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Research Report

Clinical reasoning and hypothesis generation in expert clinical swallowing examinations

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Abstract

Background: A clinical swallow examination (CSE) provides integral information that informs the diagnostic decision-making process within dysphagia management. However, multiple studies have highlighted a high degree of reported variability within the CSE process. It has been hypothesized that such variability may be the result of the clinical reasoning process rather than poor practices.
Aims: To elucidate the nature of expert, speech–language therapists' (SLTs) clinical reasoning during an initial bedside assessment of patients referred for suspected dysphagia in the acute care environment.
Methods & Procedures: An exploratory 'observation of practice' qualitative methodology was used to achieve the aim. Four expert SLTs, from two clinical services, completed CSEs with 10 new referrals for suspected dysphagia. All assessments were video-recorded, and within 30 min of completing the CSE, a video-stimulated 'think aloud' semi-structured interview was conducted in which the SLT was prompted to articulate their clinical reasoning at each stage of the CSE. Three types of concept maps were generated based on this video and interview content: a descriptive concept map, a reasoning map and a hypothesis map. Patterns that consistently characterized the assessment process were identified, including the overall structure; types of reasoning (inductive versus deductive), facts (i.e., clinical information) drawn upon; and outcomes of the process (diagnosis and recommendations). Interview content was examined to identify types of expert reasoning strategies using during the CSE.
Outcomes & Results: SLTs' approach to clinical assessment followed a consistent structure, with data gathered pre-bedside, during the patient interview and direct assessment before a management recommendation was made. Within this structure, SLTs engaged in an iterative approach with inductive hypothesis-generating and deductive hypothesis-testing, with each decision-making pathway individually tailored and informed by patient-specific facts collected during the assessment. Clinical assessment was primarily geared towards management of an initial acute presentation with less focus on formulating a diagnostic statement.
Conclusions & Implications: Variability in reported dysphagia practice is likely the result of a patient-centred assessment process characterized by iterative cycles of fact-gathering in order to generate and test clinical hypotheses. This has implications for the development of novel assessment tools, as well as professional development and education of novice SLTs.

Keywords: clinical reasoning, inductive, deductive, hypothesis, dysphagia, acute.

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What this paper adds

What is already known on the subject

- CSE practices are reportedly variable, which has led to calls for more stringent, standardized assessment tools. Emerging evidence suggests that this variation is non-random, but may arise from clinical reasoning processes.

What this paper adds to existing knowledge

- We directly observed expert SLTs conducting CSEs and identified patterns in practice that were consistent across all CSEs evaluated. These patterns were consistent in structure, whereas the content of the assessment items varied and was tailored to individual patient presentation. Overall, expert SLTs engaged in balanced cycles of inductive hypothesis generation and deductive hypothesis-testing, a hallmark of good clinical assessment and practice.

What are the potential or actual clinical implications of this work?

- Ensuring quality CSE requires a more nuanced approach that considers the role of clinical reasoning in SLTs' decision-making and the potential unintended negative consequences of standardized assessment tools.

Introduction

Every day, patients in acute care are referred for dysphagia assessments, and they rely on their healthcare providers to exercise competent clinical reasoning as they make judgements about diagnosis and care. The multidisciplinary processes of care commonly include screening patients on admission, then referral for a clinical swallow examination (CSE). Following the CSE, decisions regarding referral for further diagnostic instrumental assessments are made where appropriate. Strengthening each step in the evaluation process will support cost-effective, high-quality care, as well as manage patient exposure to risk, hospital-acquired complications and discomfort. However, the high variability in the processes used (Bateman *et al.* 2007, Martino *et al.* 2004, Vogels *et al.* 2015) has led to concerns about the quality of the CSE. These concerns are further exacerbated by the consistent finding that there is a high degree of self-reported (Bateman *et al.* 2007, Martino *et al.* 2004, Vogels *et al.* 2015) and actual variability (McAllister *et al.* 2016) in the components assessed in the CSE by speech–language therapists (SLTs). Nevertheless, despite this variability, evidence suggests that SLTs' overall judgements are valid (Gonzalez-Fernandez *et al.* 2011) and involvement of SLTs in acute care environments improves the medical and health outcomes for people with swallowing difficulties (Marsh *et al.* 2010). This evidence suggests that SLTs use CSEs to inform decisions that contribute effectively to patient care, but the underlying processes are not well understood.

It has been hypothesized that both the effectiveness of CSEs and their variability are the result of a distinct clinical reasoning process rather than poor practice (Doeltgen *et al.* 2018, McAllister *et al.* 2016). If so, this variability should show a non-random pattern influenced by the clinical reasoning underpinning the assessment process (Martino *et al.* 2004, McAllister *et al.* 2016). Research on diagnostic reasoning in medicine has clearly illustrated that information from the clinical evaluation of a patient, as well as knowledge of conditions that enable the patient's condition, are integral to the diagnostic process (Hobus 1994). Yet, how it is obtained and used in the diagnostic decision-making process may be achieved in different ways and by using different reasoning approaches depending on multiple factors (Schmidt and Rikers 2007).

Novice SLTs, for example, commonly rely on frameworks of causal knowledge related to medical conditions that they use to explain the causes and consequences of disease. During this process, they use knowledge about underlying biological or pathophysiological processes that they deem relevant to the clinical case. This may include standardized processes to gather data that might be relevant, construction of hypothesis lists and deductive testing of each of these hypotheses. This cognitively demanding, resource-intensive approach to reasoning has been long considered the primary way in which clinical reasoning is conducted (referred to as 'Type 2' reasoning) (Croskerry 2003). However, research over the last two decades has identified that this is more characteristic of novice reasoning. Expert medical practitioners frequently engage in inductive forward reasoning, where a tentative diagnosis is made based on recognition of patterns of symptoms (referred to as 'Type 1' reasoning) that correspond to certain illness scripts (Schmidt and Rikers 2007). Clinical data are then gathered during the assessment process to deductively confirm or refute the initially selected small number of hypotheses (Schmidt and Rikers 2007). Experts revert to using Type 2 reasoning when the data gathered during the assessment do not effectively confirm or refute the hypotheses tested.

