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"Losses disguised as wins" in electronic gambling machines contribute to win overestimation in a large online sample

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ABSTRACT

Introduction: Losses disguised as wins (LDWs) are a salient type of losing outcome common to electronic gambling machines (EGMs). These events occur when a gambling payout is less than the amount wagered (i.e., a net loss) but is nonetheless accompanied by the sounds and animations that accompany genuine wins. Previous lab-based studies have reported that participants tend to overestimate genuine wins when LDWs are present. This study reports an independent replication of these findings in a large online sample that included a substantial number of individuals reporting high-risk gambling and frequent EGM users.
Methods: This online study recruited a sample of 940 participants who were randomly assigned to view one of two brief videos. Each video displayed a short period of simulated online slot machine gambling and included 2 genuine wins and either 3 or 0 LDWs. Participants were asked to estimate the number of times a win occurred that *was more than the amount bet*. Participants also completed the Problem Gambling Severity Index.
Results: The mean estimated number of genuine wins was significantly larger for the condition displaying LDWs, 3.02 [95% CI = 2.82, 3.21] than the control condition, 2.14 [1.98, 2.30], $t(887.66) = 6.78$, $d = 0.44$, $p < .001$.
Conclusions: We replicated the LDW-triggered win overestimation effect previously reported in lab-based experiments that have recruited smaller samples. This effect was robust in both low-risk and high-risk groups, indicating that even experienced gamblers remain susceptible. Exploratory modelling suggested only a minority of individuals were uninfluenced by LDWs.

1. Introduction

Electronic gambling machines include a suite of structural characteristics that are believed to contribute to gambling-related harm (Yücel et al., 2018). A particularly concerning innovation are the appropriately named "losses disguised as wins" or LDWs (Dixon et al., 2010), which occur when net losses are celebrated in a manner comparable to wins. The paradigmatic case occurs in EGMs that accept simultaneous wagers across multiple pay-lines. When the combined cost of betting across numerous lines is less than a subsequent payout the event is celebrated with audio-visual stimuli in a manner comparable to genuine wins. For example, if a 5c bet is placed and 20 lines are selected, the total bet will be $1 per spin. An overall payout of 75c on this bet would result in a *net loss* of 25c, and yet the typical EGM will celebrate the outcome with a musical fanfare and an animation drawing attention to the pay line on which the return occurred.

A primary concern is that despite being net-losses, these events may be mistaken for net-gains. Many EGM products display LDWs at a rate that approaches or exceeds the frequency of genuine wins (Dixon et al., 2010; Harrigan & Dixon, 2009; Leino et al., 2016). As a result, individuals who mistake LDWs for net-gains may experience a substantial increase in the rate of positive reinforcement while gambling. While the aetiologies of addiction and gambling harm are varied and complex, the rate of reinforcement is a crucial component of a product's potential to encourage excessive, extended, or repeated use and ultimately cause harm (Griffiths & Auer, 2013).

Abbreviations: LDW, Losses disguised as wins; EGM, Electronic gambling machines; ELPD, Expected log pointwise predictive density; GLM, Generalised linear model; OSF, Open Science Framework; PGSI, Problem Gambling Severity Index.

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The concern that LDWs are perceived as small wins or may otherwise increase the rate of positive reinforcement while EGM gambling is supported by a range of existing experimental studies. Jensen et al., (2013) reported that LDWs were frequently mis-categorised as wins by a majority of research participants who were asked to verbally describe gambling outcomes aloud while under observation by experimenters. When offered a choice between EGMs that offer an equivalent expected financial return, but differ in the number of LDWs they produce, participants self-report a preference for, and are more likely to continue gamble using, machines that include LDWs (Graydon et al., 2018). Consistent with LDWs being a salient outcome, a number of lab studies have also reported that LDWs elicit autonomic arousal in a manner comparable to small wins (Dixon et al., 2010; Wilkes et al., 2010). Evidence has not been confined to laboratory studies. Leino et al. (2016) analysed data from a randomly selected day of gambling activity from 8,636 player accounts in Norway. They reported that account holders were more likely to continue gambling following LDWs relative to losses. One line of evidence that has been reported in both undergraduate (Dixon et al., 2015; Graydon et al., 2017; Jensen et al., 2013) and community samples of regular EGM users (Dixon et al., 2014a; Graydon et al., 2021; Templeton et al., 2015) is that when exposed to LDWs, research participants tend to substantially over-estimate the number of wins that have occurred during a gambling session. This “LDW-triggered overestimation effect” is straightforward evidence that LDWs are often mistaken for gains and may thereby increase the rate of reinforcement while EGM gambling.

