35   theory, had this been the case in the original study, participants would have least expected

36   the occurrence of an outcome under these conditions.

37   *Keywords:* keywords

38   Word count: X

Contingency Judgements

Introduction

Imagine that you are driving down a highway going sixty miles per hour. All of the sudden traffic slows down and you see two police cars pass by. "I guess there was an accident", you think to yourself as you anticipate a longer commute than expected. You later pass the cars involved, and also arrive twenty minutes late to work. Why did you predict that a car crash had occurred? Why did you predict that you would have a longer commute time? These types of questions are asked by researchers when studying contingency judgements. A contingency judgement can be defined as one's perception of whether a particular stimulus predicts a particular outcome. The purpose of studying human contingency judgements is to be able to gain a better understanding of the way that people learn about the causal relationships between events (Beckers, 2011). In order to study this further, we created a model using RStudio. The model attempts to help us understand the way in which contingency judgements are made. Our model is based on MINERVA 2, which is a simulation model of episodic memory. Specifically, MINERVA 2 assumes that each experience leaves an individual memory trace (Hintzman, 1986). Our model focuses on evaluating the percentage of information remembered after cues and outcomes are first presented. The model is first presented a set amount of cues and outcomes, and its "memory" is then checked by "asking" the model to predict whether an outcome will occur given that a cue was presented or not. Our experiment is based on a research study performed by Crump et al. (2007). While this study involved presenting humans with a contingency task, our computer model attempts to replicate the findings of the study, and expand upon it. The findings of the original study explain that people are generally normative. In other words, people generally act in an expected way when making contingency judgements, and this is referred to as the $\triangle P$ rule (Allan, 1993). For instance, if someone changes the brightness of their phone screen and it becomes brighter, a person

65 will likely be able to tell that an increase occurred rather than a decrease, or no change.

66 This would be expected, or normative, behavior. By the same token, human beings are not

67 robots, and each person has their own biases. For instance, one may rate contingency as

68 significantly higher or lower than actuality. These biases result in a departure from

69 expectations during research. This phenomenon is explained by the outcome density effect.

70 This states that when more outcomes occur, they lead participants to more strongly

71 predict that there is a contingency occurring in order to create the outcomes, even if there

72 is not necessarily a true contingency between events. For instance, if someone is shown a

73 circle followed by a square 95 of the time, they are more likely to predict that the circle

74 indicates that a square will be presented later, even if the order was randomly generated

75 and no connection between the two cues was intended. What psychological mechanisms are

76 involved in making contingency judgements? Several theories can be used to explain the

77 way in which contingency judgements work. MINERVA 2 assumes that repeated exposure

78 to the same information creates multiple copies rather than strengthening the same

79 memory. This is called multiple-trace theory. While this theory is assumed for the

80 purposes of this study, many other models attempt to explain how contingency judgments

81 are formed. One of these is called rule-based theory. This theory looks at people or even

82 animals as intuitive statisticians who extract contingency information by applying formulas

83 (Allan, 1993). In other words, animals and humans act as "calculators" unwittingly. For

84 instance, Another theory is associative theory, which looks at contingency learning as a

85 result of Pavolvian associations formed between all previously presented events (Allan,

86 1993). This is based on the Rescorla-Wagner model of learning, which explains that

87 learning diminishes as the conditioned stimulus becomes more familiar. This makes the

88 case that contingencies are learned through the repeated presentation of stimuli. For

89 instance, in Crump et al. (2007), when a red circle is presented after a blue square,

90 participants learn to associate the circle with the square and form a judgement that the

91 circle is contingent upon the prior presentation of the square. Signal detection theory deals

92   with measuring one's ability to differentiate between actual information and random

93   patterns that distract from it. Based on this theory, contingency judgements are formed

94   based on how well one is able to separate noise (random pairings) from actual

95   contingencies. Several factors may influence whether or not one is able to make an accurate

96   contingency judgement. First, there is a minimum amount of change necessary for one to

97   tell whether something is different from before. For instance, if someone only changes the

98   brightness on their phone by 1% would one be able to notice? There is also a minimum

99   amount of stimulation required in order for someone to be aware that something is

100   happening. For instance, if a significant amount of time is elapsed between two events, one

101   may be less likely to predict that one event caused the other to occur. For instance, if you

102   eat spoiled food but do not get sick until three weeks later, you may be less likely to

103   predict that the food caused the illness than if you got sick the next day. Further, noise

104   interference also plays a role. This is anything that distracts the participant in some way

105   while they are trying to focus on the contingency task. Other thoughts, sounds, or objects

106   in sight can create noise in one's memory. These factors can take away from or add to a

107   participant's memory of the task. Noise may reduce contingency judgement accuracy.

