**Optimizing Behavioural Observations: A Comparative Approach to**

**Simulated Sampling Methods**

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**Abstract:**

Animal behaviour research requires the use of behavioural recording methods to document the occurrence of responses observed. While continuous recording, or focal sampling, has been considered the gold standard of behavioural measurement, several other sampling methods are commonplace, including less formal *ad libitum* sampling, pinpoint or instantaneous sampling, and one-zero or interval sampling. While these sampling methods have facilitated the ability to track both multiple behaviours and animals simultaneously, researchers have questioned the utility of different sampling methods under different contexts. For instance, some researchers have suggested that pinpoint sampling is less effective for measuring frequency (event) responses than duration (state) behaviours, while others have suggested that one-zero sampling techniques should be avoided altogether. Our study examined these possibilities by comparing both pinpoint and one-zero sampling to continuous recordings under computerized simulations. Two separate simulations were generated, one for response frequency and one for response duration, with three different response frequencies (high, medium, or low) and response durations (short, medium, and long) in each simulation, respectively. Similarly, three different observation intervals (5, 50, and 500 s) were used to record responses as both pinpoint and one-zero sampling methods in the simulations. Under both simulations, pinpoint sampling outperformed one-zero sampling, with pinpoint sampling producing less bias in error rates under all frequencies, durations, and observation intervals. As observation intervals increased, both mean error rates and variability in error rates increased for one-zero sampling, while only the latter variability in error rate increased for pinpoint sampling. The results suggest that pinpoint sampling techniques are effective for measuring both event and state behaviours, and that pinpoint sampling is a less biased behavioural observation method than one-zero sampling.

*Keywords:* continuous recording, pinpoint sampling, instantaneous sampling, one-zero sampling, interval recording, behavioural measurement, sampling methods

**INTRODUCTION**

The measurement of behaviour is important for those involved in the scientific study of animal behaviour. Behavioural studies are used as a tool to measure captive animal welfare and are used more often than other welfare indicators such as glucocorticoid analysis (Fraser, 2009; Sands & Creel, 2004). For captive animals, behavioural research may also be used to investigate the prevalence of positive behaviours, such as foraging, or negative behaviours, such as stereotypies (Carlstead et al. 1991; Fernandez & Timberlake, 2008; Ward et al. 2018). Studies of behaviour are also frequently conducted for wild animal populations and to better understand natural history or investigate the impact of human disturbance (Lehner, 1998; Sand & Creel, 2004). Research on animal behaviour is now so well recognised that there are numerous journals dedicated to its study, for instance: *Animal Behaviour,* *Applied Animal Behaviour Science, and Ethology.*

The methods used in animal behaviour research can be traced back to human studies. Scientists during the mid-twentieth Century often used a mixture of both human and animal models to answer questions in the field of behavioural psychology (Domjan, 2014; Pierce & Cheney, 2013). Based on the range of different techniques that were generated by earlier studies, Altmann (1974) summarised the behavioural research methods available. This paper became fundamentally important to those interested in behavioural research, and remains a keystone paper for researchers, with at least 16,100 citations, according to a search on Google Scholar (2020). Whilst other authors, such as Martin and Bateson (2007) further refined the behavioural methods and their definitions, Altmann’s work is still regularly cited.

Since this initial review of behavioural methods, some behavioural sampling techniques became increasingly popular in animal literature, whereas others are rarely used. Several behaviour measurement techniques have received criticism in terms of their repeatability (Bernstein, 1991). For example, *ad libitum* (qualitative) sampling may be useful for developing ethograms and for pilot studies but has methodological flaws with regards to its lack of standardisation (Martin & Bateson, 2007; Rhine & Ender, 1983). However*, ad libitum* sampling is still used in animal behaviour literature, with a review by Mann (1999) identifying that between 53% and 59% of cetacean studies published in *Marine Mammal Science* used this sampling technique.

Continuous recording, or focal sampling, is considered the gold standard for behavioural sampling, as this method records all occurrences of behaviour and their durations (Hämäläinen et al. 2016). In the past, this made continuous recording challenging for researchers, as an active animal that rapidly changed behaviour would have been difficult to observe and record (Tyler, 1979). Similarly, measurement of multiple animals using a continuous method would have been incredibly challenging to document accurately, hence why the method is considered synonymous with focal sampling of one individual (Altmann, 1974; Martin & Bateson, 2007). Use of modern technology has in part ameliorated some of these issues by allowing behaviour to be recorded and analysed later (Amato et al. 2013). However, continuous recording may remain a challenge, even with camera availability. As a result, several sampling methods have been developed to measure multiple animals at one time (scan sampling), as well in a non-continuous fashion.

The use of pinpoint sampling, also referred to as instantaneous or momentary time sampling, is a commonly used method for observational study (Fernandez, Kinley & Timberlake, 2019; Lehner, 1998; Stevens et al. 2013). With pinpoint sampling, one or more responses are recorded at preselected moments in time (e.g., every 15 s for an hour). The benefits of pinpoint sampling are that it is less intensive than continuous sampling, and therefore may be more feasible for researchers to conduct (Grenier et al. 1999; Martin & Bateson, 2007; Gilby et al. 2010). The methods are also more versatile, allowing researchers to make decisions as to how long intervals should be spaced. For example, some researchers might choose to use 15-second intervals, particularly when studying an active animal or when conducting observations of a key time period, such as when enrichment is provided (Fernandez & Timberlake, 2019). On the other hand, observers might choose to use much longer intervals, such as one-, two- or five-minute intervals when their subjects are inactive or if they are observing for long time periods (Shora et al. 2020; Teixeira et al. 2017). It has been noted by some authors that shorter intervals tend to result in behavioural values that match more closely the continuous behaviour scores (Pullins et al. 2017).

