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Data Article

Data on toothbrushing study comparing infrared-based motion tracking versus video observation

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ABSTRACT

Investigations of toothbrushing habits are an important vector to understand their influence on brushing effectiveness. User compliance in toothbrushing is known to deviate from professional recommendations in brushing time, evenness across all areas of the dentition, and brushing force [1,2]. Despite the recent development of tools designed to guide users to optimised brushing habits [3,4], research on habit evaluation and tracking is limited and typically relies on labour-intensive video observation (VO) [5]. Here we present raw data on toothbrush position as determined by an automated motion tracking (MT) capability and by human VO and provide a technical description of the MT capability. The MT system described in this article was developed in collaboration with Soft2Tec GmbH (Rüsselsheim, Germany) as a potential substitute for the VO tool. The MT system consists of a monocular vision module and a target module with active infrared LED trackers. The MT system determined the position and orientation of a toothbrush relative to the jaw while subjects brushed under realistic conditions. For VO, a trained assessor coded video recording data from toothbrushing sessions. The data presented here describes a clinical study (103 subjects; 46 completed two sessions, 57 completed one ses-

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sion, altogether 149 events) comparing toothbrushing behaviour recorded with the MT system and with VO simultaneously. The raw data was deposited in Mendeley Data, under data identification number doi:10.17632/4f384xrbhm.1 [https://data.mendeley.com/datasets/4f384xrbhm/1].

Specifications table

Subject	Medicine and Dentistry (General)
Specific subject area	Infrared-based motion tracking in oral care
Type of data	Raw MT and VO data Images detailing MT components Flow chart describing MT calibration steps and experimental process
How data were acquired	Toothbrush position was measured using an infrared-based MT system equipped with 7 monocular cameras (Flir Grasshopper3 GS3-U3–23S6M) and using a video camera (Sony FDR-AX33).
Data format	Raw data in CSV files
Parameters for data collection	MT data was recorded at 100 Hz; VO data was recorded at 50 frames per second.
Description of data collection	The MT system recorded the poses of a toothbrush head relative to dentition. For VO, a trained assessor coded video recording data from toothbrushing sessions.
Data source location	Research Unit of the Procter & Gamble Service GmbH group, Kronberg, Germany
Data accessibility	The raw MT and VO data was deposited in Mendeley Data, under data identification number doi:10.17632/4f384xrbhm.1, [https://data.mendeley.com/datasets/4f384xrbhm/1] Images and flow chart are included in this article.

Value of the data

- This data provides a comprehensive assessment of a MT system as a tool for observing position and orientation of a toothbrush head compared to video observation under realistic brushing conditions.
- This article details a high throughput, objective method for tracking the poses of a toothbrush head relative to dentition and is of importance to researchers in academic, commercial, and professional settings.
- This data may be leveraged for development of future studies measuring degree of toothbrushing systematics or improvements in toothbrushing technique after instruction.
- MT has potential for use in oral care studies with manual as well as powered toothbrushes.

1. Data description

In this article, we present raw data on toothbrush position as determined by MT and by VO. The data was collected in 103 subjects who brushed with either a manual or a powered toothbrush. Forty-six subjects completed 2 brushing sessions; the second brushing session took place after subjects had received video instruction aimed at improving their brushing systematics. In each brushing session, 2 CSV files—1 file from MT and 1 file from VO—were generated. The filenames are coded with the internal labelling of the subject (first 4 numbers), labelling of the first or second brushing session ("001″ or "002″), labelling of toothbrush device (P: powered toothbrush, M: manual toothbrush) and labelling indicating whether the subject was a left- ("L") or right-handed ("R") user.

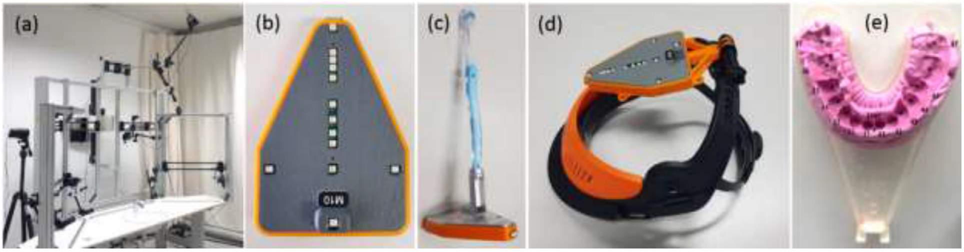

Fig. 1. MT system components.
Fig. 1 shows (a) MT cluster of 7 monocular cameras, (b) infrared LED tracker, (c) toothbrush with applied tracker, (d) headpiece tracker, (e) impression tray.