The variety of reasoning strategies employed in clinical practice may provide a plausible explanation for the degree of variability that has been consistently reported regarding CSE practices (Doeltgen *et al.* 2018, McAllister *et al.* 2016). While the skills and knowledge required to conduct a CSE are well described (Speech Pathology Australia 2012), the way in which these are combined and applied to inform judgements regarding diagnosis and management are not. Furthermore, the way in which broader clinical reasoning processes are involved to use data gathered during a CSE in acute care to formulate, implement and monitor management plans has not been evaluated.

Characterizing and understanding the nature and range of clinical reasoning processes employed during a CSE will support improved education for clinical decision-making through this assessment process, and thereby help enhance the quality of CSE practices (Croskerry 2009). This research used an exploratory 'observation of practice' qualitative methodology to directly examine expert SLTs' clinical reasoning during the CSE process. The aim was to elucidate the nature of expert SLTs' clinical reasoning during an initial bedside assessment of patients referred for suspected dysphagia in the acute care environment.

Method

Ethics approval

This research was approved by Southern Adelaide Clinical Human Research Ethics Committee.

Participants and research setting

The study was conducted across two metropolitan acute care hospitals in Australia over a 9-month period. Three expert SLTs were recruited from hospital A, a 566-bed hospital, and one SLT was recruited from hospital B, a 240-bed hospital. An expert SLT for this study was defined as a SLT with 5 or more years of experience, or an estimated minimum of 2000 clinical assessments of patients with dysphagia in an acute care environment. All four SLTs provided informed consent. Written informed consent was also sought from the patients for their assessment session to be included in the research (or their caregiver if the patient was unable to give informed consent). Data were gathered on initial CSEs (i.e., new referrals for patients unknown to the SLT) with 10 unique patients with suspected dysphagia. No a priori sample size was set for this project. Rather, data collection continued until data saturation was evident (Kuper *et al.* 2008) and a range of patient presentations were captured. This criterion was met after the 10th assessment.

Data-collection protocol

Data collection took place in two phases. First, a video recording was made of the entire CSE assessment via an unattended digital camera on a tripod. SLTs were instructed to carry out the CSE as they would normally. The camera was positioned unobtrusively to record all actions and interactions between the SLT and the patient.

Second, a video-stimulated 'think aloud' semi-structured interview was conducted with the SLT within 30 min of completing the CSE. Think-aloud protocols provide a rich source of qualitative data for reflection on action (Burbach *et al.* 2015) and have been extensively used to investigate clinical reasoning processes in a range of health professions (Coderre *et al.* 2003, Durning *et al.* 2012, Eells *et al.* 2011, Khatami *et al.* 2012, Pottier *et al.* 2010). The SLT was prompted to articulate their clinical reasoning while viewing the video from the CSE. Interviews were conducted by a qualified SLT who was not expert in CSE. This positioned the interviewer as a 'novice' to whom the expert SLT was explaining their practice. All interviews were audio-recorded and transcribed verbatim. This interview process was piloted with three expert SLTs whose data were not included in the study to ensure that questions were clear and all potential aspects of the reasoning process were included (see appendix A for the interview protocol).

Analysis

Data analysis was conducted in two steps. Step 1 used the video and interview content to generate three types of concept maps for each CSE: a descriptive concept map, a reasoning map and a hypothesis map. This analysis step identified if there were patterns that consistently characterized the assessment process, including: the overall structure, the facts (i.e., clinical information) drawn upon, the types of reasoning (inductive versus deductive) and the outcomes of the process (diagnosis and recommendations). In Step 2, the interview content alone was then examined to identify the types of expert reasoning strategies using during the CSE.

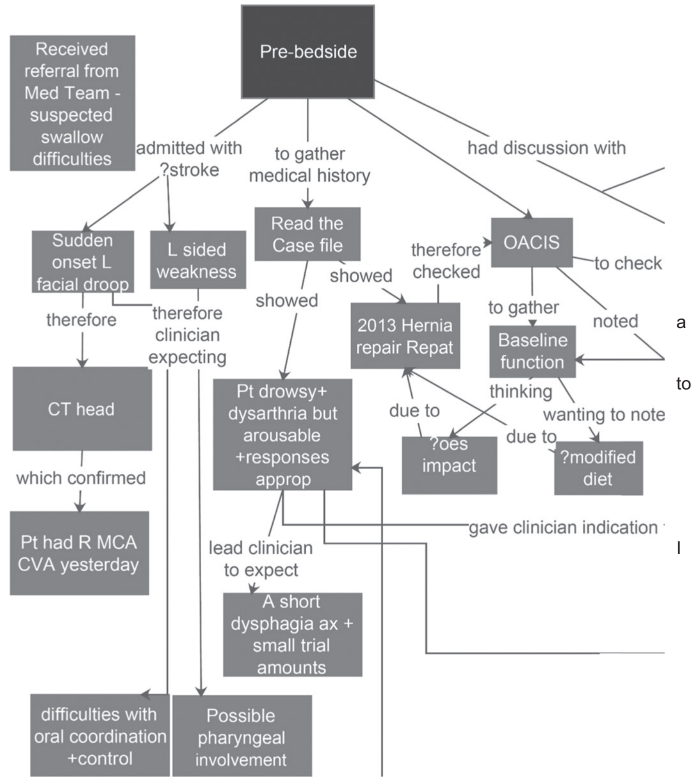
Step 1: Development of the descriptive, reasoning and hypothesis maps

Data from the interview recordings were first used to inform the development of a *descriptive concept map* (Torre *et al.* 2013) for each individual assessment. The SLTs'

Interviewee: 'I knew that he had a right CVA — right MCA CVA stroke yesterday, and that he had an acute onset of left side weakness, facial droop and slurred speech. [Came in] and CT had showed that. He then was thrombolysed yesterday and the report was that it hadn't had a great effect. He was also drowsy, from reports as well. […] so then I found out what was the cause of him coming in — what had happened. So I knew it was on the right side. He was presenting with left-sided weakness dysarthria. He was also drowsy, based on reports. Looking through his file I also found that he had a previous barium swallow back in 2013 at the hospital and a repaired hernia. So I then identified that I needed to investigate that bit further to determine if he had pre-existing oesophageal dysphagia. Was he on a modified diet — what was going on there — establish a better baseline.

