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Osteopathic clinical reasoning: An ethnographic study of perceptual diagnostic judgments, and metacognition

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ABSTRACT

Background: Clinical reasoning has been widely researched in the health sciences; however, in osteopathy it is still in its relative infancy.
Objective: To explore the moment by moment clinical reasoning processes of an osteopath whilst with patients, to understand the role of perceptual diagnostic judgments, and metacognitive processes.
Method: A qualitative interpretive study with a novel narrative method as an organising structure: the moment by moment thought processes of a single osteopath were recorded and transformed into descriptions of the interactions with patients. The descriptive texts were expanded into narratives using autoethnography and reflective practice. Narratives were then analysed using methods originating from grounded theory.
Results: Our interpretations indicate that osteopaths establish a multisensory construct during clinical reasoning which enables both analytic and intuitive decision-making strategies. Clinical reasoning was monitored by a variety of metacognitive processes, including intuitive discernments such as feeling that a decision is correct, and the judgment that there is sufficient information to make that decision.
Conclusions: This is the first study to explore the subjective moment by moment clinical reasoning and decision-making strategies of an osteopath whilst with patients. It suggests that perceptual diagnostic judgments are multisensory and include mental and visual imagery, and embodied senses. These enable analytic and intuitive diagnostic strategies that are accompanied by persistent metacognitive processes during the consultation, which guide the practitioner's decision strategies.

Introduction

Clinical reasoning is a set of complex cognitive and non-cognitive processes that healthcare practitioners engage when carrying out their clinical practice. It involves conscious cognition and metacognition, and unconscious intuitive processes within a social interaction. It also focuses on the decision-making processes that are involved in patient evaluation, diagnosis, and management [1]. It is a critical skill in healthcare clinical practice, and enables the practitioner to be effective and operate autonomously within the wider healthcare system [2]. This essential skill has similarities and differences within each profession, but it is recognised that research into this complexity is vital to educate professionals, and maintain and improve healthcare standards as required by statutory regulation [3]. Clinical reasoning and clinical decision-making are often used interchangeably in the literature (for example [4,5]), but they are considered subtly different. 'Clinical reasoning' refers to the social, cognitive and interactive processes which may result in clinical decisions with patients [1]. However, clinical decision-making is the process by which practitioners make complex choices between different courses of action, with multiple foci (for example, diagnosis, examination and treatment), using a range of knowledge sources. It is both an outcome and a component of clinical reasoning [6]. It should be noted that both are often occurring under uncertain conditions and take into account the wishes of the patient. Despite the familiarity with the procedure of clinical reasoning, most clinicians would find it hard to describe the actual cognitive processes they use when reasoning as it appears to be mostly tacit and not open for introspection [7,8].

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Decision-making has been investigated in medicine for many years, e.g. Ref. [9], and allied health professions such as nursing, e.g. Ref. [10], physiotherapy, e.g. Ref. [11] and occupational therapy, e.g. Ref. [12], have investigated clinical reasoning more extensively. Research into decision-making and clinical reasoning in osteopathy has been scarce, however, recent studies show that osteopaths use similar decision-making methods to those used in medicine [13,14]. There is a combined use of hypothetico-deductive reasoning, an analytic strategy where data is gathered to test a hypothesis(es) attributed to Elstein et al. (1978) [15], with intuitive pattern recognition where hypotheses are formed based on similarities with previous cases [16].

Perceptual diagnostic judgments

Osteopaths use palpation extensively whilst examining and treating a patient, often looking for tissue texture and joint mobility changes [17], identification of anatomical features [18] and bony landmarks [19] via the senses of touch and proprioception. Reaching a diagnosis from a neurophysiological perspective, will require an ongoing interaction between ascending and descending mechanisms in the nervous system. These two mechanisms evoke sensations, lead to perceptions and elicit stored memories. The ascending pathway begins with stimulation of sensory receptors that translate the energy present in mechanical, thermal or chemical stimuli into signals that neurons can use. Descending mechanisms allow the central nervous system to select just those events that require immediate attention; and therefore, provide the basis for interpreting meaningful ascending signals [20]. These processes underpin two important aspects of sensory physiology, namely sensation and perception. Whereas sensation refers to the detection of a stimulus of an event; perception relates to the interpretation and appreciation of that event [20,21]. Although clinicians are likely to diagnose with 'all their senses' [22], in osteopathic medicine the exploration of compliance, texture, temperature, and movement of musculoskeletal structures is arguably ideally suited to the haptic system. The haptic system is a perceptual system mediated by two afferent subsystems, cutaneous and kinaesthetic, that typically involves active manual exploration [23]. The haptic system has perceptual and memory functions involved in the recognition of object shape, and surface texture. Vision is likely to work in synergy with the haptic system, and there are also suggestions that channels for processing one modality may also serve another modality [24], and palpatory shape perception of 3-D objects activates a visual pathway e.g. Refs. [25,26]. The complexity of perceptual experience is not reflected in isolated joint mobility changes. Perception is both input to and the result of cognition and is heavily influenced by the perceivers knowledge and beliefs [27,28]. This is possibly why the subject of palpation is a difficult concept to research, assess and teach [29,30]. However, palpation remains an important part of a clinician's clinical competence profile. Exactly how palpation works at a discriminatory level may evolve with the advent of new detection methods but currently, how it accompanies clinical reasoning and diagnostic strategies has not been studied.

