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Beads task vs. box task: The specificity of the jumping to conclusions bias

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A B S T R A C T

Background and objectives: Previous research involving the probabilistic reasoning ‘beads task’ has consistently demonstrated a *jumping-to-conclusions* (JTC) bias, where individuals with delusions make decisions based on limited evidence. However, recent studies have suggested that miscomprehension may be confounding the beads task. The current study aimed to test the conventional beads task against a conceptually simpler probabilistic reasoning “box task”
Methods: One hundred non-clinical participants completed both the beads task and the box task, and the Peters et al. Delusions Inventory (PDI) to assess for delusion-proneness. The number of ‘draws to decision’ was assessed for both tasks. Additionally, the total amount of on-screen evidence was manipulated for the box task, and two new box task measures were assessed (i.e., ‘proportion of evidence requested’ and ‘deviation from optimal solution’).
Results: Despite being conceptually similar, the two tasks did not correlate, and participants requested significantly less information on the beads task relative to the box task. High-delusion-prone participants did not demonstrate hastier decisions on either task; in fact, for box task, this group was observed to be significantly more *conservative* than low-delusion-prone group.
Limitations: Neither task was incentivized; results need replication with a clinical sample.
Conclusion: Participants, and particularly those identified as high-delusion-prone, displayed a more conservative style of responding on the novel box task, relative to the beads task. The two tasks, whilst conceptually similar, appear to be tapping different cognitive processes. The implications of these results are discussed in relation to the JTC bias and the theoretical mechanisms thought to underlie it.
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1. Introduction

Recent research has looked into the role that cognitive-reasoning biases play in the formation and maintenance of delusions. The jumping-to-conclusions (JTC) bias is the most extensively studied cognitive bias in this literature, and is defined as hasty decisions based on less evidence, when compared to people without delusions or low delusional ideation. The most common approach to elucidate the JTC bias is a probabilistic reasoning task called the ‘beads task’ (Huq, Garety, & Hemsley, 1988). In a typical beads task, participants are shown two transparent containers filled with colored beads in different but reciprocal proportions. Once the containers have been removed from the participants view, they are then told that beads, one at a time and with subsequent replacement, will be randomly drawn from one of the two containers and they need to decide which container the bead *sequence* is coming from (which is actually predetermined to favour one container). The most common finding is that participants with delusions will request fewer ‘draws to decision’ and exhibit higher rates of JTC (i.e., defined as a decision on 1 or 2 beads) compared to participants without delusions (for a recent meta-analysis see McLean, Mattiske, & Balzan, 2016). The bias has also been shown to be heightened among ‘delusion-prone’ but otherwise healthy samples (Ross, McKay, Coltheart, & Langdon, 2015).

Despite the apparent robustness of the beads task at elucidating the JTC bias, recent evidence suggests that the task may be confounded by poor task comprehension (Balzan, Delfabbro, &

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Galletly, 2012; Balzan, Delfabbro, Galletly, & Woodward, 2012). Specifically, both of these studies found that over half the sample failed to understand that all beads were drawn from the *same jar*, and that these 'miscomprehending' participants were significantly more likely to exhibit a JTC reasoning style. Against this high level of miscomprehension, it is possible that participants who 'jump to conclusions' on the *first* bead may have misinterpreted that the aim of the beads task is to determine which container this *particular* bead is coming from, rather than considering the *sequence* of beads (e.g., up to 10 beads, which these participants never see). Participants who make a decision on the first bead may therefore be simply answering the question 'where does *this* bead come from?', and assume that the initial bead has come from the container with the larger proportion of that color, despite being told from the outset that they should be considering the 'bead sequence' as a whole. Additionally, the beads task is typically only presented once or twice in an effort to reduce practice effects (i.e., becoming aware that the sequence is predetermined). In other words, it is possible that due to the small number of replications, the frequency of the bias reported in the literature may be overstated. In support of this, one recent study found that when a fMRI-adapted version of the beads task was presented multiple times to the participants, group differences in JTC among 'at-risk mental state' patients compared to healthy controls could not be demonstrated beyond the initial trial (Rausch et al., 2015). Of course, this is not to suggest that all previously reported JTC represents miscomprehension; this confound can be ruled out for participants who make a decision on the *second* bead (which is still classed as 'JTC'), as this implies they are basing their decision on the bead *sequence*.