Also, looking at the notes; because he had only just come in yesterday there wasn't a great deal other than the fact that he was drowsy. However, he was easily rousable to voice and responding to questions from nursing staff. […] Just based on what I had been told was expecting that my assessment would probably be quite short and limited, given what I'd been reported; he was quite drowsy and that it would be unlikely that he'd be starting on great amounts — was my initial thoughts based on just what I'd — the information I'd gathered.'

Facilitator: 'In terms of his presentation with swallowing, did you have ideas previously about that?'



Interviewee: 'Yeah, well just based on the fact that he had the left-sided facial weakness and droop, I was expecting that he — just given the fact I'd been told that he would have some difficulties probably with some oral coordination control, given the weakness there. So he might have trouble manipulating solid foods or thin fluids with reduced control. So I was expecting a definite element of oral dysphagia giving the left facial droop had been reported, and probably also some elements of pharyngeal as well, given what I'd gathered.'

Figure 1. Representative excerpt of a descriptive concept map (participant 4, patient 4) describing how the transcribed recording of the interview with the clinician was translated into a descriptive concept map. All relevant clinical information was captured as either nodes (grey text highlights) or descriptors attached to the unidirectional arrows connecting nodes (underlined text highlights), which stated the relevance of these details to the reasoning process. See Supplemental File 1 in the additional supporting information for the complete descriptive concept map of this clinician–patient dyad.

description of the assessment process and their thinking was often non-linear and included backtracking to add additional information to a previous statement. The descriptive concept map enabled these data to be organized more coherently as well as visually representing all aspects and interrelationships between data in the SLT's descriptions of the assessment process and thinking during their interview. These concept maps subsequently made it possible to analyse the reasoning processes. The results of this analysis were then represented on reasoning and hypothesis maps for each case, as outlined below.

Descriptive concept maps were developed using standard concept mapping strategies (e.g., Novak 1990) where each node described the key information collected and the actions taken during the CSE and directional arrows with descriptive phrases linked the nodes to represent the SLT's articulated clinical reasoning. An example of this process is outlined in figure 1 for one representative SLT–patient dyad. The protocol for drawing the initial descriptive concept map was developed by two team members (C.M. and S.M.) before the study commencement through mapping pilot data (three interviews) until a consistent and replicable strategy was reached for visually representing the assessment process and the thinking articulated by the SLT.

Each descriptive concept map was developed by C.M. (interviewer) immediately after the interview. It was then provided to the SLT for inspection the next business day to confirm that it accurately reflected their clinical reasoning process. Any suggested changes were incorporated, and the concept map returned to the SLT for final confirmation.

The next phase of analysis synthesized information from the initial descriptive concept map and the transcript of the interview in order to create a *reasoning map* for each CSE conducted. A reasoning map depicts a detailed representation of only those aspects that relate

Table 1. Coding template used to generate the reasoning map

Code	Definition
Reasoning	
Inductive reasoning	Lines linking fact(s) to an inductively generated hypothesis
Deductive reasoning	Lines linking fact(s) to test a hypothesis deductively
Facts	
Referral	Information included in the referral process, including the referral note and information from other professionals
Medical history	Derived from case notes
Patient report	Generated by interviewing the patient
SLT clinical assessment	Generated by the CSE
Outcomes	
Recommendations	Recommended actions by the SLT
Diagnosis	SLT's diagnostic statement

specifically to the clinical reasoning processes employed during the CSE. The development of the analysis protocol for the reasoning map was informed by the coding method used by Pottier *et al.* (2010) and Crespo *et al.* (2004) in their analyses of clinical reasoning by medical students and practitioners. The reasoning maps were developed by attending only to the facts that SLTs explicitly articulated as leading to, or used to test, a hypothesis in the transcript and descriptive concept map data. This enabled the identification and mapping of inductive and deductive reasoning during clinical assessment and the types of facts used to develop or test hypotheses. All research team members participated in the development of the process to code reasoning and facts to generate a reasoning map. Initially, five descriptive maps were independently coded by a primary coder (C.M.) and at least two other team members to ensure consistent reproducibility of analysis. See table 1 for the codes and definitions used in this stage of analysis and figure 2 for examples of how the data captured in the descriptive reasoning map and transcripts were translated into the reasoning map. Once the consistent analysis strategy was established, the primary coder then analysed the final five descriptive maps using these codes and definitions.

Finally, a *hypothesis map* was derived from each reasoning map. This step in the analysis created a hypothesis map for each CSE by extracting only the inductively generated and deductively tested hypotheses represented on the reasoning map and the links between them (figure 3).[1] The hypothesis maps showed which hypotheses were formed and tested over the assessment process and how they informed the outcomes of the CSE. For example, the SLT hypothesized that the patient would present with difficulty with oral bolus manipulation as well as pharyngeal phase dysphagia (figure 3). This led to the hypothesis that the patient would be unlikely to manage much oral intake, which was confirmed by the oral trials and led to the management recommendation of small amounts of mildly thick fluids via cup only when alert (see Supplemental File 2 in the additional supporting information). As displayed in the last node of the hypothesis map (see Supplemental File 3 in the additional supporting information), the SLT hypothesized that even with this recommendation the patient was unlikely to have much oral intake unless he became more alert. Each hypothesis map was generated by C.M. and discussed with and confirmed by S.M. Inter-coder reliability was evaluated by calculating percentage of agreement between mapped items.

Analysis of concept maps

Each of the three concept maps generated for each SLT–patient dyad ($N = 10$) was then descriptively analysed as follows. The descriptive maps were analysed to evaluate the overall structure of each assessment as well as the types of facts generated during the assessment process. The reasoning maps were analysed to draw out the types of reasoning that were employed by the SLT. These were coded as inductive (i.e., hypothesis generating) or deductive reasoning (i.e., hypothesis testing) and linked with the types of facts specifically used in the reasoning process. Finally, the hypotheses maps were analysed to evaluate what types of hypotheses were generated and tested, and what types of decisions were made in the assessment process.

