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Dispatch information affects diagnosis in paramedics: an experimental study of applied dual-process theory

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Abstract

Purpose – Previous research has shown that paramedics form intuitive impressions based on limited "pre-arrival" dispatch information and this subsequently affects their diagnosis. However, this observation has never been experimentally studied.

Design/methodology/approach – This was an experimental study of 83 Australian undergraduate paramedics and 65 Australian paramedics with median 14 years' experience (Range: 1–32 years). Participants responded to written vignettes in two parts that aimed to induce an intuitive impression by placing participants under time pressure and with a secondary task, followed by a diagnosis made without distraction or time pressure. The vignettes varied the likelihood of Acute Coronary Syndrome (ACS) and measured self-reports of typicality and confidence. Answer fluency, which is the ease with which the answer comes to mind, was also measured.

Findings – More participants exposed to the likely pre-arrival vignette recorded a final diagnosis of ACS, than those exposed to unlikely pre-arrival information (0.85 [95%CI: 0.78, 0.90] vs 0.74 [95%CI: 0.66, 0.81]; $p = 0.03$). This effect was greater in paramedics with more than 14 years' experience (0.94 [95%CI: 0.78, 0.99] vs 0.67 [95% CI: 0.48, 0.81]; $p = 0.01$). Answer fluency and confidence were associated with the impression, while the impression and confidence were associated with final diagnosis.

Practical implications – The authors have experimentally shown that pre-arrival information can affect subsequent diagnosis. The most experienced paramedics were more likely to be affected.

Originality/value – This is the first experimental study of diagnostic decision-making in paramedics and paramedic students.

Keywords Paramedic, Emergency medical services, Decision making, Diagnosis, Dual process theory

Paper type Research paper

Paramedics are health professionals who provide care in a range of settings, most commonly in the community and away from structured clinical environments. Yet, little is known about the processes paramedics use to make a diagnosis (Andersson *et al.*, 2019; Jensen *et al.*, 2011; Paramedicine Board of Australia, 2018). Observational and survey studies of paramedic decision-making identified intuition alongside conscious deliberative decisions (Alexander, 2010; O'Hara *et al.*, 2015; Perona *et al.*, 2019; Reay *et al.*, 2018). These observations fit well with common conceptions of dual process theories (Kahneman, 2011) which argue people use two

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cognitive pathways to form judgements and make decisions. Type 1 processes are classically described as fast, intuitive, affective and automatic. Type 2 processes are classically slower, deliberative and verbal.

For many paramedics, the first information received about a patient comes in the form of pre-arrival information, gathered by an emergency dispatcher, transmitted to the paramedic and typically displayed on a data terminal in an ambulance. On reaching the patient, the paramedic can conduct their own assessment.

Several studies have observed dispatch information impacting paramedic decisions (Halter *et al.*, 2011; Jones *et al.*, 2016; O'Hara *et al.*, 2015; Reay *et al.*, 2018; Simpson *et al.*, 2017). Simpson *et al.* (2017) conducted a qualitative study of how Australian paramedics make decisions about older patients who have fallen. Semi-structured interviews and focus groups were conducted with 33 paramedics. They commented about the importance of pre-arrival advice in predisposing paramedics to certain decisions: "*... you'd go to the job with a pre-conceived notion. This is old so-and-so; they're always falling out of bed. Let's get them back to bed, they'll be fine"* (Paramedic participant quoted in, Simpson *et al.*, 2017, p. 7)*; "they've made a decision before they even walked in the door"* (Paramedic participant quoted in Simpson *et al.*, 2017, p. 7).

In a UK study, Reay *et al.* (2018) observed that paramedics form an intuitive "impression" of the patient using dispatch information; a process observed to be automatic. The authors noted that the dispatch information was often inconsistent with what was found at the scene. Researchers in other studies (Halter *et al.*, 2011; Jones *et al.*, 2016) described paramedics forming a picture of the patient's injuries based on the dispatch information. O'Hara *et al.* (2015) also considered the effect of pre-arrival information on paramedic decisions:

> Information conveyed to crews when dispatched to calls had the potential to inform and frame crew expectations, but this information was often limited and potentially misleading. (p. 50)

Dispatch information may accurately reflect what is found by the paramedics (congruent information) or may bear little or no resemblance (incongruent information), leading to a conflict between the impression and diagnosis. Despite the widespread practice of paramedics receiving dispatch information prior to meeting a patient, and several observational studies implicating it in decision-making, there have been no quantitative studies of the phenomenon.

Previous experimental studies considered several concepts implicated in paramedic intuition: likelihood, typicality, confidence and answer fluency (Keene and Pammer, 2018). *"Likelihood"* is defined here as the objective statistical association between a disease and associated signs/symptoms. "*Typicality*" is defined here as the individual's subjective representation of specific cues being associated with a disease. In other words, how typical is a patient relative to others with the same disease in the eyes of the paramedic? "*Confidence*" is the subjective "feeling of rightness" that develops alongside the intuition (Thompson *et al.*, 2011). "*Answer fluency*" represents the ease with which the impression comes to mind, operationalised by how fast the impression comes to mind (Thompson *et al.*, 2013).