Metacognition

Similarly, little is known about how osteopaths monitor and regulate their clinical and diagnostic reasoning. There is current debate about the scope and meaning of the term metacognition [31]. It was initially described as knowledge about, and regulation of one's cognitive activities in learning processes [32]. It could be considered a cognitive supervision of thinking and knowledge, and is important for accurate and consistent clinical reasoning. It describes the formation of cognitive representations that allow an interpretation of the world, enabling strategic thinking and decisions on whether to act on information gained, or defer and seek additional knowledge. Most research in the topic of metacognition has used single stream input, visual or auditory. This has been to assess the extent to which uncertainty, or accuracy of perceptual representations or judgments can be gauged e.g. Refs. [33,34], or whether answer fluency and perceptual fluency as metacognitive cues initiate analytic thinking [35]. Complex multisensory environments are beginning to be modelled, but it is currently unclear how accurately we are able to decode complex input [36].

It is generally accepted that sometimes humans will make decisions regarding probability or logic with easily accessible or misleading information [37]. Decisions about risk are also sometimes made based on the desirability of the outcome rather than its probability [38], which has negative implications in clinical reasoning. There is a growing movement to ensure high level understanding of clinical decision-making in an effort to reduce clinical error e.g. Ref. [39]. As the osteopathic profession continues to grow and become established across the globe, for example in Australia, New Zealand and France; international professional regulatory bodies and standards have arisen to ensure global quality, such as the Osteopathic International Alliance, and Forum for Osteopathic Regulation in Europe [40]. Osteopaths are recognised as important providers of neuromusculoskeletal care as acknowledged by the World Health Organisation's publication of a benchmark for osteopathy [41]. Research to understand and optimise perceptual mechanisms, and those by which actions and decisions are controlled and monitored, is important to reduce practitioner error and increase competence [42,43].

Embodiment

Embodied cognition is a relatively recent concept which suggests that cognition resides in the body and the mind is used to guide action. In this system, the brain develops as a function of interaction with the environment in order to facilitate motor and sensory functioning [44,45]. Mirror neurones found in the premotor cortex, the supplementary motor area, the primary somatosensory cortex, and the inferior parietal cortex [46] allow humans to copy and learn behaviours from others. They fire when humans are in action, and when they are observing an action in others. Dysfunction of the mirror neurone system is thought to be implicated in conditions like autism [47]. They are also evident in behaviour related to sensing human emotion in others, such as in our empathic capacity [48]. The perception-action model (PAM) at the core of the empathic capacity mechanism provides an observer with access to the subjective state of another through their own neural and bodily representations. When the subject attends to the state of the other their neural representations of similar states are automatically and unconsciously activated [49]. Behavioural evidence supports a link between the neural systems involved in the perception of visual motion and the comprehension of language describing objects in motion. Words in isolation [50–52] and sentences describing objects in motion, have the ability to activate higher order visual cortices involved in supporting the visual perception of moving objects [53]. This sharing of neuroanatomy is thought to be supportive of the concept of embodied cognition, and may support the opinion that clinical reasoning is a highly imagistic and deeply phenomenological mode of thinking based on tacit experiential knowledge [54,55].

A healthcare practitioner's thought and decision-making processes, although based on well-taught analytic strategies and a sound knowledge base, remain idiosyncratic and arguably tacit. Idiosyncratic, because information from perception is fed forward

to memory which then interacts with content and influences what we perceive [56]. Knowledge in memory has an active and subjective nature and is deeply rooted in an individual's value system [57]. In addition, our brains tend to fill-in information that is absent in order to form a perception of forms, shapes and figures [58] making our thought processes, to an extent, individual. Knowledge also has a tacit content, such as that used during the decision-making strategy of pattern recognition, that is experiential and is difficult to measure or describe. Therefore, the study of this phenomenon requires a unique methodology to attempt to elicit this tacit information. The aim of this research was an in-depth exploration of the clinical reasoning processes of a single osteopath, to provide insight into how perceptual diagnostic judgments are made and what metacognitive processes are used. The intent was not to collect data to objectively analyse, but rather to understand and interpret the phenomena under investigation. Nicholls [59] suggested that qualitative research addresses the kind of questions relevant to allied healthcare, and that these questions are pivotal to the nature of thought and practice.

Methods

The authors adhered to reporting guidelines for publishing in the rehabilitation literature. The consolidated criteria for reporting qualitative research (COREQ) were used to describe the methods employed [60]. The study was approved by the institution's Research and Ethics Committee. Each participant gave informed consent before participating, and reporting of data was anonymous. Unidentifiable information will be used in the preparation of manuscripts for peer review publication.

Study design

The study adopted an autoethnographic approach. Ethnography as a research method was developed to enable rich holistic insights into social interactions, behaviours and perceptions that occur within communities [61]. Autoethnography uses self as a source of data and follows in the tradition of ethnography, and both disciplines provide reports that are scholarly and justifiable interpretations based on multiple sources of evidence [62]. Similar to Duncan [62] (p29), the intention in this autoethnographic study was to '*externalise my inner dialogue of decision to find and develop fully the central themes and outstanding questions that were emerging*'. To gain an understanding of the momentary and potentially intuitive insights that may not be available via other methods, and directed at the clinical reasoning of an osteopath whilst with patients. Grounded in the interpretive paradigm, the researcher assumed the presence of multiple realities [63], and used a novel modified participant-observation case study method to collect the data to allow the investigation of complex concepts in context [64]. This creates an 'insider', or 'emic' perspective [65,66], considered valuable to develop inquiry [67].