One-zero or interval sampling involves choosing specific intervals of time, like pinpoint sampling, but instead recording whether one or more responses occur (or conversely, do not occur) within that interval of time (Bailey & Burch, 2017; Bakeman & Quera, 2012; Lehner, 1998). While popular with both human and non-human primate research, one-zero sampling seems to receive less representation than pinpoint sampling in most animal behaviour studies and has been criticised by previous researchers (Altmann, 1974; Kraemer, 1979). However, one-zero sampling has some of the same benefits of instantaneous sampling in that interval length can be tailored in line with the requirements of the study. Additionally, one-zero sampling has the potential to collect more behaviours during a stated period, as multiple behaviours can be recorded during each interval (Altmann, 1974). Leger (1977) identified good agreement with continuous behaviour measures when using one-zero sampling at 15-second intervals for chimpanzees (*Pan troglodytes)*. Likewise, Rhine and Flanigon (1978) found similar levels of occurrence when comparing continuous, pinpoint, and one-zero sampling methods with a colony group of stumptail macaques (*Macaca arctoides*). As noted above, one-zero (interval) sampling is also frequently used in studies on human behaviour, for example in the classroom (Dunkerton, 1981; Omark et al. 1976).

Both pinpoint and one-zero sampling overcome some of the issues associated with continuous recording by reducing the amount of input required by the researcher, while still aiming to keep the sample representative of the animal’s behavioural repertoire (Mitlöhner et al. 2001; Simpson & Simpson, 1977). However, one key question is how closely these techniques correlate with continuous recording? Pinpoint sampling is reported to lose information in terms of behaviour duration and is potentially less likely to pick up any behaviours of short duration (events) (Martin & Bateson, 2007; Xiao et al. 2005). By contrast, one-zero sampling is better at recording all observable behaviours, but both behavioural frequency and duration could be easily misrepresented: there is no way to identify whether a behaviour recorded as present for one interval was seen once or thirty times during that time period (Saibaba et al. 1996).

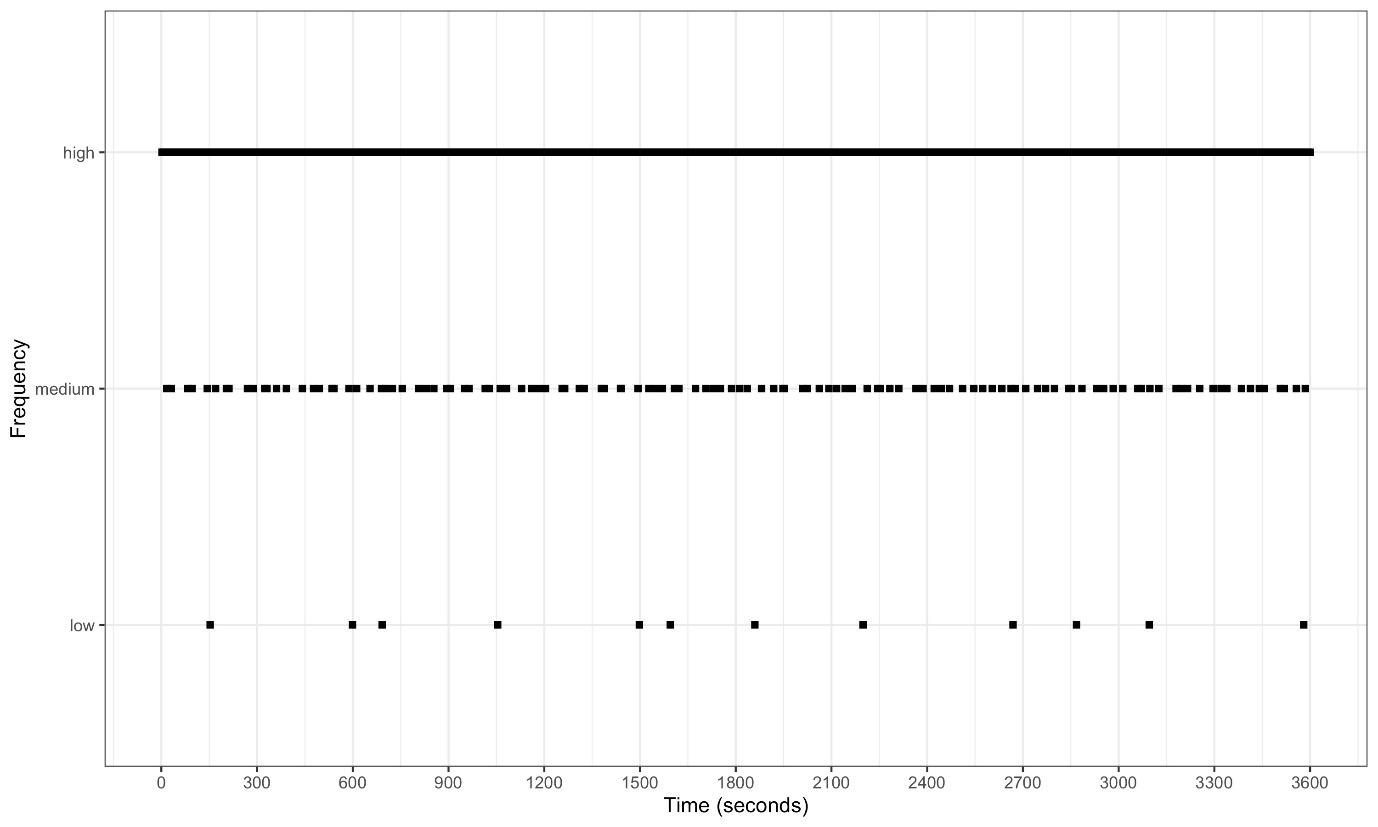
The following study proposes to compare simulated occurrence of both low/short, medium, and high/long frequency/duration behaviours, as well as similar observation intervals for pinpoint and one-zero sampling methods. We hypothesized two results: (1) one-zero sampling would be better suited (i.e., less biased) for detecting the occurrence of low frequency (event) behaviours, particularly when comparing less frequent pinpoint and one-zero observation methods (e.g., 500 second observation intervals), and (2) pinpoint sampling would provide a less biased representation of percentages of occurrence for both low, medium, and high duration (state) behaviours than one-zero sampling.

