A dental roll technique for the measurement of salivary activity

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A discussion of the development of a method for the analysis of salivary activity is presented. Results gained using this new method are compared with those obtained using a whole-mouth spitting technique. The application of the new method in real-world situations is indicated. Norms are presented for measures of salivary flow, pH, and salivary ion concentration based on experimental studies of a female working population.

Saliva is one of the most accessible body fluids available for clinical and research purposes. Changes in its rate of flow and ionic content have been reported to be sensitive to differences in personality (Corcoran, 1964; Eysenck & Eysenck, 1967; Wardell, 1974) and to reflect psychiatric disorders (Busfield & Wechsler, 1961) and mood states (Sternback, 1966). These changes appear to be regulated by both sympathetic and parasympathetic nervous activity, although the relative balance of these influences varies from gland to gland (Katz, Sutherland, & Brown, 1967).

Recently, there have been many attempts to study the immediate psychophysiological response to occupational stress in industrial settings (e.g., Cox, Thirlaway, Watts, Cox, & Mackay, 1979; Ackerman-Liebrich, Martin, Baschera, & Grandjean, Note 1). Field research within industry places extra constraints on measurement techniques, which are often reflected in a tradeoff between absolute accuracy and subject acceptability. The most accurate measures of salivary function appear to be those based on the salimeter and suction cup (Katz et al., 1967). However, such techniques are relatively impractical and costly for field use, and they have low subject acceptability. Less accurate but consistently reliable measures have been developed around whole-mouth spitting and dental roll insertion (Peck, 1959; Razran, 1935; White, 1977). Whole-mouth spitting would appear to be the easiest to apply in industry, but this also has low subject acceptability. Social taboos against spitting seem particularly strong. Dental roll techniques suffer neither of these problems, but there has always been difficulty with the extraction of the saliva from the dental roll. This technical note

describes a method that overcomes this problem. It also compares data obtained using this technique with that obtained using whole-mouth spitting.

METHOD

Standard dental rolls (Oratex No. 2; .3-.5 g) were washed in double distilled deionized water, dried, and cut in half. Each half was placed in a weighed and stoppered dry glass vial: Rolls and half rolls were manipulated using short surgical forceps. The weights of the vials and half rolls were noted, and the dry weight of the half rolls was calculated.

Subjects were asked to rinse their mouths out with double distilled deionized water and then, using the forceps, to place a half roll on each side of their mouth. They were asked to place the roll between their cheeks and jaw as far back in their mouths as was comfortable. After an 8-min period, the subjects were asked to remove the half rolls, again using the forceps, and to replace them in their vials. The vials and half rolls were reweighed, and the net saliva weight was calculated. The half rolls were then placed in sterile 10-ml plastic disposable syringes fitted with fine gauze pads. The saliva was squeezed into a weighed dry specimen bottle. The specimen bottles were then reweighed, and the recovered saliva weight was calculated.

Comparison of the net saliva weight with the recovered saliva weight (for 20 subjects) suggested that a 60% recovery rate was being achieved. For samples with a net weight of greater than .80 g, the mean recovery rate was 85%. The samples collected in this way were homogeneous, free from mouth or dental roll debris, and proved suitable for pH and ion concentration determinations. Comparison of the pH and ion concentrations of distilled water before and after the recovery treatment showed that no significant alteration of values occurred.

The 8-min collection period was determined in a pilot study that systematically varied collection times. This indicated that the weight of saliva collected using the dental roll technique was effectively a negatively accelerated function of time. Using the Oratex (No. 2) dental rolls, the most useful collection time period was 8 min. An effective ceiling was achieved with 90% of the resting subjects providing enough saliva for analytical purposes without maximum saturation of the dental roll. Flow rates determined over this 8-min period ranged between .01 g/min to .32 g/min. Previous research using the whole-mouth spitting method suggested that a much shorter, 2-min collection period was appropriate for the same sort of criteria. Recorded flow rates for this period ranged between .05 g/min to .27 g/min.

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COMPARISON OF METHODS

Twenty subjects participated in a comparison of the two techniques. A repeated-measures design was used, each subject providing two samples of saliva at the same time of day (midday) on 2 days, 1 day apart. The same general conditions were imposed on both days.

The weight of saliva produced was measured, and pH was determined electrometrically (Gilchrist & Furchtgott, 1951). Sodium and potassium ion concentration were determined by flame photometry (Varley, 1967) using a Corning EEL automatic flame photometer (Model 430).

The results of this comparative study are shown in Table 1.

Comparison with norms reported by Ferguson (1975) indicate that both these techniques provide samples of mixed saliva. However, the pH values are slightly higher than would be expected in unstimulated saliva. This indicates that there is some degree of stimulation occurring. Sources of mild stimulation are evident in both methods: Mechanical jaw action is required to retain and spit saliva in whole-mouth spitting, whereas distention of the cheek muscles and movement of the roll occurs with the dental roll technique. Stimulation increases the proportion of saliva contributed by the parotid gland, raising the overall pH of saliva.

Comparison of the two methods is obviously difficult because of the balancing of the different collection times. However, the differences in the various measures taken are not statistically significant (with the exception of the ion ratio measure), and this suggests that the saliva samples are not different in composition or origin. Generally, there is also a reasonable correlation between the different measures across subjects, the exceptions being pH and potassium concentration. The high correlation for the ion ratio measure explains the significance of the associated related-means *t* test.