Participants and sampling

Forty-five patients formed, initially, a random sample for ease of booking into a working clinic diary. This was because times were allocated in the diary for the research study. If a patient wanted to book into that time they were then approached for inclusion. Contact was either face to face, or by telephone. No specific details were given about the researcher. Patients were provided with an information sheet and opt out form, and given time to read them alone to ensure they did not feel coerced. One person refused to participate with no reason provided, or requested. At this stage, there was no specific profile targeted, but children and vulnerable adults were not included. Once the initial case information was collected from the forty-five participants, nine were then deliberately selected based on their complexity to allow rich information to be collected. The complexity was provided by patients presenting with unusual symptom pictures, multiple pain sites, the presence, or suspected presence of red and yellow flags, and the need to utilise multiple treatment models, for example. This type of complexity had the ability to provoke a reaction in the researcher that sometimes highlighted a subject needing closer inspection by reflective practice. NB this study was developed with a threefold focus around the clinical reasoning of an osteopath: how we use perceptual diagnostic judgments and metacognition, but also the effect of reflective practice on clinical reasoning. The latter concept is to be reported in a future manuscript.

Researcher (CM) Profile
Female
Previous research experience with Medical Research Council/University of Kent
Seventeen years as qualified osteopath
Undergraduate education at BSO
Osteopathic qualification BSc (Hons) Ost
Additional postgraduate degree MPhil (Radiobiology)
Tutor for 7 years at OEI

Data collection

The first author (CM) was the researcher for this study and recorded, by notes, her moment by moment though processes whilst in the presence of patients. Treatment sessions were 45 min for new patients and 30 min for existing. There were no others in attendance and CM was attempting to record naturally occurring phenomena, without undue intervention as a researcher. The notes were immediately written into a case description of the patient-practitioner interaction, the researcher ensuring the account remained loyal to the notes. Occasionally a patient would book in for a repeat treatment in an allocated session, meaning they would appear twice in the data collecting which enriched the unfolding clinical picture. Each session was treated as a separate case and thoughts for that session noted. Only one such patient was then selected for narrative development.

Nine of the forty-five case descriptions were selected to develop into narratives. Each narrative contained its relevant descriptive text. Selection was based upon an aspect within the case that stimulated the researcher to reflect. An autoethnographic [68,69] and reflective practice approach [70,71] was used to develop the narratives.The sentence should say There is an emphasis within ethnography on exploring the situation in context rather than testing hypotheses [72]. There is an emphasis on exploring the situation in context rather than testing hypotheses [72]. Autoethnography is a branch of ethnography in which the experiences of the researcher form the central material of the study [73,74]. Reflective practice has been used within healthcare to research a practitioner's clinical praxis as a route to improving practice [75]. Bolton [76] suggested reflective practice identifies '*what it is we do, rather than what we say we do*'. It has also been examined as a method to improve clinical judgment and medical expertise [77], and discussed as a way of reducing errors in prescribing [78].

The possibility that assumptions were not questioned sufficiently was addressed by regular discussions with supervisors and peers, and the maintenance of a reflexive field diary to ensure the accurate interpretations of thoughts and findings. This approach ensured high trustworthiness and robustness of the findings and

developing conceptual framework [79]. Data collection continued until no new insights developed, suggesting theoretical sufficiency had been attained [80].

Data analysis

Methods used in grounded theory were employed to analyse the data, including the strategies of Charmaz [80] Strauss and Corbin [81], Corbin and Strauss [82] and Rogan et al. [83]. The major stages in the analysis were open coding, memo writing, axial coding and constant comparative analysis. CM read and re-read the narratives whilst looking for patterns and commonalities within the text. The use of memos also served as a reflexive tool to address researcher bias, pre-conceived ideas, and a priori knowledge. A reflexive field diary was maintained throughout the study to maintain trustworthiness of the research, assist code generation, and ensure researcher reflexivity [84]. Analysis continued until no new categories arose.

Elements of Grounded Theory Analytical Methods Used in this Study
(Strauss & Corbin, 1990; Charmaz 2014; Rogan et al., 1997; Corbin & Strauss 2015)

Initially, the narratives were read and re-read to understand concepts arising.
Coding – data driven codes developed by analysing line, paragraph, and phrase.
Memo Writing – identification of broad concepts arising from data. Conceptual not descriptive. Codes and concepts compared.
Categories – development of individual categories from concepts and codes.
Constant comparative analysis – used at each level of data analysis to challenge assumptions or identify repressed data. Data compared with data, data with category, category with category, and sub-category with sub-category.
Axial Coding - identification of causal conditions, actions/interactions, and consequences. Categories and sub-categories take on a more constructed essence.

Results

The findings are divided into those for perceptual diagnostic judgments, and those for metacognition. Data analysis of perceptual diagnostic judgments indicated that in this study the osteopath 'developed a sensory construct' during clinical reasoning which contained Theme 1: 'building a picture'; Theme 2: 'mental imagery into embodied senses'; and Theme 3: 'multisensory perception enables pattern recognition and analysis'. During clinical reasoning these themes interact similar to cogs in a wheel Fig. 1 where theme 1 and theme 2 generate theme 3. They all then continue to interact during the clinical reasoning process generating further information for diagnosis and reasoning.

Data analysis for metacognition resulted in the development of constructs that fit within the already established themes of meta-knowledge, meta-skills and meta-experiences [85,86]. A model for meta-skills in nursing was developed by Ref. [87] Pesut & Herman, and it was found in this study that osteopathic clinical reasoning broadly fits their model, with some differences as observable below.

Perceptual diagnostic judgments

Developing a sensory construct - Building a picture

During clinical reasoning CM used both formal (intentional), and informal (tacitly occurring) observation during the consultation, which began from the moment the patient entered the clinic. The latter included observation of their musculoskeletal system, the way they moved, and sensing the attitude of the person and their emotional status.