**METHODS**

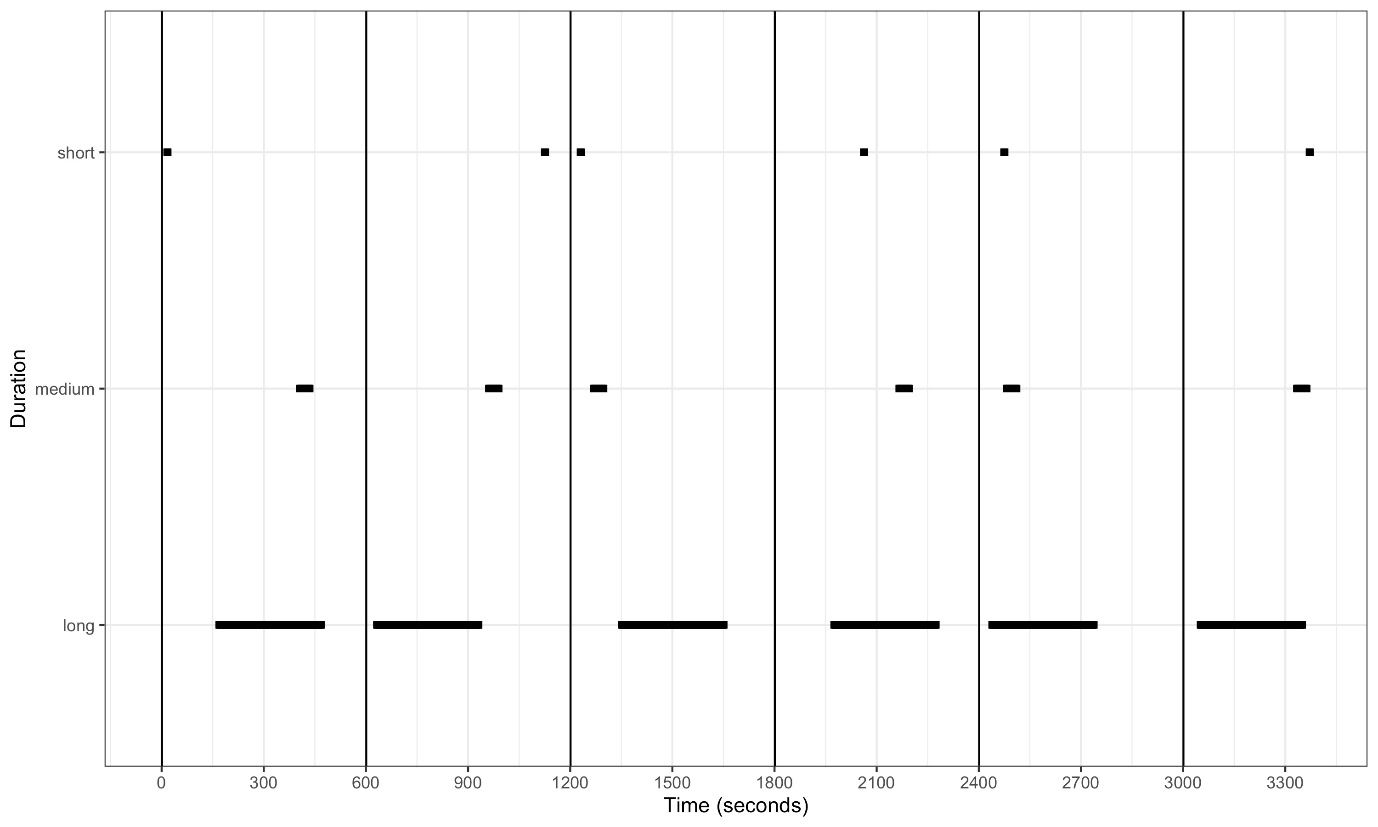
For all simulations, continuous recording methods were generated for both frequency of occurrence and percentage of occurrence, with two different non-continuous sampling methods directly compared: pinpoint (instantaneous) and one-zero (interval) sampling. Independent variables were split into two categories: Response frequency (to measure the ability of both behaviour methods to detect short, event behaviours) and response duration (to measure the ability of the methods in assessing long-term, state behaviours). Three levels for response frequency and response duration were determined, based on an arbitrarily level of frequency/duration: 3 s, 30 s, and 300 s. The interval lengths for both pinpoint and one-zero sampling were set at 5 s, 50 s, and 500 s, in order to compare the effect of interval length on test accuracy.