Step 2. Transcript review

Once the interview data had been used to develop the different reasoning maps, the transcribed interviews were then separately reviewed by three team members (S.K., S.M. and S.D.) to identify examples of how SLTs described aspects of their reasoning process to the interviewer and for evidence of general categories of types of hypotheses generated and reasoning strategies used. S.K. reviewed each transcript first; the identified instances were subsequently reviewed by S.M. and S.D. and consensus reached. These examples and categorization of SLTs' reasoning processes are presented side by side with the concept map data in the results section, rather than sequentially, in order to elucidate the observed patterns of clinical practice described in the reasoning and hypothesis maps.

Results

SLT and patient characteristics

Two expert SLTs completed three CSE assessments and two completed two CSE assessments each.

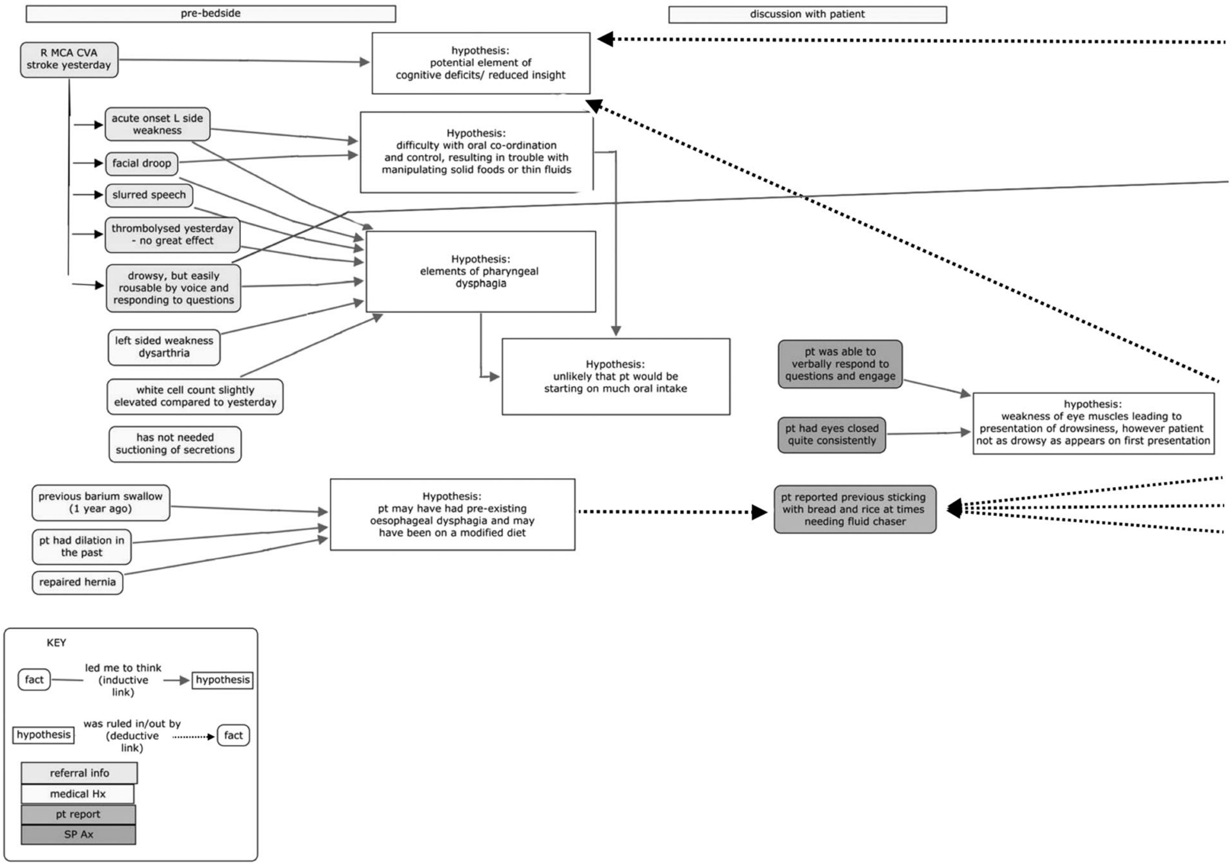


Figure 2. Representative excerpt of a reasoning map (participant 4, patient 4) describing how the corresponding descriptive concept map (Box 1) was translated into a map that described only the reasoning processes (inductive versus deductive) and the key information used in the reasoning process. Inductive ('led me to think') reasoning is represented as solid arrows, whereas deductive reasoning ('was ruled in/out by . . . ') is represented by dotted arrows. Types of facts used in this process were colour-coded as to their origin, including referral information medical history patient report and SLT assessment. For example, a full inductive—deductive reasoning cycle is depicted at the bottom of the figure, where the referral information led the clinician to think (inductive, solid arrow) that 'the patient may have pre-existing oesophageal dysphagia and may have been on a modified diet' (hypothesis derived from medical history), which was confirmed by the patient reporting some 'sticking with bread and rice at times needing a fluid chaser'. See Supplemental File 2 in the additional supporting information for the full reasoning map for this clinician–patient dyad.

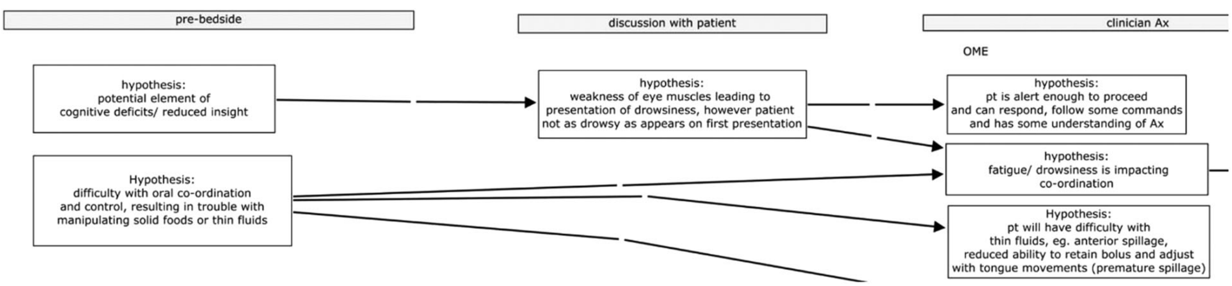


Figure 3. Representative excerpt of a hypothesis map (participant 4, patient 4) describing how the corresponding reasoning map (Box 2) was translated into a map that described only the hypotheses formed and tested during the reasoning process. See Supplemental File 3 in the additional supporting information for the full hypothesis map for this clinician–patient dyad.