> *'She is a petite, gentle woman with a lovely smile that hides a deep well of grief and emotion beneath it' (P5)*

The use of the word 'picture' occurred through many narratives when describing multisensory perception of the situated patient:

> *'The initial picture I was getting was of part of her life which has biomechanical consequences from so much sitting, but more general stresses from negotiating driving in UK traffic which can be demanding. I got the impression she looked in pretty good health, even if she was a little overweight as she sat in the chair in front of me, with her knees together and her feet splayed.' (P3)*

Multisensory perception also occurred during examination and treatment. Palpatory feedback indicated specific joint position, the nature and quality of tissue movements and overall body integration. Palpation was both direct and proprioceptive. CM appeared to be gaining a sense of the whole body whilst examining the patient:

> *'I went on to assess her body in action by asking her to walk on the spot whilst I felt the movement of SI's which were fairly equal in this position. This movement gives me a direct palpation of the pelvis but also a broad sense of the flexibility of the spine and any restriction of movement through the hips and legs as well as observing foot movement.' (P1)*

Cranial palpation was used to treat patients, support or negate previous haptic and visual findings, and inform treatment decisions. Generally, immediate conclusions were not formed, but data was gathered which informed 'building a picture'. Findings were linked from each stage of the consultation:

> *'I thought it was an interesting pattern but could fit the picture I was seeing. I waited for the resolution of this pattern and decided to finish the treatment at this point.' (P1)*

Developing a sensory construct - Mental imagery into embodied senses

Whilst developing the picture of the patient, including the presenting function and dysfunction, there appeared to be intuitive cognition occurring simultaneously throughout the osteopathic consultations. This arguably developed the multisensory perceptual information as an embodiment:

> *'Earlier when this patient had been sitting in front of me fully clothed I had a sense that her tissues were flexible, and I got that sense again when she was standing in front of me.' (P3)*

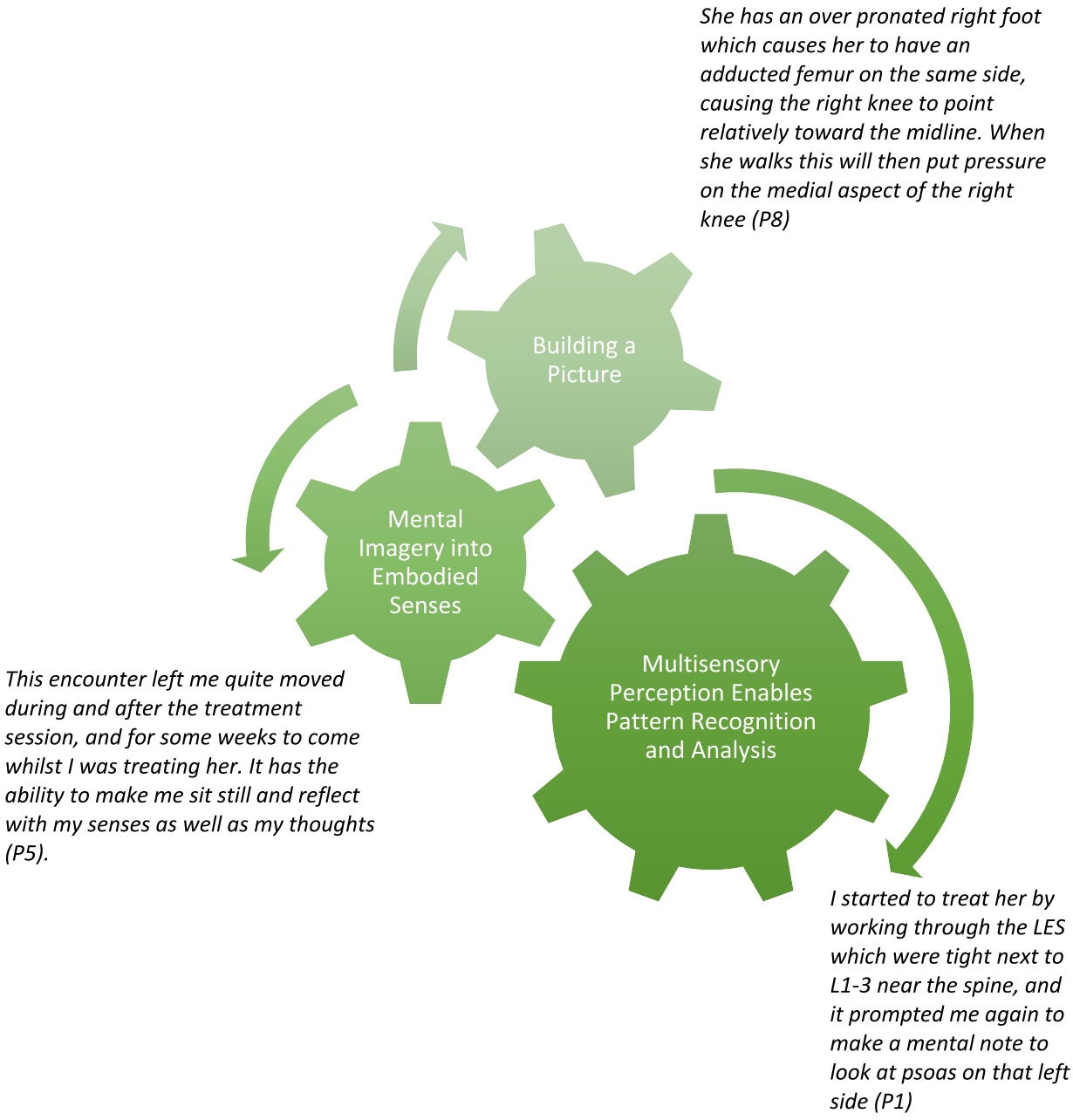

Fig. 1. Schematic of developing a sensory construct.