FURTHER STUDIES (NORMS)

The dental roll technique has now been used in several studies, and some of the results gained have been summarized elsewhere (Cox et al., 1979; Mackay, Cox,

Watts, Thirlaway, & Lazzerini, 1979). All the measures taken have been shown to be sensitive to various psychological (work) factors. In one experiment, 69 women were employed to work on a simulated sorting process, which involved three different jobs. Two jobs, loading material and then sorting it, were repetitive, and the third, minding, was treated as a nonrepetitive (at work) control. Each of the women worked for 1 week and, during that time, carried out each job. The order of presentation of the jobs was controlled. Saliva samples were collected before, during, and after each working day.

The before work samples for the minding condition presented the following data: mean flow rate $.22 \text{ g/min} \pm .10$ (SD), mean pH = $6.86 \pm .38$; mean sodium concentration = $7.9 \text{ mmoles} \pm 3.4$; mean potassium = $22.6 \text{ mmoles} \pm 5.0$; mean sodium:potassium ratio = .36. These means are consistent with the obtained sample's being mixed in origin, with a slight degree of stimulation and increased parotid contribution (see earlier).

The measures most influenced by the independent variables were salivary potassium and pH. For example, there was a clear duration of exposure effect for potassium concentration [$F(5,315) = 12.57$, $p = .0001$], although this was conditioned by payment schedule, among other things [$F(5,315) = 3.90$, $p = .002$]. Generally, potassium levels fell slightly over the morning work period and rose more dramatically during the afternoon. This is consistent with data reported in the literature (Dawes, 1974). Levels of potassium were higher for women working on a flat rate payment than those on a bonus scheme, and the afternoon changes were also more marked in that group.

CONCLUSION

The new method has been found to be easy to employ both in laboratory and field studies and is readily acceptable to subjects. It has been preferred to the whole-mouth spitting method by subjects tested in industry. Content data obtained suggest that the samples are of mixed gland origin and are sensitive to psychological manipulations.

Table 1
Comparison of Saliva Samples Collected Using Two Different Methods

Measure	Technique				Correlated Means Test	Pearson r
	Dental Roll		Whole-Mouth Spitting			
	Mean	SE	Mean	SE		
Flow Rate	.15	.07	.27	.18	†	.40*
pH	6.54	.49	6.79	.35	†	.30†
Na Concentration	7.70	3.30	7.30	3.60	†	.38*
K Concentration	23.00	5.90	22.40	4.00	†	.15†
Na:K Ratio	.35	.18	.34	.19	**	.71**

Note—Flow rate is given in grams per minute; concentrations are given in millimoles. * $p < .05$. ** $p < .001$. †Nonsignificant.

REFERENCE NOTE

1. Ackerman-Lieblich, U., Martin, E., Baschera, P., & Grandjean, E. *Investigations on repetitive tasks in the watch industry*. Paper presented to the annual conference of the Ergonomics Society, Oxford, England, 1979.

REFERENCES

- BUSFIELD, B. L., & WECHSLER, H. Studies of salivation in depression. A comparison of salivation rates in depressed, schizoaffective depressed, nondepressed hospitalized patients and in normal controls. *Archives of General Psychiatry*, 1961, 4, 10-15.
- CORCORAN, D. W. J. The relationship between introversion and salivation. *American Journal of Psychology*, 1964, 77, 298-300.
- COX, T., THIRLAWAY, M., WATTS, C., COX, S., & MACKAY, C. J. Job stress: The effects of repetitive work. *Department of Employment Gazette*, December 1979, pp. 1234-1237.
- DAWES, C. Rhythms in salivary flow rate and composition. *International Journal of Chronobiology*, 1974, 2, 253-279.
- EYSENCK, S. B. G., & EYSENCK, H. J. Salivary response to lemon juice as a measure of introversion. *Perceptual and Motor Skills*, 1967, 24, 1047-1053.
- FERGUSON, D. B. Salivary glands and saliva. In C. L. B. Lavelle (Ed.), *Applied physiology of the mouth*. New York: John Wright, 1975.
- GILCHRIST, J. C., & FURCHTGOTT, E. Salivary pH as a physiological variable. *Psychological Bulletin*, 1951, 48, 193-210.
- KATZ, R. A., SUTHERLAND, G. F., & BROWN, C. C. Measurement of salivation. In C. C. Brown (Ed.), *Methods in psychophysiology*. Baltimore, Md: Williams & Wilkins, 1967.
- MACKAY, C. J., COX, T., WATTS, C., THIRLAWAY, M., & LAZZERINI, A. J. Psychophysiological correlates of repetitive work. In C. J. Mackay & T. Cox (Eds.), *Response to stress: Occupational aspects*. Guildford, England, International Publishing Corporation, 1979.
- PECK, R. E. The SHP test—An aid in the detection and measurement of depression. *Archives of General Psychiatry*, 1959, 1, 35-40.
- RAZRAN, G. H. S. Conditioned responses: An experimental study and a theoretical analysis. *Archives of Psychology*, 1935, 28(Whole No. 191), 1-124.
- STERNBACK, R. A. *Principles of psychophysiology*. New York: Academic Press, 1966.
- VARLEY, H. *Practical clinical biochemistry*. London: Heinemann, 1967.
- WARDELL, D. Stimulus intensity and introversion-extraversion. *British Journal of Social and Clinical Psychology*, 1974, 13, 425-426.
- WHITE, K. D. Salivation: A review and experimental investigation of major techniques. *Psychophysiology*, 1977, 14, 203-212.

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