Methods

109   We used RStudio to create a model of memory. Our model was presented with six

110   different conditions. Three were high outcome density and three were low outcome density

111   conditions. Low outcome density refers to a trial in which fewer outcomes were presented

112   than cues. High outcome density refers to trials where more outcomes were presented than

113   cues. Four types of trials can be presented to the model. The model can be presented with

114   a cue and no outcome, no cue and no outcome, a cue and an outcome, or no cue and an

115   outcome. Our model was shown all four combinations. It was then asked to predict, based

116   on all of the combinations that it had been presented with, whether an outcome would

117   occur given that cues were presented first with no outcomes. The three types of streams

presented were noncontingent, contingent, and negative contingent. Noncontingent refers

to trials where cues and outcomes were presented randomly, with neither meant to predict

the other. Contingent refers to when an outcome was predicted given a cue. Negative

contingent refers to when an outcome was predicted despite no cue given. MINERVA 2 is a

multiple-trace model as it assumes that each experience leaves an individual memory trace

(Hintzman,1986). In other words, repeated exposure to the same information creates

multiple copies rather than strengthening the same memory. MINERVA 2 is mostly

focused on long-term memory. However, there is assumed to be a temporary buffer

(short-term memory) that relays information to long-term memory (Hintzman, 1988). The

original experiment by Crump et al. involved a blue square being presented as the cue and

a red circle being presented as the outcome. Our model presents cues and outcomes to the

model as sets of 0s and 1s. 0 being not present, 1 being present. Specifically, in our

simulation, the model was shown 0s and 1s as representations of cues and outcomes,

respectively. If a cue was presented first, it may have either been followed by an outcome

(1), or no outcome (0). If no cue was presented first (0), it was either followed by no

outcome, or an outcome. In theory, the more cues and outcomes presented, the more

accurate the model should be at predicting which number will be presented next.

Simulation 1

Results

Did our MINERVA model produce a similar $\triangle P$ effect and outcome density effect to

those found in the Crump et al. (2007) study? While our model did produce the effects, it

did so with regard to a higher expectation overall than that of the original study. While

the original study contained negative expectations, the model only produced positive

expectations, although the overall trend of the results was otherwise almost identical to the