Developing a sensory construct - Multisensory perception enables pattern recognition and analysis

There are many instances suggesting the incoming perceptual and embodied information enable both pattern recognition and analytic reasoning. These are cognitive strategies that are used in osteopathic clinical reasoning and diagnosis:

> *'I have often pondered over her lower thoracic spine when treating her previously. I have wondered why it should feel particularly bendy as though there is anomalous bony integrity … having just been reminded of the relationship between the kidneys and the lower thoracic spine tenderness, I wondered how much I needed to read into this tension I had just found … ' (P7)*

> *She has an over pronated right foot which causes her to have an adducted femur on the same side, causing the right knee to point relatively toward the midline. When she walks this will then put pressure on the medial aspect of the right knee (P8)*

> *I started to treat her by working through the LES which were tight next to L1-3 near the spine, and it prompted me again to make a mental note to look at psoas on that left side (P1)*

> *This encounter left me quite moved during and after the treatment session, and for some weeks to come whilst I was treating her. It has the ability to make me sit still and reflect with my senses as well as my thoughts (P5).*

Metacognitive monitoring of clinical reasoning

Identified as the strategy humans use to monitor cognition and control their actions, there are three main types as described below, and they appear throughout the osteopathic consultation:

Meta-knowledge

Meta-knowledge was demonstrated implicitly and explicitly at times during consultations, and often retrospectively, where CM demonstrated presence of intra and interpersonal differences, and self-knowledge:

'I am aware of what this feels like in my own body and I can feel the strain pattern working through her system, but I wonder how it feels to be out of balance for her'(P1)

Meta-skills

Meta-skills have been described as monitoring and self-regulation by Flavell et al. [85], and skills by, for example, Efklides [86] and refers to a person's procedural knowledge for regulating problem solving and learning activity [88]. They have a built-in feedback mechanism, because if a person is not capable of carrying out a procedure then the task will fail [89]. A meta-skills framework of clinical reasoning for nursing was proposed by Pesut and Herman [87]. It was found in this study that there are differences within osteopathic clinical reasoning, but it broadly follows the categories described in their model.

Analysing & Assessing (A&A) – a practitioner gathers a multitude of information during a consultation and it is important to be able to determine what to use, and which to ignore. A significant amount of A&A occurs during cue acquisition and examination phases of the consultation when a practitioner is developing a diagnosis. It could also be observed throughout all stages of the osteopathic consultation particularly if the diagnosis did not fit the emerging picture:

I asked him to sit and checked Adson's test and it produced the pins and needles both when I extended the arm and side bent the neck to the right. (P6)

Predicting - infers the diagnosis and aetiology from all the information gathered, and the probability that the information is related to the diagnosis. It generally occurred once cue acquisition and examination was complete, but was continuous and flexible to new information. Practitioners are constantly inquiring of themselves whether there is sufficient evidence for diagnosis (hypothetico-deductive reasoning), whether this picture fits with past experience for example (pattern recognition).

'Although she is a slight woman and 68 years of age she has been very active during her life and most of her pain was when sitting and not weight bearing which made me relax a little regarding osteoporosis, but not discount it completely.' (P5)

Planning - The meta-skills strategy of planning involves the practitioner asking themselves how best to intervene with the presenting situation in order to provide an outcome that will help the patient. This also involves trying to affect the aetiology of the problem. In clinical reasoning this could naturally involve the patient in both treatment and management strategies. It was found that planning split naturally into intervention and rationale for the intervention.

Planning - Intervention

Planning-intervention, when it revolved around treatment, was a fluid and evolving strategy based on multisensory feedback, particularly palpation. It could however also be a home-based management strategy, or psychosocial intervention.

'As I was examining I began to treat her by massaging the muscles to release above L3 and to move the fluids that were causing the bogginess around the spine. Treating as I examine helps me to receive more feedback from her body and as I am doing this I wondered whether the joints could take manipulation of any kind' (P3)

Planning - Rationale

Rationale for treatment involved consideration of the global treatment and management needs of the patient, and the local functional requirements of their body and tissues. At a technical level consideration was made regarding the use of treatment modalities and the local effect on tissues:

'I went on to think about whether to treat her cranially or structurally, and decided that the tissues needed to move and stretch, and to give her the confidence that she can move into different positions.' (P5)

Evaluation & Revision - The practitioner frequently evaluates where an intervention is taking the patient's condition. A condition could be improving, moving toward improving, not changing, or deteriorating. Evaluations could be seen to be a direct response to sensory feedback.

'She felt flexible and I noted that I didn't think the technique I was using felt effective, so I moved her position to where she was on her side' (P1)

Revision occurred if CM received information that prompted her to decide on a different course of treatment:

'Although it is a little early to change a diagnosis after treating a patient for just one session, I like to see some alteration in the symptom picture even if it is only twenty percent … ' (P8)

Meta-experiences

These occur in the affective domain and are related to rapid and often automatic feelings that occur as we are cognitively processing information. They allow us to monitor the correctness of a judgment, often intuitively. The judgment is often accompanied by a feeling of confidence in the answer which allows us to accept or discard the answer. Discarding may then engage more analytic thinking.

'I took her through the active examination but very little pain was reproduced which alerted me to look further. It was important to me to reproduce those symptoms … ' (P2)

Discussion

This study is the first of its kind to explore the subjective,

moment by moment thought processes of an osteopath during consultations with patients. The aim of the study was to explore the role of perceptual diagnostic judgments and metacognition in osteopathic clinical reasoning. There is an assumed resonance between the results arising from a single practitioner and the general osteopathic community, and the results have been interpreted accordingly. This study corroborates previous findings that osteopaths use the decision-making strategies of pattern recognition and hypothetico-deductive reasoning [13,14]. The two previous studies reported an interplay or transitioning back and forth between the two strategies, which was also evident in this study. This provides further corroboration of the dynamic use of intuitive and analytic decision-making strategies. However, it also identifies that multisensory perceptual diagnostic judgments enable those strategies, and provides confidence in the single practitioner method used in this study.

