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Multifactorial assessment of measurement errors affecting intraoral quantitative sensory testing reliability☆

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HIGHLIGHTS

- A comprehensive approach to assess multiple sources of intraoral QST variation is proposed.
- Most variability come from differences between participants and visits-within-participant.
- Comprehensive reliability appraisal aids in clinical decision-making and resources allocation.

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ABSTRACT

Background and purpose (aims): Measurement error of intraoral quantitative sensory testing (QST) has been assessed using traditional methods for reliability, such as intraclass correlation coefficients (ICCs). Most studies reporting QST reliability focused on assessing one source of measurement error at a time, e.g., inter- or intra-examiner (test–retest) reliabilities and employed two examiners to test inter-examiner reliability. The present study used a complex design with multiple examiners with the aim of assessing the reliability of intraoral QST taking account of multiple sources of error simultaneously.
Methods: Four examiners of varied experience assessed 12 healthy participants in two visits separated by 48 h. Seven QST procedures to determine sensory thresholds were used: cold detection (CDT), warmth detection (WDT), cold pain (CPT), heat pain (HPT), mechanical detection (MDT), mechanical pain (MPT) and pressure pain (PPT). Mixed linear models were used to estimate variance components for reliability assessment; dependability coefficients were used to simulate alternative test scenarios.
Results: Most intraoral QST variability arose from differences between participants (8.8–30.5%), differences between visits within participant (4.6–52.8%), and error (13.3–28.3%). For QST procedures other than CDT and MDT, increasing the number of visits with a single examiner performing the procedures would lead to improved dependability (dependability coefficient ranges: single visit, four examiners = 0.12–0.54; four visits, single examiner = 0.27–0.68). A wide range of reliabilities for QST procedures, as measured by ICCs, was noted for inter- (0.39–0.80) and intra-examiner (0.10–0.62) variation.

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Conclusion: Reliability of sensory testing can be better assessed by measuring multiple sources of error simultaneously instead of focusing on one source at a time. In experimental settings, large numbers of participants are needed to obtain accurate estimates of treatment effects based on QST measurements. This is different from clinical use, where variation between persons (the person main effect) is not a concern because clinical measurements are done on a single person.
Implications: Future studies assessing sensory testing reliability in both clinical and experimental settings would benefit from routinely measuring multiple sources of error. The methods and results of this study can be used by clinical researchers to improve assessment of measurement error related to intraoral sensory testing. This should lead to improved resource allocation when designing studies that use intraoral quantitative sensory testing in clinical and experimental settings.

1. Introduction

Somatosensory system assessment is part of a clinical examination of a patient presenting with pain, including tests to assess various sensory functions [1]. Such evaluation of the orofacial region includes traditional procedures such as thermal/electrical pulp tests, tooth percussion, palpation, and anaesthetic blocks [2] as well as various thermal, mechanical, and chemical stimuli [3]. In clinical settings, these tests are qualitative and lack standardization regarding stimulus application and assessment of evoked sensations [1,3]. When performed in a systematic manner using strictly defined stimulus properties, these tests are called quantitative sensory testing (QST) [4,5]. A standard QST protocol has been developed by the German Research Network on Neuropathic pain (DFNS) [6], and further developed for intraoral use [7].

Measurement error assessment is important for sensory testing given the multiple sources of variation: variation in stimulus (delivery methods), between examiners (experience, dexterity), between participants (sensitivity, attention, previous experiences), or between multiple visits. Intraoral QST measurement error has been investigated in healthy participants [7] and patients with persistent intraoral pain [8]. These studies focused on two measures of reliability, intra- and inter-examiner, as previously assessed in other studies of QST reliability [9,10]. This approach only accounts for one source of variation at a time – examiner or visit – and thus does not identify or measure other factors, e.g., related to participants, interactions between factors, or random error. Recently studies have investigated multiple sources of variation for sensory testing [11,12]. Such a comprehensive approach can identify factors that, once addressed, can reduce variation and guide resource allocation for studies employing sensory testing and also help evaluate these tests' applicability in clinical practice [13,14].

Our aim was to assess multiple sources of variation in a battery of intraoral QST procedures to: (i) determine their main source(s) of variation; and (ii) evaluate the influence of the number of examiners and participant visits for QST measurements' dependability.

2. Methods

2.1. Participants

Healthy participants were recruited from the UMN community. Eligibility criteria were absence of bodily pains in the previous six months and no visible oral disease. Telephone or in-person screening was initially done, then a clinical evaluation determined participant eligibility.

2.2. Examiners

Four examiners with varied clinical experience performed the intraoral QST procedures: one faculty member, one post-doctoral fellow, one dental resident, and one dental student. The faculty examiner underwent a 2-day training session in the intraoral QST protocol at the University of Washington. He then conducted a 1-day training session for the other three examiners, after which all four examiners practiced the procedures together on two further occasions.

2.3. Study design

The intraoral QST protocol was based on the DFNS adapted for intraoral use [7], retaining seven of the 13 original procedures due to time constraints and limited available resources. It included procedures measuring thresholds for thermal (cold detection [CDT], warmth detection [WDT], cold pain [CPT], and heat pain [HPT]) and mechanical (mechanical detection [MDT], mechanical pain [MPT], pressure pain [PPT]) sensory functions. Sensory testing was performed in four intraoral sites, one over the buccal premolar gingival mucosa in each quadrant. Thermal tests were performed in 2 quadrants, which were selected randomly in each participant for each thermal test done by each examiner; mechanical tests were performed in all quadrants.

Each participant was measured on two visits separated by 48 h, with each visit lasting a half-day. Before each session, all examiners convened to review the protocol. Separate dental operatory stations were used for these procedures: (1) PPT, (2) MDT, (3) MPT, and (4) thermal. Each participant remained seated in a given station and received that station's procedure(s) from each examiner, then moved to the next station to be examined by each examiner with that station's assigned procedure(s), until all seven procedures were performed on each participant by all four examiners.

2.4. QST procedures

2.4.1. Thermal testing

PATHWAY Pain & Sensory Evaluation System (Medoc, Israel) with an intraoral thermode having a round active contact surface (diameter = 6 mm) was used for all thermal tests, which were performed in the sequence: CDT-WDT-CPT-HPT. For each test, the intraoral thermode was held in place by the examiner, with a baseline temperature of 32 °C, and temperature change rate of 1 °C/s for CDT and WDT; for CPT and HPT, the rate of temperature change from baseline was 1.5 °C/s; the rate of return to baseline was 8 °C/s. Cut-off temperatures for thermal tests were 0 °C and 54 °C. Participants were instructed to hold a response unit and press its button once a particular sensation (coolness, warmth, cold pain, heat pain) was first perceived, ending the trial. Detection thresholds were calculated as the temperature difference from baseline; pain thresholds were determined from the absolute temperature reached. Each test included three measurements; the average of the three measurements was used as threshold.