This study aimed to study the relationship between the initial impression based on pre-arrival information and the final diagnosis. Thus, the research questions for this study are:

R1. What is the relationship between impression and final diagnosis?

R2. Which study factors are associated with the final diagnosis?

R3. What is the effect of congruent and incongruent information on final diagnosis?

Method

Participants

Participants were practicing paramedics employed by an Australian government ambulance service (n = 65) and students studying an accredited undergraduate paramedicine degree at an Australian university (n = 83; Table 1). Paramedics were invited to participate in the study during a regularly scheduled employer in-service program. Students were recruited during a face-to-face block of teaching on campus. No inducements or payments were offered for participation.

Design

This study used an experimental design with between and within-participant variables. We manipulated two levels of likelihood and measured self-reports of typicality and confidence on five-point ordinal scales, and participant impression and diagnosis as a forced choice from four pre-defined options. Answer fluency was measured as the response time for the impression. The experiment aimed to induce an intuitive decision by placing participants under time pressure and with an attention-demanding secondary task (De Neys, 2006; Thompson *et al.*, 2011), followed by a diagnosis made without distraction or time pressure.

Ethical review

The study protocol was considered and approved by the Australian National University Human Research Ethics Committee (2017/141) and the Australian Catholic University Human Research Ethics Committee (2017-163R).

Materials

The experimental materials were presented on Qualtrics survey software (Qualtrics, Provo, UT). Paramedics accessed the materials using a touch-screen tablet, while students used a desktop computer. Paramedics completed the experiment individually in a classroom environment ranging in size from two to 12. The paramedicine students participated individually in class groups of 20–30.

The vignettes were designed to simulate patients highly likely or highly unlikely to have Acute Coronary Syndrome (ACS), a condition commonly encountered by paramedics, characterised by ambiguity and a need for accuracy. The signs and symptoms of ACS have been studied in several retrospective case-series (Body *et al.*, 2010; Colbeck, 2016; Fanaroff *et al.*, 2015; Sharif and Upadhye, 2017). These studies have generated likelihood ratios (LR+) for a range of signs, symptoms and risk factors (see Table 2). From this a list of "cues" was generated with an associated LR+ for ACS which were used to develop vignettes highly likely or unlikely to be consistent with a diagnosis of ACS.

The likely scenario had an estimated positive likelihood ratio for ACS of 2.1–6.4, and the unlikely scenario had an estimated positive likelihood ratio of 0.1–1.0 as derived from previous research (Body *et al.*, 2010; Colbeck, 2016; Fanaroff *et al.*, 2015; Sharif and Upadhye, 2017). The range of LR+ values for each condition represents each individual cue within the vignette. Cues were chosen that did not overlap in LR+ values in order to ensure the vignettes were sufficiently different. In addition to the diagnostic cues, the vignettes contained

Group	n (%)	Age (median; IQR, years)	Gender (n;%)	Years of experience (median; IQR)
Paramedics	65 (44%)	41 (35–48)	Female: 20 (31%) Male: 45 (69%)	14 (7–22)
Students	83 (56%)	22 (20–23)	Female: 62 (75%) Male: 21 (25%)	Year of study 2nd year: 27 3rd year: 30 4th year: 26

Table 1. Characteristics of participants

Table 2.
Empirically generated likelihood ratios for signs, symptoms and other factors associated with Acute Coronary Syndrome

Category	Most likely (LR+ 2–6.4)	Likely (LR+ 1.4–1.9)	Less likely (LR+ 1.2–1.3)	Least likely (LR+ 0.1–1.1)
Pain characteristics	Pain radiating to both arms	"Typical" chest pain	Pain radiating to one arm	Duration greater 1 h
	Pain radiates to right shoulder/arm	Pain worse with exertion	Recent similar pain	Pain left anterior
	Pain similar to previous AMI	Pain radiating to neck/jaw	Pain central	Pain reproduced on palpation
	Pain changed in pattern in previous 24 h		Same as previous ischaemia	Positional pain
			Pain radiates to left arm/shoulder	"Pleuritic" pain
			"Burning" chest pain	Sudden onset pain
				Relief from nitrates
Demographics		Age > 75	Male Gender	Age < 40
History	Abnormal prior stress test	Previous AMI	Hyperlipidaemia	Obesity
	Peripheral artery disease	Cerebrovascular disease		Prior CABG
	Coronary artery disease	Combination of risk factors		Diabetes
				Any tobacco use
Signs	Observed sweating	Crackles/rales	Reported Sweating	Nausea
	Hypotension	Tachypnoea	Tachycardia >120	Palpitations
	Vomiting		Hypertension	
			Shortness of breath	

Note(s): LR+: positive likelihood ratio; AMI: Acute Myocardial Infarction; CABG: Coronary Artery Bypass Graft

additional information to provide participants with information typically gathered by paramedics in their patient assessment. The additional information was non-diagnostic; that is, in the normal range or innocuous. Both vignettes had similar word counts and presented the same number of cues (Table 3). Such vignettes are used commonly in paramedic initial and ongoing training, so the style and format were familiar to participants. Each vignette was presented as two parts (pre-arrival and post-arrival) as shown in Table 3.

