*“Problems in diagnosis have...been heavily dominated by physicians with little input from the cognitive sciences. What is missing...is foundational work aimed at understanding how clinicians in actual situations take a complex, tangled stream of phenomena...to create an understanding of them as a problem.” (Wears, 20141)*

Diagnosis is a core task for doctors and *accurate* diagnosis is crucial for safe and effective patient care. It is also an important area of study from a psychological perspective as it allows for an extension of previous research on decision making to a real-world setting with obvious translational implications. Learning about how clinicians make highly impactful decisions (as a case study) can teach us about how we, as humans, make decisions in our everyday life. Finally, past work on medical diagnosis has been based on assessing the prevalence of errors. A report from the US Institute of Medicine concluded that most patients will experience a diagnostic error within their lifetime2. Bhise et al.3 found that up to 55% of patients experienced diagnostic error. An Australian study found that 20% of adverse events were due to delayed diagnosis4. Around 32% of clinical errors have been found to be caused by the clinician’s failure to weigh up competing diagnoses5. The scale of the diagnostic error is then substantial and results in differences to treatment of patients: diagnostic errors have been found to lead to longer hospital stays and even increased patient mortality6. There has been limited work, however, looking into the causes of diagnostic errors from a cognitive psychology perspective.

My PhD in Experimental Psychology at the University of Oxford (co-supervised by Professor Nick Yeung and Professor Helen Higham) aimed to improve our understanding of the cognitive mechanisms of diagnoses. I especially studied the relationship between confidence and information seeking during diagnoses, as overconfidence has been found to be associated with inadequate patient management and lower clinical effort7. Hence, my empirical work aimed to understand how the process of seeking information during diagnostic decisions influences the confidence that participants (who in my studies were final year medical students) had in their diagnosis. I used a mixture of textual patient vignettes and virtual reality in my experiments. Medical students were able to freely seek patient information (e.g. tests, physical examinations) before recording their suspected diagnoses and the confidence they have in their diagnoses. I found that the amount of information seeking (i.e. physical examinations, testing) was associated with increases in confidence, even if some information was not supportive of their decision. This association was also found in the opposite direction, such that higher initial confidence then resulted in more tests being requested for patients. Diagnostic accuracy, however, was associated with selectivity in information seeking. In a study where participants verbalised their thought process out loud as they were making diagnoses, I found that participants used different reasoning strategies for generating diagnostic hypotheses and then seeking information to support or rule out these hypotheses. My work was also grounded within in-situ observations in A&E and Intensive Care to ensure its applicability to real medical contexts.

Taken together, my work expands our foundational understanding of the cognitive mechanisms underpinning diagnoses, as well as informing avenues for improving medical education. Design of educational and cognitive interventions should focus on prompting appropriate information seeking, as well as prompting uses of different reasoning strategies based on the properties of the patient case (such as how much diagnostic uncertainty there is associated with the patient). Whilst this work has revealed interesting results, there is still follow-up work to be done to elucidate how interventions can prompt accurate diagnostic decisions with appropriate levels of confidence. In addition, there is still limited understanding of how clinicians deal with uncertainty in their clinical practice. Uncertainty, and tolerance of uncertainty/ambiguity, is considered a key part of medical practice and education but is also a source of stress for medical students and clinicians8. This necessitates the study of uncertainty during medical decisions to understand how it can be mitigated or supported appropriately. This follow-up work is what I intend to pursue during my research fellowship.

The themes of my planned research are as follows:

**Theme 1 - Normative Diagnostic Strategies:** whilst my work has uncovered differences in how medical students approach diagnoses (despite being educated at the same university), it does not delve into how doctors (especially those who are more experienced) approach medical decisions broadly. This strand will aim at understand how clinicians think they should make decisions from a normative perspective. To understand this, I will develop a survey to distribute to clinicians, whilst also collecting information about their experience and speciality (e.g. surgery, emergency medicine, pathology). This survey will ask clinicians whether they use more structured/analytical decision strategies in their practice or rely primarily on intuition, primary types of decisions they face during their practice (e.g. diagnosis, admitting/discharging patients, administering medication etc.) and how they tend to mitigate uncertainty during their practice. The survey’s outputs will guide the subsequent research, particularly around emulating decisions that are both frequently encountered by clinicians in their practice and frequently result in situations of uncertainty. The survey results will also be used to look at differences between medical specialities, which will be used to focus subsequent on a specific speciality and its context.

**Theme 2 – Exposure to Ambiguity:** this strand will use experimental methods that build on the paradigm I developed during my PhD to investigate how the diagnostic decisional process develops with more information. Specifically, I will build on this paradigm by considering an aspect of real medical decisions (and indeed, other non-medical decisions): ambiguity. Information, such as test results may sometimes be neutral (and could be interpreted in multiple ways) or inconclusive. How do clinicians proceed with their decisions in the face of ambiguity? Do they ask for help from seniors or colleagues early on? Past work has shown that less experienced clinicians are more prone to interpreting ambiguous information as supportive of their decisions9. My hypothesis are that clinicians who see more ambiguous information reduce their confidence and seek more information as a result, but that more accurate clinicians will seek help early on in the diagnostic process.

