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Contents

Foreword

Welcome to the latest edition of the International Journal of Clinical Skills (IJOCS), Volume 7, Issue 3, May 2013.

Working out of hours is associated with heightened levels of fatigue among medical staff, when compared with day work. Professor Aidan Byrne leads a group of researchers to investigate the effect of 'out of hours' working on the mental workload of anaesthetists during routine practice. The study supports the use of mental workload measurement as a technique to measure the effect of changes in the anaesthetic working environment. The technique could be used to provide a method of identifying individuals or periods of high mental workload and to measure the effectiveness of putative risk reduction strategies.

Doctors are often interrupted during the course of their clinical activities and it is likely that such distractions contribute to medication related errors. However, the impact of distraction on an individual's ability to perform drug related calculations has never been formally tested. Our colleagues at Queen's University Belfast, Northern Ireland, investigate cognitive distraction and discuss interesting findings which should be incorporated into every medical curriculum.

Extensive research indicates that adults learn best when they are motivated, self-directed, and can choose what and how they learn. This is especially important for postgraduate continuing professional development. Dr Anita Young and Dr Helen Meldrum of Bentley University, USA, present a study focusing on continuing pharmacy education. This thought-provoking study clearly demonstrates that all stakeholders in pharmacy education need to consider moving forward to revise the underlying structure of the continuing education experience.

As always, your feedback is invaluable for the continued development of the International Journal of Clinical Skills – the only peer reviewed international journal devoted to clinical skills (e-mail: feedback@ijocs.org)

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A pilot study of the effect of on-call working on the mental workload of anaesthetists

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Keywords

Mental workload
Fatigue
Shift work
Error

Abstract

The aim of this study was to pilot the use of a previously validated method to estimate the effect of 'out of hours' working on the mental workload of anaesthetists during routine practice.

The delay in response to a vibrotactile stimulus was used as a secondary task along with a standard measure of subjective workload (NASA TLX) [1].

The longest response delays (median (quartile range)) were recorded during induction; 16.5ms (0-68) during daytime and 85ms (85-297) during out of hours, delays were lower during maintenance and emergence. The difference between the daytime and out of hours groups was statistically significant during induction ($Z = -1.274$, $P < 0.005$). There was no significant difference in subjective workload scores.

This study supports the use of mental workload measurement as a technique to measure the effect of changes in the anaesthetic working environment. Further studies will be required to determine the relationship between measured workload and performance.

Background

Working out of hours is associated with heightened levels of fatigue among medical staff, when compared with day work [2]. Many of the fatigue related problems that night workers encounter stem from the disruption of the body clock which both promotes sleep at night and also impairs recovery sleep during the days between night shifts. The restriction of opportunities for rest, recovery and sleep can be detrimental to night workers' performance at work and increases the likelihood of them making a mistake which may result in an accident. Hence, doctors working nights (3 or more nights in a week) have reported a 37% increase in risk of fatigue-related clinical error, compared to those working less than one full night [2].

It is also recognised that humans can process information at a relatively fixed rate, known as the mental capacity [3 – 7], with mental workload defined as the proportion of that capacity in use at any one time.

Research has established that mental capacity is a limiting factor in many complex situations and that high levels of mental workload are associated with both poor performance and increased levels of error. High mental workload can either be due to increased workload requirements, for example due to the patient suffering an anaphylactic reaction or due to a reduction in total capacity, for example, due to tiredness [5, 7].

Further, high risk industries such as aviation use mental workload measurements to both identify high risk environments and to evaluate risk reduction strategies [3, 8, 9]. Mental workload has more recently been used in a wide variety of settings to measure the mental workload of medical staff [5, 10, 11, 12].

Although it is not possible to measure mental workload directly, workload can be estimated by rating the task (primary workload), asking subjects to rate their own workload (subjective measure) or by measuring the change in a physiological or behavioural observation (objective measure). The secondary task method [8, 13, 14] is an objective measure which requires each subject to perform a simple, additional (secondary) task during the study period. The nature of the secondary task is unimportant, provided it requires a small amount of mental workload and interferes with the primary task as little as possible. The technique chosen, required subjects to monitor a small wireless vibrotactile device attached to their arm and respond by pressing a button when it vibrated. Prior studies have shown it to be a simple and reliable method in a variety of settings [11, 14, 15].

The aim of this study was to investigate whether it was possible to measure the effect of out of hours working on the mental workload of anaesthetists.