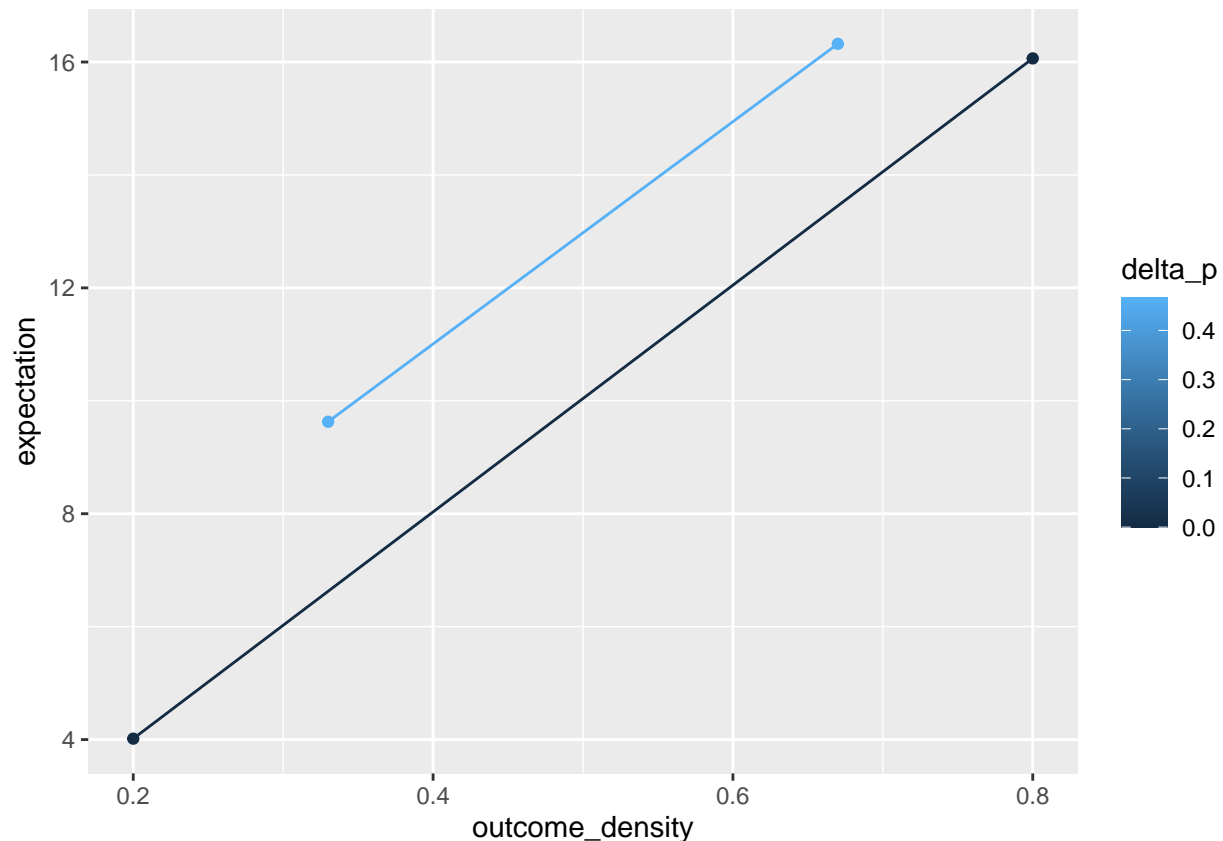original study. For both contingent and noncontingent streams of data, contingency ratings

Figure 1. Write a caption for figure 1

143 were lower when less outcomes were presented. Just like the human participants in the

144 original study, our computer model also had higher contingency ratings when more

145 outcomes were presented than cues (high outcome density). In contingent conditions

146 ($\triangle$P=.467), contingency ratings were much higher overall than noncontingent conditions

147 ($\triangle$P=0), which, as intended, paralleled the results of the original study.

148   Were we able to simulate a theoretical negative contingency condition? A negative

149 contingency condition ($\triangle$P=-.467) was not present in the original study. In this condition,

150 the presence of a cue would predict the absence of an outcome. We presented the model

151 with two negative contingency trials, one for both high and low outcome density. Our

152 results show that, in theory, had this been the case in the original study, participants

153 would have least expected the occurrence of an outcome under these conditions. In other

154 words, when compared with the two other conditions, contingency ratings were much lower

155 when the model was presented with a negative contingency. This was true for both the

156 high and low outcome density trials.

Discussion

157

158   The purposes of this experiment were to create a simulated version of the Crump et

159 al. (2007) study and additionally to experiment with new theoretical conditions within the

160 simulation. In general, our model was able to replicate several attributes of the in-person

161 study, such as the $\triangle P$ conditions and the outcome densities associated with them, as well

162 as the overall trend of the data.

163   Our model contains several key differences when compared with the original study

164 done by Crump et al. (2007). First, presenting the four possible scenarios to the cue and

165 then asking the model to predict what will happen for each of the six conditions yielded

166 results that were similar to those provided by humans. However, the results provided by

167 humans were lower in expectation than those of the model, although similar in range.

168 Scaling error may account for these differences. Another difference between our model and

169 that of the original study is the number of conditions. We included two additional negative

170 contingency conditions in order to evaluate what would theoretically occur had

171 participants predicted the absence of an outcome despite the presence of a cue.

172   By studying contingency judgements, we can gain a better understanding of factors

173 that influence learning, memory, and eventually decision making. Our results indicate that

174 there is a relationship between the number of times a result is shown, and one's prediction

175 of whether or not they will get that an outcome will occur based on a certain cue. This

176 general principle may have implications in the world of mental health, such as with

177 disorders such as anxiety and depression. For instance, it could be the case that one

178 develops depressive symptoms due in part to what they expect to happen (outcomes),

179 based on previous experiences (cues). Of course, it would require a substantial amount of

180 further research to properly examine how previous experiences shape mental disorders.

181 $$x = 1$$

182

References