During this study, there were multiple examples of analytic reasoning, and evidence of implicit intuitive processing in the form of meta-experiences resulting in a single hypothesis happening at times during various stages in the consultations. The issue of monitoring and control of these processes, and the timing of discarding intuitive answers in favour of analytic processing has been discussed in the cognitive psychology literature [90]. Pattern recognition is often described as the practitioner bringing forward information from previous cases to make a diagnosis, an intuitive process which is an intuitive process In this study, there was evidence that these are connected processes with movement backward and forward between pattern recognition and a more analytical style of reasoning, so that they were acting as a continuum as suggested by Croskerry [91]. Roots et al. [14] suggested an overlap between analytic and intuitive reasoning in osteopathic CR. Although this study corroborates some of the findings of others, it did not elicit any further data regarding cognitive timing during decision-making, more research is needed in this area.

Perceptual diagnostic judgments

It has been thought for many years that a major focus of the osteopath should be to discover and alleviate physical dysfunction by employing hands on techniques and treatment modalities [92]. Although the findings are consistent with this claim, there is clearly greater complexity that needs to be considered. There is development of a sensory construct by initially 'building a picture' of the patient beginning with visual and auditory feedback, followed by discrete and combined visual and haptic senses. Visual skills in this study are both formal and informal, the former described as conscious structured observation, actively and consciously attempting to elicit visual information from examining the patient. In contrast, informal skills appear to occur tacitly, for example, when engaged in conversation with the patient, not consciously activating observation. The findings show that a perception of the person is gained early in the consultation, virtually the moment the patient enters the clinic, and includes personal and social characteristics not simply anatomical and biomechanical [93]. This subtle and often tacit information obtained by the osteopath is available to be used during the consultation. How the information is then used is likely to depend upon the practitioner's conception of their practice [94].

The researcher describes the absorption of visual sensory information into her body, providing a perception of the patient's body prior to palpation. This is a possible exemplar of Husserl [95] and Merleau-Ponty's [96] phenomenological distinction of embodiment, describing the body in a lived sense perceiving and experiencing its surroundings. Human perception, action, and cognition are intrinsically linked [97] and the brain represents incoming information as a function of the interaction between the body and the environment [44,98]. There is debate over the level of embodiment that occurs, however, there is evidence to support the embodiment of language comprehension using imaging techniques [99]. Patients with brain lesions that create semantic impairments affecting their perceptual representations e.g. Refs. [100,101]. Visual representations of object shape and orientation are routinely and immediately activated during word and sentence comprehension e.g. Refs. [102,103]. It has also been demonstrated that accurate sentence interpretation can be disrupted if the subject is asked to perform the opposite action that the sentence requires [104]. This suggests the presence of mixed modal sensory processing, and means we do not need to be physically involved in an action to experience it [105]. There is also the evidence of the presence of mirror neurones in the body [106] which makes the theory of embodiment compelling.

Multimodal integration involved in space perception is an accepted phenomenon [107,108], but there is little research investigating sensory perception and embodiment, (for a review see Ref. [109]). However, the concept suggested by the findings in this study are not beyond the realms of possibility. An example is the interpretation of a person's anger. Observing an angry person, one might see that they are frowning and perhaps clenching their fist. Embodied perception theory (EPT) allows an observer to know anger when they see it, because they will feel and understand the state within their own body [110,111]. The phenomenon observed in this study may be limited to this single osteopath. However, there are others in physical therapy who have suggested that the dynamics of lived bodily engagement between physical therapist and patient help to constitute the clinical reasoning process [112]. If ninety-five percent of the time thought is intuitive [113,114], then clinical reasoning is largely instinctive. The dynamical interactions between the brain, body and environment go mostly unnoticed, but nevertheless they constitute our sense of self [115]. They also potentially constitute a person's sense of 'other'.

Further research into embodiment, and how it fits into the multisensory construct is necessary. The suggestion is, together they enable the osteopath's cognition, action and decision-making strategies. Perception is strongly modulated by knowledge, beliefs and values, therefore what we are taught at pre-registration and postgraduate levels and how that information is disseminated, is vitally important to our clinical competence. Current osteopathic research is developing a useful schema of the mechanisms of clinical reasoning and decision-making so that it is possible to understand the structure of reasoning. Perhaps what is important for developing an epistemology of osteopathic practice, is to understand fully the ways that information gathered is used within this structure. It may then be possible to identify the range of professional identities and values that need to be approached within the osteopathic curricula of osteopathic educational institutes. The presence of embodied cognition is significant in the search for an understanding of how we perceive, and how decisions are made by practitioners during clinical reasoning, because it could change the way learners are educated. It could direct education to focus more heavily on the felt sense, embodied and intuitive experiences during clinical reasoning. Research investigating assessment methods used in undergraduate osteopathic education [116] suggested there is a focus on technical skills and knowledge, implying that technical rationality predominates. Generally, osteopaths who conceived practice as technical rationality tend toward the biomedical view of health and disease [94]. In clinical practice being more closely aware of the felt sense will improve a practitioner's interpretation of the patient and their experience of pain. It may also assist osteopathy in further developing the biopsychosocial model of healthcare.