Method

After formal ethical approval, anaesthetists volunteered to have their mental workload measured for the duration of a single surgical procedure in a general hospital. The surgical procedure involved was not identified and in all cases the anaesthetist was instructed to follow their usual practice.

Prior to the start of the case, a small wireless device was strapped to the arm of the anaesthetist. After a Bluetooth® link was established with a laptop computer, the device vibrated at random intervals (10-90 seconds) with the anaesthetist instructed to press the button on the device as soon as it began to vibrate. Pressing the button terminated the vibration and the time to press the button was recorded by the computer (in ms). Failure to press the button resulted in continued vibration.

The researcher remained in theatre for the duration of the case and noted significant events, but acted as a passive observer. A previous study established the 'normal' response time of an anaesthetist in theatre to be less than 924ms [15]. All responses of greater than 924ms were therefore classified as delayed, with the delay calculated as the observed response time minus 924ms. The final measure used was the average delay during induction (prior to entry to theatre). The average delay during maintenance and emergence (in theatre, after the end of the surgical procedure) were also calculated, but were previously associated with low levels of workload and were not expected to show any significant change [15].

To provide a comparison, a case control design was used with each 'out of hours' case matched to a 'daytime' case reported in a previously published study [15]. Matching was by case difficulty (simple, moderate, complex) and years of training of the anaesthetist (1-7 years). Where an exact match could not be identified, the next nearest match in the recorded series was used.

The aim of the study was to compare the mental workload of two groups of staff delivering anaesthesia during the daytime (09:00 to 17:00) or during out of hours working. The assumption was that cases performed outside of the normal working day would involve an increased risk of excessive workload. We anticipated that the increased mental workload might be due to either the increased workload of operating without immediate assistance or due to a reduced capacity due to, for example, tiredness. However, this study was not designed to identify the factors responsible for the overload, merely to detect whether it was present or not. Differences between the groups were established using Wilcoxon signed-rank signed test, using SPSS 13, with 0.05 being taken as the level of statistical significance. As the size of a clinically significant change in workload has not been established, a formal power calculation was not performed.

Results

During the study period, thirteen volunteers were identified and all cases were completed without significant technological problem. In all cases data were collected successfully and analysis was possible.

The groups were matched in terms of case complexity with both containing ten cases rated by the anaesthetist as simple, three as moderate and none as complex. It was not possible to match cases exactly in terms of the number of years in training as the previous study did not include enough simple cases completed by senior trainees. The out of hours group therefore contained more senior trainees, which would be expected to result in a reduction in measured response delay due to their greater expertise [15] (Table 1).