Demographic data for the 10 patients, including presenting demographics and decisions made post-CSE, are reported in table 2 to the extent possible according to ethics approval restrictions. The cohort was 60% female, with the predominant referral conditions being 60% neurological conditions and 40% other conditions, including cardiac disease, diabetes or reflux disease. Severity of dysphagia was classified from normal to moderate based on the SLT diagnostic statement, with 70% classified as mild and 30% as moderate.

Table 2. Patient characteristics as reported by the SLTs

Case	Referral information and medical/social history	SLT's diagnostic statement
1	Female; new-onset left vocal fold palsy of unknown origin and coughing on oral intake	Moderate pharyngeal dysphagia with a suspected oesophageal component
2	Female; hospital-acquired pneumonia and diarrhoea on background cardiac disease and recent bereavement of husband, presenting with loss of appetite, difficulty chewing solids and swallowing tablets	Mild oropharyngeal dysphagia with compounding factors
3	Male; acute onset right cerebrovascular accident; left facial droop, dysarthria and elevated white cell count, history of oesophageal dilatation and hernia repair	Acute moderate oropharyngeal dysphagia
4	Male; pneumonia on background mild cognitive impairment, noninsulin-dependent diabetes mellitus and ex-smoker. Reports food sticking and poor nutrition	Mild oral dysphagia; moderate pharyngeal dysphagia
5	Female; new-onset cerebellar stroke on background previous stroke and long-standing gastro-oesophageal reflux disease. Presents with ataxic gait, mild dysarthria, dizziness	Chronic mild oral dysphagia
6	Male; new-onset left temporal lobe intracranial haemorrhage, drowsy, aphasic, tolerating fluids only	Mild to moderate oropharyngeal dysphagia
7	Male; bilateral haemorrhagic stroke, severe dysarthria, drowsy, visual neglect, reduced insight	Moderate oropharyngeal dysphagia
8	Female; new chest pain on background chronic pharyngo-oesophageal dysphagia and gastro-oesophageal reflux disease	Chronic mild to moderate pharyngeal phase dysphagia with an oesophageal component
9	Female; recent cognitive decline and coughing on oral intake on background reflux and previous transient ischaemic attack	Likely oesophageal dysphagia; normal oropharyngeal swallow with no signs of aspiration, able to tolerate normal ward diet consistencies
10	Female; hypercalcaemia and anaemia secondary to renal cell cancer, recently increasing dysphagia	Mild–moderate oral dysphagia; mild pharyngeal dysphagia and querying an oesophageal component

Concept mapping reliability

Coding agreement for the facts that SLTs clearly articulated as leading to or testing a hypothesis was high: between 94.7% and 100% agreement across the five reasoning maps co-coded by the primary coder (C.M.) and two team members. Reliability for coding of all 10 hypotheses maps was 100% (C.M. and S.M.).

Structure of the clinical swallowing examination process

The descriptive concept maps created across the 10 CSEs revealed that a consistent CSE structure was used by all four expert SLTs. The components of this structure included: (1) pre-assessment information gathering, (2) patient subjective interview, (3) incidental observation, (4) physical examination and (5) initial management planning. However, the specifics of the assessment process varied for each patient. The mapping identified multiple factors considered by the SLT to determine how the examination would be conducted. These included the patient's presentation, determined primarily by consequences of aetiology, and the patient's ability and/or willingness to participate in the examination process combined with the assessment items the SLT determined would most usefully contribute to understanding the patient's clinical picture. The overarching structure represented in all CSEs evaluated in this study served as a framework within which SLTs engaged in cycles of information gathering, clinical reasoning, decision-making and hypothesis generation and testing, as outlined in the following.

Types of facts gathered

The SLTs gathered facts before the CSE, including referral information, past medical history and information from medical team members (commonly nurses) about the patient's cognition and current medical status. The SLTs used the patient subjective interview to observe aspects of cognitive function (e.g., alertness, engagement in conversation) and physiological function. This included clarity of speech, voice quality and patient reports of difficulty eating and swallowing. The information gathered during these two phases of the assessment, in combination with incidental observations (e.g., untouched food items, observed facial droop), prompted the SLT to draw on illness scripts (Type 1 reasoning; see the next section) to inductively generate hypotheses that were subsequently tested in the physical examination phase of the assessment.

During the physical examination and related swallow trials SLTs gathered facts regarding the overall integrity of the head and neck anatomy as well as function related to swallowing. However, the selection of specific items assessed and facts gathered were highly dependent on the patient's presentation and the hypotheses inductively generated in the prior phases of the CSE. Consequently, the examination was not inclusive of all items typically listed in a structured CSE protocol.

Types of reasoning used during clinical swallowing examinations: Type 1 versus Type 2

A specific set of initial inductive hypotheses was identified in the reasoning maps (figure 2, and see Supplemental File 2 in the additional supporting information) developed based on pre-assessment information gathering. Qualitative review of the interviews found that non-analytical Type 1 reasoning was routinely being employed, for example, identifying patterns of dysphagia/illness scripts typically associated with the presenting aetiology.

> Pretty much from that [pre-assessment], I was able to determine the areas of the brain that had been involved. [. . .] So that information already told me it could be more severe, it could be increased chance of things like silent aspiration and things like that. [. . .] I was able to then predict what I might actually see on the assessment. (SLT 4, patient 7)

It was also apparent that the SLTs used analytical Type 2 reasoning during the pre-assessment and patient subjective interview phases to build an overall picture of cognition, communication and alertness to judge the patient's ability to actively cooperate in the CSE. This was used to determine the choice of assessment items and process.