In the present study we sought to replicate this LDW triggered win-overestimation effect in a large online sample. The value of open replication by independent research groups, in large or diverse samples, in different settings, using alternative research designs has been well articulated in a recent discussion in the journal International Gambling Studies (Blaszczynski & Gainsbury, 2019; LaPlante, 2019; Wohl et al., 2019), alongside a number of highly publicised concerns about current rates of reproducible research in psychology and medicine (Open Science Collaboration, 2015; Szucs & Ioannidis, 2017). Replication is particularly important where research findings are intended to inform public policy, such as in the regulation of gambling products.

Online recruitment and research methods can provide a meaningful complement to traditional recruitment and lab-based studies, by enabling recruitment of large and potentially more diverse samples of research participants (Buhrmester et al., 2011; Casler et al., 2013; Goodman et al., 2013). At the time of writing, previous studies investigating the LDW triggered overestimation effect had been predominately conducted by researchers at the Gambling Research Lab at the University of Waterloo (Graydon et al., 2021). Studies by other researchers have reported conceptual replications using alternative outcomes measures. Though these have also largely been conducted in a Canadian setting, with only one conducted in an Australian setting (Wilkes et al., 2010). We therefore sought to confirm that findings would independently replicate and generalise to an Australian sample. LDWs have featured in recent high-profile Australian legal proceedings and media coverage, as well as in a documentary film about Australian EGM gambling (Evershed et al., 2017; Manning and Director, 2015; Willingham, 2015). Considering that explicit explanation of LDWs substantially attenuates the LDW-triggered overestimation effect (Graydon et al., 2017), these sources of publicity may have raised community awareness about LDWs and mitigated this effect in Australian samples.

Another open question is whether the LDW-triggered overestimation effect is either positively or negatively associated with the severity of gambling harm or experience. A mitigation effect might occur because experience with EGMs eventually leads consumers to become aware of LDWs. Conversely, individuals reporting high-risk gambling may have been particularly susceptible to the influence of LDWs. Dixon, Harrigan and colleagues (Dixon et al., 2014b) reported that self-reported moderate and higher levels of gambling-related harm was associated with higher estimates of the perceived number of wins relative to those reporting no gambling harm. We are aware of two further studies that have investigated a potential interaction effect between LDWs and gambling harm severity (Dixon et al., 2014a; Templeton et al., 2015). In each case, this interaction was reported to be non-significant, or that participants grouped by gambling risk reported comparable estimates. In an exploratory analysis, we sought to clarify whether we would observe group differences in win-overestimation as a function of the severity of gambling harm measured using the Problem Gambling Severity Index (PGSI, Ferris & Wynne, 2001).

2. Methods

This study was conducted as part of a larger investigation of gambling activity during the closure of Australian gambling venues due to COVID-19 related public health restrictions (Livingstone et al., 2023). Prior to recruitment, a succinct study outline was pre-registered using the Open Science Framework (OSF). All study materials, de-identified data and analysis scripts used in the present report have been made available. OSF project weblink: https://osf.io/ej74q/.

2.1. Design

This study employed a randomised between-groups experimental design with two groups.

2.2. Intervention

Participants in each condition viewed one of two videos composed using fragments of screen capture recordings of an online demonstration of the slot game “Dolphin Treasure”. The two videos were approximately the same length (1 min 15 s and 1 min 17 s) and were identical up until approximately the 30 s mark. Each video began with the cursor selecting the number of active lines (20) and the amount bet per line (0.30 credits, total bet = 6.00), before proceeding to make 10 wagers or 'spins'. Genuine wins occurred at the same spin number across both conditions. The sequence of outcomes in the control video (hereafter “control condition”) and the intervention video (hereafter “LDW condition”) are displayed below in Table 1. These videos can be viewed and downloaded on the OSF project page for this experiment, and a screen capture is displayed in Fig. 1.