The pre-arrival and post-arrival information was combined to form four vignettes each with two parts: Unlikely–Likely (UL); Likely–Unlikely (LU); Unlikely–Unlikely (UU); Likely–Likely (LL). The LL and UU vignettes were considered congruent; and the LU and UL vignettes were considered incongruent.

Procedure

Participants were briefed by the lead researcher that the research aimed to understand the processes paramedics and paramedic students use to make diagnostic decisions. They were informed that they would be presented with brief written clinical scenarios and asked to make decisions based on the information presented. The focus on pre-arrival and post-arrival information was not included in the briefing.

After providing consent, participants undertook six practice tasks following on-screen instructions. Each of the first three practice tasks displayed an image of a street map with two markers on it. Participants were instructed to map a route between the markers. The map

	Likely (LR+ 2.1–6.4)	Unlikely (LR+ 0.1–1)
Pre-arrival information	You are dispatched to a patient with chest pain *radiating to both arms*. The pain is *similar to a previous heart attack*. The patient has *coronary artery disease*, *hypotension* and *vomiting*	You are dispatched to a patient with chest pain that changes with their *posture* and *breathing*. The patient has history of *obesity* and *diabetes*. The patient is complaining of *palpitations*
Post-arrival information	You have arrived at the patient described in the pre-arrival information	You have arrived at the patient described in the pre-arrival information
	You find a male patient in his 50s. He is sitting partially reclined, is alert, oriented and speaking clearly in complete sentences. You observe he is *sweating* profusely and he is moving his limbs normally with no loss of power	Your patient is an alert and oriented 53 year old male. He is sitting partially reclined and speaking clearly in complete sentences. He is moving his limbs normally with no loss of power
	He reports *pain in his chest radiating to the right shoulder and arm*. When you examine him, you find him *hypotensive*	He is complaining of *nausea* and *left anterior chest pain* for the *past several hours*
	He has a history of *peripheral artery disease* and a previous *abnormal stress test*	He is a *smoker* and previously received a *coronary artery bypass graft*
	You note his vital signs as	You note his vital signs as
	Pulse 94 regular	Pulse 92 regular
	Respiratory rate 18	Respiratory rate 20
	Blood pressure 90/70	Blood pressure 105/80
	Pulse oximetry 98% (room air) temperature 37.5 C	Pulse oximetry 96% (room air)
		Temperature 37.3 C
	Blood sugar level 5.2	Blood sugar level 7.2
	Glasgow coma score 15	Glasgow coma score 15
	Pain 7/10	Pain 7/10
	ECG: Normal sinus rhythm	ECG: Normal sinus rhythm

Note(s): Diagnostic cues are italicized here for emphasis. They were not emphasised to participants. ECG: Electrocardiogram

Table 3. Clinical vignettes

appeared on the screen for only 12 s before automatically advancing, regardless of whether the full route had been marked or not.

The first three practice tasks consisted of the navigation exercise only; the second three practice tasks combined the navigation exercise with pre-arrival information. At the top of the map was brief written clinical information similar to that seen by paramedics when traveling to a patient (for example, see Figure 1). Again, the participant had only 12 s to complete the task and read the information provided.

Following the navigation task, participants were asked the following questions (possible responses in square brackets):

(1) Thinking just about the pre-arrival information, what do you think is most likely to be wrong with the patient? (Choose one option) [Presented in random order: Acute Coronary Syndrome; Respiratory Tract Infection; Musculo-skeletal injury; Pulmonary embolism]

(2) For the previous question, you chose [response to previous question]. Based on the pre-arrival information you saw, how confident are you about your answer? [Not at all confident; Low confidence; Confident; Very confident]

(3) Based just on the pre-arrival information you saw, how representative or typical was that patient compared to others with [response to first question] you know about or