***Simulations***

All of the simulations were done in the R computing language using the GUI RStudio (code publicly available at https://github.com/jonotuke/animal\_simulation\_2020). For the response frequency simulations, for a frequency of every k seconds, we split the entire time period into b blocks of length k seconds. We then randomly selected one second within each block using a discrete uniform distribution and designated that as the time the event occurred. An example of a simulation with all three frequencies is given in Figure 1.

 ***Figure 1.*** *Example of simulated data for response frequency for high (3 s), medium (30 s), and low (300 s) frequency behaviours. This results in the frequency (event) occurring for exactly 33, 3.3, and 0.3% of the one-hour simulation, respectively.*

For the response duration simulations, of duration d, we split the entire time period into 6 blocks, each of length 600 seconds. For each block, we then chose a random number using a discrete uniform on the numbers from 1 to (600 – d), this was then designated as the start time of the event in the block, and the end time of the event was this time plus d. Each block had its own random starting time. An example of a simulation with all three durations is given in Figure 2.



***Figure 2.*** *Example of simulated data for response duration for short (3 s), medium (30 s), and long (300 s) duration behaviours. The location of each state was selected at random within its 600 s period. This results in the duration (state) occurring for exactly 0.5, 5, and 50% of the one-hour simulation, respectively.*

***Response frequency***

This simulation focused on the recording of event behaviours: behaviours of short duration (Martin & Bateson, 2007). For the purpose of the simulation, the duration of all event behaviours was set to exactly one second. Next, three different frequencies of event behaviour were selected: high (3 s), medium (30 s) and low (300 s) frequency of occurrence. The observation period was one-hour in length (3600 seconds). A total of 100 simulated data sets were generated for each of the three response frequencies. The exact time that each event occurred within the 3, 30 or 300 second period was randomised using a block structure.

The real (continuous) occurrence of each simulated response frequency was determined by calculating the number of seconds of each event that were possible in a simulated hour of data (observation period divided by frequency of occurrence; high frequency = 1200 s; medium frequency = 120 s; and low frequency = 12 s). The event behaviour seconds were then transformed into a percentage of total time (as is often shown in behaviour studies in the form of an activity budget), as well as frequency of occurrence. Thus, high frequency (3 s) responses occurred 33% of the hour, medium frequency (30 s) responses occurred 3.3%, and the short frequency (300 s) responses occurred 0.3% of the time.

To compare against this real (continuous) measurement, pinpoint and one-zero sampling were used on the simulated data sets. One-zero sampling recorded an event if it occurred at any point during the observation period, also commonly referred to as partial interval recording (PIR). Three interval lengths (5, 50, and 500 seconds) were used for both pinpoint and one-zero sampling. This resulted in nine-hundred data sets (nine combinations of simulation parameters and sampling parameters, each combination simulated 100 times) being developed.

The data generated from the pinpoint and one-zero sampling was then converted into percentages to compare against the continuous data. The error rates for one-zero and pinpoint sampling were calculated for each of their three interval lengths.

***Response duration***

This simulation was developed for longer duration or state behaviours. In the literature, state behaviours can be of variable length, lasting anywhere from seconds to minutes or hours. In order to accommodate this, three levels of behavioural duration were selected. These durations were set as short (3 s), medium (30 s) and long (300 s) durations of occurrence. Each of these states were treated separately (only short, medium, or long behaviours occurred in each simulation). As per the *Response frequency* investigation, the observation period was set to one-hour in length (3600 seconds). Each behavioural duration simulation was repeated 100 times.

The chosen behaviour occurred once per 600 s period. The exact time that each behaviour occurred within its respective 600s period was selected at random (though the behaviour was not allowed to slip into the next period of 600 s). Continuous data sets were developed by using the raw, simulated data and transforming this into percentages. This meant that each behaviour occurred six times during each hour simulation, with the short duration (3 s) responses occurring 0.5% of the hour, the medium duration (30 s) responses occurring 5%, and the long duration (300 s) responses occurring 50% of the time.

Each of the three behaviour durations (short, medium, and long) were measured using one-zero (PIR) and pinpoint sampling. Three interval lengths, again consisting of 5 s, 50 s and 500 s, as had been selected for the *Response frequency* investigations. These interval lengths were used for both the pinpoint and one-zero sampling. Once complete, the results were then transformed into percentages and compared to the continuous data to determine the level of error.