2.3. Procedure

All study procedures were approved by the Monash University Human Research Ethics Committee (MUHREC) Project ID: 24093. Participants were aged 18+ years, living in Australia, and recruited via targeted advertising on social media. Participants were directed via a web-link to Monash University's Qualtrics research platform. All participants were required to read a plain-language description of the study. Consenting participants completed a series of questionnaires, described below. Following the questionnaire, participants were randomly assigned to experimental groups and the corresponding video was displayed. Participants were given the following instructions: “The video below demonstrates 10 spins on a common Australian poker machine. If possible, view the video with sound on. Watch the video to the very end and pay attention as if you were the one betting. The next question will ask about the number of wins that occur in this video.” Note that EGMs are usually referred to as “pokies” or “poker machines” in Australia, and so that is the language we adopted in the survey.

2.4. Measures

2.4.1. Primary outcome measure

The primary outcome measure asked participants “On how many spins did the player win more than they bet? If you are unsure of the exact number, please enter your best guess.“ Participants were able to

Table 1
Sequence of Outcomes Displayed in the EGM Video.

Condition	Spin Number									
	1	2	3	4	5	6	7	8	9	10
Control	$0.00	**$19.20**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$12.00**	$0.00
LDW	$0.00	**$19.20**	$0.00	$2.40	$0.00	$0.00	$3.60	$0.00	**$12.00**	$3.60

* Total bet was $6.00 per spin. Genuine wins are highlighted in bold. LDWs are underlined.

Fig. 1. Screen capture of the LDW video displaying a loss disguised as a win. The total bet indicates that the cost of the wager was $6, representing the combined cost of multiple simultaneous bets on 20 pay lines at 30c pet line. The spin has returned $3.60 for a net loss of $2.40. The sunset symbol at position 2 on the second reel from the left is a wild card that can substitute for any symbol and doubles the payout on any match. In this EGM design the 9 symbol results in a payout of double the bet per line on a match of 2 consecutive symbols. On this spin the 9 symbol has matched with the sunset wild card. The player had placed a wager on 20 lines, three of which intersected with the 9 and the wildcard for a total return of $3.60 (30c × 3 lines × 2 (9 symbol multiplier) × 2 (wildcard multiplier)). This bewildering combination of multiple small contributing events is relatively common in this EGM design.

enter a numeric response.

2.4.2. *Questionnaire items*

Data were collected in parallel to a major survey of Australian gambling during the closure of terrestrial gambling venues due to the COVID-19 pandemic. This study included additional questionnaire items presented prior to viewing the intervention video. The details of these questionnaire items are reported elsewhere (Livingstone et al., 2023). Participants were asked to provide their gender identity, age, state and postcode, highest education level, past-year gambling activity, current employment status and occupation.

Participants were also asked to complete the Problem Gambling Severity Index (PGSI) relating to the period "12 months before pokies venues closed at midday on 23 March 2020." The PGSI is a 9-item questionnaire that has been widely adopted in gambling research and prevalence studies as a measure of at-risk gambling behaviours (Armstrong et al., 2018; Currie et al., 2013; Ferris & Wynne, 2001; Miller et al., 2013). Responses to each item range from 0 ('never') to 3 ('almost always') and are summed to produce a total score. Participants were grouped according to standard criteria: no gambling harm (score 0), low-risk (score 1–2), moderate-risk (score 3–7), and high risk (score 8+).

2.5. *Participants*

Data collection occurred between June 6th, 2020 and June 29th, 2020. 3,164 respondents accessed the survey information page. 2,689 continued past the consent page and entered at least one response. 1,200 consenting respondents were lost to survey dropout throughout the questionnaire and prior to experimental randomisation, leaving 1,489 respondents at randomisation (see limitations in Discussion).

The following exclusion criteria were outlined in the study pre-registration. First, following the video, participants were asked to report if they experienced technical difficulties viewing the video. Participants who reported being able to view the video without issue (n = 1,048) were presented with the primary outcome measure, whereas those who reported technical issues (n = 441) were taken directly to the study conclusion and excluded from analyses. We utilised the Qualtrics timer function to record the length of time participants spent on the video page. Participants who spent less than 77 s (the duration of the intervention) were excluded from our analysis (n = 75). 20 participants reported over 10 wins (i.e., more than the total number of spins displayed) these participants were excluded from the analysis, except for one participant who left a comment in the final response box correcting their response from 20, to 1.