> Just to get an idea of whether having oral intake will be appropriate to see if the level of alertness will be adequate for me try to oral trial. So that's the purpose of the first part of the interview. (SLT 1, patient 1)

The physical examination always included oral motor and cranial nerve examinations. The latter were routinely examined, regardless of the aetiology suggested by the pre-assessment information provided or patient presentation. However, where the ability or willingness of the patient to cooperate in the assessment process was reduced, the SLT would make considered judgements to maintain patient cooperation and prioritize assessment items to maximize information gathering for decision-making:

> I'm not getting anywhere—I need to get this sorted—let's just use some oral trials. Obviously, first of all I did—basic OME. I try and do a bit from everywhere—a bit from each cranial [nerve] as much as possible. There are some bits that I missed out or I left out because she was sort of like, what's the point of this? (SLT 3, patient 3)

Review of the interview transcripts also revealed that SLTs drew on the current evidence base, which is not always represented in standardized dysphagia assessment protocols:

> It [gag reflex] doesn't tell us anything. It's more about whether it's unilateral or not, but he did have palatal elevation to 'aaah'. So there was movement there—nothing that looked asymmetrical [. . .]. (SLT 4, patient 3)

> if [they] do aspirate that, we know that Free Water Protocol, the pH levels, it's not harmful. [. . .] Then that's sort of me pushing to see if she's got a cough reflex as well [. . .]. (SLT 4, patient 5)

Food and/or fluid trials were only trialled once the SLT had made a judgement that the patient was likely to be safe with regard to cognition, alertness, motor function and coordination. Usually, several of these factors were considered in combination. The SLTs drew on a wide range of information gathered across all phases of the examination to make this decision.

> she seems like she does have good range of movement—it's probably slow and maybe a little bit weak, but it's a generalised weakness. [. . .] More of the picture of de-conditioning. Nursing staff had reported she was tolerating thin fluids well. So that's why I went for thin fluids first. A bit dry in her mouth so I thought, try fluids first before I try solids [. . .]. (SLT 3, patient 2)

Types of reasoning used during clinical swallowing examinations: inductive versus deductive

Analysis of the coding of the reasoning maps demonstrated that for all assessments, the expert SLTs used a balance of inductive and deductive reasoning, with a mean of 23.3 (SD = 7.5) inductive links connecting facts and mean of 27.4 (SD = 10.1) for deductive links. This represents cycles of inductive (Type 1) and deductive (Type 2) reasoning throughout the assessment, where hypotheses are developed, ruled in or out, and new hypotheses generated until a conclusion was reached and recommendations could be made.

Inductive reasoning is more apparent in the reasoning maps during the phases of pre-assessment information gathering and patient interview/observation. As noted above, the SLTs consistently entered the patient's room with a set of hypotheses inductively developed through their pre-assessment data gathering, guided by pattern recognition (Type 1). The number of initial hypotheses was most commonly two or three (six cases), with four (one case), five (two cases) and seven (one case) generated for more complex patients. Further

Table 3. Hypothesis themes identified in the hypothesis maps

Hypothesis category	*n*	%
Pulmonary: history or risk of aspiration and penetration, any respiratory problems or infections	23	16.9
Neurological: any deficits relating to sensory function, communication, cognition	43	31.7
Oral: oral phase, hygiene	21	15.4
Structural/anatomical abnormalities	3	2.2
Pharyngeal: obstruction, motility, residue	12	8.8
Oesophageal: stasis, sensation of food stuck	8	5.9
Strategies: behavioural, diet modification	24	17.6
Pre-existing swallowing problems	2	1.5
Total	136	100

hypotheses were inductively generated during the patient interview and observation. For example, SLT 4 noted during her conversation that patient 3 had a left-sided facial weakness and droop, which led to an additional two hypotheses: the patient would have difficulty manipulating solid foods and thickened fluids due to poor oral coordination; and that it was likely that there would be elements of pharyngeal dysphagia.

Development and testing of the hypotheses

The four expert SLTs generated a total of 136 hypotheses across the 10 patient cases (see figure 3 for an illustrative hypothesis map; for a full-size version, see Supplemental File 3 in the additional supporting information). Eight categories of hypotheses were apparent in the data (table 3), the most common being related to neurological/sensory impairment (31.7%), safe strategies/diet (17.6%) and impact or risk of respiratory complications/infection (16.9%). These hypotheses were directed to determining two types of decisions: diagnosis and management. Hypotheses were generated and tested in parallel rather than sequentially. Clinical diagnostic hypotheses were informed by data on oral motor function, direct swallow observation, palpation and patient self-report regarding the swallow phase affected. Management hypotheses were informed by identification of co-morbidities that will influence nutritional risk and dietary intervention, and assessment of the patient's ability to self-manage symptoms or participate in behavioural interventions.

Transcript review identified that hypotheses were inductively generated throughout the assessment through a process of pattern recognition and subsequently deductively tested. It was apparent that the SLTs categorized data gathering into six primary groupings to inform decisions to rule hypotheses in or out:

- Phase of swallow: does impairment occur in the oral, pharyngeal or oesophageal phase of swallowing?
- Stability of the physiological system: is the current presentation acute/unstable or chronic/stable?
- Aetiology: is the underlying aetiology of neurological or non-neurological origin?
- Aspiration: is aspiration likely or unlikely to occur?
- Responsiveness to instruction: is the patient responsive or not responsive to instructions?
- Current diet: is the current diet normal or modified?

Types of decisions made

The types of decisions made on completion of the initial assessment were primarily focused on immediate safety to eat and drink, with specific recommendations to manage the dysphagia in the short or long term depending on the patient's presentation. Recommendations were also made for further data gathering, although instrumental assessments were only recommended on two occasions. Recommendations for clinical reassessment were made for seven of the 10 cases.