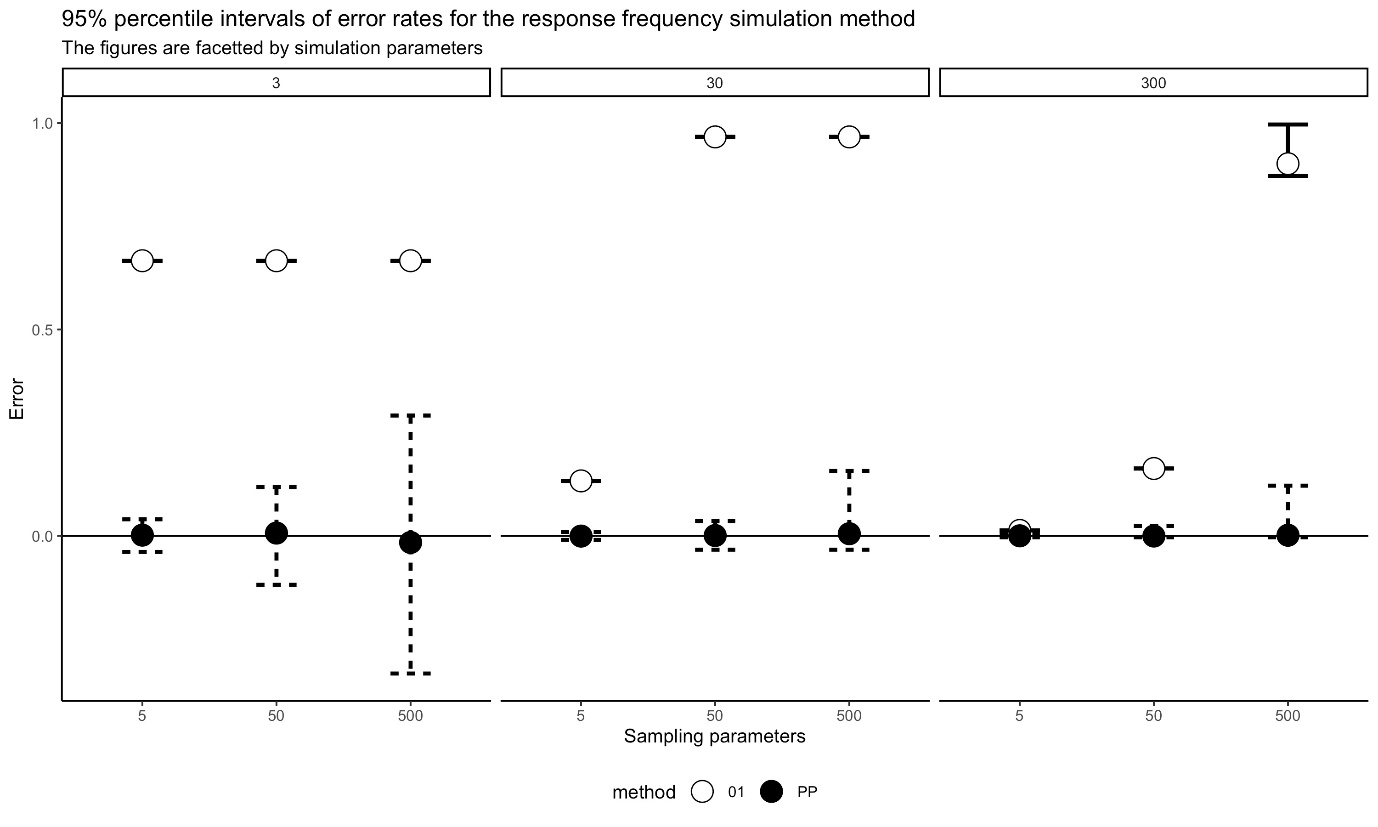
***Statistical Analysis***

Statistical analyses were conducted on the mean error scores for pinpoint and one-zero sampling at each respective interval length. The Friedman test was used to investigate whether there was a statistically significant effect of sampling method on the estimation error. The sampling/simulation combination was used as a blocking factor. The non-parametric Friedman test was used due to the non-normality of the errors and the observed heteroscedascity. When significant differences were found, paired Wilcoxin tests were used to compare the treatments. To compensate for multiple comparisons, we used an FDR adjustment.

**RESULTS**

***Response frequency***

The mean error rate for both pinpoint and one-zero sampling was calculated for each interval length and each of the three behavioural frequencies (see Figure 3).



***Figure 3.*** *Mean error rates (with 95% percentile intervals of the errors bars) for the response frequency simulation and the pinpoint and one-zero sampling methods for the 5s, 50 s and 500 s observation intervals. PP: Pinpoint sampling, closed circles; 01: One-zero sampling, open circles.*

The mean error for pinpoint sampling was minimal for all interval lengths and behavioural frequencies. However, variance for the pinpoint sampling increased as interval length increased. For one-zero sampling, error rates increased as the interval length increased, with the 500 s interval showing the largest error rates irrespective of behavioural frequency.