In addition to pre-registered exclusions, we excluded 12 cases with identical IP addresses and matching demographics. An additional 2 respondents did not submit a response to the dependant variable and were excluded. The final sample size was 940 (Control = 491, LDW = 449). Participant demographics are reported in the appendix.

Participants were asked to self-report whether they were able to view the video with sound on, and 225 participants reported viewing the video without sound. Based on the results of an equivalence test (a two one-sided *t*-test procedure) and negligible mean differences between those viewing the video with and without sound we opted to retain these data, see appendix.

3. Results

3.1. *Pre-registered primary analysis*

Fig. 2 displays mean win estimates and the observed proportion of each response by experimental group. As hypothesised, the mean estimated number of genuine wins was larger for the LDW condition, 3.02 [95% CI = 2.82, 3.21] than the control condition, 2.14 [1.98, 2.30]. A Welch two-sample *t*-test found that this mean difference of 0.88 [0.62, 1.13] genuine wins was significant, $t(887.66) = 6.78$, $d = 0.44$, $p < .001$. Win estimates in the LDW condition were also higher than the number of genuine wins that occurred in the video (i.e., 2), $t(448) = 10.2$, $p < .001$.

We performed an equivalence test (a two-one-sided *t*-test procedure, see Lakens et al., 2018) to determine whether participants in the control

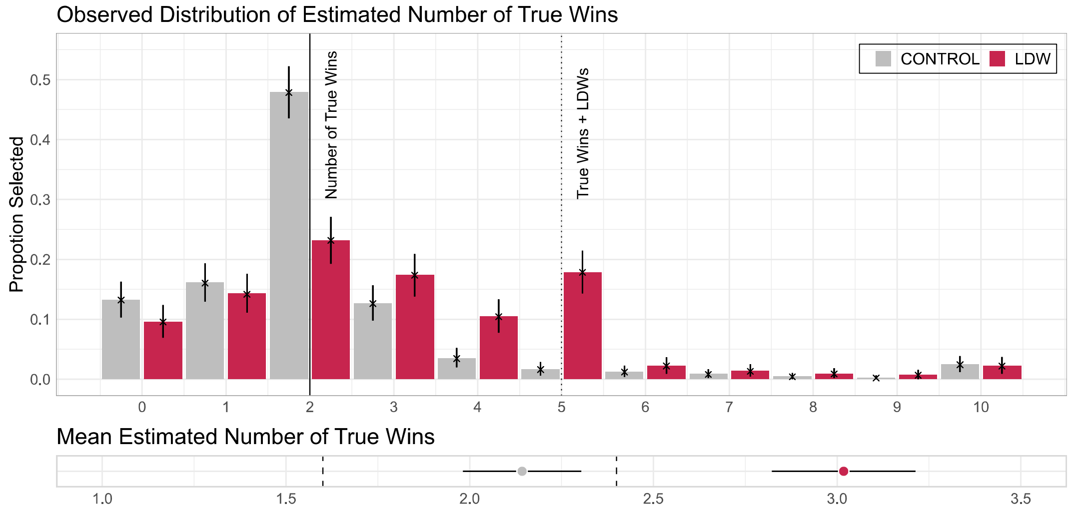

Fig. 2. Observed proportions and group means for the estimated number of true wins in each condition. Error bars on upper plot indicate 95% bootstrapped proportions from 10k re-samples. Error bars on lower plot indicate frequentist 95% confidence intervals. Dashed lines on lower plot indicate "equivalence" bounds (*d* +/- 0.22).

condition recalled the number of wins with reasonable accuracy on average. A pre-registered power analysis indicated that to reach 90% power with our anticipated sample size, at an alpha level of 0.05 we should set "equivalence" bounds at an effect size of Cohen's $d = 0.22$ (a difference of approximately 0.4 on the raw scale). We also felt that these bounds would be sufficient to indicate reasonably accurate aggregate recall. This equivalence test was significant, $t(490) = -3.14$, $p < .001$, and the null hypothesis test was non-significant, $t(490) = 1.74$, $p = .083$. Based on these combined results we can conclude that the mean estimates in the control group fell within the equivalence region.