This study demonstrates why the senses, including palpation, are of central importance within osteopathic clinical reasoning [117]. Haptic feedback was achieved using both structural and cranial osteopathic techniques, and was focused on muscle tone, joint and bone health, and range and quality of movement, in agreement with other authors [118]. Findings also suggest cranial palpation was used both as a treatment and as a method for supporting, or negating, previous haptic and visual findings. It also enabled judgments that informed treatment decisions, regarding when to move on to treat another area and whether the treatment is at an appropriate point to finish. Structural palpation also informed treatment decisions by giving specific feedback about joint restrictions, ranges of movement, and tissue health, and allowing decisions to be made regarding modes of treatment and patient management. Palpatory feedback was iterative and was also used to test hypotheses. The findings suggest that cranial palpation could be encouraged from an early stage at undergraduate level. This could potentially provide a wider understanding of treatment effects and prognosis. This is not ignoring the lack of inter and intra-rater reliability of both cranial [119] and structural palpation, e.g. Refs. [120,121]. It is likely that lack of palpatory reliability is due to the complexity of perceptual cognition and its relationship to knowledge and beliefs. It is also possible that it is effected by the palpatory technique used in research, as combined methods provide greater agreement [122]. Methods to integrate various ways to palpate to enhance clinical reasoning would be interesting to research.

Metacognition

This study has explored the use of metacognitive processes during clinical reasoning to assist in identifying ways of enhancing osteopathic clinical reasoning at both pre-registration and post-graduate levels. Improving the ability of clinicians to accurately sense errors is of interest in healthcare. When clinicians overestimate their performance, they may reach diagnostic closure too quickly, resulting in poor diagnosis [123,124].

The study shows the use of implicit and explicit meta-knowledge in the form of intra and interpersonal differences, and self-knowledge. This aids the practitioner in assessing the patient's demeanour in relation to themselves, and helps improve patient care. Although moment by moment thoughts were recorded, implicit judgments in this study were found to be too rapid to capture using the methods employed. However, it is possible to infer intuitive thinking by the presence of feelings of rightness (FOR) and judgments of learning (JOL). These are intuitive metacognitions that are thought to accompany meta-experiences, and occur in the background driving the thought processes during clinical reasoning. Particularly present was feelings of rightness, which can be a conscious or unconscious feeling that information arriving is correct [125]. It allows the practitioner to know if they need further information before forming a diagnosis. Feelings of rightness, and judgments of learning occurred during intuitive hypothesis generation, at which point it could be seen that further analysis and questioning occurred to improve the level of confidence in the hypothesis, or of the information given, as has been suggested happens in decision-making [126]. Whether the fraction of time spent in the non-analytic mode of reasoning is as high as ninety-five percent during clinical reasoning is uncertain and is not able to be determined by this study. However, as tacit and conscious perceptual mechanisms drive clinical reasoning [127] and knowledge influences perception [128], how perception and cognition is supervised is therefore important to avoid cognitive bias, and ensure clinical safety [129].

Meta-knowledge and meta-experiences are brought together in a meta-skills framework (Fig. 2), which includes analysing & assessing, predicting, planning treatment, evaluating and revising. This framework describes the metacognitive model used in nursing, although this study suggests that within osteopathy there are some differences. In this study, the osteopath didn't sit and plan the treatment but was clearly making decisions during the whole consultation, and could fluidly change direction if the situation dictated. This demonstrates an ability to maintain an open mind and has been observed in other studies involving osteopathic clinical reasoning [13,14]. It helps a clinician avoid premature closure, which is a short cut that has been identified as potentially creating error in reasoning [130]. It is thought that most diagnostic errors are not due to incompetence or inadequate knowledge but frailty of human thinking strategies [131]. Metacognition has been suggested as a method for helping prevent cognitive bias [132]. It was found in this study that any treatment was also accompanied by a strong rationale, or theory behind the approach used. This is a metacognitive strategy that is instilled during pre-registration training. Development of a strong metacognitive framework for osteopathy, and education in all aspects of metacognition could enhance osteopathic decision-making.

Study considerations

The study forms part of the findings from a doctoral project and as such is strongly connected to the existing literature. It has been developed with quality and critique in mind throughout [133]. The single practitioner/researcher nature of this study is both its strength and provides challenge. Rather than asking practitioner's what they were thinking retrospectively, the novel method employed in this study was adopted in an attempt to get as close to the actual moment by moment thoughts of the practitioner during clinical reasoning whilst with patients. A potential weakness of the method is, that on occasion during the treatment phase of the consultations it would not be appropriate to leave the patient to note a thought, therefore some were not recorded. However, empirical data not being needed, this does not detract from the information gained, and should not change the interpretation of the study. The subjectivity is a strength because examining one's own thoughts provides the potential to inhabit a microcosm of cognition during clinical reasoning. Employing a narrative method [134] Bolton (p1) suggests, that we uncover '*what we know but do not know we know*'. Donald Schön [135,136] was concerned with uncovering the tacit knowing-in-action of the professional, which he felt was often ignored in favour of technical objective knowledge. He suggested that both are required for complete knowledge to emerge. Qualitative research allows for reality being variable and not entirely external and is created by, and moves with, the perceptions and beliefs of the viewer [62]. Such a framework will have the voice of personal interpretation and show how the researcher made sense of the world [67].

As a practicing osteopath, there was familiarity with the culture, and no need to try to comprehend an unfamiliar philosophy with a different set of values. However, that also places the researcher close to the subject matter, and the study is influenced by this. It could be argued that someone from another background may interpret the findings differently, or even this researcher at another time, or in another context [137]. It must be noted that research on the cognition of a singular osteopath can only be interpreted with caution to the wider osteopathic community without further research, and only provides a partial vantage point [138].