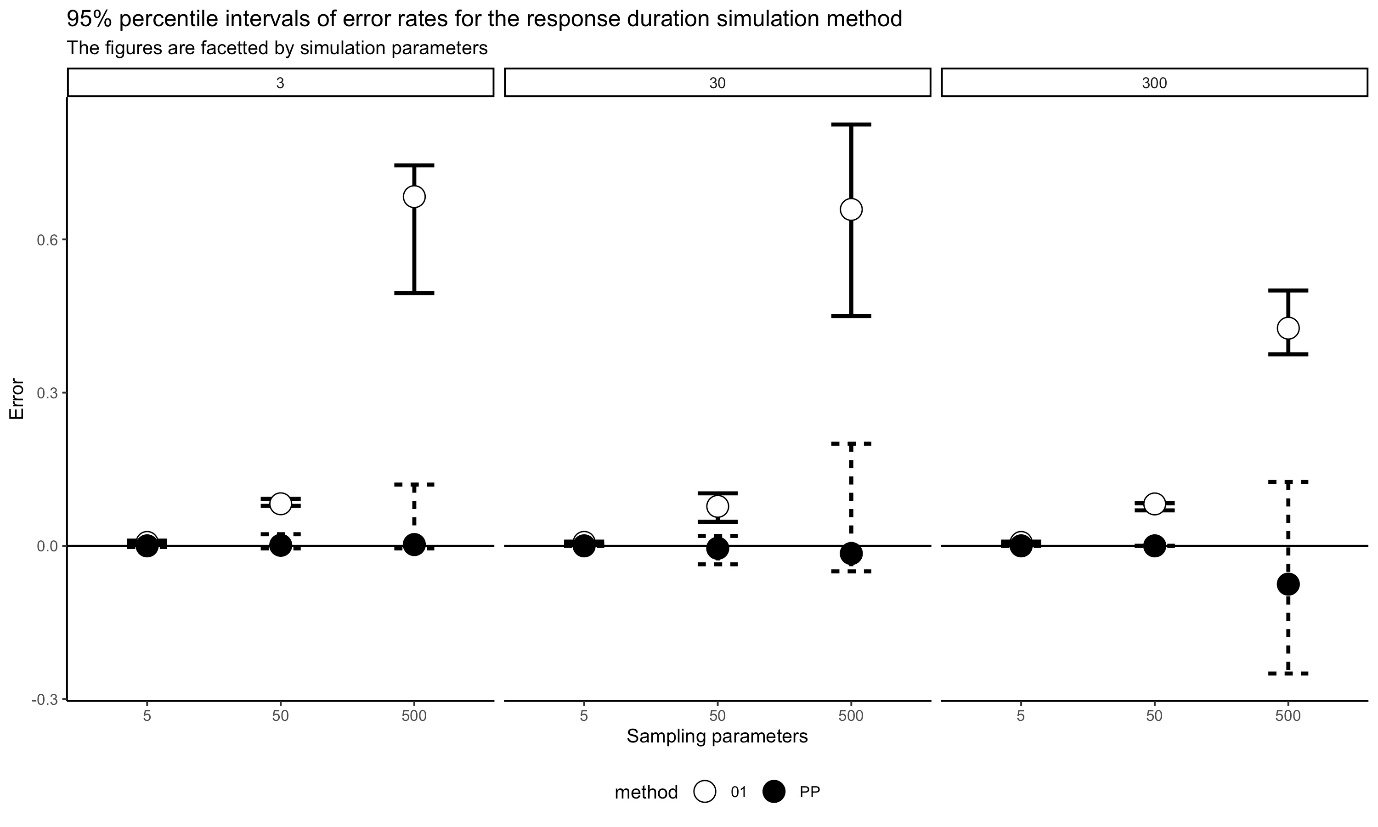
Overall, mean error rates were consistently lower for the pinpoint sampling method in comparison to the one-zero sampling method (χ2 = 9, *df* = 1, *p* = 0.0027, *W* = 1) (see Table 1). Post-hoc tests for all 9 comparisons (3 frequencies x 3 recording intervals) were *p* < .001.

***Table 1.*** *Mean error rates for each sampling method under 5 s, 50 s and 500 interval lengths for the response frequency simulation.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Simulation parameters | Sampling parameters | Proportion of time event occurs | Mean error | Lower 95% percentile of error | Upper 95% percentile of error |
| **One-zero** |  |  |  |  |  |
| 3 | 5 | 0.333 | 0.667 | 0.667 | 0.667 |
| 3 | 50 | 0.333 | 0.667 | 0.667 | 0.667 |
| 3 | 500 | 0.333 | 0.667 | 0.667 | 0.667 |
| 30 | 5 | 0.033 | 0.133 | 0.133 | 0.133 |
| 30 | 50 | 0.033 | 0.967 | 0.967 | 0.967 |
| 30 | 500 | 0.033 | 0.967 | 0.967 | 0.967 |
| 300 | 5 | 0.003 | 0.013 | 0.013 | 0.013 |
| 300 | 50 | 0.003 | 0.163 | 0.163 | 0.163 |
| 300 | 500 | 0.003 | 0.902 | 0.872 | 0.997 |
| **Pinpoint** |  |  |  |  |  |
| 3 | 5 | 0.333 | 0.002 | -0.039 | 0.0403 |
| 3 | 50 | 0.333 | 0.007 | -0.118 | 0.118 |
| 3 | 500 | 0.333 | -0.0158 | -0.003 | 0.292 |
| 30 | 5 | 0.033 | -0.0004 | -0.010 | 0.010 |
| 30 | 50 | 0.033 | 0.0010 | -0.033 | 0.036 |
| 30 | 500 | 0.033 | 0.005 | -0.033 | 0.157 |
| 300 | 5 | 0.003 | 0.0003 | -0.003 | 0.005 |
| 300 | 50 | 0.003 | -0.0003 | -0.003 | 0.024 |
| 300 | 500 | 0.003 | 0.0017 | -0.003 | 0.122 |

***Response duration***

The accuracy of both pinpoint and one-zero sampling was calculated for each interval length and all three behavioural durations (short, medium, and long) (see Figure 4).