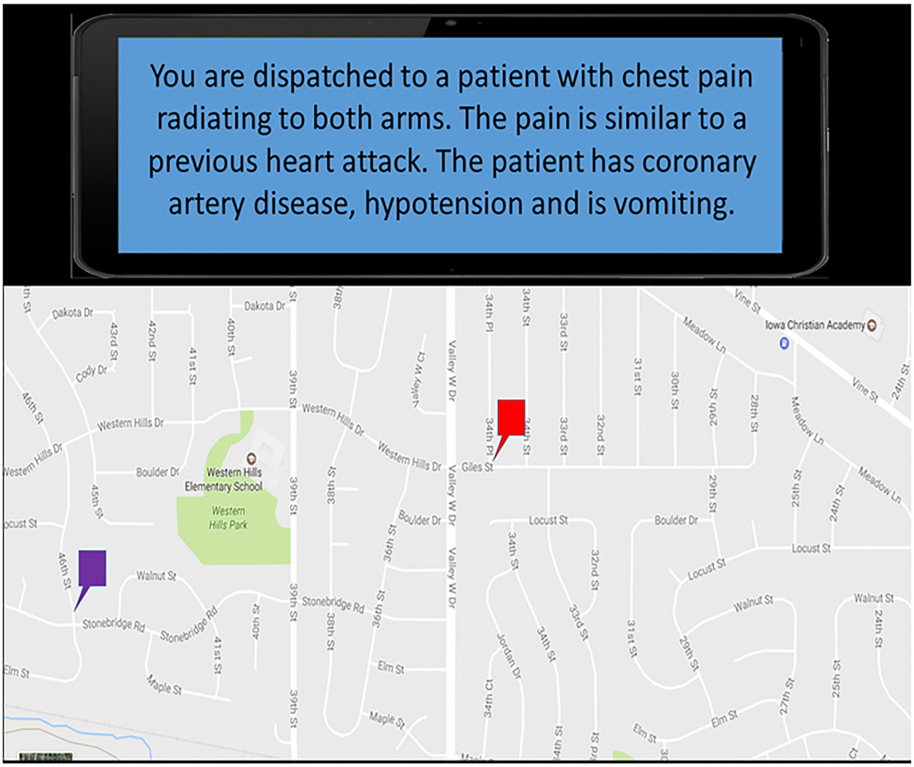


Figure 1.
Example of the stimulus material provided to participants

have experienced? [Very atypical; Atypical; Neither typical nor atypical; Typical; Very Typical]

Responses are referred to below as "impression", "confidence" and "typicality", respectively.

After completing the practice tasks, participants were randomly assigned by the software to one of two groups: congruent or incongruent. Two vignettes were presented to each participant in two parts. The first part of each vignette was presented identically to the latter three practice tasks and participant responses were recorded. Following this, participants were presented with the second part of the vignette; the post-arrival information. There was no time limit applied to this information and the participant could move onto the next questions when they were ready. When they did so, they were asked to consider the information they had just read and asked to respond to the same three questions presented earlier. Figure 2 outlines the experimental procedure.

Statistical analysis

Sample size was calculated using the "GLIMMPSE" calculation tool (Kreidler *et al.*, 2013) in order to detect a 20% difference in the proportion of participants diagnosing ACS. To detect this difference with 80% power, a total sample size of 132 is required.

Statistical analysis was conducted using "*R*" version 3.4.2 (R Core Team, 2017). Frequency data are reported as count, proportion (95%CI). Continuous variables are reported as median (IQR). Comparisons of categorical data were conducted using Fisher's Exact Test and

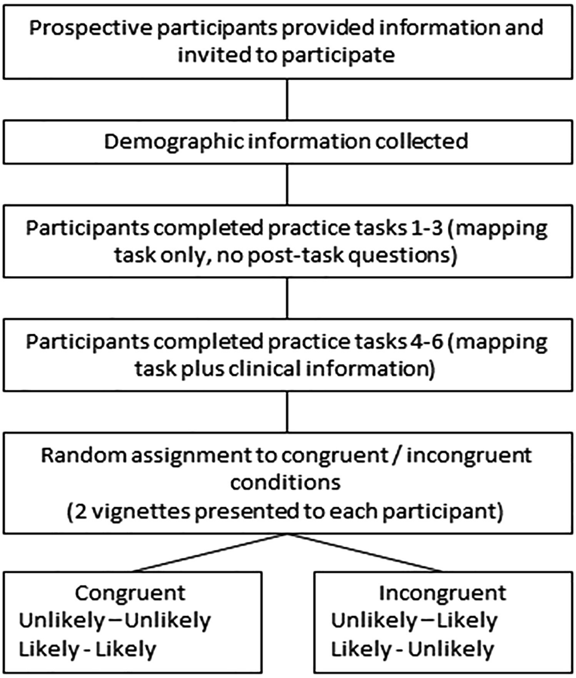


Figure 2. Summary of experimental procedure

continuous variables were compared using the relevant non-parametric test with p-values set at 0.05 two-tailed. Correlations were calculated using the "rmcorr" *R* package (Backdash and Marusich, 2018) for repeated-measures correlations. To consider the role of experience, the paramedic group was divided according to the median: Less experienced (<14 years) and more experienced (>= 14 years). The raw data is available under Creative Commons License at: DOI 10.25911/5e701e8946cd8.