The columns of the MT files are structured as follows: Frame (number of event, column header: Frame); Time (timestamp of MT recording, brushing session started at "Start", row 7, and was completed at "Stop", row 8, column header: Time); Sextant (segmentation of brushing into sextants, column header: Region); Tooth (segmentation of toothbrushing position related to FDI tooth position scheme, column header: Tooth); Surface (segmentation of tooth area related to vestibular, oral and occlusal, column header: Surface); Interpolation (data interpolation— 0: no, 1: yes, column header: interpolated); Area (another compact coding of sextant:tooth:surface without additional information compared to previous columns, column header: segment); Brush head centre (z-coordinate of brush head centre related to head, front teeth upper jaw is zero, lower jaw <0. This provides information on how wide the mouth was opened, column header: BHCz). The parameter Sync in row 6 is the timestamp when a trigger signal occurred in order to synchronise MT and VO data.

The columns of the VO files are structured similarly: Frame (number of event, column header: Frame); Time (timestamp of VO recording, brushing session started at "Start", row 7, and was completed at "Stop", row 8, column header: tFrame); Sextant (segmentation of brushing into sextants, column header: sRegion); Surface (segmentation of tooth area related to vestibular, oral, and occlusal, column header: sSurface); Outlier (remark if video assessor was not able to code an event, column header: sOutlier); Brushing style (e.g., circular movement, column header: sStyle); Area (compact coding of sextant:tooth:surface without additional information compared to previous columns, column header: sSegment). Since an exact tooth position of the brush head is not detectable via VO, tooth position is always coded with "00″.

In addition, we provide a technical description of the MT capability, including the MT system components (Fig. 1) and the calibration steps required to collect data using MT (Fig. 2). Fig. 1 shows the semi-circular positioning of MT system cameras as well as the active infrared LED trackers associated with a toothbrush and with headpiece. A dental impression tray is also shown. Fig. 2 describes the calibration steps necessary to allow tracking of toothbrush movement relative to dentition with the MT system.

2. Experimental design, materials, and methods

2.1. Experimental materials and setup

Toothbrush position with either a manual (Oral-B Indicator 35 soft, type OM010, Newbridge, Ireland) or a powered toothbrush (Oral-B Genius, type 3765, with a Cross Action Power brush head, Marktheidenfeld, Germany) was measured using an infrared-based MT system equipped with 7 monocular cameras (Flir Grasshopper3 GS3-U3–23S6M with applied infrared bandpass filter) and using a video camera (Sony FDR-AX33).

The MT system contains 2 complementary modules: a monocular vision module comprised of 7 cameras (Fig. 1a) and a target module with active infrared LED trackers (Fig. 1b). The cameras recorded signals from infrared trackers mounted on toothbrushes (Fig. 1c) and on headpiece