Trustworthiness of the study [3] was maintained by researcher immersion in the narratives, and adherence to analytic methods used in grounded theory [80,82,83] that allowed themes to emerge rather than being forced [83]. The methods were reported so that

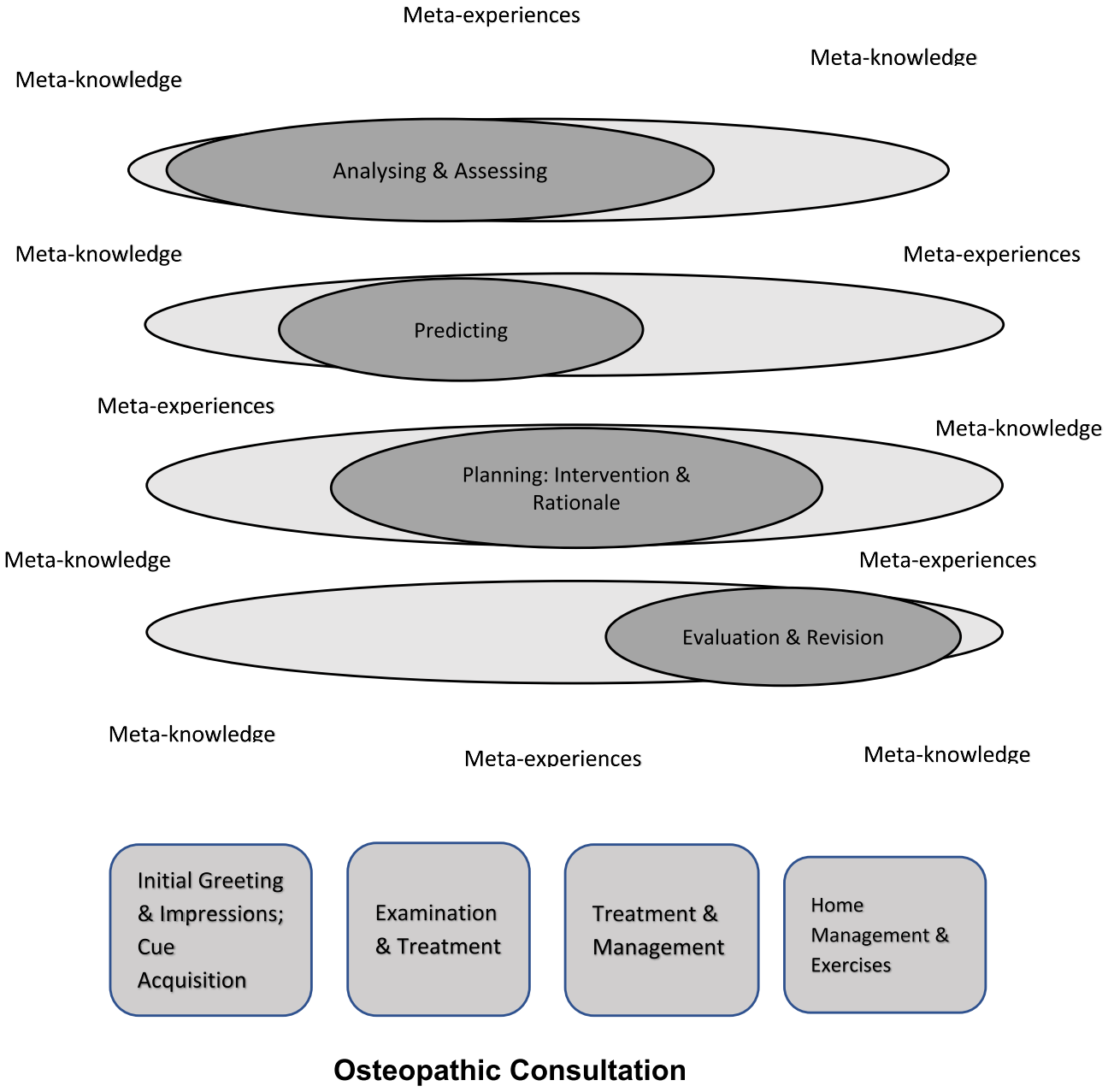

Fig. 2. Osteopathic metacognitive framework.

the reader could see an audit trail [139]. The use of memos as a reflexive tool, 'thick descriptions' reported in the findings, the use of a reflexive field diary maintained throughout the study [84], peer review of narratives and dialogue with the literature [71,75], all to address researcher bias, pre-conceived ideas, and a priori knowledge, and show a decision trail [140]. In order to further triangulate the data, methods employing video or digital recording with concomitant transcripts were considered. However, it was decided that a naturalistic setting was a priority and digital recording may have caused an alteration in the thoughts and behaviour of the practitioner and patient. Also 'think aloud protocols' where the researcher/practitioner speaks their thoughts into a microphone for vocal recording, was an alternative [141]. This is often used retrospectively with stimulated recall. However, thinking aloud during differential diagnosis sometimes includes discussion of pathology, which is likely to cause the patient unacceptable distress, so was discarded for this study. Such methods could be used in a further study, but perhaps using osteopathic students instead of patients, or other practitioners, who would have a greater understanding of differential diagnosis and therefore less likely to be distressed. Equally, it was not possible to involve the patients in the process of verification of the themes developed via interview, or focus group, because they were not privy to the thoughts of the practitioner and therefore would not be able to confirm details.

Conclusion

The findings in this study suggest that osteopaths use multisensory perceptual diagnostic judgments during clinical reasoning.

This feedback enables the two previously identified diagnostic strategies of hypothetico-deductive reasoning and pattern recognition. It is suggested that multisensory perception during clinical reasoning is embodied, which could change the way we teach clinical reasoning to undergraduates, but more research is needed to further elucidate this finding. The osteopath in this study demonstrated the use of well-developed metacognitive skills including the presence of intuitive responses that guided decision-making. The findings in this report support previous research on clinical reasoning and decision-making in osteopathy, and theoretical ideas regarding multisensory and embodied clinical reasoning. Although the research questions differed, the similarity with some of the findings from other research provides a level of confidence for the novel method used in this study. However, further research is needed to determine whether these findings are reproducible amongst the wider osteopathic population.

Conflict of interest

None.

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Ethical approval

British School of Osteopathy Ethics committee (BSOREC) approved the research 21st January 2013.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ijosm.2018.03.005.

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