Linear mixed models are an extension of simple linear models that allow for both fixed and random effects. They also allow for within-group and between-group analysis from the same data and are increasingly used for modelling non-independent data sets (Bates *et al.*, 2015; Luke, 2017). The effects of the measured variables (likelihood, confidence, answer fluency and typicality) on participants' impression were examined using participant as a random effect and the other predictors as fixed effects. The navigation task was assessed by the number of points participants added to their route selection. Impression was modelled as a dichotomous variable (ACS vs non-ACS). Gender and group (Paramedic vs Student) were modelled independently and as interactions to determine if the gender differences between the groups played a role. The first model included all the predictor variables with non-significant predictors removed stepwise. Models were compared using ANOVA with chi-square to determine differences (Magezi, 2015). Models were also generated to determine the presence of an interaction between experience and the other predictors. Reported below are the results for those models that showed best fit.

Results

R1: What is the relationship between impression and final diagnosis?

When exposed to the Likely pre-arrival vignette, the proportion of participants recording an impression of ACS was 0.95 (95%CI: 0.89, 0.97), compared to 0.26 (95%CI: 0.20, 0.34) in the

Unlikely vignette (95%CI: 0.20, 0.98; p < 0.001; Figure 3). Using linear mixed models as described above, likelihood and self-reported confidence were associated with impression but answer fluency and typicality were not (Table 4). Overall, there was a difference in answer fluency between the likely and unlikely dispatch conditions on impression (3.79 (2.12, 6.53) vs 9.56 (5,57, 13.31); Kruskal–Wallis chi-squared = 77.3, df = 1; $p < 0.001$). Answer fluency and self-reported confidence were well correlated ($r = -0.531$, $p < 0.001$).

When exposed to a post-arrival vignette likely to be ACS, the proportion of participants overall recording a final diagnosis of ACS was 0.80 (95%CI: 0.73, 0.87). When exposed to the Unlikely post-arrival information, this was 0.79 (95%CI: 0.71, 0.85). Despite one post-arrival vignette designed to be highly likely to be ACS and the other highly unlikely, participants overall responded to both post-arrival vignettes virtually identically (Table 5).

R2: Which study factors predict final diagnosis?

Only two variables were associated with a final diagnosis of ACS: the pre-arrival likelihood and the post-arrival confidence (Table 6). For participants exposed to the Likely pre-arrival

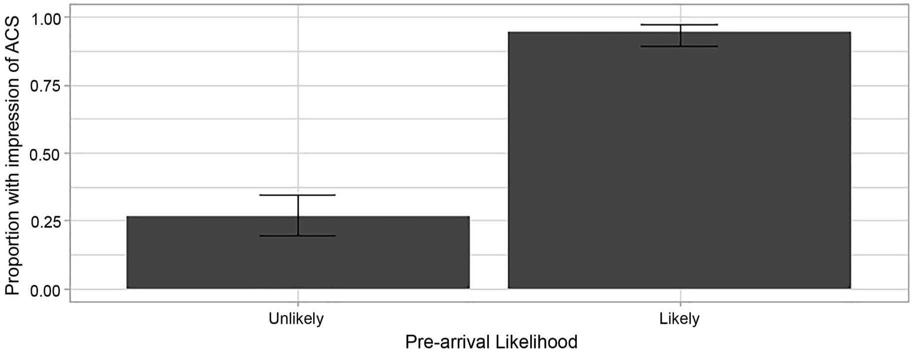


Figure 3. Proportion (95%CI) of participants with impression of ACS by pre-arrival likelihood

Table 4. Selected linear mixed model using participant impression as the outcome variable (ACS vs non-ACS)

Variable	Estimate	SE	z value	p-value
(Intercept)	1.20	1.33	0.91	0.37
Navigation	−0.03	0.03	−1.26	0.21
Likelihood	−3.76	0.45	−8.31	$p < 0.01$
Typicality	−0.06	0.34	−0.19	0.85
Answer fluency	0.01	0.02	0.41	0.68
Confidence	0.95	0.36	2.65	0.01
Experience	−0.28	0.23	−1.22	0.22

Note(s): Participants were added as a random effect; all others were added as fixed effects

Table 5. Participant responses to the post-arrival vignettes across all conditions

	Likely	Unlikely
Proportion diagnosing ACS (95%CI)	0.80 (0.73, 0.87)	0.79 (0.71, 0.85)
Confidence (median (IQR))	3.00 (1.00)	3.00 (1.00)
Typicality (median (IQR))	4.00 (1.00)	4.00 (1.00)
Answer fluency (median (IQR); seconds)	4.11 (7.85)	3.79 (7.23)

Note(s): Confidence and Typicality responses were recoded numerically with 1 being least confident or typical vignette, the proportion of participants recording a final diagnosis of ACS was 0.85 (95%CI: 0.78, 0.90), compared to 0.74 (95%CI: 0.66, 0.81) when exposed to the Unlikely pre-arrival information (95%CI: 0.27, 0.94; $p = 0.03$). This was explored by considering the role of experience in potentially moderating the effect of pre-arrival likelihood on final diagnosis. In paramedics with greater than 14 years' experience, 67% made a final diagnosis of ACS when exposed to Unlikely pre-arrival information compared to 94% when exposed to Likely pre-arrival information (95%CI: 0.01, 0.70; $p = 0.01$; see Table 7 and Figure 4). There was no difference in self-reported confidence between impression and final diagnosis (median (IQR): 3(2, 3) vs 3(2, 3); Kruskal–Wallis chi-squared = 3.66, df = 1, p-value = 0.06).