Table 1: Experience of those included in the study

Year of Training	Day Time	Out of Hours
7	4	4
6	1	8
5	6	0
4	1	0
1	1	1

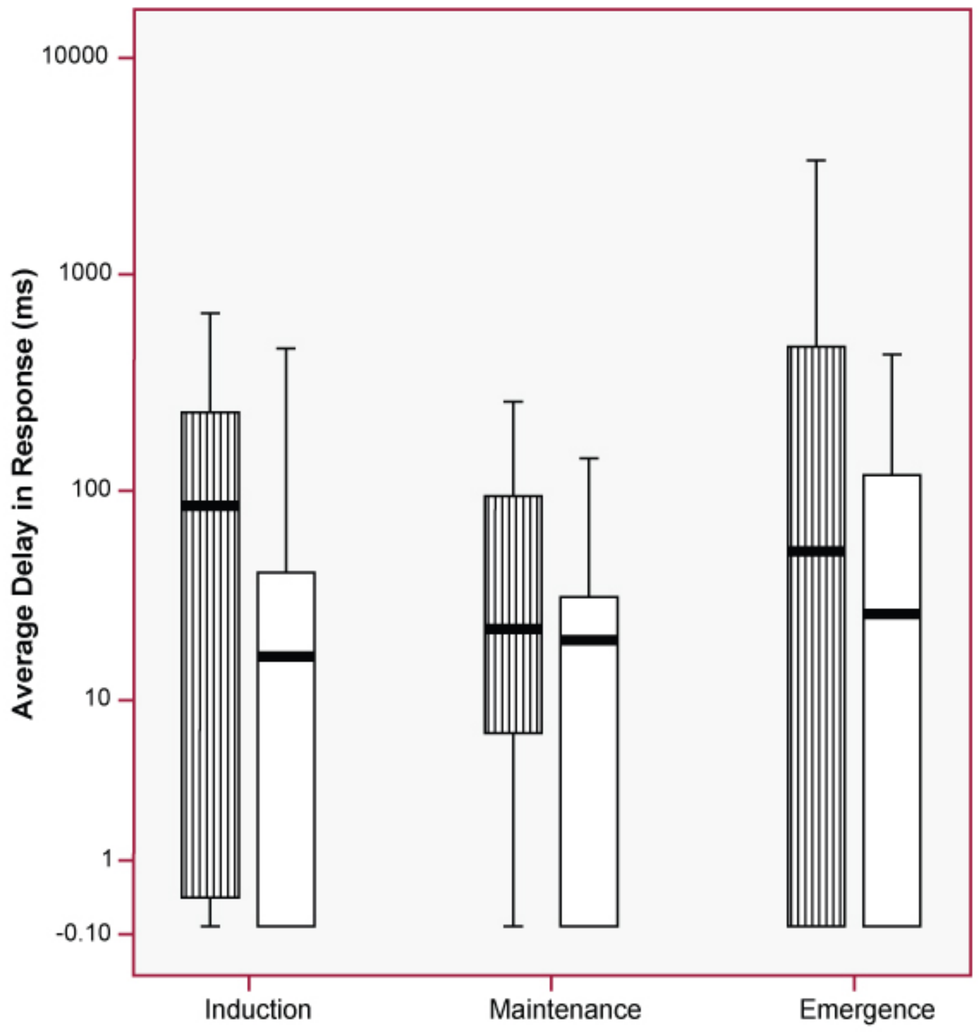
The subjective workload of the out of hours group was slightly lower in all categories with the exception of perceived success, although there were no statistically significant differences (Table 2).

Table 2: Results from the NASA TLX Questionnaire. All results on a ten point linear scale (very low – very high) except success (perfect – failure)

	Out of Hours	Day Time
How mentally demanding was the task?	4.19 (1.5-7.5)	4.5 (2-8.5)
How physically demanding was the task?	2.12 (1-5)	3.75 (0.5-7)
How hurried or rushed was the pace of the task?	2.65 (1-5)	3.65 (1-7.5)
How successful were you in accomplishing what you were asked to do?	3.69 (0.5-6)	3.26 (1-6.5)
How hard did you have to work to accomplish your level of performance?	3.08 (0-6.5)	3.73 (0.5-6)
How insecure, discouraged, irritated, stressed and annoyed were you?	1.54 (0-6.5)	1.81 (0.5-6.5)

Variability in the measured response time delay (Figure 1) was high (0-1049ms), consistent with previous studies, results are shown as (median (quartile range – range)). The longest response delays were recorded during induction; 16.5ms (0-68) during the day and 85ms (85-297) during out of hours, lower during maintenance; 13ms (3-94) daytime and 20ms (037) out of hours and some higher values during emergence; daytime 8ms (0-428), out of hours 26ms (0-207). The difference between the two groups was statistically significant during induction ($Z = -1.274$, $P < 0.005$), but failed to achieve statistical significance during maintenance and emergence.

Figure 1: Average delay for the out of hours group (shaded) and day time (open) group. Note that the Y axis uses a logarithmic scale as the average delay for some subjects were very long



Discussion

Although there is increasing evidence of the importance of mental workload to the performance of clinicians in general and anaesthetists in particular, there is still relatively little data available [11, 15]. It is therefore not possible to equate a 'standard unit' of workload to any measure and certainly not with a particular level of performance or risk. This is therefore a pilot study and results must be interpreted with caution.

The two groups were reasonably well matched, although the out of hours group was more experienced and subjectively reported reduced levels of workload. Both of these factors should have resulted in reduced objective workload.

Despite this, the statistically significant increase in response times for the out of hours group indicates that their workload was higher during induction. The lower levels of workload associated with maintenance and emergence confirmed the results of prior studies [6, 15].

The measured increase in workload could either be due

to two factors. Firstly, a decrease in the mental capacity of those studied due to, for example, tiredness. Secondly, an increase in workload due to, for example, having to work unaided, having to make more decisions or perhaps due to having to take the responsibility for any complications that might occur [3, 6, 13]. Importantly, the lack of difference in TLX scores suggest that whatever factors were responsible, the subjects did not seem to be conscious of their presence [1].