***Figure 4.*** *Mean error rates (with 95% percentile intervals of the errors bars) for the response duration simulation and the one-zero and pinpoint sampling methods for the 5 s, 50 s and 500 s observation intervals. PP: Pinpoint sampling; closed circles, 01: One-zero sampling, open circles.*

For all simulation frequencies, pinpoint sampling was less biased, with minimal error rates. By contrast, mean error rates were much higher for one-zero sampling, and these increased as interval length increased. For both pinpoint and one-zero sampling, the variance in results increased with interval length.

The pinpoint sampling method consistently produced lower error rates than the one-zero method (χ2 = 9, *df* = 1, *p* = 0.0027, *W* = 1) (see Table 2). Post-hoc tests for all 9 comparisons (3 durations x 3 recording intervals) were *p* < .001.

***Table 2.*** *Mean error rates for each sampling method under 5 s, 50 s and 500 interval lengths for the response duration simulation.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Simulation parameters | Sampling parameters | Proportion of time event occurs | Mean error | Lower 95% percentile of error | Upper 95% percentile of error |
| **One-zero** |  |  |  |  |  |
| 3 | 5 | 0.005 | 0.006 | 0.003 | 0.010 |
| 3 | 50 | 0.005 | 0.082 | 0.078 | 0.092 |
| 3 | 500 | 0.005 | 0.684 | 0.495 | 0.745 |
| 30 | 5 | 0.050 | 0.007 | 0.004 | 0.008 |
| 30 | 50 | 0.050 | 0.008 | 0.047 | 0.103 |
| 30 | 500 | 0.050 | 0.659 | 0.450 | 0.825 |
| 300 | 5 | 0.500 | 0.007 | 0.003 | 0.008 |
| 300 | 50 | 0.500 | 0.082 | 0.069 | 0.083 |
| 300 | 500 | 0.500 | 0.426 | 0.375 | 0.500 |
| **Pinpoint** |  |  |  |  |  |
| 3 | 5 | 0.005 | <0.001 | -0.002 | 0.003 |
| 3 | 50 | 0.005 | 0.001 | -0.005 | 0.023 |
| 3 | 500 | 0.005 | 0.002 | -0.005 | 0.120 |
| 30 | 5 | 0.050 | <0.001 | <0.001 | <0.001 |
| 30 | 50 | 0.050 | -0.004 | -0.036 | 0.019 |
| 30 | 500 | 0.050 | -0.015 | -0.050 | 0.200 |
| 300 | 5 | 0.500 | <0.001 | <0.001 | <0.001 |
| 300 | 50 | 0.500 | <0.001 | <0.001 | <0.001 |
| 300 | 500 | 0.500 | -0.075 | -0.250 | 0.125 |

**DISCUSSION**

Our study attempted to answer two hypotheses: (1) one-zero sampling would be better suited (i.e., less biased) for detecting the occurrence of low frequency (event) behaviours, particularly when comparing less frequent pinpoint and one-zero observation methods, and (2) pinpoint sampling would provide a less biased representation of percentages of occurrence for both low, medium, and high duration (state) behaviours than one-zero sampling. The first hypothesis was not supported, as pinpoint sampling was less biased at detecting frequency responses than one-zero sampling, even when events occurred less frequently, and particularly when recording intervals were longer. The second hypothesis was supported in that pinpoint sampling was less biased than one-zero sampling for detecting duration behaviours. One-zero sampling was similarly capable at detecting duration behaviours of any length at low (5 s) or medium (50 s) recording intervals. At longer recording intervals (500 s), pinpoint sampling substantially outperformed one-zero sampling for the detection of duration behaviours. Finally, for both sampling methods, increasing the interval recording length appeared to increase the bias or variability in error rates for both frequency and duration responses. As the recording interval increased, one-zero sampling became more biased, as observed by an increase in mean error rate. Increased recording intervals also increased variability in the mean error rate for one-zero sampling of duration responses. Pinpoint sampling maintained low error bias regardless of the recording interval length, however, as the recording interval increased, pinpoint sampling showed greater variability in the mean error rate for both frequency and duration responses.

Taken together, the results suggest that pinpoint sampling was more accurate (i.e., less biased) in detecting responses than one-zero sampling. Below we consider implications for this and other studies, as well as factors that should influence the selection of behavioural sampling methods.

