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Research paper

Can degrading information about patient symptoms in vignettes alter clinical reasoning in paramedics and paramedic students? An experimental application of fuzzy trace theory

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ABSTRACT

Background: Research has shown paramedics form rapid intuitive impressions on first, meeting a patient and these impressions subsequently affected their clinical reasoning. We report an experiment where theory-based interventions are developed with the goal of reducing reliance on intuitive reasoning by paramedics and paramedic students in simulated patients.
Method: Australian paramedics (n = 213; 49% female) and paramedicine students (n = 83; 55% female) attending paramedic conferences completed a 2 × 2 fully between participants experiment. They saw a written clinical vignette designed to be representative of Acute Coronary Syndrome (ACS) in which key clinical information was precise or degraded (stimulus), they then either chose the single most likely diagnosis from a list, or ranked competing diagnoses (response). Outcome variables were diagnostic rate and response time.
Results: There were no differences in the proportion of participants choosing ACS across the four stimulus-response conditions (0.75 [0.65, 0.84] vs 0.79 [0.68, 0.87] vs, 0.78 [0.65, 0.87] vs 0.72 [0.59, 0.82], p = 0.42)
Conclusion: This is the first study attempting to experimentally examine clinical reasoning in paramedics using a theory-based intervention. Neither of the interventions tested succeeded in altering measures of clinical reasoning. Similar to previous research on physicians, paramedic reasoning appears robust to manipulation.

Introduction

Paramedics exercise clinical judgement and diagnose a range of medical conditions [1]. Accurate paramedic decision-making has been shown to improve patient outcomes for a number of conditions [2–6]. However, other studies have shown inaccurate or delayed paramedic diagnosis can result in errors or patient harm [7,8]. While there is considerable interest in interventions to alter the decision-making of physicians [9], there has not been the same focus on improving paramedic decision-making.

Since 2012, there have been at least four structured literature reviews on strategies to alter decision-making in physicians, encompassing 28–87 published studies depending on the exact question being asked [10–13]. All reviews reached similar conclusions: that the overall evidence base was weak; no intervention consistently altered decisions; and there was a lack of theory underpinning interventions. General advice to slow down and think about problems appears to have no effect other than to increase diagnostic time. Interventions to improve or restructure knowledge may have a small effect but this is limited in both effectiveness and consistency [12]. Overall, physician reasoning appears highly robust to manipulation, though the reviews identified a need for more theory-based interventions. Our study addresses this concern by trialling theory-based interventions to alter decision-making in paramedics.

Abbreviations: ACS, Acute Coronary Syndrome; AHPRA, Australian Health Practitioner Regulation Agency; FTT, Fuzzy Trace Theory; GR, Gist Response; GS, Gist Stimulus; VR, Verbatim Response; VS, Verbatim Stimulus

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Fuzzy trace theory [FTT; 14] posits that people make judgements by processing information and forming cognitive representations with varying levels of fidelity: from verbatim to gist. Whereas verbatim representations are literal and precise, the gist gets to the bottom-line meaning of a given situation [15]. Even when time allows for verbatim processing, adults tend to rely more on gist processing as expertise develops [16]. Blalock and Reyna [17] conducted a systematic literature review of FTT across a range of healthcare settings, identifying 94 studies. While most favoured gist for accurate decisions in experienced decision-makers, biases were observed, particularly if appropriate representations were not retrieved. Interventions to alter gist and/or increase verbatim reasoning may change the effect of gist on verbatim reasoning.

To make an accurate decision according to fuzzy trace theory [14], an appropriate representation must be retrieved from memory and matched to the current situation. Whether a gist or verbatim representation is retrieved is partially based on the specificity of the cues available and perceived by the decision-maker [17]. Changing the manner in which the cues are elicited by paramedics may affect the level of representation retrieved.

In practice, paramedics are exposed to and actively seek a large number of cues, including signs and symptoms, vital signs, medical history and precipitating events. These are often elicited and reported verbatim (e.g. pulse is 72, respirations are 16) rather than gist (e.g. pulse and respirations are normal). The latter could be considered 'degraded' information in that it is less precise but FTT argues the additional precision does not necessarily lead to better decisions, particularly in experienced practitioners. In a diagnostic decision, explicitly acknowledging that multiple diagnoses are possible with differing probabilities may assist the decision-maker to consider the options and activate different representations.