Diagnostic statements had to be either prompted or sometimes in later interviews were provided as an afterthought for all 10 cases. These statements generally described the phase of swallowing during which the dysfunction that was contributing to the dysphagia occurred and severity, for example, mild oropharyngeal dysphagia.

Discussion

This study provides empirical data that shed light on the nature of expert SLT's clinical reasoning during the first CSE conducted with a patient admitted to an acute care hospital and referred for suspected dysphagia. The analysis across 10 unique initial CSEs clearly demonstrates that expert SLTs engage in a decision-making process that results in a unique patient-focused assessment process with a strong focus on management. This process has a consistent structure, yet is tailored to the specific presentation of each patient in terms of the range and types of assessment data gathered and hypotheses generated and tested. Both Type 1 and Type 2 reasoning are used, with Type 1 reasoning driving the steps taken in the assessment process. It thus demonstrates elements that would be expected of a high-quality clinical reasoning process used by expert clinicians (Schmidt and Rikers 2007).

Reasoning process

The overarching process of the CSE was similar across all 10 assessments. The SLT always commenced the CSE with patient-specific data collection from the referral note, medical files and treating medical team, particularly nurses. This process informed the inductive generation of hypotheses that aligned with a recognized pattern of signs associated with a particular dysphagia presentation. Therefore, the expert SLT entered the patient's room with a set of hypotheses that were then revised with reference to the specific patient presentation observed during the subjective patient interview. These inductively generated hypotheses were then deductively tested during the physical examination by gathering assessment data to confirm or reject each hypothesis as well as inform the generation of alternative hypotheses (Croskerry 2009). It was noted that the physical examination always included oral motor and cranial nerve examinations, regardless of the apparent aetiology or patient presentation, suggesting that these are core items for all CSEs. This suggests that expert SLTs are engaging in a heuristic to manage the potential patient harm that might arise through assuming there is no contributing neurological condition (Croskerry 2009).

The similarity in the use of this heuristic as well as the overarching structure may in part be due to the fact that all participating clinicians worked in hospitals that are governed by the same local health network and received similar professional development. However, in each case the clinician engaged in patient-specific reasoning that balanced the benefits of non-analytical, intuitive Type 1 reasoning (less cognitive effort, efficient and rapid pattern-based hypothesis generation) with the benefits of analytical, data-based Type 2 reasoning (objective, data-driven hypothesis testing). This combination of Type 1 and 2 reasoning matches expert practices that underpin efficient, high-quality patient clinical assessments in other health professions (Schmidt and Rikers 2007).

The finding that the facts required for inductive hypothesis generation and subsequent deductive hypothesis-testing were all specifically driven by the individual patient presentation explains why much of the previous research in this area has consistently documented great variability in the specific assessment items used during CSE. Previous research methodologies (self-report and review of assessment forms) did not provide information on the patient-specific and situational contexts or the level of clinical expertise of the SLT, both of which influence clinical reasoning and therefore selection of assessment items (Schmidt and Rikers 2007). Indeed, SLTs elaborated in interviews that differing clinical presentations would lead them to include or omit assessment items, supporting the notion that CSE and management are not homogenous, linear processes (Vogels *et al.* 2015).

In a previous study (McAllister *et al.* 2016), we hypothesized that observed variation in adherence to an assessment protocol might be influenced by the clinical reasoning process. The findings of the current study clearly demonstrate that expert SLTs do not strictly adhere to assessing a prescribed or standardized set of assessment items; rather, they engage in clinical reasoning processes to determine which components to assess during a CSE. Cycles of inductive and deductive reasoning are central to accurate diagnostic reasoning by experts (Coderre *et al.* 2003, Norman *et al.* 2007), and the process of refining hypotheses to inform precise diagnoses and recommendation decisions is characteristic of these processes (Crespo *et al.* 2004, Forsberg *et al.* 2013, Khatami *et al.* 2012). Seminal research on expert medical practitioners found that they can only achieve diagnostic accuracy that is superior to novice doctors when information about the broader patient presentation is provided (Hobus 1994). On this basis, we suggest that requiring SLTs to implement standardized CSE protocols alone may not sufficiently support quality assessment and patient outcomes as intended, at least not for more experienced SLTs.

A quality CSE process is not likely to be supported by requiring the SLT to adhere solely to a novice level Type 2 reasoning process where facts are generated by working through a standardized assessment protocol. Quality may be better supported through assisting SLTs at all levels of clinical experience to develop a strong meta-cognitive understanding of the advantages and disadvantages of each type of reasoning and when to apply them as they draw on their knowledge and skill base (Doeltgen *et al.* 2019). Advanced meta-cognitive awareness of one's own approach to reasoning is likely to support novice SLTs to more rapidly develop advanced reasoning skills and enhanced accuracy.

Furthermore, this meta-cognitive awareness will enable expert SLTs to be cognisant of the biases inherent in the unchecked use of Type 1 reasoning. Balancing the use of efficient Type 1 reasoning with analytical Type 2 reasoning allows SLTs to undertake a CSE process that is patient centred, as well as meet current increasing demands for rapid access to timely assessment and management that minimizes potential for patient harm. This will assist SLTs to provide quality assessment and management in an acute care system where high patient throughput, rapidly changing patient acuity, and very short lengths of stay may preclude timely access to instrumental or more time-intensive assessment processes. Given the similarity of the task and the nature of the acute care environment, it is not surprising that the clinical bedside assessment and reasoning processes employed by experienced SLTs are the same as those used by doctors in their clinical examinations.

When conducted by an expert SLT, the initial CSE in acute care is a holistic synthesis of all relevant information that is specific to each patient in order to develop a management plan that accounts for each patient's unique presentation and situation. In this study, the focus of the initial CSE was on identifying whether dysphagia is present or absent, the degree of apparent risk to airway protection, strategies for management and whether further information needed to be gathered. This primacy of management rather than diagnosis may be related to the nature of the initial assessment in this setting where patients' respiratory safety is considered highest priority. Of note, the factors that informed the selection of management strategies by the experienced SLTs in this study were largely based on patient-specific factors unrelated to the specific physiological basis of the swallowing impairment, but rather the presence of other co-morbidities, contextual and behavioural factors that were likely to contribute to the patients overall nutritional intake and safety. In light of this, it is worth considering whether psychometric frameworks oriented to measuring the 'amount' of dysphagia through summing severity ratings on a list of items maps well to the task being undertaken by SLTs and the reasoning process required. This may account for the findings by Gonzalez-Fernandez *et al.* (2011) that ordinal, or holistic, risk ratings made by SLTs on completing a standardized assessment protocol were better than the total numeric score for predicting the presence/absence of aspiration on videofluoroscopic swallowing assessments.