Variable	Estimate	SE	z value
(Intercept)	−0.78	1.26	0.53
Pre-arrival likelihood	0.41	0.18	−2.26 ($p = 0.02$)
Post-arrival likelihood	−0.03	0.16	−0.18
Pre-arrival confidence	−0.28	0.35	−0.81
Post-arrival confidence	1.17	0.39	2.99 ($p < 0.01$)
Pre-arrival typicality	−0.30	0.33	−0.91
Post-arrival typicality	0.30	0.28	1.05
Experience	−0.03	0.21	−0.13

Note(s): Participants were added as a random effect; all others were added as fixed effects

Table 6. Selected linear mixed model using final diagnosis as the outcome variable (ACS vs non-ACS)

	Pre-arrival likelihood	
Experience	Unlikely	Likely
Student	0.76 (0.65, 0.84)	0.84 (0.74, 0.91)
Less experienced (<14 years)	0.78 (0.60, 0.90)	0.78 (0.60, 0.90)
More experienced (>= 14 years)	0.67 (0.48, 0.81)	0.94 (0.78, 0.99) ($p = 0.01$)
Overall	0.74 (0.66, 0.81)	0.85 (0.78, 0.90) ($p = 0.03$)

Table 7. Proportion (95%CI) of participants choosing final diagnosis of ACS by pre-arrival likelihood and experience

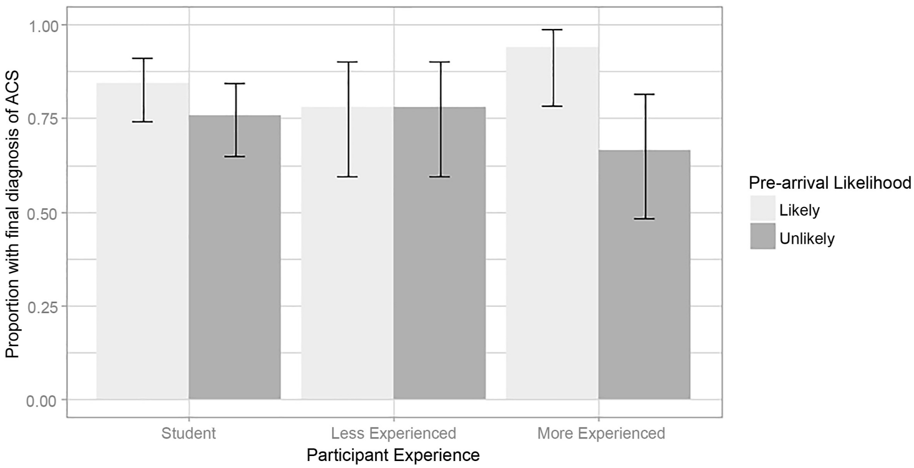


Figure 4. Proportion (95%CI) of participants with final diagnosis of ACS by pre-arrival likelihood and experience

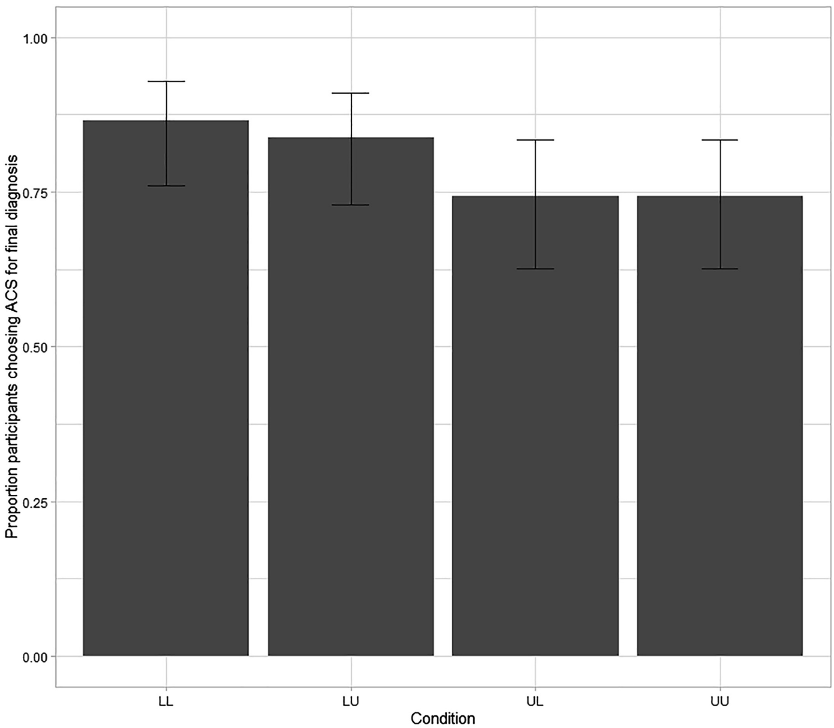
R3: What is the effect of congruent and incongruent information on final diagnosis?
Despite pre-arrival likelihood being associated with final diagnosis, there was no effect of the congruency manipulation. Congruent and incongruent combinations of pre- and post-arrival likelihood behaved in the same way due to the similarity in responses to the two post-arrival conditions (see Table 8 and Figure 5). Adding congruency to models had no effect and did not improve the fit of the models presented here.