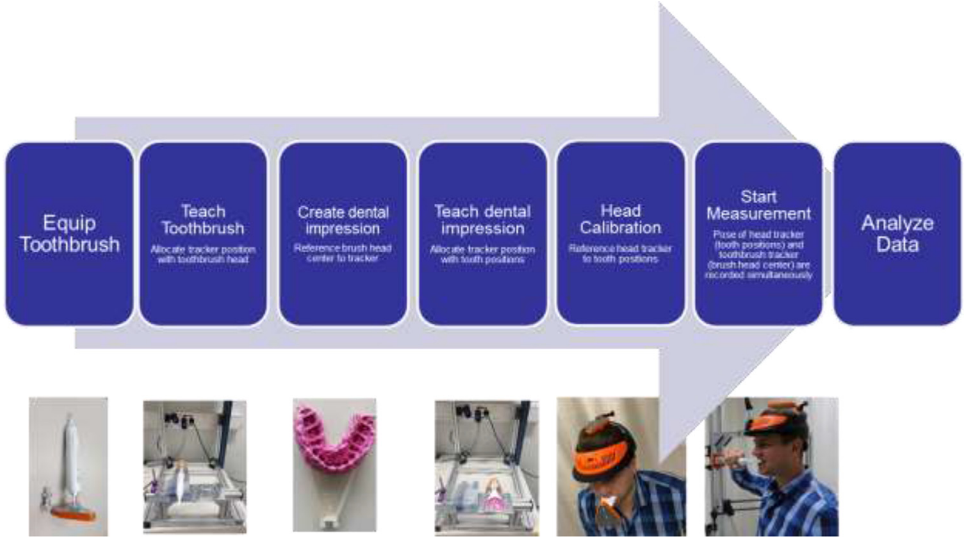

Fig. 2. MT calibration and experimental overview.
Fig. 2 shows the calibration steps necessary to allow tracking of toothbrush movement relative to dentition.
Step 1: equip toothbrush with infrared tracker.
Step 2: allocate tracker position with toothbrush head.
Step 3: create dental impression for each subject.
Step 4: equip dental impression with infrared tracker in order to allocate tracker position with respective tooth positions.
Step 5: reference head tracker to tooth positions: subject wears dental impression with infrared tracker and head tracker while standing in front of monocular camera cluster.
Step 6: collect data: subject wears head tracker and uses equipped toothbrush while brushing. Both trackers record simultaneously, and toothbrush head pose is referenced to tooth position.

(Fig. 1d). A tracker was also applied at a dental impression tray for each subject (Fig. 1e). A localization algorithm [6] determined the marker positions in the camera images and derived the pose of the trackers in 3D space. The cameras were positioned in a semicircular arrangement to allow optimal recording of tracker signals (Fig. 1a). A cluster of 7 monocular cameras was established to provide sufficient space coverage and to accommodate the normal body and head movements that occur under realistic brushing conditions. The MT system is independent of environmental conditions and allows sampling at 100 Hz. The wireless infrared markers minimise disturbance during brushing.

Several calibration steps are necessary to allow tracking of toothbrush movement relative to dentition (Fig. 2):

Step 1: equip toothbrush with infrared tracker.
Step 2: allocate tracker position with toothbrush head.
Step 3: create dental impression for each subject.
Step 4: equip dental impression with infrared tracker in order to allocate tracker position with respective tooth positions.
Step 5: reference head tracker to tooth positions: subject wears dental impression with infrared tracker and head tracker while standing in front of monocular camera cluster.
Step 6: collect data: subject wears head tracker and uses equipped toothbrush while brushing. Both trackers record simultaneously, and toothbrush head pose is referenced to tooth position.

Subjects were placed in the centre of the MT cameras in front of a mirror, and a video camera was placed behind a semitransparent mirror. The video camera was mounted in a black box with a mirror in front and was synchronised with the MT system. Subjects brushed with a toothbrush equipped with a tracker while wearing the headpiece tracker. Brushing was recorded by the MT system and by VO at the same time.

2.2. Measurement procedures

For MT recording, the poses of both the headpiece tracker and of the toothbrush were recorded simultaneously for each subject. Brushing and head movements were then transformed into a relative coordinate system with stationary dentition positions. A segmentation algorithm allocated brush head positions to tooth positions and surfaces (occlusal, oral, vestibular). In a first step, the algorithm separated between the upper and lower jaw by the z-coordinate of the brush head centre. Next, the distances to all teeth of either the upper or lower jaw were calculated, and the tooth with the smallest distance was identified (provided the distance was smaller than a given threshold). Tooth surface was determined by the direction vector of the brush head. A detailed description of VO procedures is provided elsewhere [5].

2.3. Location of raw MT and VO data

The raw MT and VO data was deposited in Mendeley Data, under doi:10.17632/4f384xrbhm.1, [https://data.mendeley.com/datasets/4f384xrbhm/1]

Declaration of Competing Interest

M. Wolf, R. Engelmohr, J. Erb and R. Gübler are full-time employees of Procter & Gamble Service GmbH, Kronberg, Germany.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2020.105867.

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