***Previous studies***

Prior to this study, researchers have compared differences between pinpoint and one-zero sampling methods. Early simulations lacked the precision and/or ability to run extensive repetitions of their simulations to accurately assess sampling method differences (Griffin & Adams, 1983; Harrop & Daniels, 1986; Repp et al. 1976). Other researchers have attempted to make similar methodological comparisons via the data collection of actual behavioural occurrences (Gardenier et al. 2004; Leger, 1977; Meany-Daboul et al. 2007; Murphy & Harrop, 1994; Radley et al. 2015; Rapp et al. 2007; Rhine & Flanigon, 1978). While the results of differences in sampling methods for real occurrences of behaviour varied, most studies found pinpoint sampling to be more accurate than one-zero sampling, at least with respect to duration (state) behaviours. Nonetheless, caution should be used in making determinations of the validity of any result based on specific examples, as exceptions to any rule can and do occur.

Only three recent studies, all conducted by behaviour analysts interested in behavioural observations for applied, behaviour change purposes with human populations, have attempted to simulate data sets and compare some aspect of pinpoint and one-zero sampling methods (Devine et al. 2011; Rapp et al. 2008; Wirth et al. 2014). In two of these studies (Devine et al. 2011; Rapp et al. 2008), limited simulations were produced via the rolling of die and pinpoint sampling was compared to a type of one-zero sampling, partial interval recording (PIR; the same as our one-zero sampling procedure), in which the response only need occur at any point during an observation interval to be recorded. In both studies, pinpoint sampling generally outperformed one-zero sampling for the detection of duration responses, with some variation in the ability of PIR to accurately detect frequency responses compared to pinpoint sampling and continuous recordings. Wirth et al. is the only other study to date to use extensive computer-generated simulations to examine differences between pinpoint and one-zero sampling methods, in their case both PIR and whole interval recording (WIR), where the duration response must occur during the entire observation interval to be recorded. Like our study, they generated 100 simulations, and found pinpoint sampling to be more accurate (less biased) than PIR or WIR, which overestimated and underestimated cumulative event durations, respectively. One limitation of their simulation was that it used a truly randomized rather than block structures for the simulated responses, as ours did, which more directly limits the applicability of their simulation to real-world behaviours (behavior is rarely, if ever, truly random). Regardless, their results were similar to our study in that pinpoint sampling was generally less biased than one-zero sampling methods.

***Which behavioural method is most appropriate for my study?***

Pinpoint sampling has not been recommended for measuring frequency (event) responses, particularly those of low occurrence (Altmann, 1974; Lehner, 1998). However, in our simulation this method was accurately able to detect low occurrence (<1%) frequencies. Therefore, the use of pinpoint sampling to measure any event responses, regardless of their frequency of occurrence, appears to be a viable option if large amounts of behavioural data is collected. Similarly, one-zero sampling methods are often preferred as an observational method because of the ease with which behaviours can be observed, recorded, and assessed for Interobserver Agreement (IOA; Cooper et al. 2019; Poling et al. 1995). The same can also be said for pinpoint sampling, which provides an equally user-friendly research method when compared to continuous (focal) recordings. In addition, researchers attempting to account for under- or over-estimates of one-zero recordings have devised different sampling methods, including partial, whole, occurrence, and nonoccurrence interval (one-zero) recordings. Still, the difficulty here is that, if pinpoint sampling provides a more accurate representation of behavioural occurrence, then the solution should be to adopt this method rather than adjust a less accurate one-zero recording method.

An added benefit of using either pinpoint or one-zero sampling methods over continuous recordings are they negate the difficulty in making comparisons between frequency (event) versus duration (state) behaviours. For instance, if a researcher were assessing the impact of pacing on the welfare of some animal, how would they compare 10 instances of 6-second paces to one instance of a 60-second pace? Lehner (1998) suggests that the former could be assessed as a bout of event responses, but it is still not clear how to evaluate the difference between a bout of responses to less frequent but longer duration behaviours. Pinpoint and one-zero sampling methods avoid this problem by only recording whether the response occurred during some observation period, regardless of the frequency or duration of the recorded response. This makes these observation methods valuable in circumstances where presence or absence of a particular behaviour is more important than the measurement of its frequency or duration, such as in studies of courtship or reproduction (Fraser, 2009).

***Sampling methods concluded***

Historically, a major factor in determining behavioural observation methodology has been the prevalence of that sampling method within some field/observational species. For instance, Mann (1999) found that over half of all cetacean studies in their review used *ad libitum* sampling, even though such sampling methods are recognized to be both less quantitative and systematic. Likewise, one-zero sampling methods are typically used by primatologists and behaviour analysts for the study of non-human primate and human behaviour, respectively (Cooper et al. 2019; Doran, 1992; Merrell 2001; Omark, 1976; Rapp et al. 2007; Rhine et al. 1985; Seyfarth et al. 1977). The concept of using methodology passed down from previous studies and labs has been referred to as “laboratory lore” and is an asset to the cultural transmission of scientific knowledge (Buskist & Johnston, 1988; Johnston & Pennypacker, 2010). Nonetheless, the selection of behavioural observation methods, like all aspects of scientific research, should be based on the efficacy of the methodology used. In the case of selecting between pinpoint or one-zero sampling methods to estimate behavioural occurrences, our study indicates that pinpoint sampling outperforms one-zero sampling on all frequency and duration measures simulated. Thus, laboratory lore aside, pinpoint sampling seems to be the better option for measuring some aspect of behavioural prevalence when compared to one-zero sampling methods.

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