It is possible that these results are due to random variations in response times, or even that the subjects chose to press the button more slowly, although it is difficult to consciously press a button with a delay of a few milliseconds. A more significant problem is that subjects were at times not able to press the button due to both of their hands being occupied, for example, during intubation with a laryngoscope, although this would not be expected to differ between the groups. The need to keep to the same protocol for both groups prevented us recording and excluding such delays, but subsequent studies will record any physical inability to press the button.

It is important to note that any observed delay in response can in no way be interpreted as 'clinically' significant in that the stimulus is not part of clinical practice. However, while the delay cannot be interpreted directly in clinical terms, it nevertheless identifies periods when individual anaesthetists workload is close to their capacity and therefore at increased risk of poor performance and error [7, 13, 16].

Further studies will be required to establish normal/abnormal ranges for different study populations and to estimate the workload associated with specific anaesthetic tasks. However, this technique may provide a method of identifying individuals or periods of high mental workload and to measure the effectiveness of putative risk reduction strategies.

Declarations

This project received no external funding and requires no declarations.

The authors have no financial or other interests to declare in relation to this paper.

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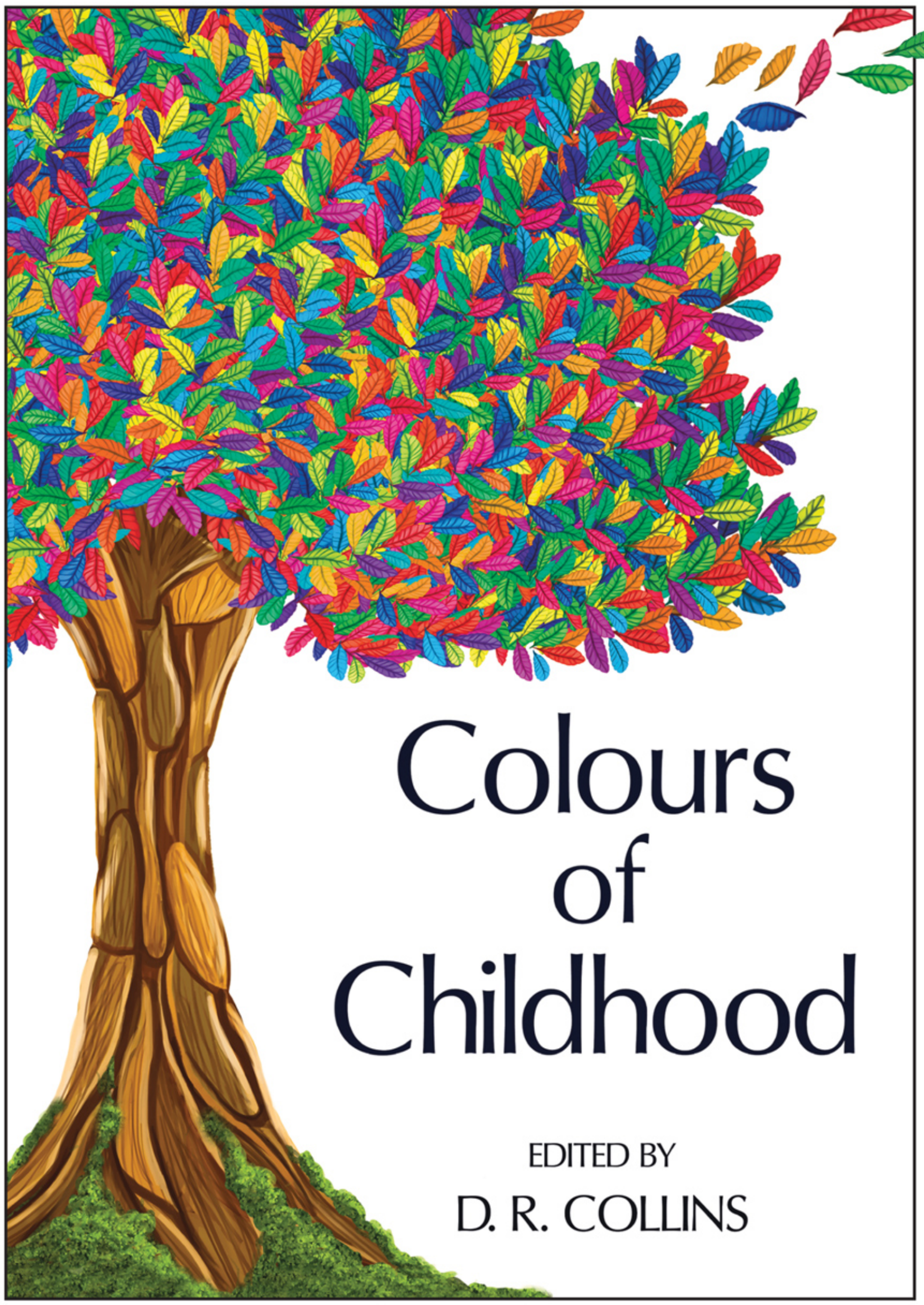