Based on the findings of this study, we propose that an overall swallowing assessment process that considers all facts relevant to a patient's presentation may be more accurate in determining swallowing safety and a relevant management plan than solely relying on data generated from ratings on a strictly administered standardized CSE protocol. Consequently, we propose that an alternative strategy for improving CSE (and ultimately patient) outcomes would be to investigate ways in which the quality of the clinical reasoning process as a whole can be supported; in particular, during the transition from novice to expert.

Limitations

This study captures data from 10 instances of a single clinical assessment event by four expert SLTs following initial referral after concerns were raised regarding a patient's swallowing status in an acute healthcare environment. It is apparent from the types of decisions made from this initial assessment (e.g., seven out of 10 recommended for reassessment) that the first assessment of dysphagia is only one step towards making a final decision on safety, management and rehabilitation of the patient's swallowing. This is due to the dynamic nature of an acute patient's status and the need to gather further data to finalize a decision. Focusing on the initial CSE only does not provide insight into what further information is gathered over time and how this influences the reasoning processes. Furthermore, the role of a diagnostic statement regarding the severity and site of the dysphagia is unclear. For example, it may be a tool used by SLTs to summarize their observations for the purpose of communicating these with other professionals for whom it has a shared meaning but does not appear critical for determining management and intervention decisions.

There is evidence to suggest that SLT CSEs contribute to positive patient outcomes (Marsh *et al.* 2010) and this study aimed to deepen our understanding of this process through characterizing the nature of SLT reasoning during CSE and further illuminate the issue of variability in practice. However, it is not known whether this dynamic reasoning process is superior to an item-based protocol in supporting a correct decision regarding the nature and implications of the presenting dysphagia. Further research investigating SLTs' reasoning processes when they deviate from or don't complete a standardized dysphagia assessment tool or protocol would further illuminate how such tools do or do not support quality reasoning and assessment.

Therefore, longitudinal studies are required for two reasons. First, to understand how the reasoning process unfolds over a full episode of patient care, how it informs decisions regarding management after discharge and the role of diagnostic statements in this process. Second, to evaluate the accuracy of the SLT's decision-making against longer term outcome data such as subsequent episodes of aspiration pneumonia or adverse events related to dysphagia. These studies could incorporate additional data such as the results of instrumental assessments and expert second opinion.

Finally, this study investigated the nature of expert SLTs' clinical reasoning in our healthcare setting and the structure and processes may have been influenced by local protocols and professional development. Investigation of the reasoning of novice SLTs and the trajectory of development towards expert reasoning would assist in developing strategies to accelerate this development and optimize patient care. Further research across different healthcare settings or systems would also deepen our understanding of how context and local practices influences the reasoning and decision-making processes.

Conclusions

This study has demonstrated that expert SLTs use clinical reasoning to inductively generate hypotheses, which focus and drive an individually tailored CSE process of deductively testing these hypotheses. Therefore, the often-documented variability of CSE processes may not be random, but the consequence of high-quality, patient-centred assessment practice. The reasoning used by expert SLTs during initial CSE with patients in acute care aligns with previous research on clinical assessment in other areas of healthcare (Schmidt and Rikers 2007). It provides a foundation for future research to evaluate whether, and to what extent, the SLTs' reasoning processes have led to quality patient outcomes in the longer term, as well as for developing pre- and post-professional training strategies that support the development of quality clinical reasoning during CSE.

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Note

1. Explanatory excerpts in figures 1–3 are provided for illustrative purposes. Full-size, high-resolution versions are provided in the additional supporting information to allow opportunity for detailed examination.

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Appendix A: Interview guide

This process is about knowing more about the relationship between what you know of the patient and the items you need to assess/gather during the swallow assessment to make your clinical decisions.

Can you first tell me about the referral?

- Where did it come from?
- Why was it thought this patient needs a swallow assessment?

Was there anything you did before going to see the patient?

- Why did you do this?
- How did this help with your assessment?

[Start Video]

We'll look through the video of your assessment now. Can you talk me through what you did?

Video-stimulated recall of decisions:

- Can you talk me through what you're doing?
- Is that what you normally do?
- Explain what you mean by X
- When you say X, what does that mean?
- Can you tell me how this helps with your assessment?
- Why did you want to know X?
- How does that effect your assessment?
- What does that tell you about the patient?
- When you say X, what is that in relation to?
- I can see you did X, can you tell me why?
- Is there anything you thought of doing but decided not to do?
- What information did you gain from doing X?

Summary

- Can you summarise what you decided was the status for this patient?
- Can you tell me what is likely to happen next?

VFSS/FEES

- Do you think an instrumental assessment is needed for this patient?
- At this stage, if you did a VFSS/FEES, what features would you expect to see in the oral and pharyngeal phases of swallowing?

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supporting Information

Supplemental File 1. Representative example of a descriptive concept map. Note the structure of the assessment, which includes phases of pre-bedside information collection, conversation with the patient, formal assessment and formulation of management recommendations. A full-size copy of this figure is available in the additional supporting information.

Supplemental File 2. Representative example of a reasoning map, depicting the types of reasoning and hypotheses generated by the SLT during the assessment process. Solid lines represent inductive (hypothesis-generating) reasoning, whereas dotted lines represent deductive (hypothesis-testing) reasoning. A full-size copy of this figure is available in the additional supporting information.

Supplemental File 3. Representative example of a hypothesis map, depicting only the hypotheses generated by the SLT during the assessment process. A full-size copy of this figure is available in the additional supporting information.