3.2. Exploratory analyses

To assess the influence of PGSI on response accuracy we conducted a Bayesian monotonic logistic regression (Bürkner & Charpentier, 2020). Participant estimates were recoded as a binary variable representing response accuracy (i.e., a response of 2 coded as 1, any other response coded as 0) and the predictors included a dummy coded variable representing experimental condition and a monotonic predictor representing each level of the PGSI. Results indicated an increasing response accuracy as self-reported gambling risk increased. However, we observed no evidence of an interaction between the LDW condition and the tendency toward increased accuracy as PGSI increased. Posterior estimates suggested that the disturbance in response accuracy generated by LDW exposure was not mitigated by increasing gambling exposure or harm. Likewise, a comparable analysis suggested that the proportion of individuals reporting an overestimate (i.e., responses of greater than 2 recoded as 1) was greater in the LDW condition than the control condition at all levels of the PGSI, see appendix.

We also performed a series of analyses to explore the apparent bimodality in the data distribution displayed in Fig. 2 above. Exploratory bootstrapping indicated that the multimodality in the LDW condition was robust to resampling (>95% of 10,000 resamples included modes at 2 and 5). The location of each of these modes reflected either the 2 genuine wins, or the combined number of genuine wins and LDWs displayed in the LDW video (i.e., 5). To further explore this pattern, we composed a custom Bayesian probability model that sought to better account for the structure of outcomes displayed in the video. This model estimated that 38% [27, 48] of participants in the LDW condition were estimated to have responded as though all LDWs were losses, comparable to participants in the control condition. Approximately 20% [9, 31] of participants were estimated to have made a single error, 3% [0, 10] made two errors, and 39% [29, 48] were estimated to mistake all 3 LDWs for gains. The appendix includes a more detailed explanation of the modelling process and results.

4. Discussion

Our primary results unambiguously replicated the LDW triggered over-estimation effect. Consistent with previous studies (Graydon et al., 2021), we observed a tendency for participants exposed to LDWs to overestimate the number of wins relative to both the number of genuine wins that occurred, and to estimates made by participants in a control group who were not exposed to LDWs. An equivalence test provided further support for the LDW win-overestimation hypothesis by demonstrating that in the absence of LDWs individuals recalled the frequency of genuine wins with a reasonable degree of accuracy (see appendix for an estimate adjusted for outliers). This procedure provides a more severe test relative to a simple null finding, by specifying a region within which we expected to find estimates prior to seeing the data. These results do not suggest that the average response in the control group was *exactly equivalent* to 2 genuine wins, rather the test considered whether aggregate accuracy falls within pre-specified bounds. By contrast the tendency to overestimate the number of wins in the LDW condition fell well outside these bounds (see Fig. 2).

We also investigated whether self-reported gambling harm was related to the LDW triggered win overestimation effect. These analyses found that overestimation in the LDW condition was present among individuals reporting all levels of gambling harm as measured using the PGSI. This suggests that LDWs may be relevant to both the acquisition and maintenance phase of addictive EGM use. We outlined two opposing theories in the introduction that motivated an interaction analysis: a mitigation of the effect due to experience, or an amplified effect due to an increased susceptibility in the high-risk gambling group. These theories each predicted an interaction effect between exposure to LDWs and PGSI risk-level. We did not observe a reliable interaction between experimental condition and gambling risk groups, as predicted by either theory. However, the absence of a positive finding does not directly entail the absence of an effect given the wide compatibility interval on the observed interaction.

Across participants in the LDW condition, the distribution of reported wins was bimodal: participants tended to either report the total number of true wins (2) or the sum of true wins and LDWs (5). A bimodal distribution could be generated by a sub-population mistaking LDWs for gains, while another sub-population accurately perceived these as net losses. This would be broadly consistent with a "gamble aloud" study reported by Jensen et al. (2013) in which some participants appear to have been cognisant of the difference between LDWs and genuine wins without prompting, whereas 61% of participants failed to report any indication that they were losing money following and LDW. Similarly, data from an event-categorisation task by Dixon et al. (2015) revealed that approximately one-third of participants realised that they lost money on LDWs. Each of these previous findings are strikingly similar to the estimates derived from exploratory modelling in the present study (see appendix). Collectively these results suggest a pervasive influence of LDWs on win estimation for most, rather than a minority of individuals.