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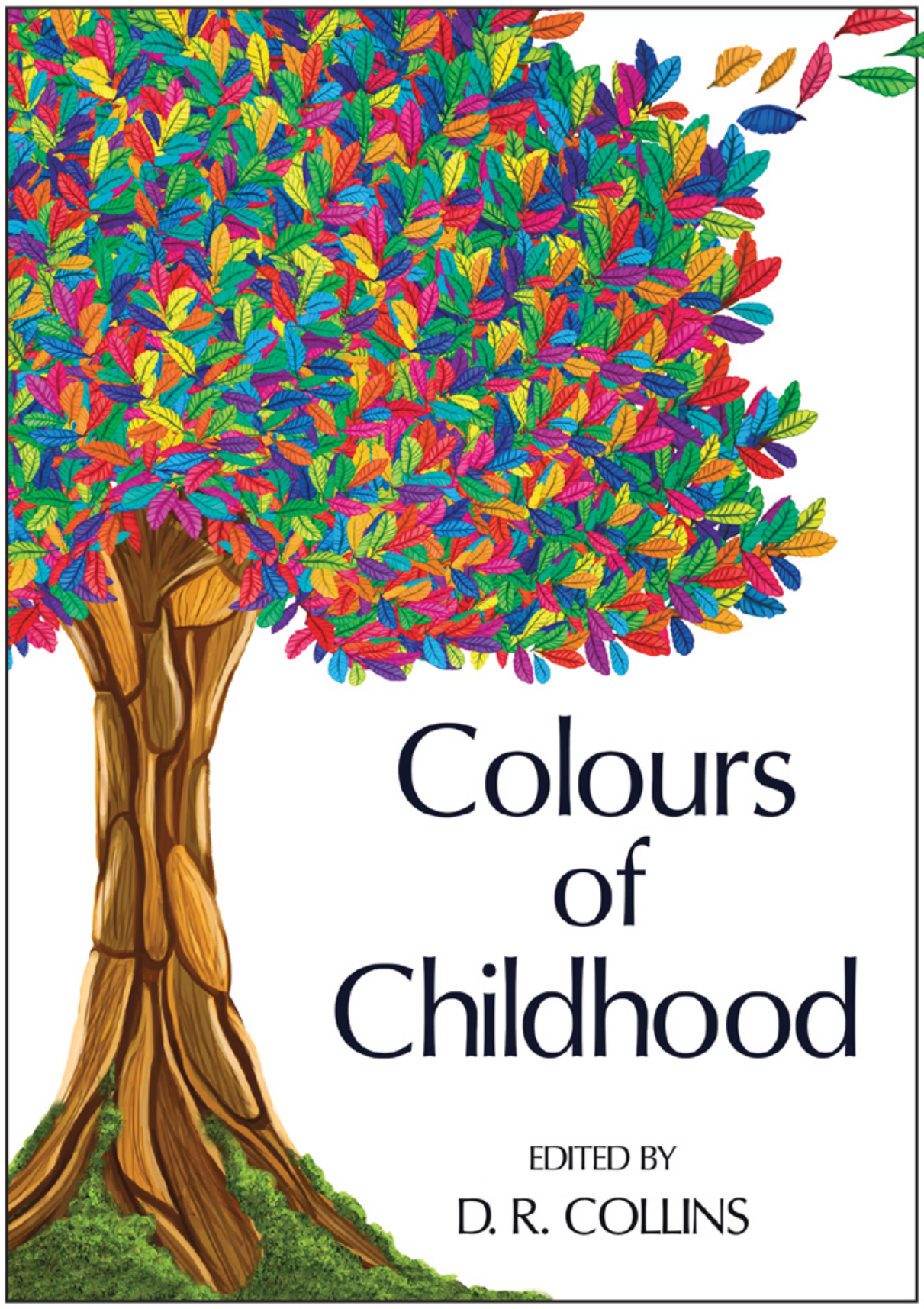

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