Discussion

This study exposed paramedics and paramedic students to a brief snapshot of information about the patient to induce an impression, followed by detailed information to elicit a final diagnosis, similar to how many paramedics receive information in real life. Previous observational studies have argued that the initial impression formed by the paramedic

Table 8. Proportion (95%CI) of participants choosing final diagnosis of ACS by condition and congruency

Unlikely–unlikely (UU)	0.74 (0.63, 0.83)
Unlikely–likely (UL)	0.74 (0.63, 0.83)
Likely–unlikely (LU)	0.84 (0.73, 0.91)
Likely–likely (LL)	0.86 (0.76, 0.93)
Congruent conditions (UU, LL)	0.80 (0.73, 0.86)
Incongruent conditions (UL, LU)	0.79 (0.71, 0.85)



Note(s): LL: Likely-Likely; LU: Likely-Unlikely; UL: Unlikely-Likely; UU: Unlikely-Unlikely

Figure 5. Proportion (95%CI) of participants with final diagnosis of ACS by experimental condition

subsequently biased their final diagnosis (Alexander, 2010; O'Hara *et al.*, 2015). This was the first experimental study to consider this phenomenon.

We have experimentally shown pre-arrival information can potentially mislead paramedics. Across all participants, final diagnosis of ACS dropped from 85% when exposed to Likely pre-arrival information to 74% in the Unlikely pre-arrival condition. This effect was most pronounced in paramedics with greater than 14 years' experience where diagnosis of ACS dropped from 94% to 67%, depending on the pre-arrival information seen.

This study was designed around an implicit assumption that the post-arrival information is superior to pre-arrival information and, therefore, a greater determinant of a correct final diagnosis. However, each vignette here combines pre- and post-arrival information in a way that makes this assumption implicit, rather than explicit. The experimental design attempted to make this explicit by instructing participants to make their final diagnosis based on the post-arrival information. There was no manipulation check to confirm this occurred but the results suggest that the pre-arrival information had a greater influence on diagnosis than the post-arrival information. If the assumption holds, then we could conclude that an error has occurred when the paramedic's final diagnosis is influenced by the pre-arrival information to a greater extent than the post-arrival information.

There is limited literature on accuracy of pre-arrival information in the real world and the influence of this on diagnosis. Swedish studies have suggested that accuracy of dispatch information may vary from 17% to 30% in patients with ACS, indicating that incongruent information is something paramedics regularly encounter (Gellerstedt *et al.*, 2016; Rawshani *et al.*, 2014). Brandler *et al.* (2015) studied New York paramedics' accuracy for diagnosis of stroke. They found certain pre-arrival information was associated with increased false-positive diagnosis, while other information was associated with decreased missed diagnosis (Brandler *et al.*, 2015). There is a need for further research on dispatch accuracy, but what literature there is suggests that paramedics should discount pre-arrival information in forming their diagnosis.

In our study, under-diagnosis based on likelihood of ACS increased from 15% to 25% depending on which pre-arrival information was seen. Alexander (2010) opined that ACS is a salient diagnosis that paramedics do not want to miss. If the presentation is ambiguous then paramedics may revert to the risk-averse choice (that is, ACS). However, this did not occur here, which suggests participants are comfortable not diagnosing ACS with some ambiguity (at least, under experimental conditions). Furthermore, diagnosis of ACS decreased significantly when the participant was exposed to Unlikely pre-arrival information. Thus, any risk aversion was modified by the pre-arrival information.