Here, we test interventions to alter verbatim or gist reasoning using both sides of the stimulus-response equation. Participants are presented with diagnostic information in a way that is consistent with either verbatim or gist processing (for example, "pulse is 94" vs. "pulse is normal") and asked to respond in a way to facilitate such processing (e.g., choosing one option versus ranking several options). As FTT proposes that gist reasoning increases as experience grows, we hypothesised that any intervention that alters gist will be most effective in more experienced practitioners and less effective in inexperienced paramedics and students.

This is the first study attempting to experimentally alter clinical reasoning in paramedics, using a theory-based intervention. Ideally, the intervention would work to increase the proportion of participants choosing the most likely diagnosis. However, given this is the first time such an intervention has been tried on paramedics, we sought to determine if diagnosis changed in either direction. Thus, the aim of this study was to determine whether an intervention changes the diagnosis of paramedics or students in a simulated patient.

Method

Design

We conducted a 2 × 2 cross-sectional experiment with two independent variables: stimulus and response. The primary dependent variable was the proportion of participants diagnosing Acute Coronary Syndrome; the secondary outcome was participant response time. The study was pre-registered on AsPredicted.org (https://aspredicted.org/qg8hh.pdf).

Ethics

The study protocol was considered and approved by the Australian National University Human Research Ethics Committee (2017/141) in accordance with the Australian National Health and Medical Research Council's National Statement on Ethical Conduct in Human Research [18]. All participation was voluntary and no inducements or incentives were offered for participation. All responses were anonymous and the researchers were unable to identify individual responses. Participants had to press a 'submit' button at the end of the survey instrument for the response to be included in the analysis. Only responses that were submitted by participants were included in the analysis. Participants who submitted but did not answer all questions were analysed with the missing data noted in the relevant section of the results. Participants were informed that they could withdraw their participation after submission but prior to analysis by providing an anonymous code to the lead researcher; no participant has done so.

Participants

In Australia, paramedics are centrally regulated by the Australian Health Practitioner Regulation Agency (AHPRA). Registration generally requires completion of a 3-year bachelor-level university degree in paramedicine from an AHPRA accredited program. However, there are some legacy vocational qualifications and programs that permit an Australian paramedic to be registered. While most paramedics in Australia work in prehospital settings, they can work in other healthcare settings. Participants were Australian AHPRA registered paramedics and paramedic students studying an accredited undergraduate paramedicine degree at an Australian university. A total of 296 participants were recruited at the Australian and New Zealand College of Paramedicine annual conference in Melbourne, Australia in August 2019, and the Dare to Know Student Paramedic Conference in Bathurst, Australia in September 2019. Table 1 outlines the details of participants.

Materials

Acute Coronary Syndrome (ACS) is an umbrella term for several life-threatening conditions including acute angina pectoris, ST-elevation myocardial infarction, and non-ST-elevation myocardial infarction. We employed a clinical vignette previously designed and used as highly representative of ACS in an out-of-hospital setting [19]. In that study, 80% of participants exposed to the vignette recorded a final diagnosis of ACS, providing a useful baseline for this study.

The vignette consisted of five diagnostic cues, along with several non-diagnostic cues. The latter were non-diagnostic by virtue of being innocuous or within normal ranges. Non-diagnostic cues were added because they represented information routinely sought as part of a paramedic patient assessment. Two variations of the vignette were created for the stimulus manipulation (Table 2). In the verbatim version, all non-diagnostic cues were precisely defined (Verbatim Stimulus; VS). In the gist version, the non-diagnostic cues were presented as a range or categorised as normal versus abnormal (Gist Stimulus; GS). In both cases, the diagnostic cues were presented identically.

In the Gist Response (GR) manipulation, participants were asked: "What do you think is wrong with the patient? (Choose one option)". In the Verbatim Response (VR) manipulation, participants were asked: "What do you think is wrong with the patient? (Drag and drop the options so the most likely is at the top and least likely at the bottom)". In both manipulations, participants were presented with four response options in random order: Acute Coronary Syndrome; Respiratory Tract Infection; Musculo-skeletal injury; Pulmonary embolism. The survey materials and raw data can be found at: DOI: 10.25911/kt49-4n92.

Table 1
Characteristics of participants.