The misperception of LDWs as gains would substantially increase the rate of positive reinforcement while gambling at no cost to the house and little benefit to the consumer. The award of small financial gains can be readily used to maintain behaviour on a random ratio schedule of positive reinforcement (Haw, 2008) and LDWs may thereby contribute to the repetitive or extended use of EGMs and associated harm. Regulators seeking to minimise these harms would do well to consider the LDW design feature (Livingstone et al., 2019; Yücel et al., 2017). LDWs are not a necessary component of EGM design and policymakers could introduce regulation that would eliminate or mitigate the influence of this feature. For instance, outcomes that return less than the wager could be prohibited entirely, or on-screen information displayed to the user could highlight net return, rather than gross payout. In addition, the audio-visual celebration of net negative payouts could be prohibited, as occurs in the Australian states of Queensland and Tasmania (Livingstone et al., 2019). Although we would note that the data quality measures in the present study suggest that removing sound alone may not be enough to mitigate the LDW illusion. In the LDW condition, the difference in mean estimates between those viewing the video with sound off was negligible and fell within equivalence bounds. Although the current study was not intentionally designed to investigate the role of sound, others have noted that the influence of LDWs is not completely ameliorated by the removal of celebratory sound effects. Dixon et al., (2015) deliberately investigated the influence of sound on the LDW triggered win overestimation effect. They found that when wins were accompanied by celebratory sounds[1] but no sound was played following LDWs there was a mild attenuation of the overestimation effect, but that overestimates still occurred, suggesting that the removal of sound following LDW events may not completely mitigate the potential harms.

Finally, this study had several key limitations. The recruitment procedure or dropout during the preceding survey study may have introduced systematic sampling bias. In addition, the fact that the experiment was situated at the end of a long survey (median completion time was 19 min 6 s) may have left remaining participants fatigued when viewing the video, and therefore less attentive. Furthermore, our experimental materials were admittedly simple, and participants did not gamble for money. However, the methods employed provided other advantages. The online setting enabled the recruitment of a large demographically diverse sample of Australians across all states and territories, which included a significant proportion of individuals who reported substantial gambling-related harm, as well as both regular and irregular EGM use. The larger sample enabled more detailed modelling, more robust inferences about interactions and the use of equivalence bounds. The online recruitment also enabled better access to difficult-to-reach sectors of the population, thereby supporting inferences about the pervasiveness of the influence of LDWs on gambling cognition. This is an important consideration if collective research findings concerning LDWs are to inform policy development. The approach of displaying randomised video content of EGM features could easily adapted to rapidly assess the comprehension of various EGM structural characteristics or integrated harm reduction messages (Monaghan & Blaszczynski, 2010; Newall et al., 2022; Wohl et al., 2013).

[1] Participants experiencing sound issues in the present study would have heard silence following both LDWs and genuine wins, which may explain the apparent difference with the present study.

CRediT authorship contribution statement

Dan Myles: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Daniel Bennett:** Formal analysis, Writing – review & editing. **Adrian Carter:** Supervision, Writing – review & editing. **Murat Yücel:** Supervision, Funding acquisition, Writing – review & editing. **Lucy Albertella:** Writing – review & editing. **Cassandra de Lacy-Vawdon:** Project administration, Writing – review & editing. **Charles Livingstone:** Conceptualization, Project administration, Funding acquisition, Writing – review & editing.

Conflict of Interest

Role of Funding Sources

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Declaration of Competing Interest

The authors declare that they have no conflict of interest in relation to the publication of this article.

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Data availability

De-identified data, analysis scripts, analysis notes, and study materials have been made available on the OSF: https://osf.io/ej74q/.

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Stan developer, Martin Modrák, responded to a query by D.M. had about combining a series of binomial distributions to model an observed sum on the stan users' forums (see: https://discourse.mc-stan.org/t/participants-reporting-sum-of-two-distinct-types-of-events/25208/2). This provided an excellent starting point for the exploratory analysis outlined in the appendix.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.abrep.2023.100500.

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