**Theme 3 – Timing Prompts of Uncertainty:** this strand will build on previous work10,11 looking at the optimal time during a diagnostic decision to ‘prompt’ uncertainty. When is the best time for clinicians to reconsider their diagnosis during a patient case? If prompted at the wrong time, clinicians may either ignore important information (if prompted too late) or proceed down an erroneous line of thinking (if prompted too early). These prompts will take the form of a cognitive intervention taken from existing literature: guided reflection to consider of alternative diagnoses12 (such that participants are asked if they think they missed any possibilities). Participants will either be instructed to do this throughout at the start of the task, will be prompted early on during a decision or prompted later on. We will also look at the effects of framing the cognitive intervention/prompt as advice coming from a Large Language Model (LLM, e.g. ChatGPT), which is important to study given AI’s ever-growing usage within healthcare. My hypothesis is that clinicians with higher confidence will be less susceptible to prompts of uncertainty when provided later.

During my PhD, I have developed research collaborations in Oxford with medical professionals who can assist with ensuring the ecological validity of my experimental designs. I also intend to work with a wide range of collaborators in my network who can assist with the practical aspects of my research, including design of experiment materials, participant recruitment and engagement of stakeholders within the medical community, all of which I gained experience with during my PhD and will help greatly with delivering this research. Where possible, I will make use of existing materials (e.g. sample patient cases for experiments) and clinician recruitment opportunities (e.g. conferences, training sessions, workshops).

I believe this work can be incredibly valuable for guiding future medical education and clinical practice. There is a lot that the methods and theories from cognitive psychology can offer to multi-disciplinary research, especially in an important context such as medicine. This research could be extremely useful for informing medical/diagnostic uncertainty as a ‘soft skill’ that can be developed and prompted appropriately during medical decisions. My goal is to use this research to better understand when clinicians experience uncertainty, how this manifests when they ask for tests or for help and how uncertainty can be cultivated appropriately to reduce instances of error.

**References**

1. Wears RL. Diagnosing diagnosis. Annals of Emergency Medicine. 2014 Dec 1;64(6):586-7.
2. McGlynn EA, McDonald KM, Cassel CK. Measurement is essential for improving diagnosis and reducing diagnostic error: a report from the Institute of Medicine. Jama. 2015 Dec 15;314(23):2501-2.
3. Bhise V, Meyer AN, Singh H, Wei L, Russo E, Al-Mutairi A, Murphy DR. Errors in diagnosis of spinal epidural abscesses in the era of electronic health records. The American Journal of Medicine. 2017 Aug 1;130(8):975-81.
4. Wilson RM, Harrison BT, Gibberd RW, Hamilton JD. An analysis of the causes of adverse events from the Quality in Australian Health Care Study. Medical Journal of Australia. 1999 May;170(9):411-5.
5. Schiff GD, Hasan O, Kim S, Abrams R, Cosby K, Lambert BL, Elstein AS, Hasler S, Kabongo ML, Krosnjar N, Odwazny R. Diagnostic error in medicine: analysis of 583 physician-reported errors. Archives of internal medicine. 2009 Nov 9;169(20):1881-7. (Hautz et al., 2019)
6. Hautz WE, Kämmer JE, Hautz SC, Sauter TC, Zwaan L, Exadaktylos AK, Birrenbach T, Maier V, Müller M, Schauber SK. Diagnostic error increases mortality and length of hospital stay in patients presenting through the emergency room. Scandinavian journal of trauma, resuscitation and emergency medicine. 2019 Dec;27:1-2.
7. Kovacs RJ, Lagarde M, Cairns J. Overconfident health workers provide lower quality healthcare. Journal of Economic Psychology. 2020 Jan 1;76:102213.
8. Stephens GC, Rees CE, Lazarus MD. Exploring the impact of education on preclinical medical students’ tolerance of uncertainty: a qualitative longitudinal study. Advances in Health Sciences Education. 2021 Mar;26(1):53-77.
9. Kostopoulou O, Russo JE, Keenan G, Delaney BC, Douiri A. Information distortion in physicians’ diagnostic judgments. Medical Decision Making. 2012 Nov;32(6):831-9.
10. Sibbald M, Monteiro S, Sherbino J, LoGiudice A, Friedman C, Norman G. Should electronic differential diagnosis support be used early or late in the diagnostic process? A multicentre experimental study of Isabel. BMJ Quality & Safety. 2022 Jun 1;31(6):426-33.
11. Eva KW, Cunnington JP. The difficulty with experience: does practice increase susceptibility to premature closure?. Journal of Continuing Education in the Health Professions. 2006 Jun;26(3):192-8.
12. Hess BJ, Lipner RS, Thompson V, Holmboe ES, Graber ML. Blink or think: can further reflection improve initial diagnostic impressions?. Academic Medicine. 2015 Jan 1;90(1):112-8.