	Condition								All participants	
	VSVR		GSGR		VSGR		GSVR			
	Paramedics (n = 47)	Students (n = 16)	Paramedics (n = 61)	Students (n = 23)	Paramedics (n = 53)	Students (n = 29)	Paramedics (n = 52)	Students (n = 15)	Paramedics (n = 213)	Students (n = 83)
Gender n(%)										
Female	20 (42.6%)	8 (50.0%)	30 (49.2%)	12 (52.2%)	26 (49.1%)	16 (55.2%)	30 (57.7%)	10 (66.7%)	106 (49.8%)	46 (55.4%)
Male	26 (55.3%)	8 (50.0%)	31 (50.8%)	11 (47.8%)	26 (49.1%)	13 (44.8%)	22 (42.3%)	5 (33.3%)	105 (49.3%)	37 (44.6%)
Other	1 (2.1%)	0 (0%)	0 (0%)	0 (0%)	1 (1.9%)	0 (0%)	0 (0%)	0 (0%)	2 (0.9%)	0 (0%)
Age										
Median [IQR]	31.5 [13.0]	23.0 [7.5]	30.0 [12.5]	23.0 [9.5]	36.0 [12.0]	25.0 [10.0]	34.0 [12.5]	22.0 [6.5]	32.0 [13.0]	23.0 [9.50]
Missing n(%)	1 (2.1%)	0 (0%)	1 (1.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (0.9%)	0 (0%)
Years of experience										
Median [IQR]	7.00 [10.0]	NA	4.00 [7.25]	NA	7.50 [12.0]	NA	6.00 [10.0]	NA	6.00 [11.0]	NA
Missing n(%)	0 (0%)		1 (1.6%)		1 (1.9%)		3 (5.8%)		5 (2.3%)	
Year of study n(%)										
1st year	NA	3 (18.8%)	NA	8 (34.8%)	NA	5 (17.2%)	NA	4 (26.7%)	NA	20 (24.1%)
2nd year	NA	6 (37.5%)	NA	6 (26.1%)	NA	9 (31.0%)	NA	5 (33.3%)	NA	26 (31.3%)
3rd year (single degree)	NA	5 (31.3%)	NA	8 (34.8%)	NA	12 (41.4%)	NA	4 (26.7%)	NA	29 (34.9%)
4th year (combined degree)	NA	1 (6.3%)	NA	0 (0%)	NA	0 (0%)	NA	0 (0%)	NA	1 (1.2%)

Notes. GSGR: gist stimulus-gist response; GSVR: gist stimulus-verbatim response; IQR: Inter-quartile range; NA: Not applicable; VSGR: verbatim stimulus-gist response; VSVR: verbatim stimulus-verbatim response.

Procedure

The experimental materials were presented on Qualtrics survey software (Qualtrics, Provo, UT). Participants were recruited during a plenary conference presentation. Conference attendees were invited to participate and shown an internet link to the experimental materials.

Participants accessed the materials on phones or tablets over the internet. On accessing the internet link, participants viewed a participant information sheet and provided consent to participate. They were then randomly assigned by the Qualtrics software to one of four conditions: gist stimulus-gist response (GSGR); gist stimulus-verbatim response (GSVR); verbatim stimulus-gist response (VSGR); or verbatim stimulus-verbatim response (VSVR). Participants were instructed to take as much time as they wanted to read the vignette. After reading the vignette, participants pressed a “next button” to load the response manipulation. The software recorded the time in seconds from the loading of the response options to the participant’s choice; this is referred to as response time. Results for response time are described in the supplementary materials.

Following the vignette and response, participants completed a distractor task prior to a conjoint recognition activity. Details of the conjoint recognition activity are described in the supplementary materials and are not discussed further here.

Statistical Analysis

For an 80% chance of detecting a change of ten percentage points in diagnosis at a baseline of 80% with 0.05 level of significance, 62 participants were required for each group [20]. Statistical analysis was conducted using ‘R’ version 3.4.3 [21]. Frequency data are reported as count, proportion (95%CI). Continuous variables are reported as median (IQR). Comparisons of frequency data were conducted using Fisher’s Exact Test and continuous variables were compared using the relevant non-parametric test. P-values were set at 0.05 two-tailed, with Bonferroni adjustments for multiple comparisons.

