A New Paradigm for Human Taste Measurement

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ABSTRACT
We previously developed a high throughput system for in vivo measurement of taste quality and palatability using rats as subjects (Palmer et al., 2013, PLoS ONE). We now have extended this technology to creation of a new paradigm for taste measurement in humans. The system is fully automated and is comprised of a robotic sample delivery system, a touch-sensitive display (TSD) that records the subjects’ responses, and a command computer that runs subject-interactive algorithms and communicates with a database. The algorithms that operate the taste testing method are “gamified” - structured according to operant conditioning and signal detection theory and are structured to provide rewards are virtual poker chips with point values that are directly remunerated for actual currency at the end of a session. The algorithms are designed to incorporate principles of operant conditioning and signal detection theory and are structured to provide consequences to the subject’s response on each trial. Thus, taste-testing performance and rate of testing are incentivized. Subjects typically complete a 96-trial session in 45-60 minutes with high performance accuracy and test-to-test reproducibility. The software is designed to accommodate flexibility in experimental design so that a large area of test protocols can be operated under the interactive algorithms.

ENTRY LEVEL TRAINING MODULE: CALIBRATION, GRADED REWARD VALUE

A) In this example, the tastes of sucrose (sweet and palatable), quinine (bitter and unpalatable), and water (neutral) are mapped to specific coordinates on a Cartesian grid appearing on the display. Targets are invisible to the subject, who must discover their locations and area of each target are input variables under the control of the test administrator.

B) Touch responses made within the target areas on control (standard taste) trials are reinforced by the appearance of a poker chip on the display. There are three poker chip values (high, intermediate, and low)—magnitude of point value is an input variable set by the test administrator prior to the start of a session. Points accumulate across trials. Consequences of errors (responses made outside of the target areas) can be either neutral or negative. Negative consequences include a time-out, in which the display dims and a delay before the next trial, is imposed, and/or subtraction of points earned.

C) Configuration of the 96-well plate used for the training module.

CALIBRATION FOR LEVEL 2 TRAINING MODULE

A) After proficiency in performance is achieved in the entry level training mode, subjects are advanced to a higher level. In this Level 2 Training Module the touchscreen is calibrated with the addition of salty and sour taste standards.

B) Configuration of the 96-well plate used for the training module.

SINGLE SUBJECT, SINGLE TEST SESSION, 4 CONCENTRATION-RESPONSE FUNCTIONS FOR TASTE

A) Concentration response functions were generated in single test sessions using the plate shown in (A). Data are plotted as the average for each point across two consecutive test sessions, error bars = SEM. Curves were fit by non-linear regression (GraphPad Prism). Control standards: QUI=0.5 mM quinine, CIT=10 mM citric acid, SUC=100 mM sucrose, NaCl=100 mM NaCl, and water.

B) Concentration response functions were generated in single test sessions using the plate shown in (A). Data are plotted as the average for each point across two consecutive test sessions, error bars = SEM. Curves were fit by non-linear regression (GraphPad Prism). Control standards: QUI=0.5 mM quinine, CIT=10 mM citric acid, SUC=100 mM sucrose, NaCl=100 mM NaCl, and water.

TYPICAL TRAINING RESULTS FROM SINGLE SUBJECT

Subjects quickly learn the concept and fundamental rules of the game. In this example, the graph shows the results of a subject that exceeded a criterion of 700 points within 25 trials. Surpassing the criterion qualified the subject for advancement to a higher challenge level in which additional taste stimuli were included in the algorithm.