One of the aims of the current study is therefore to reduce this potential confound for those who JTC on the first bead, by using an alternative 'draws to decision' probabilistic reasoning task referred to as the 'box task'. The box task, adapted by the senior author from the Information Sampling Task of the CANTAB Battery (Clark, Robbins, Ersche, & Sahakian, 2006), is conceptually much simpler than the beads task. Participants are shown a number of grey boxes on screen (e.g., 25), each of which conceals one of two colors. Participants are told that one color is always in the majority (e.g., 80%), and that they must decide which color this is by clicking on as many of the grey boxes as they wish. Once they have decided which color is in the majority they are told to click on that color at the bottom of the screen. Importantly, the total amount of *potential evidence* is immediately available and obvious from the outset of the task (e.g., 25 boxes), reinforcing the notion that participants have the ability to consider a *sequence of evidence* should they choose to (as opposed to the beads task, where this is not as obvious from the outset). Therefore, should a participant make a decision on the first opened box, it is more likely to represent genuine JTC rather than a misunderstanding of the task's instructional set.

Moreover, the box task offers the opportunity to systematically manipulate factors affecting the salience of the evidence; for example, in addition to altering the ratio of evidence, as typically done in the beads task (e.g., 80/20 vs. 60/40 ratio), the box task can also vary the total amount of evidence that participants can choose from the outset of the task (e.g., 25 boxes, 49 boxes, 100 boxes). In this way, the box task can more effectively manipulate the *strength* of the evidence requested; that is, the salience of the evidence will be stronger when participants can choose from 25 on-screen boxes compared to when they have 49 boxes to choose from. This manipulation becomes useful when investigating the underlying mechanisms of the JTC bias. For example, several studies have posited that heightened JTC may be driven by a hypersalience of evidence-hypothesis matches, whereby people with delusions are more likely to make hasty decisions when faced with hypothesis-congruent evidence (e.g., Balzan, Delfabbro, Galletly, & Woodward, 2014; Speechley, Whitman, & Woodward, 2010). It follows that people with delusional tendencies should request *less evidence* when hypothesis-evidence matches are stronger, relative to non-delusional individuals.

Furthermore, the box task has an objective endpoint, which allows the requested 'proportion of evidence' to be determined in addition to just raw 'draws to decision'. This becomes important when comparing different on-screen box quantities (e.g., 25 with 49 boxes), as participants may request more raw 'draws to decision' with 49 boxes compared to 25 boxes, but this might simultaneously represent *proportionally less* evidence. Having an objectively correct number of 'draws' on the box task also allows a 'deviation from optimal solution' measure to be determined. For example, on an 80/20 ratio with 25 boxes, it would only take 6 draws of the same color to determine the solution with full confidence; the number of draws *below* this solution would represent *objective* JTC, while draws above this would represent *objective* conservatism.

In sum, due to some slight methodological differences, the box task may offer some advantages over the beads task (i.e., may reduce miscomprehension, easy to modify salience of evidence, has a definite solution, multiple trials). Despite these differences, the two tasks should still be consistent in the way they assess the 'draws to decision' construct. Accordingly, it is expected that participants who categorically JTC on the beads task (i.e., decision made $\leq$ 2 beads) will also request *less* evidence on the box task, consistent with a pilot study comparing the beads and box tasks (Chu, Sun, & So, 2015). Moreover, as JTC has been shown to be heightened in delusional groups, it is also expected that high-delusion-prone participants will request less evidence than the low-delusion-prone participants in both the beads and box task. Finally, throughout the box task, high-delusion-prone participants should request proportionally less evidence and exhibit objectively greater hastiness than low-delusion-prone participants, particularly for box scenarios where the salience of evidence is stronger.

2. Method

2.1. Participants

A total of 100 undergraduate students (76 females, 24 males) were recruited from Flinders University for partial course requirement or a small amount of reimbursement for their time. They were aged 18–62 years (M = 23.56, SD = 7.30). Participants were excluded if they had impaired color vision (relevant to both bead/box tasks).

2.2. Materials

2.2.1. The beads task

Participants were presented with an adapted computerized version of the original beads task (Huq et al., 1988), using the 'draws to decision' method and the standard conventional instructional set (for full details see McLean et al., 2016). They were shown a picture of two containers filled with 100 colored beads in reciprocal proportions (one trial with a bead ratio of 80/20 and one trial of ratio 60/40; ratio order was randomised between participants). They were told that the computer would randomly select beads from one container, and that the goal of the task was to determine which container the bead sequence was coming from. However, the task had a predetermined sequence of (up to) ten beads per trial, and ended once a container had been selected (note: if a decision was not made by 10 beads, the 'draws to decision' score was classified as 11). Pictures of the containers remained displayed during the task to ensure that participants remembered the proportion of beads in each container, and the sequence of beads was also shown at the

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