Results

Overall, 75% of participants chose ACS in the control condition (VSGR); more paramedics chose ACS than students but not significantly (0.79 (0.66, 0.89) vs 0.69 (0.49, 0.84); p = 0.42). There were no differences in diagnosis rate for ACS across the four conditions (Fisher’s Exact test; p = 0.346; see Table 3). As with the control condition, student diagnosis rates were lower than for paramedics in all groups except GSVR but non-significantly (Fisher’s Exact test; p = 0.677).

Table 2
Stimulus manipulation.

Verbatim Stimulus (VS)	Gist Stimulus (GS)
You have a 53 year old male patient.	You have a male patient in his 50 s
He is sitting partially reclined, is alert, oriented, and speaking clearly in complete sentences.	He is sitting, is alert, oriented, and speaking normally.
You observe he is sweating profusely and he is moving his limbs normally with no loss of power.	You observe he is sweating and he is moving all his limbs.
He reports pain in his chest radiating to the right shoulder and arm. When you examine him, you find him hypotensive. He has a history of peripheral artery disease and a previous abnormal stress test.	He reports pain in his chest radiating to the right shoulder and arm. When you examine him, you find him hypotensive. He has a history of peripheral artery disease and a previous abnormal stress test.
You note his vital signs as:	You note his vital signs as:
Pulse 94 regular	Pulse normal
Respiratory Rate 18	Respiratory Rate normal
Blood Pressure 90/70	Blood Pressure low
Pulse oximetry 98% (room air)	Pulse oximetry normal
Temperature 37.5 C	Temperature normal
Blood Sugar Level 5.2	Blood Sugar Level normal
Glasgow Coma Score 15	Glasgow Coma Score normal
Pain 7/10	Pain severe
ECG: Normal sinus rhythm	ECG: Normal

Table 3
Numbers and proportions of participants choosing ACS in each condition.

Condition	All participants		Paramedics		Students	
	Number choosing ACS	Proportion (95% CI)	Number choosing ACS	Proportion (95%CI)	Number choosing ACS	Proportion (95%CI)
VSGR	62 / 82	0.75 (0.65, 0.84)	42 / 53	0.79 (0.66, 0.89)	20 / 29	0.69 (0.49, 0.84)
GSGR	66 / 84	0.79 (0.68, 0.87)	50 / 61	0.82 (0.7, 0.9)	16 / 23	0.7 (0.47, 0.86)
VSVR	49 / 63	0.78 (0.65, 0.87)	38 / 47	0.81 (0.66, 0.9)	11 / 16	0.69 (0.42, 0.88)
GSVR	48 / 67	0.72 (0.59, 0.82)	37 / 52	0.71 (0.57, 0.83)	11 / 15	0.73 (0.45, 0.91)

Notes. ACS: Acute Coronary Syndrome; CI: Confidence Interval; GSGR: gist stimulus-gist response; GSVR: gist stimulus-verbatim response; VSGR: verbatim stimulus-gist response; VSVR: verbatim stimulus-verbatim response. In both response conditions, participants were presented with four response options in random order: Acute Coronary Syndrome; Respiratory Tract Infection; Musculo-skeletal injury; Pulmonary embolism.

Table 4
Numbers and proportions of participants choosing ACS in each condition by experience for paramedics.

Condition	Least Experienced Paramedics (0–3 years)		Experienced Paramedics (4–11 years)		Most Experienced Paramedics (12–44 years)	
	Number choosing ACS	Proportion (95%CI)	Number choosing ACS	Proportion (95%CI)	Number choosing ACS	Proportion (95%CI)
VSGR	12 / 16	0.75 (0.47, 0.92)	10 / 13	0.77 (0.46, 0.94)	19 / 23	0.83 (0.6, 0.94)
GSGR	21 / 25	0.84 (0.63, 0.95)	20 / 22	0.91 (0.69, 0.98)	9 / 13	0.69 (0.39, 0.9)
VSVR	16 / 18	0.89 (0.64, 0.98)	14 / 15	0.93 (0.66, 1)	8 / 14	0.57 (0.3, 0.81)
GSVR	8 / 14	0.57 (0.3, 0.81)	16 / 19	0.84 (0.6, 0.96)	11 / 16	0.69 (0.42, 0.88)

Notes. ACS: Acute Coronary Syndrome; CI: Confidence Interval; GSGR: gist stimulus-gist response; GSVR: gist stimulus-verbatim response; VSGR: verbatim stimulus-gist response; VSVR: verbatim stimulus-verbatim response. In both response conditions, participants were presented with four response options in random order: Acute Coronary Syndrome; Respiratory Tract Infection; Musculo-skeletal injury; Pulmonary embolism.