Likelihood represents the best objective estimate of the relationship between the symptoms and the disease. In our study, post-arrival likelihood was not associated with the final diagnosis. Similar results have been found for medical practitioners. De Alencastro *et al.* (2020) conducted a study on General Practitioners (GP) in the USA and Switzerland in which the participants completed clinical vignettes for appendicitis and pharyngitis. The vignettes were designed based on the objective likelihood of the disease using a very similar process to that used here. The purpose of that study was to compare GPs' subjective probability of disease to the actual probability. They found only a minority of GPs correctly estimated the probability of disease (29% correctly assessed appendicitis, 39% for pharyngitis). The authors concluded that GPs use more than the probability of disease to make diagnostic decisions. They argued that the objective numbers are less important than the meaningfulness of the decision, but were unable to determine what additional factors might influence that meaningfulness. Interestingly, they found treatment decisions more closely aligned to likelihood (74% for appendicitis, 66% for pharyngitis). This suggests diagnosis may differ according to whether the participant is asked to "label" a disease (as in our study) or to initiate a treatment, which implies a diagnosis even if not explicitly labelled. Future paramedic research should consider this distinction.

Results from our study also show there are factors other than likelihood associated with paramedic decisions. Answer fluency and confidence were associated with the impression, while the impression and confidence were associated with the final diagnosis. Furthermore, answer fluency and confidence were highly correlated, lending some support for metacognitive theory (Thompson *et al.*, 2011). Thompson *et al.* proposed that there is a metacognitive process that generates a "feeling of rightness" about the accuracy of the Type 1 output. Previous research has shown that answer fluency predicts "feeling of rightness" judgements which predicted the degree of Type 2 processing. A strong feeling of rightness inhibited type 2 processing on two-stage reasoning problems but this has not been studied with clinical problems until now.

Confidence can be considered an alternate representation of feeling of rightness. According to metacognitive theory, increasing confidence in the impression should decrease activation of deliberate processes. If so, pre-arrival confidence should predict final diagnosis, which did not occur here. This may reflect the lack of difference between the two post-arrival vignettes. A limitation of this study is the narrow range in which participants responded to the item about confidence. It is possible that the measure was not sensitive enough to detect a relationship.

Self-reported confidence was associated with the impression and the impression was associated with the final diagnosis along with self-reported confidence. Previous experimental studies have shown poor calibration between confidence and diagnostic accuracy in doctors (Berner and Graber, 2008; Meyer *et al.*, 2013). We have now shown a similar effect in paramedics. Interestingly, while confidence in the final diagnosis predicted that decision, confidence in the impression did not, even though the impression clearly had an effect on final diagnosis. This is an area for further study.

Students showed accuracy comparable to the most experienced paramedics, and those paramedics showed greater influence of pre-arrival information than students and their less experienced colleagues. Common dual-process theories argue that gaining experience leads to greater reliance on type 1 processes (Corbin *et al.*, 2015; Hafenbrädl *et al.*, 2016), which may explain the greater influence of pre-arrival information on the most experienced paramedics. However, relying on type 1 processes can lead to increased errors (Kahneman, 2011). This is an active area of research across medicine and psychology (De Neys and Pennycook, 2019; Purcell *et al.*, 2020; Stanovich, 2018) in an effort to understand how such errors occur and how to remedy them.

Limitations

Experimental design forces compromises that limit interpretation of the results. Intuition is not usually made explicit in real life, so forcing an intuitive choice experimentally may alter it. Similarly, using a forced response may not reflect how information is used in real life. Future studies could replicate this one without the explicit forcing of intuition to consider if the effect on the subsequent diagnosis is based on making the impression explicit.

One limitation with written vignettes is that all the information is provided to the clinician, whereas in real life, the clinician has to search for that information, a process that may be hindered or otherwise affected by the initial impression. This study could not consider how the impression might affect how paramedics gather diagnostic information. Similarly, this study only tested two pre-arrival vignettes and two post-arrival vignettes. In our study the estimated likelihood was based on the observed likelihood ratios for the individual cues. We have estimated the LR+ for the vignettes as being representative of the individual cues. However, when combined together in a vignette, the true likelihood of the combination of cues is unknown and may have the effect of reducing the differences between the two vignettes. The method used here could be used to design differently worded vignettes, with similar likelihood to replicate this study and explore these limitations.

Another limitation is the narrow range in which participants responded to the item about confidence. It is possible that the measure was not sensitive enough to detect a relationship. Further research is needed to consider this but in the meantime, it may be a useful recommendation to paramedics to discount their feeling of confidence in their impression when making a diagnosis. Finally, this research was conducted with Australian paramedics from one employer and students from one university. This will limit the generality of results.

Conclusion

We have replicated the observations of earlier qualitative studies (Alexander, 2010; O'Hara *et al.*, 2015; Perona *et al.*, 2019; Reay *et al.*, 2018) by showing that pre-arrival dispatch information affects final diagnosis, the first time this has been shown experimentally. When assessed against likelihood, participants were highly accurate in their impressions, despite the lack of information and other pressures. However, accuracy decreased when provided with detailed clinical information under no time pressure where both over- and under-diagnosis occurred. Paramedics routinely receive pre-arrival information in their normal practice. The results here suggest potential vulnerability to error as a result. Further research and a better understanding of their decision-making and diagnostic processes are crucial for patient safety and quality.

List of abbreviation

ACS Acute Coronary Syndrome

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