We also hypothesised that the effect of a verbatim intervention would be least effective in students and inexperienced paramedics, and most effective in experienced paramedics. If so, we would expect to see greater differences between the VSGR condition and other conditions in more experienced paramedics, compared to the less experienced paramedics or students. To assess this, we divided the paramedic participants into three equal groups based on their years of experience (see Table 4). There was no effect of experience on diagnosis rate across the conditions (Fisher's Exact test; $p = 0.163$).

Discussion

Here, we employed simple theory-based interventions aiming to alter the paramedic's level of representation at the time a diagnosis is made; the first study we are aware of to do so. Our prediction was that changing the wording of the diagnostic information would change the level of representation and the subsequent diagnosis. We focused on issues of representation retrieval as these were most amenable to practical application at the point of decision. Neither of the interventions altered the diagnosis rate in either direction and this did not change with participant experience.

There are several potential explanations for the failure of the interventions trialled here. Previous research has shown investigators can cue different levels of gist-verbatim representations using simple interventions to predict health decisions in patients and clinicians [22–27]. In those studies, different representations were cued by marking a single point estimate on a visual analogue scale when compared to two marks estimating the upper and lower bounds of the risk [28,29].

The analogous manipulation here compared a single choice of the most likely diagnosis compared to ranking a series of possible diagnoses. A recent study [30] presented clinical vignettes to medical students; half were asked to respond to a multiple choice format with 10 potential options, half responded in a free-text field. Researchers found differences in accuracy, confidence and guessing rates across the groups but they were not systematic, and no significance testing was undertaken so conclusions are unclear. However, it did show that changing how the response is elicited can alter the decision. In our study, participants responded to only four potential options, which may have been insufficient to cue a different level of representation. Furthermore, participants did not generate the potential diagnoses themselves but chose from a predetermined list. If participants had developed and ranked their own list of potential diagnoses, this may have been more successful but has not been previously tested.

The stimulus manipulation here attempted to cue different representations by 'degrading' the information available to paramedics. The gist stimulus vignette provided the same information as the verbatim vignette but with less precision. The reduced precision had no effect on diagnosis. In experimental vignettes all the information, degraded or otherwise, is provided to clinicians without them having to seek it out, but in real life this information would need to be sought by the clinician. Changing the manner in which cues are actively elicited by paramedics may affect the level of representation retrieved [17]. Future research should consider the effect of paramedics actively seeking degraded or non-degraded information, rather than passively reading.

Limitations

Data was collected during conference presentations rather than in the workplace or somewhere contextually similar to the workplace, which may have altered responses. Participants may have felt under time pressure and not taken the time to fully read the verbatim stimulus material, essentially treating it the same as the gist stimulus material.

In the gist-stimulus conditions, there is a limit to how far stimulus information can be degraded without affecting the accuracy and utility of the vignette. Here the degraded information was confined to cues that could be reasonably and practically altered without making the vignette unrealistic. This may have been insufficient to alter the cued representation, though there is little point in presenting a vignette so degraded as to be unrealistic.

Conclusion

Paramedics make critical decisions with incomplete and ambiguous information. Despite this, little is known about their reasoning processes, and adopting a theory-based approach may assist. Therefore, we used fuzzy trace theory [14] as a basis for attempting to shift the level of cognitive representations about a simulated patient. The interventions trialled here were unsuccessful in altering paramedic decisions. However, these results do not invalidate the need for theory-based interventions to improve clinical reasoning. Future research should use this approach to build a better understanding of paramedic clinical reasoning to improve education, reduce error and improve outcomes.

Author contributions

TK, KP and EN conceived and designed the study. TK, KP and EN developed the study protocol. TK and KP supervised data collection. TK analysed the data. TK, EN, and KP prepared and approved the manuscript.

Author note

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Conflicts of interest

The authors have no conflicts of interest to report.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.auec.2023.02.002.

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